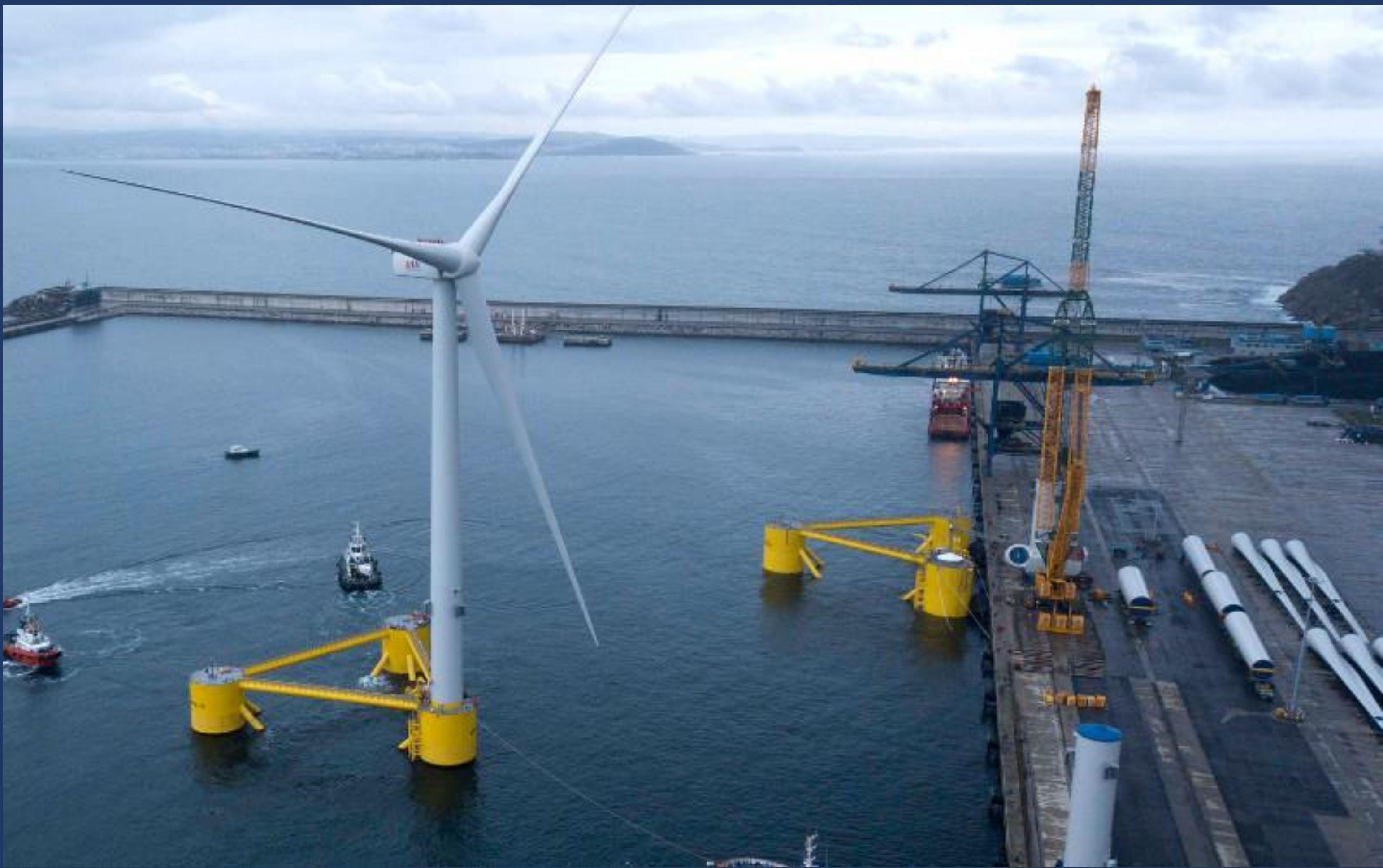
Dublin Offshore



Growth of Onshore to Offshore Wind – Atlantic Region Wind Energy & Supply-Chain Feasibility Study

July 2022

Client

The study was commissioned by the Mid-West, North-West and West Regional Enterprise Offices and funded by the Enterprise Ireland Regional Enterprise Transition Scheme, Clare County Council, Donegal County Council, Leitrim County Council, Limerick County Council, Mayo County Council, Tipperary County Council and the Western Development Commission. Dublin Offshore Consultants were selected by tender to develop a report and briefings on how public bodies and educational bodies can support the development and growth of the wind energy industry and supply chain from onshore to offshore in the Atlantic region (from Donegal to Limerick, covering the NUTS3 areas defined by the Mid-West, Northwest and West Regional Enterprise Plans.

About this Report

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The Project Team authored this report based on an impartial analysis of primary and secondary sources, including stakeholder consultation. The Authors would like to thank everyone that has contributed their time and expertise during the preparation and completion of this report. Special thanks go to Leitrim County Council and the Stakeholder group whose input and feedback were invaluable in completing this report.

Disclaimer

Executive Summary

The Atlantic Region, comprising of the Northwest, West, and Midwest regions (from Donegal to Limerick) has an abundance of natural resources along its coastline. The Atlantic region has an established onshore wind industry that already accounts for more than half of the wind energy generated in Ireland. Within the study area, Donegal and Tipperary have delivered the highest installed wind capacity per square kilometre (>90kW/km^2).

It is clear from all stakeholders that there is strong support and ambition in tackling climate change and that wind energy in the Atlantic Region can play a significant part. Wind energy is seen as an opportunity to deliver on climate goals, to deliver jobs, economic development, infrastructure, innovation and Foreign Direct Investment in the Atlantic Region. Whereas 2GW of onshore wind was built in the Atlantic Region in 20 years, 30GW of floating offshore wind could be built in 30 years. Local stakeholders recognise that there is an unprecedented opportunity for the Atlantic Region.

Wind Energy in the Irish Atlantic Region

Ireland has amongst the best wind energy resources globally. Wind projects onshore can avail of wind speeds of approx. 7 m/s, which are high in global terms. The wind speeds available off the Atlantic coastline, are far higher at up to 11 m/s within Irish Territorial Waters (12 nautical mile limit) and up to 15 m/s in the Irish Exclusive Economic Zone. Wind power is a function of the cube of the wind speed so even minor increases in wind speed can deliver significant increases in the energy yield. Wind speeds observed offshore in the Atlantic Region are significantly greater than the up to 10 m/s wind resource on the East coast of Ireland. The quality of wind resource further offshore means that the energy captured as a percentage of the capacity of the turbine can increase from the Irish average of 28% onshore to 57% observed for a floating wind project in Scotland.

The Current Context of Government Targets

The Irish Government have set a target for 80% renewable electricity in Ireland by 2030, including 8GW of onshore wind capacity, and 5GW of offshore wind capacity. The target of 8GW of onshore wind capacity by 2030 represents an almost doubling of existing wind capacity. Of the 5GW of offshore wind contained within the 2030 targets, 3GW is expected to be delivered on the East coast of Ireland with the remaining 2GW delivered on the South coast in the Celtic Sea, and on the West coast. The Programme for Government ‘Our Shared Future’ aims to take advantage of the “at least 30 GW of offshore floating wind power” off the Atlantic coast by 2050.

Pipeline Projects in the Atlantic Region

Almost 40GW of offshore wind projects are in development in Ireland of which more than 10GW are in the Atlantic Region. In early 2022 the first six commercial scale offshore wind projects comprising nearly 4GW were given “relevant projects” status to allow fast track development. Five of these projects are in the Irish Sea, the other, the 400MW Sceirde Rocks project, is off the Galway coast.

The majority of the remaining projects in the Atlantic Region are focused on access to the Moneypoint and nearby Tarbert grid connections, anticipated to become available from 2025. These projects are located off the Clare and North Kerry coasts and intend to use floating platforms due to the limitations on water depth for traditional fixed-bottom foundations. With the exception of those utilising Moneypoint and Tarbert grid connections all other future installed FOW capacity will require upgrades in grid

connection availability, battery storage, or alternative routes to market such as the production of Green Hydrogen.

Estimated Economic Impact

In 2022 it is estimated that across the Atlantic Region there is a total pipeline of 3,550 MW of onshore wind capacity, including 930 MW under development, 460 MW under construction, and 2,160 MW in operation. Despite offshore wind in the Atlantic Region being in the development stage, projects such as Sceirde Rocks are already generating economic activity.

For the future development of wind energy in Ireland, our analysis has considered three build-out scenarios considering *Steady, Rapid,* and *Aspirational* outcomes. The projections from the analysis in this study indicate that the offshore wind sector will overtake the onshore industry in the Atlantic Region within the period considered (15 years).

The longitudinal economic model built in this study estimated that the combined GVA of onshore and offshore wind in the Atlantic Region will be €2.85bn up to 2037 in the 'Rapid' build out scenario. In the 'Steady' scenario the GVA is reduced to €1.86bn and for the 'Aspirational' scenario the GVA is increased to €4.21bn to 2037. The modelled scenarios anticipate that the level of economic activity in the region will grow throughout the 2030s. By 2037 it is expected that in the Atlantic Region the wind sector will annually generate €220 million GVA in the Rapid Build Out Scenario (€170 million GVA in the Steady Build Out Scenario, and €400 million GVA in the Aspirational Build Out Scenario). Not all of this spending takes place within Ireland, as turbine components, for instance, are imported. In general, each region is expected to secure between 15 – 30% of the CAPEX of projects built in their area.

The economic model was also used to estimate the direct, indirect and induced employment supported by the wind industry. The results indicate that in the 'Rapid' build out scenario the wind industry can support 44,000 years of employment between now and 2037 in the Atlantic Region, with over 3,000 FTE jobs supported from 2028 to 2037.

Barriers to Delivery of Offshore Wind Potential in the Atlantic Region

The study identifies five significant barriers to delivery that must be overcome:

- **Route to Market - Grid Infrastructure:** including constraints to existing grid infrastructure, inadequate upgrade targets nationally, and a lack of forward planning for grid development post-2030. Grid capacity to support large-scale offshore wind developments extremely limited in the Atlantic Region with Sceirde Rocks and Moneypoint the only identified grid connections available.
- **Alternative Routes to Market:** Offshore wind resources exceed domestic demand – export markets are required to fully exploit the available wind resource. Green Hydrogen is considered a key enabler to decarbonise the Irish economy for transport and as an alternative to natural gas for heat and power, but the economic viability and relative merits of green hydrogen, ammonia and other alternative fuels are not yet fully established. A national hydrogen strategy is required in tandem with offshore wind to deliver the required industrial capacity and capability.
- **Port Upgrades:** There are significant gaps between existing port infrastructure in the Atlantic Region and in Ireland, and the requirements to support delivery of large-scale offshore wind, particularly for Floating Offshore Wind (FOW). Port infrastructure is not currently available to support FOW platform construction and FOW turbine assembly, two areas with the largest potential

for GVA. If the delivery of port infrastructure is delayed, offshore wind projects in the region may be constructed out of UK and European Ports with the opportunity for local economic development lost.

- **Clear Policy Signals:** Clear signals from government are critical to deliver the full potential of the wind energy industry in Ireland and the Atlantic Region. Specific targets for installed capacity of offshore wind post-2030 are required. Clear signals on a pipeline of wind energy activity in the Atlantic Region will enable ports to finance and commence upgrades, project developers to develop construction schedules, and educational bodies and training providers to tailor courses and ramp up activity to support industry needs.
- **Industrial Strategy:** A lack of an industrial/supply chain strategy aligned with clear signals on FOW build out is preventing the maximum capture of economic impact of the FOW projects within the Atlantic Region. FOW platform fabrication presents a massive economic opportunity, accounting for approximately 30% of project CAPEX. Other opportunities could include grid infrastructure upgrades, interconnectors, alternative fuels, innovative transmission, and storage technologies, such as high-voltage, direct-current interconnection, and green hydrogen.

Study Recommendations

Wind energy is a major part of the solution to Ireland's climate change commitments, but the benefits extend beyond improving our environment. Offshore wind can deliver hugely significant direct and indirect employment in regions that are historically disadvantaged economically. With sufficient ambition and support Ireland's wind industry can deliver our energy needs and establish us as an energy exporter.

To fulfil this ambition for the Atlantic Region and Ireland, the study identified the following recommendations:

- Deliver a regionally inclusive national energy strategy to co-ordinate route to market (grid & hydrogen), port upgrades, industrialisation and policy requirements, and to align national policies for maximum benefit.
- Ensure government provide clear signals on post-2030 capacity, with grid upgrades along the Atlantic region, and national strategies for alternative fuels, port development and supply chain.
- Ensure regional strategy supports delivery of onshore wind within counties with low levels of existing wind energy activity and limited offshore pipeline i.e. Leitrim, Sligo, Roscommon, Mayo, Galway.
- Enable new industry by identifying opportunities in the offshore wind value chain for new industrial development in the Atlantic Region, identifying early supply chain opportunities, including digital, clear signalling of 'Route to Market', and supports through the development of industry cluster(s).
- Support wind industry ramp-up activities by providing the necessary consenting, cabling, technical and financial support for FOW developers at SmartBay and AMETS test sites.
- Develop new courses and centres targeted at wind energy sector, with a particular emphasis on FOW skills and expertise not currently offered by Irish educational bodies.
- Raise awareness of offshore wind industry in the Atlantic Region as a business and career opportunity to ensure there is a pipeline of students, apprentices and transferees from related industries to support the sector as it develops.
- Establish a supporting framework for the grant of planning permission for the construction of onshore substations and cable routes to ensure developers have clarity on the process to successful award.
- Stakeholder supports should be made available to facilitate dialogue from project initiation through to operation between project developers and relevant stakeholders.

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Abbreviations

AHTS	Anchor Handling Tug Supply Vessel
AMETS	Atlantic Marine Energy Test Site
BoM	Bill of Materials
B2B	Business-to-Business
CAP	Climate Action Plan
CAPEX	Capital Expenditure
CD	Chart Datum
CTV	Crew Transfer Vessel
DAFM	Dept.of Agriculture, Food & Marine
EI	Enterprise Ireland
EIS	Environmental Impact Statement
EMEC	European Marine Energy Centre
EPS	European Protected Species
ESB	Electricity Supply Board
FLO-FLO	Float On / Float Off
FOW	Floating Offshore Wind
GIS	Geographic Information Systems
GVA	Gross Value Added
GW	Gigawatt
ha	Hectare
HAT	Highest Astronomic Tide
HGV	Heavy Goods Vehicle
HW	High Water
IDA	Industrial Development Agency
IMDO	Irish Maritime Development Office
INTOG	Innovation and Targeted Oil and Gas
JUB	Jack Up Barge
km	Kilometre

LAT	Lowest Astronomic Tide
LOA	Length Overall
LO-LO	Lift On - Lift Off
Metocean	Meteorology & (physical) Oceanography
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MW	Megawatt
NDP	National Development Plan
NM	Nautical Mile
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
ORESS	Offshore renewable Energy Support Scheme
RAG	Red-Amber-Green
REP	Regional Enterprise Plan
RNA	Rotor Nacelle Assembly
RO-RO	Roll on roll off
SAC	Special Area Conservation
SBOS	Stick Building On-Site
Semi-Sub	Semi-Submersible Platform
SHC	Self-Hoisting Cranes
SOV	Service Operation Vessel
SPMT	Self-Propelled Modular Truck
TLP	Tension Leg Platform
WD	Water Depth
WTG	Wind Turbine Generator

Extended Summary

Report Purpose

The Atlantic Region, comprised of the Northwest, West, and Midwest regions (from Donegal to Limerick) has an abundance of natural resources along its coastline. The Atlantic region has an established onshore wind industry with significant potential for offshore wind in the medium term (5-10 years). A supply chain has developed to cater for the onshore wind industry and an offshore supply chain has developed to support fisheries and O&G activities in the region and internationally. For Ireland and the Atlantic Region to realise the full potential of their wind resources, and facilitate private investment and job creation, the supply chain must be encouraged to both develop further to cater for onshore wind and to diversify to cater for the future offshore wind industry.

The purpose of this study is to develop a report and briefings on how public bodies and educational bodies can support the development and growth of the wind energy industry and supply chain from onshore to offshore in the Atlantic region. This report and subsequent webinar events will form the basis of subsequent projects, educational courses, initiatives to support the development and growth of the onshore and offshore wind along the Atlantic Region.

Wind Energy in Ireland

Ireland has some of the best wind resources in Europe and globally. Despite early progress in offshore wind in Ireland, the wind industry has developed almost exclusively onshore in the past 20 years, taking advantage of the relative ease of construction and enabling cost-effective development of small to medium projects. The SEAI Wind Atlas illustrates the wind speed at a height of 100m across Ireland and offshore. Wind projects at development locations onshore can avail of wind speeds of approx. 7 m/s, relatively high in global terms but substantially lower than the wind speeds offshore, where wind speeds are observed in excess of 10 m/s.

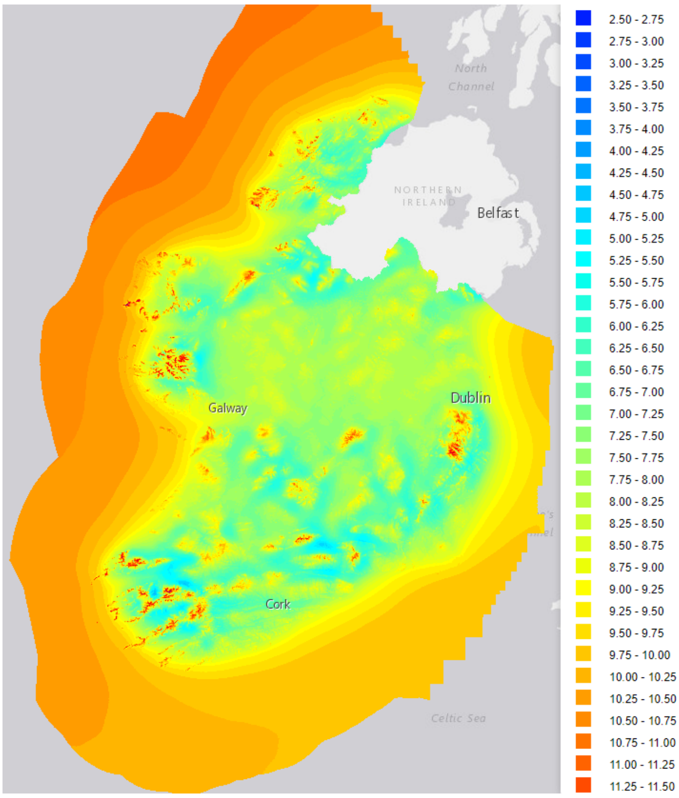


Figure 1: SEAI Wind Energy Resource Map

In addition, there is a significant difference in the wind resource between the East coast of Ireland and wind speeds observed offshore in the Atlantic Region with wind speeds approximately 1 m/s higher in the Atlantic Region.

The wind power is a function of the cube of the wind speed so even relatively minor increases in wind speed can deliver significant increases in the energy captured and, as a result, increased revenue to the project developer.

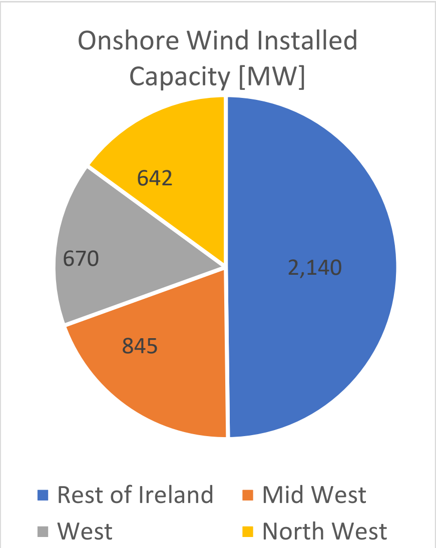
The improved wind resource found offshore, and especially far offshore at typical floating offshore wind sites is demonstrated by historical capacity factors, the measure of the energy captured as a percentage of the nameplate capacity of the turbine or windfarm. In Ireland the capacity factor recorded for onshore wind in the 5 years up to 2019 was 28.3% [1]. In contrast the Hywind floating offshore wind project in Scotland delivered a capacity factor of 56.8% in the past 12 months [2]. Improved capacity factors are expected in FOW projects generally. If this trend is repeated in Ireland, it would indicate substantially greater returns for offshore projects can be achieved.

Existing Wind Projects

Ireland has abundant wind energy resources, with installed capacity of more than 4.3GW in the Republic of Ireland. In addition, there is approx. 25MW installed capacity of offshore wind at Arklow Bank.

The Atlantic region accounts for more than half of the wind energy generated in Ireland, as of July 2021. The existing distribution of wind energy in Ireland is shown in Figure 2 with a breakdown of wind energy between each of the counties and sub-regions in the Atlantic Region and the remainder of the country.

Onshore wind projects in the Atlantic Region which have been successful in the two Renewable Energy Support Scheme (RESS) auctions are also included.



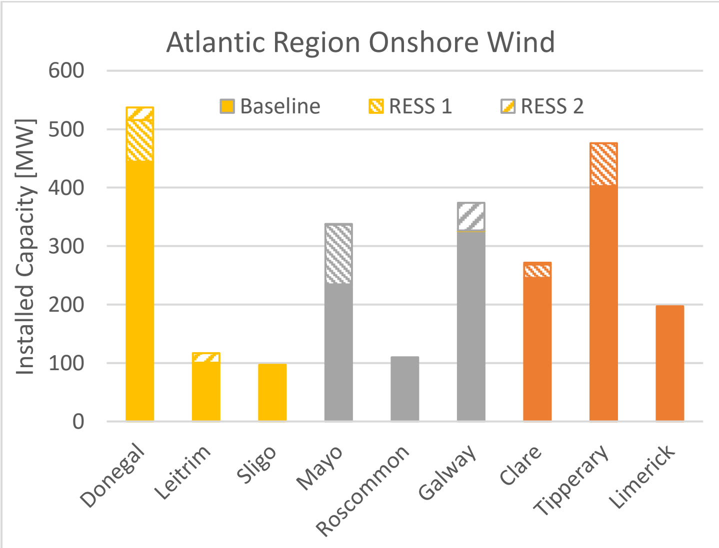


Figure 2: Distribution of Onshore Wind Capacity in Ireland including successful RESS 1 and 2 projects [R]

Government Targets

The Joint Oireachtas Committee on Climate Action published its cross-party report in 2019 entitled: Climate Change: A cross-party Consensus for Action, detailing recommendations including a target for 70% renewable electricity in Ireland by 2030. The 70% target was formally adopted in the Government’s Climate Action Plan and increased to 80% in 2021, including:

- 8GW of onshore wind capacity, and
- 5GW of offshore wind capacity.

The target of 8GW of onshore wind capacity by 2030 represents an almost doubling of existing wind capacity. However onshore wind faces a number of challenges not least planning with proactive stakeholder engagement and policy revision likely required to enable successful delivery of the targets. The projects announced under the RESS 1 and RESS 2 auctions illustrated in Figure 2 indicate there is significant additional capacity required to meet the onshore target.

Of the 5GW of offshore wind contained within the 2030 targets, 3GW is expected to be delivered on the East coast of Ireland with the remaining 2GW delivered on the South coast in the Celtic Sea, and on the West coast.

The Programme for Government 'Our Shared Future' aims to take advantage of the "at least 30 GW of offshore floating wind power" off the Atlantic coast by 2050. Irelands Offshore Renewable Energy Development Plan (OREDP) outlines the possibility of 27 GW of floating wind in Irish waters (7GW of which is on the West Coast).

Pipeline Projects

Almost 40GW of offshore wind projects are in development in Ireland of which more than 10GW are in the Atlantic Region, and nearly 4GW of schemes given "relevant projects" status to allow fast track development. In early 2022 the first six commercial scale offshore wind projects off Ireland were declared. Five of these projects are in the Irish Sea, with just one on the West Coast of Ireland, the 400MW Sceirde Rocks projects off the Galway coast.

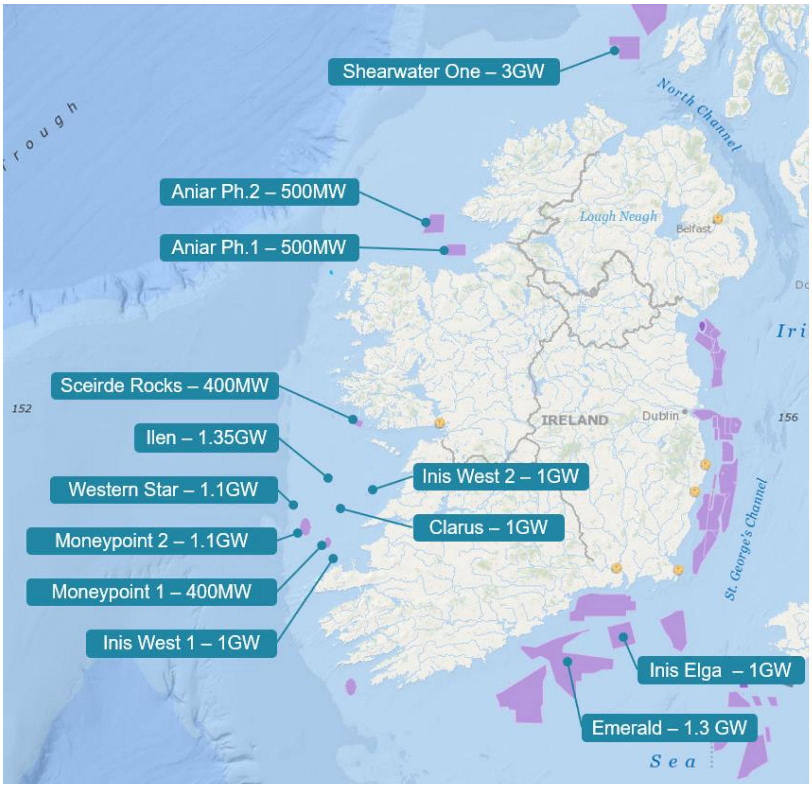


Figure 3: Atlantic Region Offshore Project Pipeline

The majority of Phase 2 projects in the Atlantic Region are focused on access to the Moneypoint grid connection, which is anticipated to become available from 2025, however they are competing for less than 2GW of grid connection capacity. These projects are located off the west Clare coast and will be developed using floating platforms due to the limitations on water depth for traditional fixed-bottom foundations. Currently there are at least seven specific floating offshore wind farm projects in the Atlantic Region in the very early stages of planning.

Future installed FOW capacity may be related to upgrades in grid connection availability, or potentially production of Green Hydrogen as a vector fuel. Combined fixed and floating offshore wind projects are also planned off the Sligo and Donegal coasts in the North-West region and are at an early stage of project definition and planning.

Wind Build out Scenarios

In order to quantify the scale of the opportunity that the development of onshore and offshore wind offers to the Atlantic Region, this study examined the pipeline of declared wind projects, the Programme for Government [3], the Climate Action Plan 2019 [4] and 2021 [5], Eirgrid's 'Shaping Our Electricity Future' report [6] and an extensive list of academic and industry sources [7] [8].

Three build-out scenarios were established for the future development of wind energy in Ireland considering *Steady, Rapid,* and *Aspirational* outcomes. The projections are presented in Figure 4 and indicate that the offshore wind sector is set to overtake the onshore industry in the Atlantic Region within the 15-year period considered in the study.

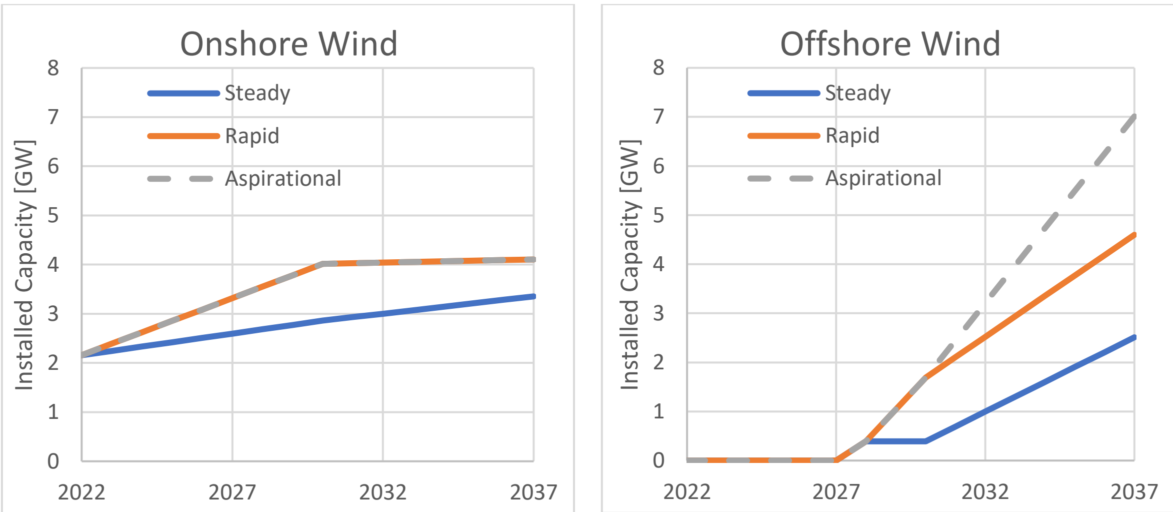


Figure 4: Steady Rapid and Aspirational Build Out Scenarios for the Atlantic Region

Economic Impact

The onshore wind industry in the Atlantic Region is already well established and in order to understand the potential growth from onshore to offshore wind it was necessary to determine a baseline of economic activity in the sector. It was estimated that in 2022 across the Atlantic Region there were a total 3,550 MW of onshore wind in construction, development or operation, of which:

- 930 MW is under development;
- 460 MW is under construction; and
- 2,160 MW is in operation.

A similar approach was taken to estimate ethe economic impact of offshore wind projects currently in development. The offshore wind sector in the Atlantic Region is in its infancy and there are no operational offshore wind farms off the west coast however there are project proposals such as Sceirde Rocks, which are in the development stage and generating economic activity.

A longitudinal economic model was developed to estimate the current activity and to account for future wind activity across each of onshore, fixed offshore and floating offshore wind segments. The results of the longitudinal model for the baseline (current year) and projected economic impact are presented in Table 1 for the Rapid build out scenario. It is estimated that in the Rapid build out scenario the combined GVA of onshore and offshore wind in the Atlantic Region will be €2.85bn to 2037.

Table 1: Onshore and Offshore Wind GVA by Region - Rapid Scenario

Region	Onshore GVA [€m]		Offshore GVA [€m]	
	2022	to 2037	2022	to 2037
Northwest Region	8	110	1	460
West Region	16	200	4	610
Mid-West Region	21	270	2	1,200
Atlantic Region	45	570	6	2,300
Republic of Ireland	199	2,600	85	13,100

Not all of this spending takes place within Ireland, as turbine components, for instance, are imported. For example, in the baseline onshore wind case the total spend across the Atlantic region, inclusive of any spending associated with developments not located within this area, was estimated at €110 million. This is equivalent to 14% of the total expenditure on the onshore wind sector in the Republic of Ireland in 2022. In general, each region is expected to secure between 15 – 30% of the capital expenditure of projects built in their area [9].

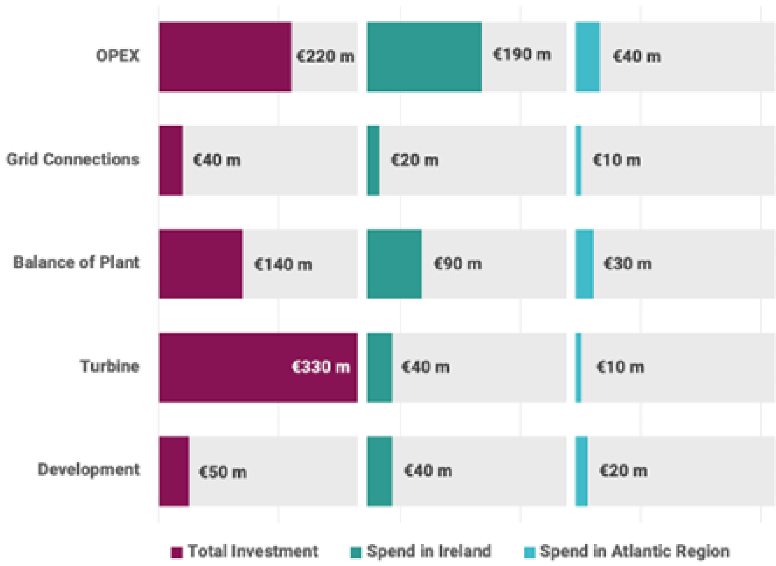


Figure 5: Spend in Ireland Onshore Wind Sector 2022

Employment Impact

Based on the levels of spending identified in Table 1, it was possible to estimate the direct employment supported over the period to 2037. This was done by allocating spending across each contract to the industrial sector of those businesses likely to be involved in its delivery. Spending by sector and area was then divided by sectoral Irish turnover per job ratios.

In addition to the direct employment supported by contracts for the development, construction and operation of onshore wind farms, impacts across the supply chain (indirect impacts) and from the spending of those carrying out the contracts (induced impacts) were estimated and are presented in Table 2 for the 'Rapid' build out scenario. The results indicate that in this scenario the wind industry can support 44,000 years of employment between now and 2037.

Table 2: Onshore and Offshore Wind Total Employment Numbers by Region (Direct, Indirect, and Induced) - Rapid Scenario

Region	Onshore Years of Employment		Offshore Years of Employment	
	2022	to 2037	2022	to 2037
Northwest Region	130	1,700	10	7,010
West Region	270	3,290	60	9,100
Mid-West Region	350	4,470	20	18,750
Atlantic Region	750	9,460	90	34,860
Republic of Ireland	3,460	41,390	1,240	160,690

Scenario Analysis

The economic impact of the wind energy sector varies significantly between scenarios. In the 'Rapid' scenario, the level of development and construction activity is front loaded, which creates a significant peak in employment in the late 2020s. This level of employment reduces in the 2030s as the level of development and construction activity is scaled back.

In the 'Steady' build out scenario, there is an expectation that the level of development and construction activities will be greater in the 2030s than the late 2020s. As a result, the level of employment in this scenario grows more steadily.

In the 'Aspirational' scenario, the significant level of activity that is seen in the 'Rapid' build out scenario to 2030 continues throughout the decade. This includes a significant proportion of floating offshore wind, which utilises the ports and supply chain in the Atlantic Region.

The estimated employment in the wind industry in the Atlantic Region is presented in Figure 6.

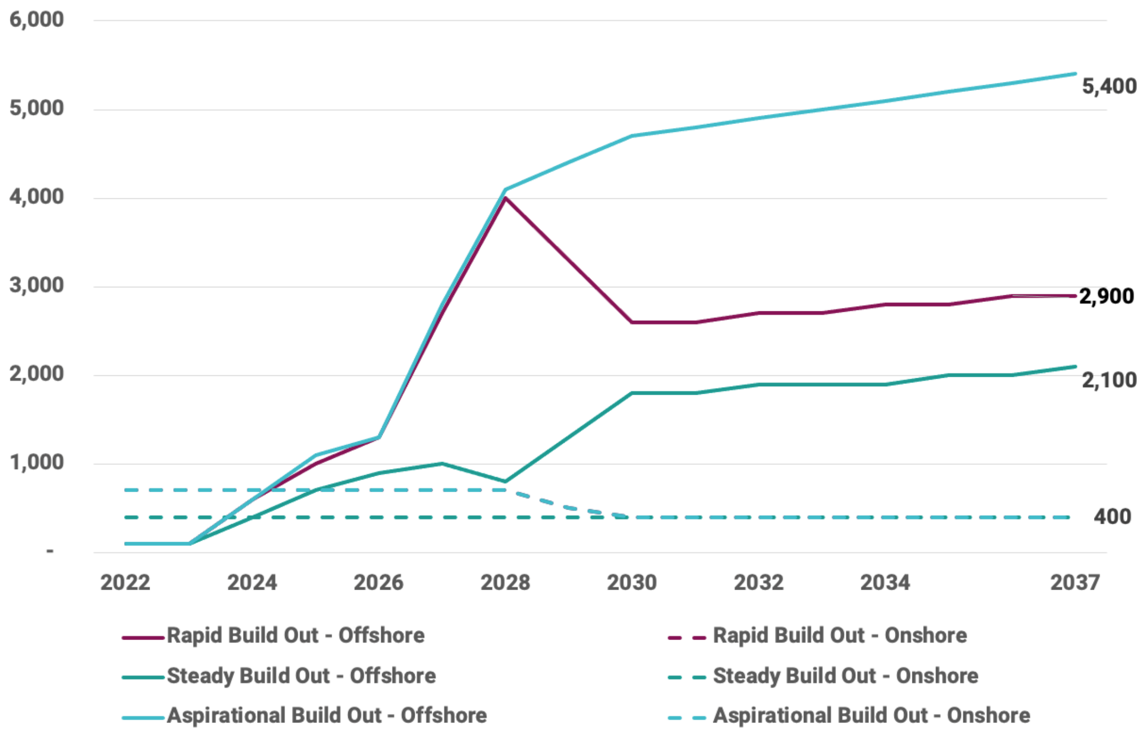


Figure 6: Jobs supported by the wind energy sector in the Atlantic Region

In all scenarios, the value and relative importance of the onshore wind sector declines. To meet the targets for 2030 set in each of the scenarios, the level of activity and employment in the offshore wind sector will increase significantly from 2024. Around this time, it is expected that the economic impact of the offshore sector will overtake that of the onshore wind sector in the Atlantic Region. The total employment in the onshore wind sector in 2037 in all scenarios is expected to be around 400 jobs. Therefore, by 2037 it is expected that there will be at least 5 offshore wind supported jobs for every 1 job supported by the onshore wind sector.

The differences in Gross Value Added in each sector are also driven by the offshore wind sector. As with employment, the level of economic activity in the region will grow throughout the 2030s. By 2037 it is expected that in the Atlantic Region the wind sector will annually generate:

- €170 million GVA in the 'Steady' build out scenario;
- €220 million GVA in the 'Rapid' build out scenario; and
- €400 million GVA in the 'Aspirational' build out scenario.

The cumulative impact of this difference presented in Figure 7 highlights the scale of opportunity that could be reached in each scenario.

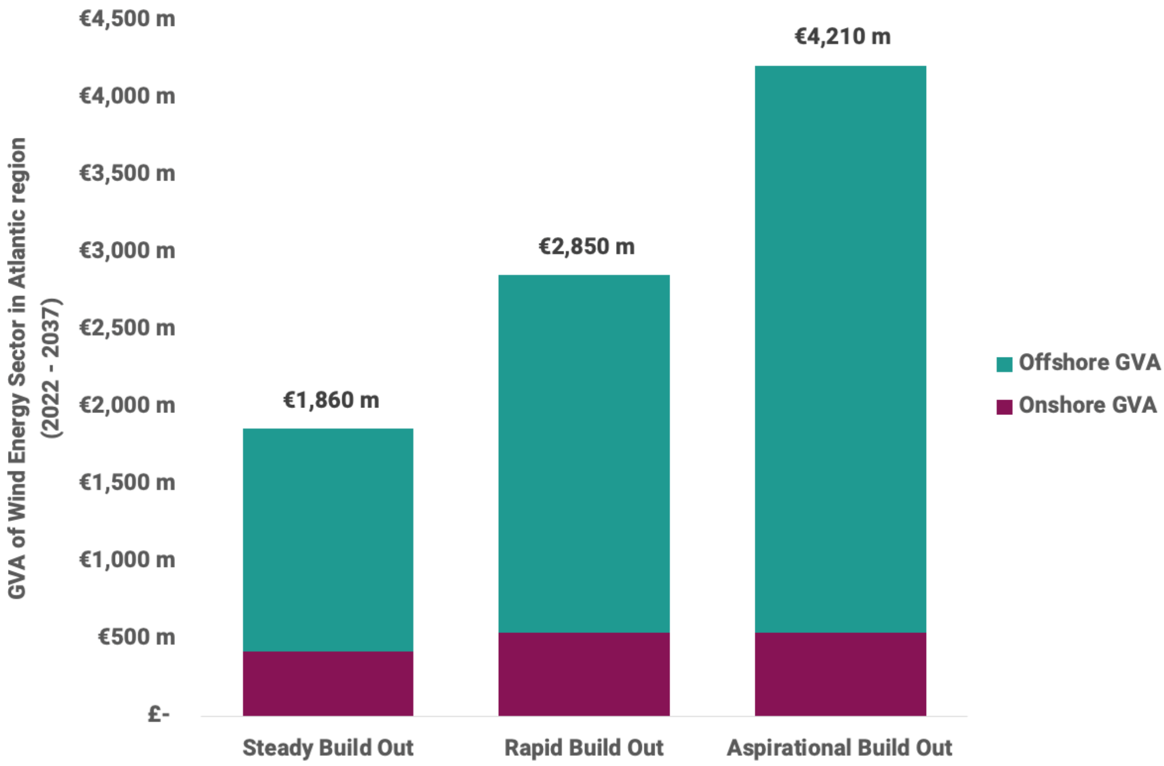


Figure 7: Cumulative GVA in Atlantic region from Wind Sector, by Scenario (2022 – 2037)

Barriers to Delivery

The key barriers to successful delivery of the build out scenarios identified in this study are presented in Table 3.

Table 3: Barriers to delivery

Route to Market	**Grid Infrastructure** • Much of the grid infrastructure in the Atlantic Region is limited to 110kV. • Planned grid improvements to 5.7GW of wind capacity falls short of the 8GW target in the Programme for Government and Climate Action Plan. • There is a lack of visibility on grid development post-2030. Uncertainty makes development of onshore and offshore projects challenging, heightening the likelihood of delays or projects being abandoned entirely. • Grid capacity to support large-scale offshore wind developments extremely limited in the Atlantic Region with Sceirde Rocks and Moneypoint the only identified grid connections available. **Alternative Routes to Market** • Offshore wind ambitions exceed domestic demand – export markets are required to fully exploit the available wind resource. • Green Hydrogen is considered a key enabler to decarbonise the Irish economy for transport and as an alternative to natural gas for heat and power. • Economic viability and relative merits of green hydrogen, ammonia and other alternative fuels not established. • A national hydrogen strategy is required in tandem with offshore wind to deliver the required industrial capacity and capability.

Port Infrastructure	**Port Upgrades** • Ports are the key driver of economic activity in offshore wind. • Irish ports are in competition for contracts with the UK and European ports. • There are significant gaps between existing port infrastructure in the Atlantic Region and in Ireland, and the requirements to support delivery of large-scale offshore wind, particularly for FOW. • Port infrastructure is not currently available to support FOW platform construction and FOW turbine assembly, two areas with the largest potential for GVA in the region. • A number of ports have developed port masterplans to support offshore wind, but upgrades are of significant cost. Investment should be made based on National and Regional Port Strategy to ensure co-ordinated delivery of the necessary infrastructure. • If the delivery of port infrastructure is delayed, offshore wind projects in the Region may be constructed out of UK and European Ports with the opportunity for local economic development lost.
Policy & Signals	**Clear Signals** • Clear signals from government are essential to deliver the full potential scale of the wind energy industry in Ireland and the Atlantic Region • Specific targets for installed capacity of offshore wind post-2030 are required. Targets to 2050 exist but are not specific. • The offshore wind projects and infrastructure upgrades required are major projects of approximately 10 years' duration. The policy environment needs to be clearly signalled beyond a 10-year horizon to support investment. • Clear signals on a pipeline of wind energy activity in the Atlantic Region will enable port authorities to finance and commence upgrade works, project developers to develop construction schedules, and educational bodies and training providers to tailor courses and ramp up activity to support industry needs. **Industrial Strategy** • An industrial strategy aligned with clear signals on FOW build out would allow for the maximum capture of economic impact of FOW developments within the Atlantic Region. • The strategy should be delivered in tandem with a Regional Port Strategy and consider grid infrastructure upgrades, interconnectors, alternative fuels, innovative transmission, and storage technologies, such as high-voltage, direct-current interconnection, and green hydrogen. • FOW platform fabrication presents a massive economic opportunity for the Atlantic Region, accounting for approximately 30% of project CAPEX. • Additional components within a floating wind project may be suitable for production in Ireland if a clear pipeline of projects exists, including the manufacture of fibre ropes, building on existing supply chain capability within the Atlantic Region, and the opportunity to manufacture inter-array and export cables.

Recommendations

The scale of the challenges in addressing the structural gaps facing the wind industry in the Atlantic Region require a commensurate scale of response. Therefore, some of the key actions and recommendations to support the industry should happen at national level. Nevertheless, the study has identified specific recommendations actionable by public and educational bodies to support the growth of wind energy from onshore to offshore.

Wind energy, and particularly the scale of offshore wind projects, is widely discussed as a solution to Ireland's climate change commitments, but the opportunity presented by offshore wind can address a much wider array of challenges than climate alone. The projected scale of the industry and regional distribution of Ireland's wind resource mean that offshore wind can deliver significant employment in areas that are historically disadvantaged economically. This industry can deliver Ireland's energy needs and establish Ireland as an energy exporter. A national energy strategy is required to co-ordinate the grid, port, industrialisation, and policy requirements of the offshore wind sector, and to align national policies for maximum benefit.

Figure 8: Pillars of a National Energy Strategy

Lobby Government	• Develop a national strategy to co-ordinate wind energy activities including port, grid, alternative fuels, offshore wind and industrialisation strategies. • Provide clear signals on post-2030 capacity – provide a roadmap to 2050 Net Zero. • Upgrade grid in West and North-West to meet Programme for Government Targets. • Ensure FOW benefits are captured within ORESS process i.e. local content and capacity factor.
Enable Industry	• Identify opportunities in the offshore wind value chain for new industrial development in the Atlantic Region. • Identify supply chain ramp up opportunities in the Atlantic Region including SmartBay and AMETS. • Establish Route to Market through grid upgrades or alternative fuels.
Cluster Formation & Support	• Develop an Atlantic Region offshore wind port strategy to ensure investment in port upgrades is co-ordinated to deliver the industry's needs. • Provide cluster supports to attract relevant business activity within identified strategic ports. • Exploit synergies in the digital and data analytics domain between wind energy activities and established specialisations within the regions.
Educational Supports	• Raise awareness of offshore wind industry in the Atlantic Region to ensure there is a pipeline of students and apprentices to support the industry as it develops. • Develop new courses and centres targeted at wind energy sector, with a particular emphasis on FOW skills and expertise not currently offered by Irish educational bodies. • Progress mutual recognition of transferable skills to enable transfer of personnel from related industries.
Stakeholders & Planning Support	• Stakeholder supports should be made available to facilitate dialogue from project initiation through to operation between project developers and relevant stakeholders. • Planning Framework - Establish a supporting framework for the grant of planning permission for the construction of onshore substations and cable routes to ensure developers have clarity on the process to successful award.

1 Introduction

1.1 Project Team

Leitrim County Council, in collaboration with regional partners, have instructed Dublin Offshore (DOC) and their project team to investigate the role of public and educational bodies in supporting the development and growth of the wind energy industry in the Atlantic region. The project team combines deep experience of offshore construction, floating wind, environmental constraints and an understanding of the Irish market. The Team is presented in Table 4.

Table 4: Project Team

Team Partner	Role
Dublin Offshore	Dublin Offshore (DOC) are a dedicated marine engineering consultancy with over 30 years combined experience at the leading edge of offshore construction, with particular focus on the renewable energy industry. DOC are the Prime Contractor and have delivered the baseline assessment, analysis of the supply chain and created the scenarios for wind development.
BiGGAR Economics	BiGGAR Economics (BE) are an expert economic consultancy. The aim of BiGGAR Economics is to deliver meaningful impact while ensuring that the best quality economic evidence possible is available to decision-makers. BE have delivered the economic modelling aspects of the project.

1.2 Client & Stakeholders

Leitrim County Council have engaged Dublin Offshore and BiGGAR Economics, on behalf of the collaborative partners, to develop a report and briefings on how public bodies and educational bodies can support the development and growth of the wind energy industry and supply chain from onshore to offshore in the Atlantic region.

The project is a collaborative effort, being led by the Northwest Regional Enterprise Plan Programme Manager, and includes:

- The Local Authorities in the Atlantic Region,
- The Western Development Commission, and
- The Atlantic Region REP Programme Managers.

In the course of preparing this report Dublin Offshore engaged with a wide range of wind energy stakeholders in the Atlantic Region including representatives of county councils, educational bodies in the public and private sector, project developers, ports and harbours and the wider supply chain. The contributors to the project are listed in Appendix A: List of Contributors.

1.3 Atlantic Region & Sub-Regions

The study area under consideration in this work is the Atlantic Region and its Sub-Regions as defined in the Regional Enterprise Plans and illustrated in Figure 9.

The Atlantic Region extends from Co. Donegal in the North to Co. Limerick in the South, including the Northwest Region (Donegal, Leitrim and Sligo), the West Region (Mayo, Roscommon and Galway), and the Mid-West Region (Clare, Limerick and Tipperary).

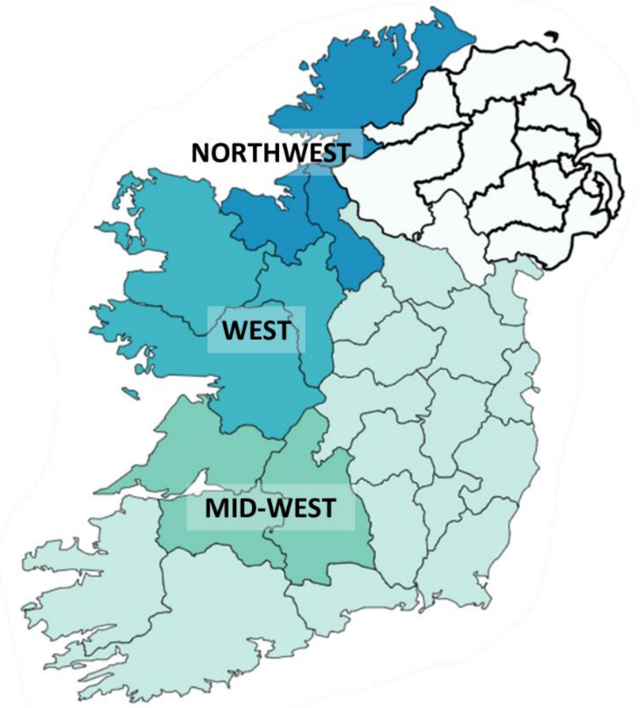


Figure 9: The Atlantic Region and Sub-Regions

1.4 Report Purpose

The Atlantic Region, comprising of the Northwest, West, and Midwest regions (from Donegal to Limerick) has an abundance of natural resources along its coastline. The Atlantic region has an established onshore wind industry with significant potential for offshore wind in the medium term (5-10 years). A supply chain has developed to cater for the onshore wind industry and an offshore supply chain has developed to support fisheries and O&G activities in the region and internationally. For Ireland and the Atlantic Region to realise the full potential of their wind resources, and facilitate private investment and job creation, the supply chain must be encouraged to both develop further to cater for onshore wind and to diversify to cater for the future offshore wind industry.

This study supports objectives and actions within each subregion's Regional Enterprise Plan [9]. The Regional Enterprise Plans (REPs) 2021-2024 are an initiative of the Department of Enterprise, Trade and Employment (DETE) comprising nine such regional plans that supersede the 2017-2020 REP. These plans have emerged from a refresh and refocus of the Regional Action Plan for Jobs (RAPJ) initiative which originally focused on the 2015-2017/8 period. The purpose of the new versions of the REPs is to further build on the positive regional collaboration fostered by the RAPJs over the period to 2020, taking account of the changed and improved economic circumstances nationally, the emergence of new challenges to enterprise development and competitiveness both domestically and internationally, and the persistence of uneven economic progress across the subregions in Ireland.

The REPs provide perspective and ideas from the 'ground-up'. They are informed by an understanding of unique local strengths and assets and have the potential to enable more effective translation of national policy into regional and local impact. They focus on leveraging the added value from regional and local actors working collaboratively, and by doing so, they aim to complement and build on the existing activities being undertaken by the Enterprise Agencies, the LEOs and the wider range of State

Bodies directly involved in supporting enterprise development in the regions. As a result, the Plans are focused on a suite of selected priority objectives requiring a collaborative regional effort and are not meant to be comprehensive economic development strategies on their own. They are also strongly aligned with the smart specialisation strategies of the respective regions.

The purpose of this study is to develop a report and briefings on how public bodies/educational bodies can support the development and growth of the wind energy industry and supply chain from onshore to offshore in the Atlantic region. This report and subsequent webinar events will form the basis of subsequent projects, educational courses, initiatives to support the development and growth of the onshore and offshore wind along the Atlantic Region.

The overall aim of the study is to:

- Summarise existing activity within the onshore and offshore wind industry within the three sub regions
- Map the existing supply chain supporting the wind energy industry within the three sub regions
- Summarise existing educational offerings related to wind industry within the three sub regions
- Detail the current economic and enterprise impact of the wind industry to the Atlantic region
- Identify and detail how public agencies/Higher Educational Institutes (HEIs) can encourage the growth/diversification of the wind energy industry and supply chain opportunities
- Detail the forecast contribution to Atlantic regional enterprise and economic development through the growth of the wind industry in the next 0-15years
- Assist in informing the public agencies/HEI's on the typical concerns of their stakeholders and how to address them due to the growth of the wind energy industry
- Identify subregional specific competencies/opportunities within the wind industry for each of the REP areas (with a specific focus on matching niche opportunities within the industry to the smart specialisations of each of the regions) and how these opportunities can be encouraged by public bodies/educational institutes.
- Provide recommended actions to support the growth of the industry with maximum regional benefit.

1.5 Outline Methodology

The study team carried out this body of work through a combination of literature search, stakeholder interviews and economic modelling.

The first step in assessing the potential for growth of the wind industry was to establish a baseline. Through a combination of public databases, literature review and stakeholder engagement a baseline installed wind capacity for each county was established. Existing grid capacity, supporting infrastructure and educational bodies were mapped as a reference to establish suitability for large scale deployments in subsequent sections of the report. The baselining activity is focussed on onshore wind activity however much of the future economic potential in the region arises from offshore wind, especially floating wind. A detailed analysis of the three forms of wind energy was developed to provide greater understanding and context for the widest possible audience, for which this report is intended. The detailed comparison of onshore, fixed offshore and floating wind is presented in Appendix B.

An economic model was developed in parallel with the baseline assessment. Consideration of the 3 forms of wind energy was essential to establish the economic impact and potential impact in the Atlantic Region as they each exhibit substantially different costs, cost breakdown, supply chains and different potential for local content. These differences were identified through literature review and author experience and incorporated in a longitudinal economic model developed for the Atlantic Region.

Three build out scenarios were developed based on the pipeline of onshore and offshore wind projects, government targets, the Climate Action Plan and relevant academic and industry material. The projections included '*Steady', 'Rapid'* and '*Aspirational'* scenarios with installed wind capacity predictions extending for the 15-year period considered in the study. The economic impact and employment figures were estimated using the longitudinal economic model.

The next step in the study was to identify the necessary supports, and the gaps that exist in the infrastructure required to enable project build out and to ensure projects deliver significant economic impact to the Region. Industry supports implemented internationally to support delivery of local content were considered in Section 4.

The potential economic impact and the gaps in infrastructure and supports that may delay or prevent the growth of the industry are discussed in Section 5 with clear actions and recommendations developed and presented in Section 6.

2 The Baseline

2.1 Wind Resource in Ireland

Ireland has some of the best wind resources in Europe and globally. The World Bank global wind resource map, Figure 10, illustrates the relative wind power density in regions across the globe. The map demonstrates the significant potential for wind energy in Ireland. Increased wind power density ensures reduced cost of energy and improved returns for project developers. The World Bank identified a technical potential in Ireland of 51GW of fixed offshore wind and 553GW of floating offshore wind at very high wind speeds.

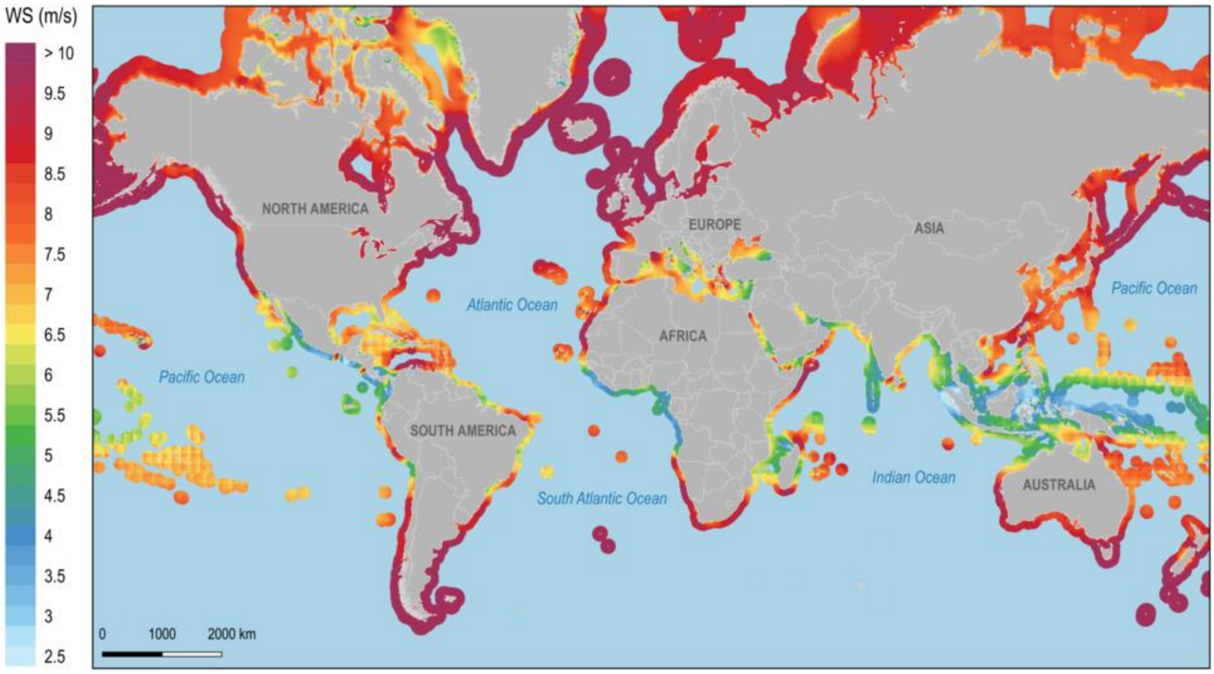


Figure 10: Wind Power Density Potential – World Bank mapping [10]

Despite early progress in offshore wind in Ireland, the wind industry has developed almost exclusively onshore in the past 20 years, taking advantage of the relative ease of construction, and enabling cost-effective development of small to medium projects. The SEAI Wind Atlas presented in Figure 11 illustrates the wind speed at a height of 100m across Ireland and offshore. Wind projects at development locations onshore can avail of wind speeds of approx. 7 m/s, relatively high in global terms but substantially lower than the wind speeds offshore, where wind speeds are observed in excess of 10 m/s. The wind power is a function of the cube of the wind speed so even relatively minor increases in wind speed can deliver significant increases in the energy captured and, as a result, increased revenue to the project developer.

Figure 11 shows there is a significant difference in the wind resource between the East coast of Ireland and wind speeds observed offshore in the Atlantic Region with wind speeds approximately 1 m/s higher in the Atlantic Region.

The improved wind resource found offshore, and especially far offshore at typical floating offshore wind sites is demonstrated by historical capacity factors, the measure of the energy captured as a percentage of the nameplate capacity of the turbine or windfarm. In Ireland the capacity factor recorded for onshore wind in the 5 years up to 2019 was 28.3% [1]. In contrast the Hywind floating offshore wind project in Scotland delivered a capacity factor of 56.8% in the past 12 months [2]. Improved capacity factors are expected in FOW projects generally. If this trend is repeated in Ireland, it would indicate substantially greater returns for offshore projects can be achieved.

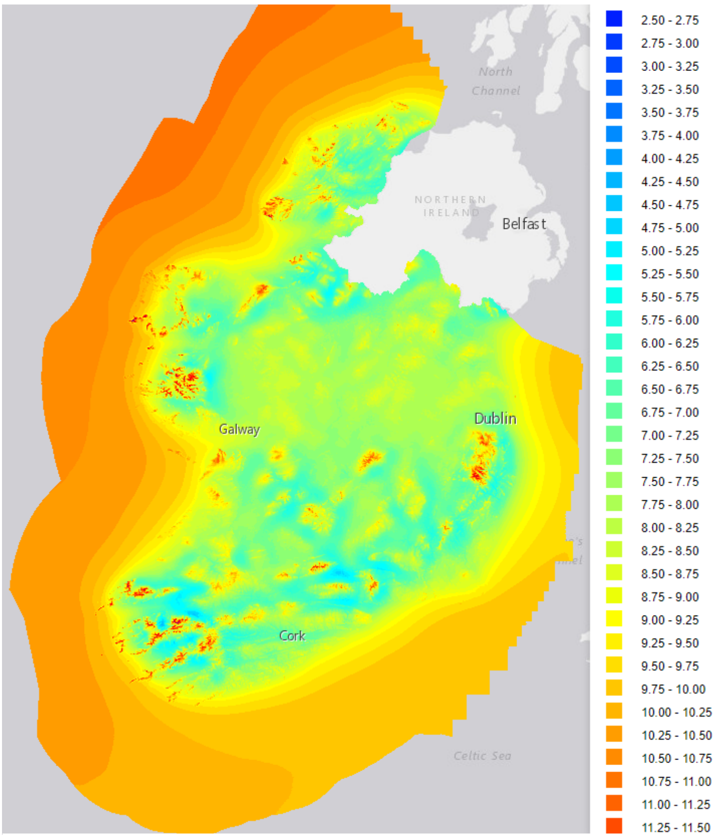


Figure 11: Wind Speed in Ireland, SEAI Wind Atlas (at 100m) [80]

2.2 Existing Wind Projects

Ireland has abundant wind energy resources, with installed capacity of almost 5.6GW on the island of Ireland at the time of writing, comprising almost 400 wind farms [11]. More than 4.3GW of wind energy projects are currently installed in the Republic of Ireland and this is the focus of the present study.

Onshore wind currently delivers large amounts of clean, reliable electricity to the country's largest population centres. This plays a major role in addressing Ireland's climate commitments and represents an enormous opportunity to local supply chain, distributed throughout the country as illustrated in Figure 12.

Figure 12: Onshore windfarm locations [83]

In addition, there is approx. 25MW installed capacity of offshore wind on the East coast at Arklow Bank.

In 2020, wind energy supplied 36% of electricity demand in the Republic of Ireland, and a peak wind generation record was set with 3,659MW generated at 1pm on February 11th 2021 [12]. As wind farm development continues and ability to integrate variable electricity sources such as wind into the national grid, these records will continue to be broken.

2.2.1 Regional distribution

Wind energy generation is not distributed evenly across the country. The Atlantic Region accounts for more than half of the wind energy generated in Ireland, as of July 2021. The existing distribution of wind energy in Ireland is shown in Figure 13 with a breakdown of wind energy between each of the sub-regions in the Atlantic Region and the remainder of the country. A breakdown of capacity by county is presented in Figure 14.

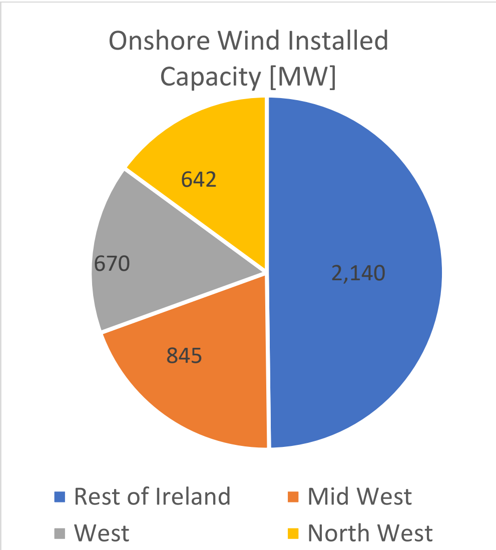


Figure 13: Onshore Wind Installed Capacity

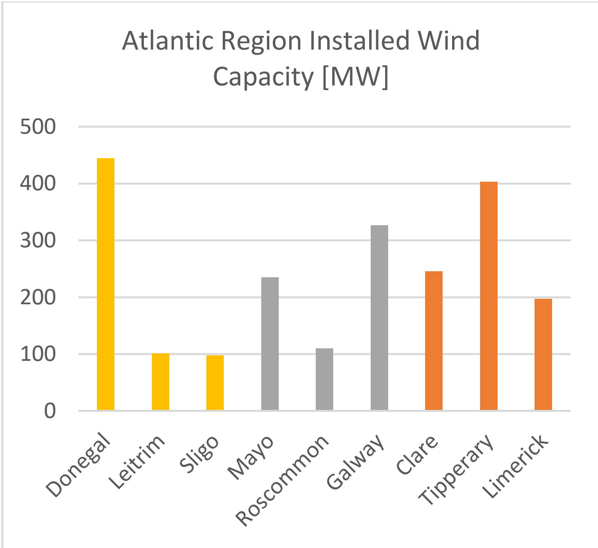


Figure 14: County Capacity Breakdown

A large variation between counties is visible in Figure 14 showing the focus of some counties on the onshore wind industry. However, the land area of each county is not considered, along with other important variables such as population density and wind resource. Table 5 shows a summary of the installed capacity in each county, the county's population as of the last published census and size of the county. This county size is taken as the total size of the county, and does not consider urban areas, national parks or other areas that may be excluded from wind generation development. This data is used to obtain the population density (population / size [km^2]) and wind energy utilisation (installed capacity [MW] x 1000 / size [km^2]) of the county.

Table 5: Wind Generation Capacity Density

County	Installed Capacity [MW]	2016 Population	Size(km2)	Pop. Density (population/km^2)	Wind Energy Utilisation (kW/km2)
Donegal	444.5	159,192	4,861	32.75	91
Leitrim	100.6	32,044	1,590	20.15	63

Sligo	96.9	65,535	1,838	35.66	53
Galway	325.8	258,058	6,149	41.97	53
Mayo	234.5	130,507	5,586	23.36	42
Roscommon	109.7	64,544	2,548	25.33	43
Clare	245.6	118,817	3,450	34.44	71
Limerick	197.0	194,899	2,756	70.72	71
Tipperary	402.8	159,553	4,305	37.06	94
North West	641.9	256771	8,289	30.98	77
West	670.1	453109	14,283	31.72	47
Mid-West	845.4	473,269	10,511	45.03	80
RoI	**4297.8**	4,757,976	**70,275**	67.71	61

Results are compared in Figure 15, which shows less drastic change between counties once the size of the county is taken into account. It is still clear to see counties which have focussed on wind generation, notably Donegal and Tipperary. A higher population density does not equate to a lower wind energy utilisation, illustrated by the equal wind energy utilisation of Limerick and Clare, despite Limerick having more than double the population density. When comparing sub-regions, it is clear to see the Mid-West leads on wind-energy utilisation, despite also having the highest population density of the three regions. The North-West is similar in utilisation and the vast majority of that is accounted for by Donegal, with Leitrim and particularly Sligo lagging behind in energy produced per square kilometre. The West sub-region is further behind again, with Galway increasing the population density and wind energy utilisation for the sub-region. This shows great opportunity for Mayo and Roscommon to maximise the utilisation of their land for deployment of onshore wind where grid capacity is made available.

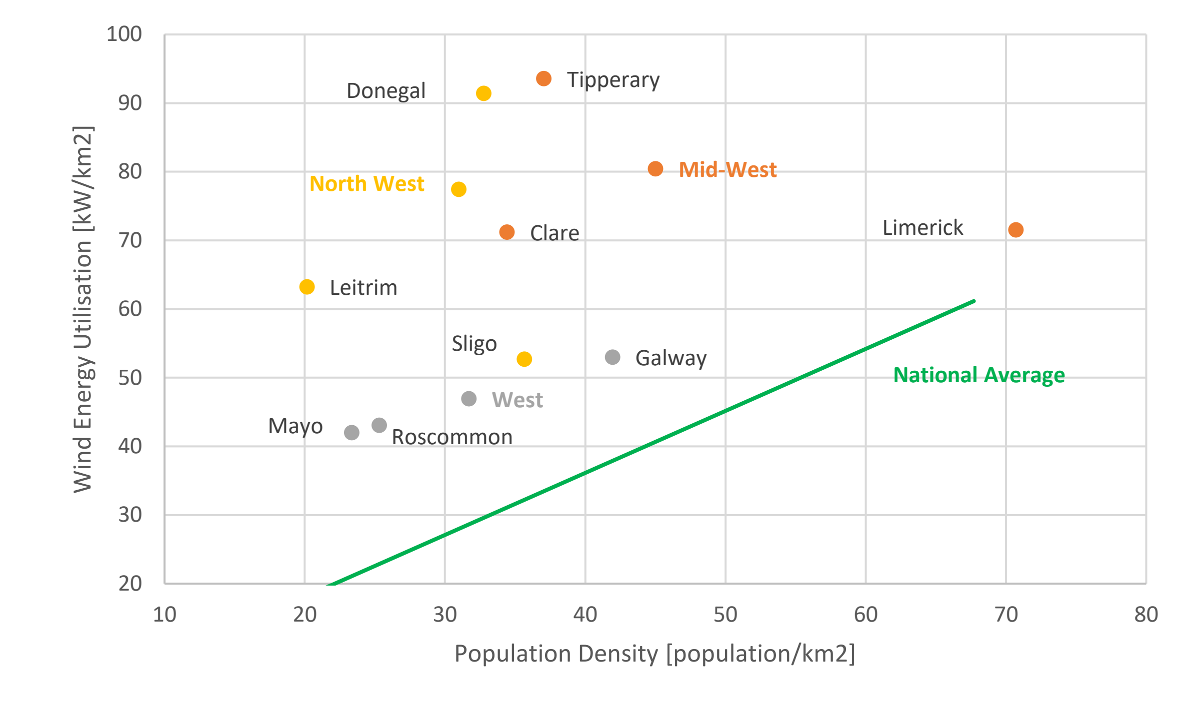


Figure 15: Population Density vs Wind Energy Utilisation

The average installed turbine size in Ireland is 1.73MW. This value is impacted by small test turbines in universities and research centres, community led single turbine developments and private turbines powering single businesses. A full list of turbines in the region is included in Appendix C: Installed Capacity in the Region. This table is organised by county with the capacity and number of turbines included, along with the feeding station and the 110kV feeding station. 3.6MW is the typical onshore wind turbine size in 2022, however, projects are still installing much smaller turbines, visible in the previously mentioned appendix as well as Figure 16. This figure shows that the relationship between the number of turbines and the installed capacity per annum is changing as the industry adopts larger turbines.

Figure 17 shows the number of turbines installed within each capacity range. The large number of turbines in the 0.8 to 2.4MW range indicates a possible underutilisation of spatial resources, with the possibility of repowering with larger capacity turbines at the end of the project life.

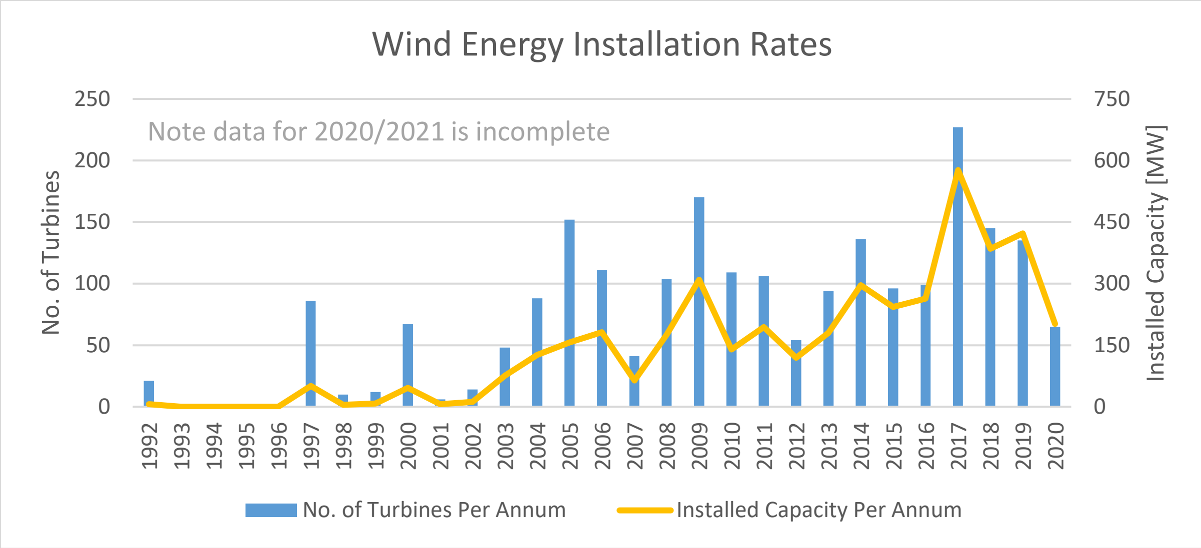


Figure 16: Rates of wind energy installation in Ireland

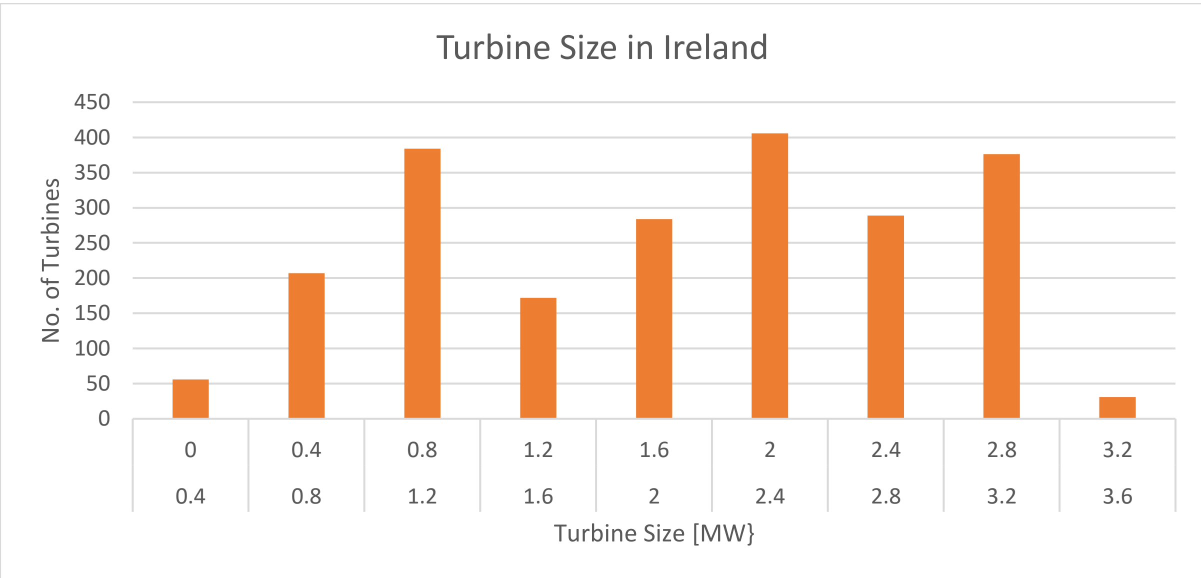


Figure 17: Distribution of Wind Turbine Generator size installed in Ireland

2.3 Existing Grid Infrastructure

The existing transmission grid is shown in the above figure. Connectivity through the Atlantic region is limited to predominantly 110kV lines, and a low density of available connection points. Existing onshore wind, hydro and fossil fuel generation is distributed across the grid.

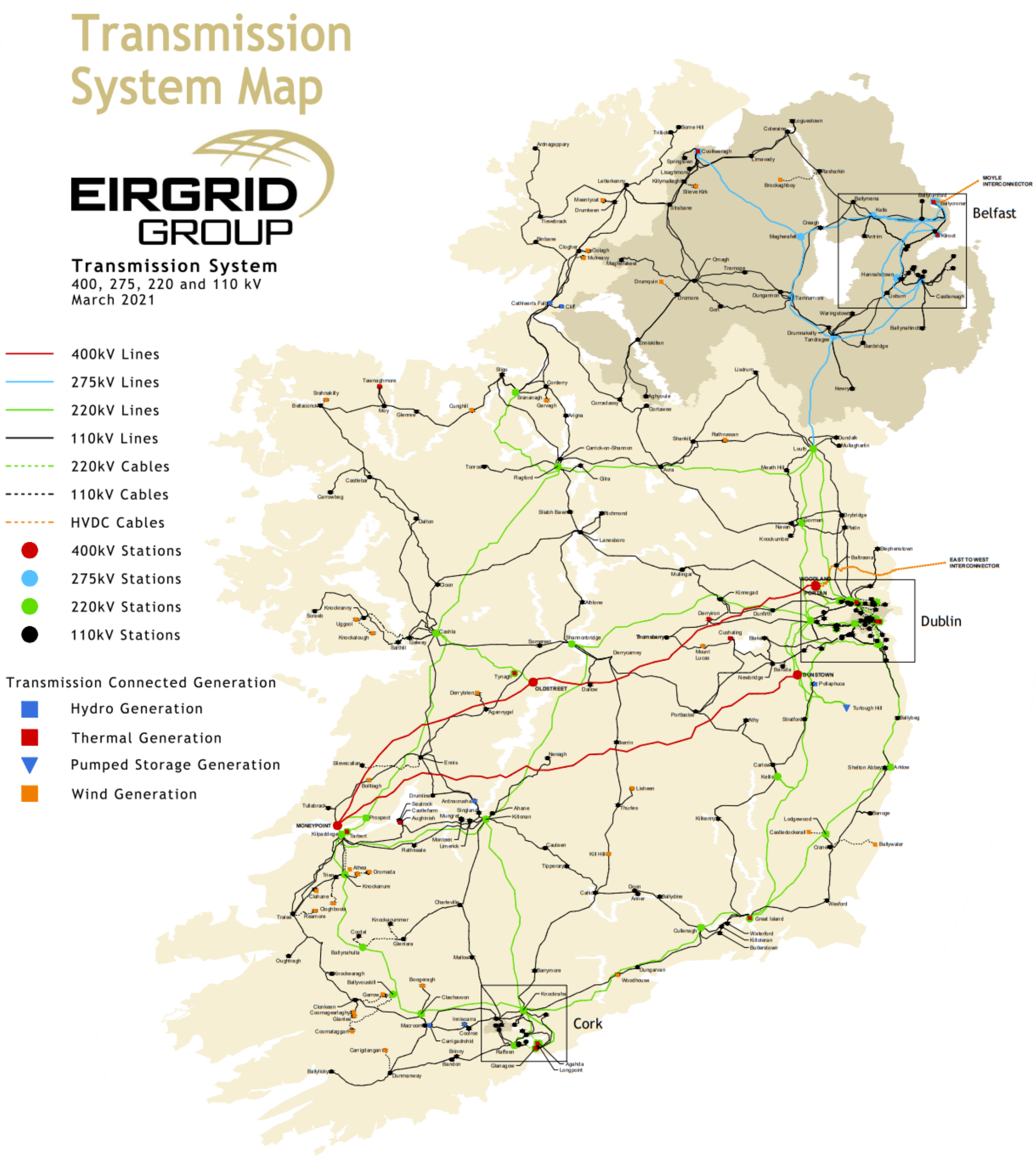


Figure 18: EirGrid Transmission Map (March 2021) [13]

As noted by Donegal County Council in the recent discussion with EirGrid prior to their publishing the updated strategy, restrictions on grid capacity and access regionally create a significant bottleneck in the development of onshore and offshore wind [14]. The 5.7GW planned to be accounted for by EirGrid in improved grid capacity by 2030 falls short of the 8GW target in the Programme for Government and is a result of the lack of suitable grid connectivity.

Upgrades to the grid, as detailed below up to 2022, have not been developed to support the Programme for Government target of 8GW of onshore wind by 2030.

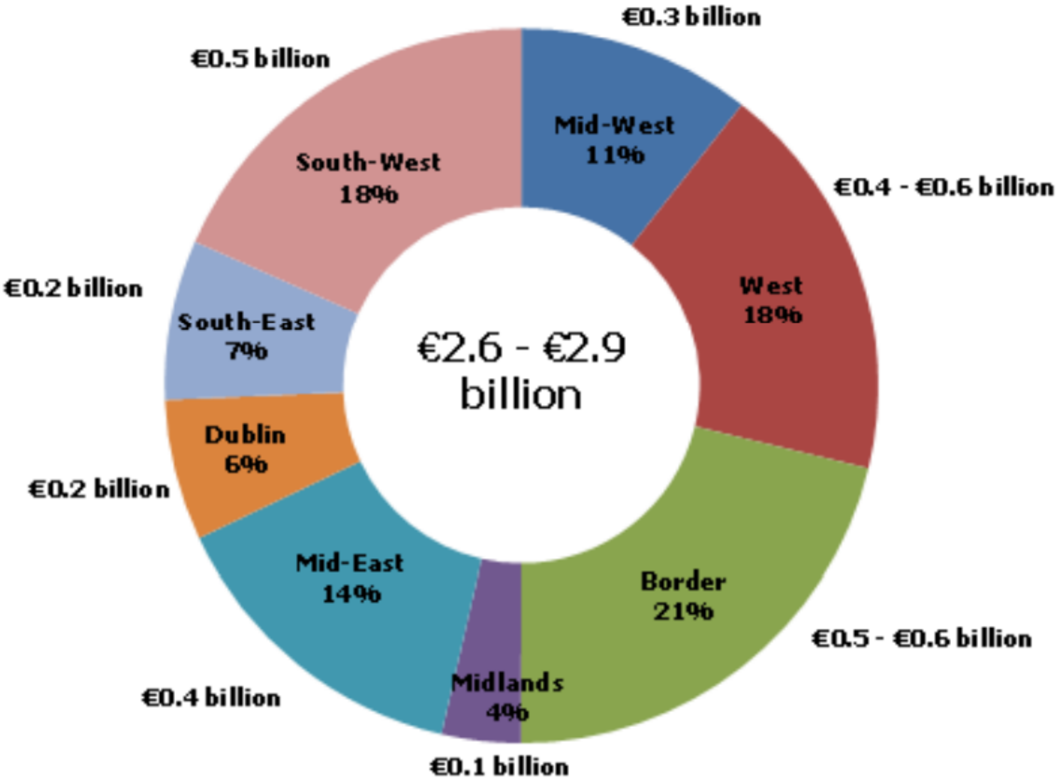


Figure 19: Grid investment up to 2022 [15]

2.3.1 Alternative Fuels & Route to Market

For the longer-term ambitions, alternative routes to market will be required. The potential for green hydrogen, as opposed to hydrogen created from fossil fuels, is noted in Ref [11] as an alternative route to market for offshore wind in particular, with the potential to bypass grid infrastructure. At a domestic level, hydrogen is seen as a key enabler to decarbonise the Irish economy. In the short term, heavy vehicles such as trucks and buses will be powered by hydrogen rather than batteries and in the medium term, hydrogen is being investigated as an alternative to natural gas for heat and power. The recent announcement of the Hydrogen Valley hub, Ref. [16], is an indication of increasing investment in the space regionally.

Perhaps more exciting than the domestic market, there is a growing demand for green hydrogen (and hydrogen derivatives such as ammonia) in mainland Europe. The expected performance of floating offshore wind farms means that hydrogen manufactured in Ireland may be cost competitive with other global sources and that opens a real export market opportunity. Taking into account both domestic demand for hydrogen and the export opportunities, the Atlantic Region is well placed to be a hub for hydrogen supply chain in the coming years. In addition, hydrogen and hydrogen technologies are enablers of energy system integration, contributing to improving the overall efficiency of the system and cost reductions in the energy sector and across the economy.

The European Green Deal identifies green hydrogen as key to a clean and circular economy. Furthermore, the European Union hydrogen strategy launched in 2020, includes phases to promote a fast and targeted development of production capacities for green hydrogen:

- By 2024, the production of green hydrogen should increase to one million tons per year.
- By 2030, the production of green hydrogen should increase to ten million tons per year.
- From the period between 2030 and 2050, green hydrogen is to be produced on a systemically relevant scale.

2.3.2 Grid Innovation

Innovation is not limited to technology but must also consider innovation in grid architecture in order to reach 30GW of floating wind capacity. Early steps can occur in Irish waters with consideration of hybrid interconnectors with the UK and Mainland Europe.

Innovation in grid technologies will be vital in achieving the most efficient and effective energy system. Innovation in DC technologies includes areas such as HVDC connections, superconductors i.e., SuperNode's supergrid concept [17], and DC arrays. The latter two will require demonstration to progress towards commercialisation.

2.4 Pipeline projects

The Joint Oireachtas Committee on Climate Action published its cross-party report in 2019 entitled: Climate Change: A cross-party Consensus for Action, detailing recommendations including a target for 70% renewable electricity in Ireland by 2030. The 70% target was formally adopted in the Government's Climate Action Plan and increased to 80% in 2021, including:

- 8GW of onshore wind capacity
- 5GW of offshore wind capacity
- 1.5 – 2.5GW of solar PV capacity

The target of 8GW of onshore wind capacity by 2030 represents an almost doubling of existing wind capacity. The Atlantic Region is home to strongest wind resource in the country and is therefore well placed to benefit from the increased economic activity associated with the build out of 3.7GW of onshore wind. However onshore wind faces a number of challenges not least planning with proactive stakeholder engagement and policy revision likely required to enable successful delivery of the targets.

Of the 5GW of offshore wind contained within the 2030 targets, 3GW is expected to be delivered on the East coast of Ireland. The remaining 2GW of offshore wind is likely to be delivered on the South coast in the Celtic Sea and on the West coast. Here the metocean conditions typically favour floating offshore wind (FOW) due to water depths in excess of 50m. This technology allows for the provision of over 15GW of offshore wind in the Atlantic Region.

2.4.1 Onshore

The pipeline of onshore wind projects is spread across Ireland with planning applications processed by individual councils. The status and project intentions within this geographically spread database is complex and varies significantly between projects for project specific reasons. Through considering the projects successful in the RESS1 and RESS2 auctions it is possible to develop a comprehensive and robust database of projects with verifiable status.

The Renewable Energy Support Scheme (RESS) is a series of auctions from 2020 to 2025 which provide pathways for renewable energy developers to plan and develop projects. The auctions each have different focuses, with RESS 1 (2020) looking at community benefit and RESS 2 protecting Irish consumers from fossil fuel price variability. Onshore wind projects from the report area which have been successful in the two RESS auctions thus far are shown in Table 6. This is not an exhaustive summary of onshore projects in development in the Atlantic region, as project visibility is poor until development is well advanced.

Table 6: Successful RESS Auction Onshore Wind Projects in the Report Area [18] [19] [19]

Project Name	Size (MW)	County	Round
Clooncon East Single WTG	0.9	Galway	RESS 1
Crossmore Windfarm	15	Clare	
Dooleeg More Windfarm	2.5	Mayo	
Lenalea	30.5	Donegal	
Mully Graffy	29.9	Donegal	
Oweninny Power 2	83	Mayo	
Sheskin Windfarm	16.8	Mayo	
Sorrell Island WF Ext	8	Clare	
Upperchurch Wind Farm	73.326	Tipperary	
Clogheravaddy Windfarm (Phase 2)	10.8	Donegal	
Dooleeg More Wind Farm	1.3	Mayo	RESS 2
Gortaheera CM2 Wind Farm	3	Clare	
Knockranny Wind Farm	47.3	Galway	
Dooleeg More Wind Farm Extension	1.2	Donegal	
Clogheravaddy Wind Farm	3.6	Donegal	
Tullynamoyle Wind Farm 5	16.35	Leitrim	
Lettergull Wind Farm	16.8	Donegal	

A noticeable variation between the RESS projects in development/construction and the small selection of publicly declared projects is the size difference. Despite 3.6MW being the standard bearer for onshore turbines, smaller projects are still being constructed such as the 0.9MW Clooncon East single wind turbine in Clare. As land availability reaches saturation and turbines reach the end of their lives, after approximately 25 years, repowering will likely occur, maintaining the productivity of the onshore wind industry in the region. Repowering involves replacing turbines at the end of their life span with new turbines, typically turbines which provide more power. This may involve increasing turbine size, or alternatively turbine density in an already developed location may be increased to allow for more power production from the same area.

2.4.2 Offshore

Almost 40GW of offshore wind projects are in development in Ireland of which more than 10GW are in the Atlantic Region, and nearly 4GW of schemes given “relevant projects” status to allow fast track development. High profile announcements include Ocean Winds and Iberdrola interest in the market, and the large projects in development off the south and west coasts of Ireland by ESB, Simply Blue, DP Energy and Inis Energy.

The interest comes from increased commercial confidence about the industry’s ability to deliver floating offshore wind at scale. With a supportive framework and stable policies and a very good resource, Ireland is seen as a priority market for roll out of floating offshore wind.

In early 2022 the first six commercial scale offshore wind projects off Ireland were declared. Five of these projects are in the Irish Sea, with just one on the West Coast of Ireland, the 400MW Sceirde Rocks projects off the Galway coast.

The first phase of currently publicly declared offshore wind projects on the Atlantic coast are focused on access to the Moneypoint grid connection, which is anticipated to become available from 2025. These projects are located off the west Clare coast.

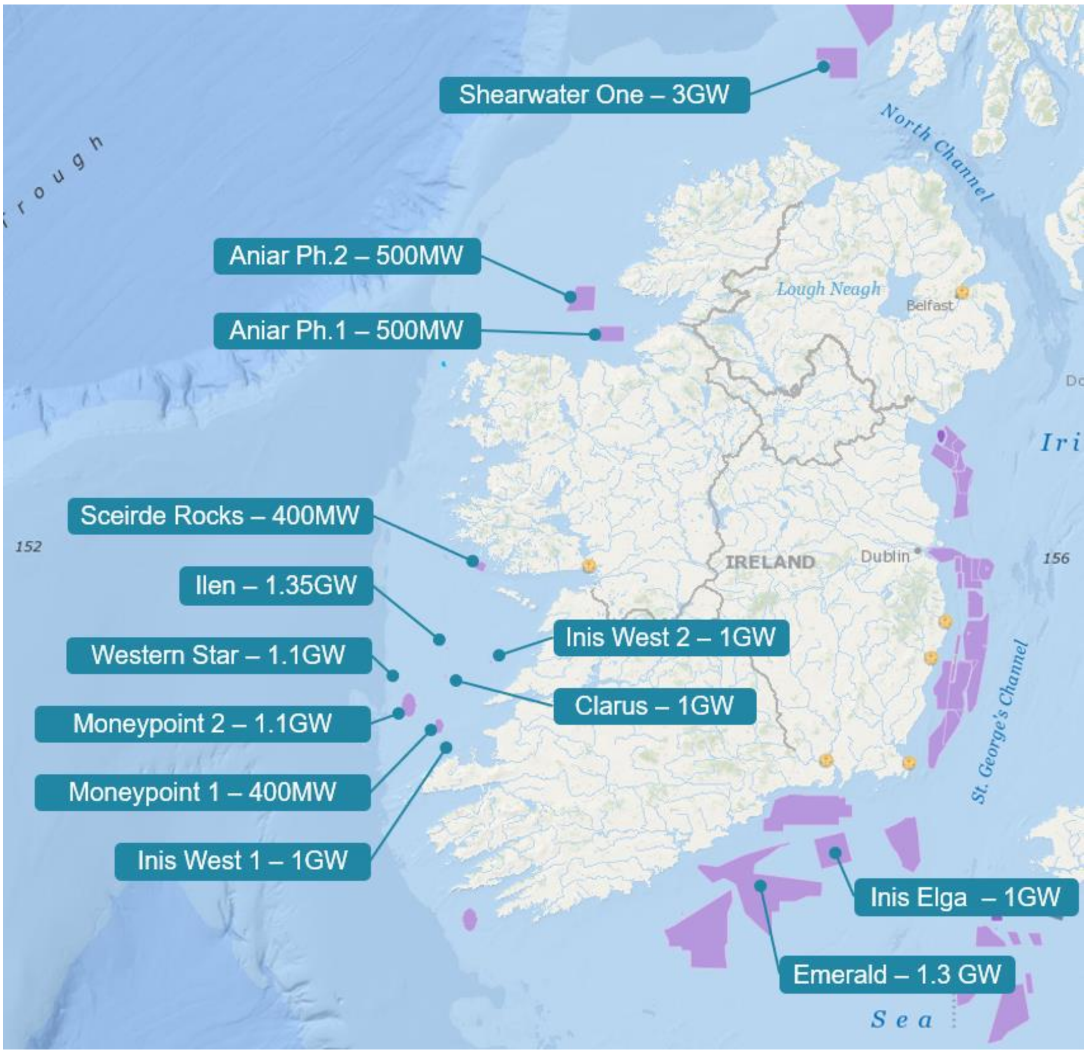


Figure 20: Map of Proposed Offshore Wind Projects [20]

The subsequent phases of developments have significant potential, with installed capacities of over 30GW technically achievable, and are held back by a number of factors, including:

- The Permitting Environment: The Maritime Area Planning Act (MAP) was signed into law in December 2021 and applies to offshore energy development as well as other offshore elements such as aquaculture and gas storage. The MAP Act provides two separate key consents, required for offshore renewable energy generation. The first is the legal right to occupy a particular area, essentially acting as a lease of the seabed. This is called the Maritime Area Consent (MAC) and this is a prerequisite for a developer before development permission can be sought. Development permission can then be obtained through the Planning and Development Act 2000, which was amended in the MAP Act to specifically cater for offshore renewable energy projects [21]. The process is illustrated in Figure 21.
- Grid connection on the Irish west coast is weak. Currently, Ireland does not have the infrastructure for storage and export of green hydrogen, but a number of organisations are involved in developing solutions. If green hydrogen production becomes a commercially feasible power export option, this

will de-couple FOW development from grid access and allow maximisation of project development potential, leading to even greater requirement for port facilities in the medium term, beyond current projections. High capacity factors allow substantial energy generation, offsetting the challenges of developing in aggressive Atlantic conditions.

- Port infrastructure on the Irish west coast currently does not have the capacity to support project build-out. A pipeline of over 10GW of projects is likely to require more than a single suitable port hub, and significant investment may be required.
- The Governments Climate Action Plan aims for 5GW of offshore wind by 2030, with 'relevant' projects already chosen, including the Sceirde Rocks project off the Galway coast.

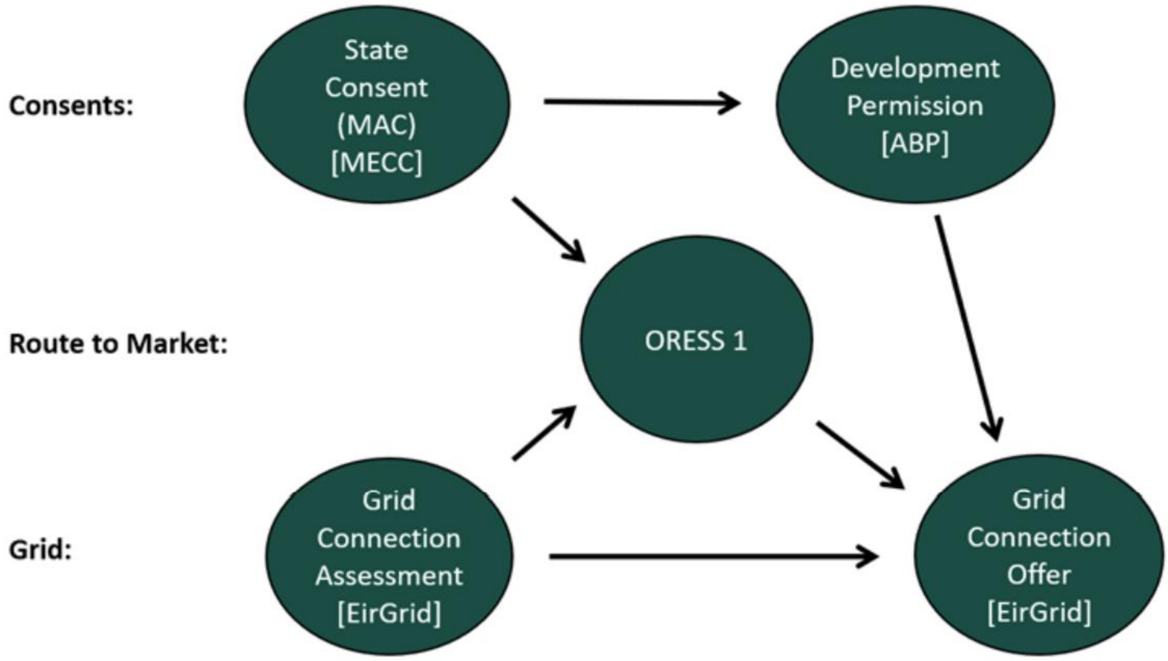


Figure 21: Summary of Phase One Process for Relevant Projects [22]

The timing of the offshore project pipeline will be key in identifying the necessary lead time for port infrastructure investment decisions. The Green Tech Skillnet report, undertaken by the Carbon Trust for Wind Energy Ireland, identified the necessity for a strategic investment decision for an east coast port by 2020. The slightly later phasing of west coast wind means that a strategic investment decision for a west coast support port is likely to be required by 2023. The importance of giving clear signals to FOW developers that port infrastructure will be available is also a factor in the decision timing.

There are a number of known floating wind farm developments planned off the west coast, and distance to farm will be a key consideration in port selection. However, the shift from fixed to floating gives more flexibility for developers regarding choice of port, with an ability to tow platforms longer distances ready for installation. Experience from both the Hywind Scotland and Kincardine projects demonstrates that developers will consider using ports further afield for construction and assembly activities if suitable local ports are not available, or cost factors work against their use. It is worth highlighting activity in nearby markets like Scotland where the west coast ports of Kishorn and Hunterston are actively considering options regarding supplying floating offshore wind as well as Wales (while less suitable in terms of scale Pembroke Dock/Milford Haven and Newport are assessing how to respond to floating offshore wind). Slightly further afield, the growing French floating offshore wind pipeline will see larger ports in Brittany and Normandy seeking to supply into floating offshore wind. In Northern Ireland, Belfast has already benefited from investment to support fixed offshore wind assembly and could potentially be adapted to support floating offshore wind projects as well.

Figure 20 shows the proposed offshore wind projects along with their approximate location off the coast of Ireland. These projects are presented tabularly in Appendix D: Proposed Offshore Wind Projects on the Island of Ireland. All publicly proposed offshore projects around the island of Ireland are included here, as supply chains for these projects will use facilities, infrastructure, and activities from across the country.

2.5 Existing supply chain

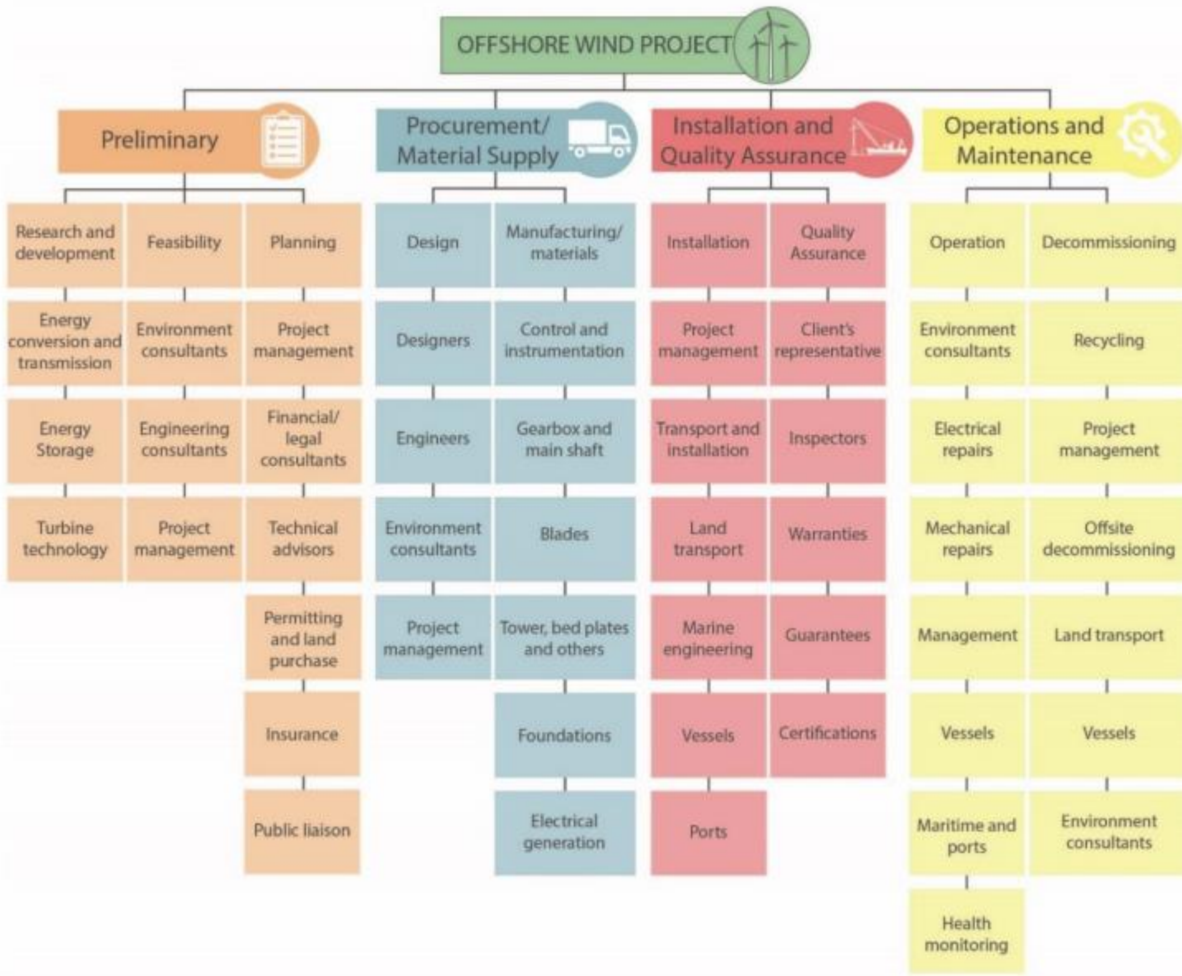


Figure 22: Overview of the supply chain

According to SEAI [23], one of the greatest challenges to developing a sustainable energy supply chain in Ireland is the need for adequate skills. The onshore wind industry supply chain has been established over the past 2 decades and adequately supports the current onshore industry. The forecast growth in the offshore wind industry along with the scale of development mean that significant growth is required in this area, so that both onshore and offshore development can continue. The skills required in offshore wind are varied and unique to each stage of a project's lifecycle. Specialised fabrication and manufacturing skills are necessary for the numerous components involved; ranging from the large scale rolled steel required for XL monopiles to specialised carbon fibre knowledge for turbine blades. The installation process is a short-term requirement (1-3 years) that needs expertise in offshore processes including pile hammering, and heavy crane lifts offshore. Whereas operations and maintenance require long term expertise (20+ years) in wind turbine repairs, ranging from annual predetermined maintenance to the corrective maintenance and replacement of large turbine blades. These activities require skills that are not currently present in Ireland in the numbers required to support the predicted sector growth.

Furthermore, the lifecycle processes of offshore wind need to be supported by an effective supply chain. An offshore wind farm contains numerous components (Table 7) for its initial construction and as spare parts for operation and maintenance. At present, these can be sourced at various locations across Europe, and transported for use to an installation port on the Irish coast. However, many of these components are very large, and difficult to transport, leading to logistical challenges.

Table 7: Components in an offshore wind farm

Component	Breakdown
Turbine	Tower
	Blades
	Spinner
	Nacelle Cover
	Generator
	Gearbox
	Main Shaft
Transition Piece	Transition Piece
Foundation/Platform	Steel or concrete structure
Substation	Transformers
	Switchgear
	Reactors
	Backup Generator
	Substation Foundation/Platform
Cabling	Inter-array Cables
	Export Cables

This section explores the skillsets and industries present in Ireland that would benefit the offshore wind industry development and considers their impact on the supply chain.

2.5.1 Future Offshore Wind Supply Chain

The ability of an economy to take benefit from offshore wind farm developments in 2030 or 2040 will be significantly different to what it is today. In such a specialised industry, skills and experience can take a long time to acquire. The sector in Ireland is in its infancy and as a result, there is not currently a well-developed offshore wind specific supply chain in Ireland. However, there are many companies which do have the specialist expertise that will enable them to participate in the supply chain when opportunities arise. An assessment by the Carbon Trust [24] found that the largest business base that would be able to immediately take advantage of these opportunities were in Dublin and the Southwest of Ireland.

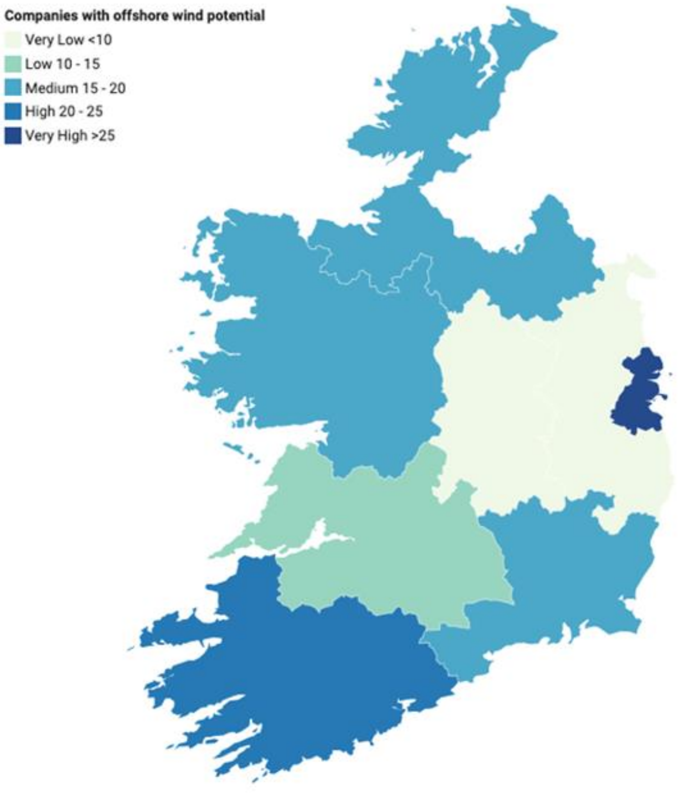


Figure 23: Regional Split of Current Irish Offshore Wind Supply Chain Potential

The North-West and West Regions were assessed to have a medium capacity to serve the supply chain, with particular strengths in the Development and Consent and the Operations and Maintenance phases of the development. The Mid-West was assessed to have a low number of companies with offshore wind potential. For all areas of activity during the construction period, namely Turbine Supply, Balance of Plant Supply and Installation and Commissioning the West of Ireland was assessed as having a low business base.

This represents the current business capability in the West of Ireland and the wider Irish supply chain. The future business base and supply chain is likely to look different, particularly if clusters are developed around ports to provide services during the construction, operations and maintenance phases of the offshore wind sector.

2.5.2 Development & Consenting

The following specialist areas are key to the development and consenting stage of an offshore wind farm, with existing companies in Ireland capable of carrying out the environmental, geotechnical and geophysical surveys required by the offshore wind industry with some already having significant offshore wind experience [25].

Table 8: Specialist Areas for development and consent

Specialist Areas for development and consent
Environmental Impact Assessment
Legal services
Software development
Offshore & marine consulting
Industrial diving
Technical benthic and pelagic studies
Project Management
Geophysical & geotechnical surveys
Aerial & vessel monitoring for seabirds & marine mammals
Energy analysis & measurement campaigns

For those companies that have yet to gain offshore wind experience but have the skills base to serve the industry, their capabilities could easily be expanded with the right capacity building activities. These companies present high near-term opportunity in the development and consenting stage of the offshore wind supply chain.

Table 9: Development and consenting activities and Irish supply chain suitability

Life-Cycle Activity	Current Irish Supply	Main Levers	Main Barriers	Opportunity for Ireland
Environmental Impact Assessment	High number Medium-High experience	Significant synergies to multiple offshore industries and onshore renewable energy	Requires specialist staff in a range of technical disciplines	High Near or longer term
Site Surveys	High number Medium-Low Experience	Significant synergies to multiple offshore industries	Requires specialist staff and equipment	High Near term

Front end engineering and design studies	Medium number Medium-High experience	Significant synergies to other industries (e.g. oil and gas) Low set-up cost Exportable	Requires specialist staff, software and know-how	High Near term

2.5.3 Turbine Supply

Wind turbine manufacturers are mainly concentrated in China, Denmark, France, Germany, India, Japan, Spain and the United States. Blade manufacturing has shifted from European to locations in North America as well as South and East Asia – led by proximity to markets [26].

Turbine components are large and require specialised and expensive manufacturing facilities. The large project pipeline required to justify investment of such facilities, as well as the preference of developers to utilise existing suppliers for these components, make them a low opportunity area for Irish offshore wind supply chain development.

Table 10: Suitability of Irish supply chain for turbine supply

Life-Cycle Activity	Current Irish Supply	Main Levers	Main Barriers	Opportunity for Ireland
Blades	Low number (one) Medium experience	Synergies with onshore wind industry	High investment – large pipeline required Large facility required	Low Longer term
Tower	Low number (one) Medium experience	Synergies with other industries Standardised, relatively simple to fabricate	Large facility required	Medium Near or longer term
Nacelle	None	Synergies with onshore wind and other power industries	Experience is preferred by turbine OEMs	Low Longer term
Other large fabrications	None	Less specific skills required Synergies with large components required by other industries	Large facilities required	Medium Longer term

Nacelle Assembly	None	Synergies with onshore wind	Large facilities required	Low

2.5.4 Balance of Plant Supply

Large balance of plant components also requires large facilities and significant investment. Suppliers need scale to thrive, making it a potentially difficult market to break into without clear signals of market demand.

Ireland could have clearer opportunities in secondary steel works or the supply of electrical systems. For secondary steel, existing steel fabrication facilities and companies could perform this with minimal or some adaptation.

Ireland has some experience in the design of cables and substations for the onshore wind sector. If they can build an offshore wind pipeline that justifies the investment in associated manufacturing facilities, they could utilise this onshore experience to build a cable and electrical offshore wind supply chain for the offshore industry.

Table 11: Suitability of Irish supply chain for balance of plant supply

Life-Cycle Activity	Current Irish Supply	Main Levers	Main Barriers	Opportunity for Ireland
Support Structure	Low number No tier 1 fabricators	Moderate synergies with oil & gas and other manufacturing industries (e.g., welding, painting, corrosion, protection)	Large facilities required High investment, large pipeline required	Medium low Longer term
Mooring system supply	Low number	Market is still developing – no monopoly	Large facilities required Optimised solutions needed	Medium
	Medium experience in design, low in supply	Synergies with oil and gas and the shipping industry		Longer term
Subsea cables (array & export)	Low number Medium experience	Synergies with other power industries and subsea lines	Large facilities required High investment-large pipeline required	Medium-low Longer term

Offshore substation	None	Synergies with oil and gas	Large facilities and deep ports required	Low Longer term
Electrical systems (offshore & onshore)	Medium number Medium experience	Synergies with other power industries	Requires specialist staff and manufacturing facilities	Medium Near or longer term
Secondary steel works	Low number Medium-low experience	Significant synergies with steelwork industries – Ireland has the capacity and experience Relatively simple to fabricate	Potentially a cost driven market	Medium Near or longer term

2.5.5 Installation & Commissioning

The market for lead installation & commissioning work is consolidated between a reduced number of tier 1 suppliers with significant track record and expertise, making it difficult for new entrants. Nonetheless, Windhoist is an Irish supplier that installs offshore wind turbines and is building its capacity and track record in this area. Furthermore, there may be opportunities to provide cable installation services given some of the existing capacity in Ireland.

Table 12: Installation and Commissioning Supply Chain Suitability

Life-Cycle Activity	Current Irish Supply	Main Levers	Main Barriers	Opportunity for Ireland
Support structure installation	None One company with high grouting experience	Synergies with other offshore industries Ireland has the required port infrastructure to support this market	Requires large facilities Expensive investment – large pipeline required Key market players exist	Low Long term
Substation installation	Medium Number Medium experience	Synergies with other power industries	Experience is preferred by procurers Key market players exist	Medium-Low Near or longer term

Cable Installation	Medium Number Medium Experience	Ireland has the vessel capability to support the market	Offshore installation requires specialised equipment and skill High risk so experience is preferred by procurers	Medium Long term
Turbine Installation	Low number (one) High experience	Ireland has the vessel and port capability to support this market	High risk Key market players exist	Medium-Low Near or longer term

2.5.6 Ports and Harbours

The ports of significance for onshore and offshore wind in the Atlantic Region are shown in Figure 24. These ports are essential for the onshore and offshore industries. Short term, these ports play an essential role in the import of onshore wind farm components – tower pieces, nacelles and blades. The transportation of these bulky parts is difficult, with onshore blades reaching up to 80m in length at times. For a single turbine, a truck is required for each blade, one for each of the nacelle and the hub and a further 3 trucks for the tower sections. This is a total of 8 trucks per turbine, so port proximity to wind farm sites is a key consideration.

With the growth of offshore wind in the region and elsewhere on the island of Ireland, the role of these ports will develop.

Figure 24: Atlantic Region Port Locations

2.5.6.1 Killybegs Harbour

Killybegs is a natural harbour situated on the north coast of Donegal Bay. Harbour development has been closely linked to the growth in the pelagic fishing fleet, with vessels over 90m LOA common and harbour infrastructure predominantly designed to service the fleet’s requirements.

It is a regionally significant port and has handled smaller onshore wind farm importation and some general cargo. Killybegs has a strong local maritime supply chain and was the operations port for the Corrib Gas Field build out.

Figure 25: Killybegs Harbour

Developments in Killybegs related to support of the FOW industry are being actively pursued by private companies. Killybegs is the only Irish port on the west coast with the existing capacity to technically service the assembly of FOW platforms without additional significant investment.

- The South Quay provides 300m of berthing in 12m Water depth CD and has space for semi-submersible FOW platforms. The quay is accessed by water directly from the deeper approach channel from Donegal Bay.
- Mobile cranes of 1000T lift capacity have previously been mobilised to the South Quay, and the quay could support the necessary lift equipment for full alongside FOW assembly.
- There are significant set-down areas being developed within 1.5km of quayside which can be readily accessed.
- The Port has recent experience in handling importation of onshore wind farm projects, and has handled blades up to 58m long, and associated nacelle and tower structures. Local stevedoring works 365 days pa, is cost effective, and has experience in quick turnaround of related cargo transfer.
- The fishing activities in the harbour are busiest during the winter (November – February) period and managing parallel wind energy activities would be critically challenging in this period. However, the assumed preferred assembly and deployment summer period for wind projects would be expected to coincide with significantly reduced fishing activities, and free up access to port infrastructure.
- Killybegs has a strong local supply chain focussed on the marine industry. Local skills in vessel repair and marine systems are significant and have high suitability for transfer to the FOW industry.
- Killybegs offers poor opportunities for local wet storage of platforms. The inner harbour is too shallow, and sheltered areas of the approach channel and Donegal Bay have existing fish farms on long term leases which may prohibit wet storage of FOW platforms.

2.5.6.2 Sligo Port

Sligo is a medium-sized port with two working jetties (Deepwater and Barytes), handling mostly general cargoes of coal, timber, fish meal and scrap. Sligo is the most northerly commercial port on the west coast of Ireland. The Deepwater Jetty is 77m long and the Barytes Jetty 55m. According to the harbour office ships of 3,500 tonnes can be accommodated and the maximum draught for vessels is 5.2m, maximum length 110m with bow thrusters and 100m without bow thruster. The maximum length of the vessels recorded to having entered this port is 90 meters. The maximum draught is 3.7 meters. The maximum Deadweight is 3732t. The port is currently underutilised.

Figure 26: Sligo Port

2.5.6.3 Rossaveel Harbour

Rossaveel is located in the northwest of Galway Bay and serves as a busy fishing port and a hub for the Aran Islands ferry. The port is operated by Udaras na Gaeltachta, who also own landbanks in the surrounding area.

The existing facilities include a 60m quay with 5.8m alongside, and 365m of quay with 3.7m alongside. The approach channel to the inner harbour has minimum depth of 3.8m.

Figure 27: Rossaveel Harbour

Rossaveel does not currently have the capacity to support offshore construction activities. However, planning permission was granted to the Department of Agriculture, Food and the Marine in 2018 for a 200m quay with a berthing pocket of -12mCD alongside [27]. The quay has been proposed to support larger fishing vessels and has not been developed with consideration for the offshore wind industry.

- Planning permission granted for deepwater quay, and FEED level engineering and costing undertaken. €25 million investment in the port was announced by the Department for Agriculture, Food and Marine in February 2022 [28].
- Large landbank adjacent to potential deepwater quay which could be developed for set-down area and warehousing.
- Location is isolated, does not have a significant local supply chain, and road access would be problematic for large project cargo.
- Harbour space is restricted and logistic bottlenecks within Rossaveel may be anticipated. FOW activity would require dedicated quayside and onshore facilities and occasional priority over existing traditional ferry and fishery users.

2.5.6.4 Port of Galway

The Regionally Significant Port of Galway sits at the northeast of Galway Bay, within the bounds of Galway City and currently services transfer of liquid bulk, dry bulk and break bulk. Access to the port basin is tidal restricted.

The Port has six quays, with a total quay length of 1000m, and a minimum of 3.6m CD in the lock-gate controlled basin. There are no fixed cranes, with occasional mobile cranes of approximately 40T. The approach channel to the Port is maintained at 3.4m CD.

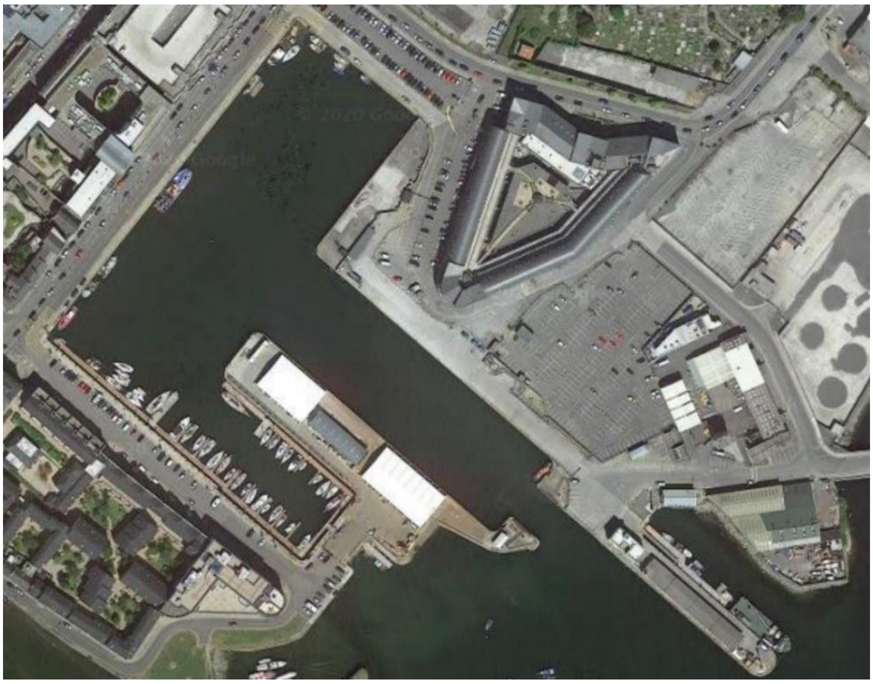


Figure 28: Port of Galway

Galway Harbour Company is seeking to develop the port significantly, with plans for over 20 hectares of land reclamation and new deepwater berths to the southeast of the harbour, including construction of 660m long quayside, dredging the approach channel to -8m CD and the construction of a breakwater to protect the deepwater quay.

The Port of Galway have given consideration to the berthing of FOW platforms, access to the deepwater quay through a channel to the east of the proposed breakwater, and suitability to support the logistics of assembly at quayside.

Wet storage of all project platforms in Galway Bay would be readily achievable, both at existing vessel anchorages and future dedicated anchoring locations. Galway Bay is partially sheltered.

- Galway City has the capability to support the number of personnel required for establishing a large-scale assembly hub.

2.5.6.5 Kilronan, Inis Mor

Kilronan Harbour is the main port facility in the Aran Islands, on the west of Galway Bay. The port services ferry, fishing and leisure activities. The harbour was upgraded in 2008 to include a Ro-ro slipway, deep water berth pocket and a breakwater creating an additional outer harbour. A Severn Class lifeboat is permanently stationed at a dedicated jetty in the new harbour. Kilronan port cannot be considered for the onshore wind industry supply chain due to its island nature, but the port may have a role in the fixed and floating offshore wind industries.

Figure 29: Kilronan Harbour

2.5.6.6 Moneypoint

Moneypoint is located on the north coast of the Shannon estuary in Co. Clare. The deepwater jetty, 25m CD, is dedicated to the import of solid fuel feeding the adjacent 915MW coal fired powered station, which has been in operation since 1987. The power station is scheduled for de-commissioning in mid-2025. A replacement usage and alternative industry has not currently been identified for the facility.

Moneypoint is privately owned by the ESB, and significant developments related to the FOW industry are currently proposed to support the Moneypoint floating offshore wind farm including a wind turbine construction hub, platform construction, green hydrogen and energy storage. Construction of a

Synchronous Compensator as part of ESB's proposed Green Atlantic programme has already commenced.

Moneypoint is relevant for consideration due to its open development potential and possible overlapping timelines of availability with Atlantic Region Offshore wind activity. The deepwater facility is connected to a significant landbank of 227 hectares with potential for development as on-shore set-down and support areas.

Figure 30: Moneypoint Power Station and jetty

Port characteristics affecting suitability

- 380m long deepwater berth, -25m CD, in close proximity to offshore wind projects off the west coast.
- Significant landbank with commercial usage and potential for conversion to large set-down and support areas for FOW project cargo.
- Identified as a Strategic Development Location, [29]. Moneypoint is of strategic importance to Irelands energy supply and support of marine related industry is part of the SIFP.
- Privately owned, and ESB are not under obligation to support FOW industries however they have clearly stated ambitions in this field.
- Significant investment required to achieve suitability to effectively support FOW industry. Brownfield site, with unknown site conditions.

2.5.6.7 Foynes

The inner harbour at Foynes Port is sheltered to the North by Foynes Island and provides 270m at the West Quay and 290m at the East Jetty of berthing with 10.5m CD alongside. The Quays are predominantly used for break-bulk and dry bulk cargos, and do not have permanent cranage capacity.

A 116.5m extension to the East Jetty, connecting it to the West Quay is proposed, allowing continuous operations between the berths [30]. This development is being undertaken to support additional handling capacity for existing cargo streams and is not focussed on the marine construction support market. The East Jetty and West Quay have a long history of providing a major point of import for the mid-west region, and their cargo handling capacity is a requirement for multiple industries in the region. It is not envisaged by SFPC that additional dredging would be undertaken at the berths, and they are not considered likely candidates for FOW platform assembly.

Foynes Port does have experience in handling large scale onshore wind farm project cargo. Although water depth is restricted, the port may be suitable for floating wind platforms being brought quayside at high tide and allowing local contractors engage in turbine assembly alongside, bottoming out at low tide. The 3 knots of current reduce this likelihood however, and the quayside would need reinforcement to accommodate heavy lifting.

Foynes Island is an island of approx. 1 square kilometre to the north of Foynes Port. It is not connected to the mainland and the island contains a derelict liquid bulk jetty in deepwater on the northwest of the island. A land bridge to the island has been proposed, although this access would be on the wrong side of the island and the island is also a Special Area of Conservation, a National Heritage Area, and part of the River Shannon SPA.

The SFPC have identified FOW as a major source of future revenue and regional investment. To facilitate this investment, plans by the SFPC include the development of an ORE assembly and marshalling facility at a new Foynes Deepwater Terminal, estimated to cost €350m and to be completed by 2028, thereby enabling the deployment of floating wind projects by the end of the decade [31].

Figure 31: Foynes Port West Quay and East Jetty [L] and Foynes Island [R]

2.5.7 O&M activities

O&M activities provide large numbers of permanent jobs, based out of an O&M port chosen for each project, which will be a port within easy travel distance of the project site, and that can accommodate the required number of crew transfer vessels as well as office space and accommodation.

Ireland has a strong history in vessel design, building and repair and the industry has recently begun to lend expertise to the offshore wind industry through production of industry specialised vessels and equipment. The same trend has been seen in the design of ROV's, training of industrial divers and repair of electrical equipment. This has allowed Ireland to begin developing an operations and maintenance supply chain that has a good possibility of serving current and future offshore wind projects.

Table 13: O&M Supply Chain Suitability

Life-Cycle Activity	Current Irish Supply	Main Levers	Main Barriers	Opportunity for Ireland
Monitoring, inspection and maintenance	High Number	Synergies with other offshore industries	Requires specialised skill and equipment	High
	Medium Experience	Low investment cost		Near term
Vessel and equipment supply	High Number	Ireland already has large vessel building	Facilities are expensive	Medium-High
	Medium-high experience	Synergies with oil & gas		Near term

2.5.8 Data Analysis & Digital Services

The growth and drive to reduce the LCOE of onshore and offshore wind generation has resulted in a digital revolution in the industry with a greater focus on cloud platforms and digital application capabilities for O&M processes to reduce costs while improving production [33]. There are six main O&M use cases including:

- Alerts, alarms, warnings and faults
- Troubleshooting and minor corrective maintenance
- Failure prediction and major component replacement
- Scheduled maintenance
- Wind power curve analysis and production losses
- Production forecasting

Wind operators typically use custom-built solutions on legacy systems, but their adequacy is largely unknown. Larger industry players have developed in-house capabilities using big data and advanced analytics to raise performance levels across technology types. This requires heavy investment in strategic platforms favouring custom solutions, rather than off-the-shelf applications.

The Atlantic Region has the skillsets within existing onshore industries and could be well placed to develop solutions and services within this sector by leveraging digital services and data analytics capabilities.

Table 14: O&M Supply Chain Suitability

Activity	Current Irish Supply	Main Levers	Main Barriers	Opportunity for Ireland
Connectivity (5G, Wi-Fi, LAN)	High Number	Synergies with other onshore industries	Requires specialised wind industry knowledge	Medium
Sensing (IoT / Ind 4.0)	High Number			Medium
Data Analysis	High Number			Medium-High
Cloud Services	High Number			Medium-High

2.5.9 Decommissioning

Decommissioning is still a developing market, untested at commercial scale and not critical for Ireland in the near term. However, Ireland could be well placed to deliver this work in the long term with the adequate port infrastructure and local vessel supply. This could also include component reuse, repurposing, refurbishment and recycling.

Table 15: Supply Chain Suitability for Decommissioning

Life-Cycle Activity	Current Irish Supply	Main Levers	Main Barriers	Opportunity for Ireland
Decommissioning	Low Number	Developing Market	Developing market – low demand or experience yet	Medium-low
	Low Experience	Synergies with other offshore industries		Longer term
Life Extension & Refurbishment	Low Experience	Synergies with manufacturing industries		Medium-low

2.6 Training and Educational Offerings to Industry

The Atlantic region is home to four universities and a broad collection of level 6 and 7 institutions as well as specialised training centres. Recently, a number of Institutes of Technology (IT) have grouped together to attain university status: Galway-Mayo IT, Sligo IT and Letterkenny IT have formed the Atlantic Technological University (ATU). The Technical University of the Shannon has gone through a similar process with Limerick IT and Athlone IT, combining to attain university status and increase the educational offering to students.

Some of the occupations and skills required to support the wind industry in Ireland include engineering; environment, science and humanities; construction and technical; legal and professional services; transport and logistics; electrical maintenance and infrastructure. Currently, the Irish supply chain for onshore wind is capable of supporting current development levels, however, offshore wind supply chain is predominantly focused on development activities, lacking the diverse array of specialised skills required for fixed and floating offshore wind.

Engineering, applied sciences, logistics and supply chain management are essential skills for the growth of the wind energy industry in the Atlantic region. The institutions in the region provide a substantial range of courses at various levels to provide for the wind industry in the future. Exact numbers for each course are difficult to quantify/not available, however the balance between apprenticeships and solely academic courses is noticeable.

Shortages have been identified within engineering, financial services, logistics, technical skills (welders, technicians etc.). The following sections provide an overview of the key roles required to support the wind industry, with the main employment areas outlined. Universities, colleges, and institutions which provide training in these areas are mentioned. This is not an exhaustive list and gives an indication of course location, as well as the numbers in full time employment (FTE) across the island of Ireland in each of these areas where data is available. Due to a lack of publicly available data, and annual variation depending on demand, course numbers for each course provided are not available.

2.6.1 Engineering

Engineering is one of the most important occupations for the design, construction and operation of onshore and offshore wind energy developments. Civil, Mechanical and Electrical Engineering are the most common disciplines required, however more specialised areas such as environmental, energy and marine engineering are required in the industry. Civil and environmental engineers play a particularly important role in the planning and Environmental Impact Assessment process.

The primary entry route for engineers is through universities and institutes of technologies. Undergraduate degrees cover the most common disciplines, postgraduate qualifications may be necessary for more specialist subject areas. There is a skills gap in Ireland for these specialist areas, particularly for offshore engineering, with no institutions on the island of Ireland offering postgraduate education in offshore or marine engineering, and no naval architecture courses at any level [32]. The Bryden Centre, based in Queens University Belfast but also operating in the ATU, Letterkenny campus in Donegal, is providing training and doctorate research in offshore subjects, as is the Marine Research Institute in Cork, but these institutions offer a limited number of courses and likely do not provide sufficient training for the numbers required in Ireland going forward. Course offerings within the Atlantic Region and the estimated numbers in full time employment nationally in each discipline are provided in Table 16.

Table 16: Engineering course offerings and numbers in full time employment in each discipline

Occupation/Course Name	Offered By	2019 FTE Est.
Civil Engineer	NUIG, UL, TUS, ATU	9,300
Mechanical Engineer	NUIG, UL, TUS, ATU	5,200
Electrical/Electronic Engineer	NUIG, UL, TUS, ATU	8,900
Production & Process Engineer	UCC	3,600
QC & Planning Engineer	n/a	2,600
Energy Engineer	NUIG, ATU, TUS	n/a

2.6.2 Environment, Science & Humanities

Environment, Science and Humanities refers to subject matter experts, typically involved in the planning and design phases of wind energy developments. This includes planners, environmental scientists, ecologists and social scientists. Many of these broader roles would have a focus on renewable energy and would offer significant contributions to the Environmental Impact Assessment process of wind energy developments. Other areas of input would include ecologists involved in ornithology and marine biology, geologists, hydrologists and acoustic scientists.

While the initial entry route to many of these roles is through the third level education system, many of the wind development tasks require postgraduate study. NUIG provides some postgraduate courses in some of these areas, such an MSc in Coastal and Marine Environments, and Environmental Leadership. Other important postgraduate study areas are offered in Ireland, but not within the Atlantic Region. This specialisation is essential to support the wind energy industry in the study area, and these roles may be lost to other areas in Ireland due to the lack of postgraduate training within the Atlantic Region. Course offerings within the Atlantic Region and the estimated numbers in full time employment nationally in each discipline are provided in Table 17.

Table 17: Environment, Science & Humanities course offerings and numbers in full time employment in each discipline

Occupation/Course Name	Offered By	2019 FTE Est.
Physical Scientists	ATU, TUS, UL, Limerick College of Further Education	750
Social & Humanities Scientists	NUIG, UL, ATU	650
Conservation Professionals	ATU	600
Environment Professionals	UL, TUS	1,700
Architects & Town Planners	UL, ATU	6,500

2.6.3 Remote Sensing, Data Analysis & Digital Economy

Remote sensing, data analysis and the provision of digital services is an important and growing sector within the renewable energy sector. There is a wide range of educational offerings and research infrastructure to support activities in this space within the Atlantic Region. Many of these are provided by MaREI, the Science Foundation Ireland Research Centre for Energy, Climate and Marine, coordinated by University College Cork, but with partner institutions including NUIG and UL.

Figure 32: MaREI Insitutions

The Centre for Robotics & Intelligent Systems (CRIS) at UL is focused on developing practical and industry-relevant marine technologies and robotic systems from marine platforms to navigation, sensor development, emergency response planning, remote operated vehicle (ROV) and unmanned aerial vehicle (UAV) technologies. The research centre, founded in 2000, brings together an engineering group consisting of postdoctoral researches and PhD students from disciplines including electronic, computer, mechanical and aeronautical engineering backgrounds.

The INSIGHT SFI Research Centre for Data Analytics is co-hosted by NUIG, with partner institutions including UL. INSIGHT researchers undertake high impact research in data analytics that has significant benefits for the individual, industry and society by enabling better decision making. The research centre's central hypothesis is that making good decisions is dependent on having the best and most accurate information at your fingertips, helping to transform data into knowledge.

The recently announced Data2Sustain European Digital Innovation Hub (EDIH) coordinated by ATU is a consortium led by Atlantic Technological University, Sligo, which aims to develop a service programme to increase the transformation capacity and transformation speed of SMEs, with a focus on circular economy, operations and sustainability areas. Using a data-driven innovation approach, the EDIH aims to achieve disruptive digital transformation of the region's smart specialisation target sectors, with a focus on circular economy and smarter and greener processes, systems, products, services and business models.

2.6.4 Offshore Research Infrastructure

A broad range of offshore research infrastructure is available to support technical training and research and development activities by both academia and industry. The Marine Institute is the State agency responsible for marine research, technology development and innovation in Ireland. They provide scientific and technical advice to Government to help inform policy and to support the sustainable development of Ireland's marine resource. They operate a number of research facilities, test sites and research vessels including the Celtic Explorer and the recently completed Tom Crean.

The Marine Institute established the SmartBay test site in 2006 as Ireland's national marine test site and observatory. It provides continuous oceanographic and environmental data in near-real time and hosts three types of facilities: a ¼ scale ocean energy test site, data buoy, and subsea cabled observatory. The facilities can be accessed by users to test innovative and novel marine technologies.

The Atlantic Marine Energy Test Site (AMETS) located near Belmullet, Co. Mayo was developed by the SEAI to facilitate testing of full scale wave energy converters in an open ocean environment. SEAI was granted a Foreshore Lease for the AMETS site in 2014. Activity at the site to date has focussed on data collection. No testing has commenced at the site and related infrastructure including connection to grid are yet to be installed. In 2018, SEAI began the process of expanding the scope of the site to include testing of floating offshore wind technologies, with current planning indicating the first deployment of an FOW platform could occur in 2025.

2.6.5 Apprenticeships, Construction & Technical

Construction and technical resources are required in various tasks throughout the installation and operation of a wind energy project, including construction, maintenance and repairs. These roles include general construction workers, crane drivers and supervisors, as well as more specialist electrical and technical roles for the operational phases.

Apprenticeships have traditionally offered a career path in technical streams, and this is reflected with numerous offerings across the region. Additionally further education offers pathways for specialists in multiple sectors, with relevant areas for the wind energy supply chain presented in Table 18.

Table 18: Apprenticeship offerings in Atlantic Region supporting wind energy delivery

Institution	Course Name	Level
Limerick & Clare ETB; Galway & Roscommon ETB; Mayo, Sligo & Leitrim ETB; Donegal ETB	Metal Fabrication	6
	Mechanical Automation & Maintenance Fitting	6
	Electrical	6
	Electrical Instrumentation	6
Kerry College FET	Wind Turbine Maintenance Technician	6
University of Limerick	Principal Engineer	10
	Equipment Systems Engineer	9
	Supply Chain Manager	9
	Supply Chain Specialist	
	Supply Chain Associate	7

Entry routes to technical and construction occupations vary and formal education is not always required. In these instances, certification and training are a prerequisite, such as Safe Pass. Machinery operators or crane drivers will also require further training. The Construction Skills Certification Scheme (CSCS) may be required to work in the sector.

Table 19: Construction skills courses and numbers in full time employment

Occupation/Course Name	Offered By	2019 FTE Est.
Construction & Trade Supervisors	ATU, NUIG, TUS, UL	4,600
Project Managers	ATU, NUIG, TUS, UL	2,000
Crane Drivers	ETBs	750
Electrical & Electronic Technicians	ETBs	3,300
Health and Safety Officers	NUIG	7,600
Building & Civil Technicians	ETBs	7,600
Energy Plant Operatives	ATU	1,000

2.6.6 Legal & Professional Services

The legal and professional services group includes occupations providing specialist legal and financial services and advise developers of large-scale wind energy projects. These occupations include solicitors, accountants, tax experts and investment analysts. These roles are particularly involved in the early stages of energy projects with central roles in financial feasibility, land ownership, certification, contracts and regulation.

Third level education provides the standard entry route into these professions, followed by relevant qualification and chartership with professional institutions. Knowledge and experience of the wind energy sector is essential for wind energy development. Numbers in these occupations are unlikely to present an issue for the development of wind energy projects, but sector-specific experience and knowledge of the industry may be limited.

Table 20: Legal and professional services in Ireland

Occupation/Course Name	Offered By	2019 FTE Est.
Solicitors	NUIG, ATU, TUS, UL	12,000
Chartered Surveyors	ATU, TUS	4,800
Accountants & Tax Experts	UL, ATU, Limerick CFE, TUS, Galway Technical Institute	36,500
Managers & Proprietors in other services	Donegal ETB, ATU, TUS, Galway Community College, Galway Technical Institute,	4,500

2.6.7 Transport & Logistics

Transport & logistics are essential for the procurement and construction phases of wind energy projects, transporting materials and equipment. Vessels and aircraft (generally helicopters) are required to transport workers to and from offshore wind sites, throughout all project phases. Light aircraft may also be used during the development phase to conduct surveys.

Table 21: Transport and logistics

Occupation/Course Name	Offered By	2019 FTE Est.
Managers & Directors in Transport & Distribution	Donegal ETB, ATU, TUS, Galway Community College, Galway Technical Institute, North Connaught College	7,100
Aircraft Pilots & Flight Engineers	DCU, MTU	1,500
Ship Officers		400
LGV Drivers		21,500
Marine & Waterway Transport Operatives	NMCI/MTU	600

2.6.8 Training Courses

Training courses focussed on the wind industry show a lack of availability in the region itself, with wind industry specific courses offered elsewhere in Ireland. Some of these courses require specific infrastructure such as that supplied in the National Maritime College of Ireland in Ringaskiddy, Cork, but others such as work at height training and rescue could be offered by Education and Training Boards (ETB) alongside their other strong offerings.

Table 22: Wind energy training courses in Ireland and the Atlantic Region

Institution	Course Name
ETBs	Safe Pass
Renewables Academy (Wexford)	Wind Turbine Safety Rules
	Work at Height Training
	Work at Height and Rescue – Wind Turbines
	High Voltage Substation Access
National Maritime College of Ireland (Cork)	Minimum Industry Standard Training
	Basic Offshore Safety Induction & Emergency Training
	Further Offshore Emergency Training
	Helicopter Underwater Egress Training & Emergency Breathing System-Opito
	Offshore Lifeboat Coxswain Initial Twinfall Training
	Offshore Lifeboat Coxswain Freefall Supplementary Training
	Renewable UK Marine Safety Training

Seamanship Center Killybegs (Donegal)	MCO Approved Able Seafarer Deck Course
	MCA Approved Stability. Under 24m Workboat
	MCA Approved Slinger Banksman Course
	MCA Approved Deck Crane & Safe Lifting Course
	MCA Approved Confined Space Awareness Course
	STCW Personal Safety & Social Responsibility
	STCW Ship Security Awareness
	STCW Ship/Port Security with Designated Security Duties
	STCW Medical Care Aboard Ship
Errigal Training Center (Donegal)	Basic Safety Training (BST) Offshore Package
	BST Onshore
	BST Fire Awareness
	BST Manual Handling
	BST Working at Heights
	BST First Aid
	BST Sea Survival & Boat Transfers
	Work at Height and Rescue – Wind Turbines
Green Tech Skill Net (Kildare)	Wind Turbine Technician Retraining of unemployed people into the Wind and Renewables Industry
Arch Safety (Clare)	GWO Working at Height & Advanced Rescue for the Emergency Services GWO Basic Safety Training GWO Basic Safety – Refresher Training GWO Working at Height – 2 day GWO Working at Heights – Refresher – GWO approved – 1 day GWO First Aid – 2 day GWO First Aid Refresher – 1 day GWO Fire Awareness GWO Manual Handling Hub Access and Rescue Confined Space Entry GWO Advanced Rescue IRATA ROPE ACCESS IRATA Rope Access Level 1 Training IRATA Rope Access Level 2 Training IRATA Rope Access Level 3 Training Ladder and Roof Top Safety

	Pole Top Rescue Radio Frequency Safety Awareness Roof Top Safety MATS Initial Basic Tower Climber & Rescue Training MATS Initial Basic Tower Climbing and Rescue – Revalidation SUPPORTING SKILLS PPE Inspection First Aid Response Safepass

Most of the training courses provided in the region are by private operators who have identified the opportunity in the industry. Kerry ETB now offer Wind Turbine Technician Training and it is hoped that other ETBs will begin to provide this training along with other renewable focussed training.

2.6.9 Clusters

There is an existing network of clusters and clustering initiatives in the Atlantic Region focused on the offshore sector in addition to others with a focus on complimentary areas of expertise. A non-exhaustive selection is presented below.

The Killybegs Marine Cluster is an industry-driven marine cluster that aims to build capacity with businesses working within the blue economy. The core objectives of the Cluster are to establish new business opportunities in international markets, foster skills and talent, and provide the members access to research development and innovation. The cluster was founded in 2001 and encompasses many industries including commercial fishing (base industry), fish processing, marine engineering, aquaculture, renewable energies and offshore marine services.

The Marine Ireland Industry Network is a national body made up of an array of companies, state organisations, research groups and higher education institutes, all working in Ireland's blue economy. The group focuses on collaboration between members as well as providing opportunity for members to showcase their products, services and recent achievements to industry, researchers and international companies.

The Galway Hydrogen Hub (GH2) is a consortium consisting of seven members with a proposal to develop a Hydrogen Valley in the Galway region, similar to those launched in other European countries, that links hydrogen research, production, distribution, and transportation with various end users such as transport and industry. The utilisation of indigenous renewable hydrogen at Hydrogen Valleys is considered an important step towards enabling the development of a new hydrogen economy. GH2 aims to position Galway as the home of Ireland's first Hydrogen Valley, providing green hydrogen for use in transport, industry and within local communities in the greater Galway region.

CoLAB Incubation centre in Donegal provides support as an innovation centre championing entrepreneurship in the North-West. The centre facilitates entrepreneurs starting their own business and supports high potential start-ups. The facility is linked to what was formerly known as Letterkenny IT, now part of ATU, and aims to support the cluster and innovation centres in Killybegs alongside other work in the region. Similar incubation centres exist across the Atlantic Region such as ATU (formerly GMIT) iHubs, ATU Sligo (IT) Innovation Centre, Galway Technology Centre, NUIG Business Innovation Centre and the PorterShed in Galway, a coworking and collaborative space for Technology focused Innovation Driven Enterprises.

The Digital Futures Manufacturing Centre in Sligo was set-up in 2021 through a consortium of IT Sligo (now ATU) and Sligo and Leitrim County Councils and was funded by Enterprise Ireland. The base will be a centre of excellence to prepare companies in the Northwest to embrace new technologies such as automation and Artificial Intelligence and establish Sligo as a research lead in manufacturing supply chains. The Centre will also provide a central location for industry collaboration and space for companies to meet and explore new projects and technologies as well as providing a gateway to the other centres such as Confirm, in University of Limerick, I-Form, hosted by UCD and the Irish Manufacturing Research centre.

Tech Northwest is a cluster of companies working in the technology sector in the northwest of Ireland. Their goal is to promote Sligo-Leitrim as a unique and thriving location for businesses and employees. The group brings together ICT employers and educators from the Sligo and Leitrim area to run career fairs and networking events, as well as promoting collaboration through hackathons and cross-sectoral initiatives. They focus also on increasing collaboration with local education and training bodies through initiatives such as student placements, tech apprenticeships, mentorship from industry, and study trips to employer organisations and research partnerships.

The Mid-West Renewable Energy Research and Education cluster is a virtual cluster set up to establish a close dialogue between educational bodies and industry in the Mid-West. The close ties with industry in emerging renewable energy fields make it an excellent template to ensure that education and training resources address the future needs of the regional economy.

2.7 Economic Impact

2.7.1 Previous Work

In 2021, Wind Energy Ireland commissioned a report by KPMG, funded by Bord na Mona, Brookfield, Coillte and Statkraft. The report examined the economic impact of onshore wind energy in the Republic of Ireland, from 2020 up to 2030. The report assumes that the government's CAP goals are achieved, and the economic and labour results were presented on this basis. The regions are not aligned with the regions defined in this report. A map of the regions used by KPMG is shown in Figure 33, making direct comparison with the outputs of this report difficult.

The KPMG analysis also highlighted the contribution of the wind sector to Local Authorities as illustrated in Figure 34.

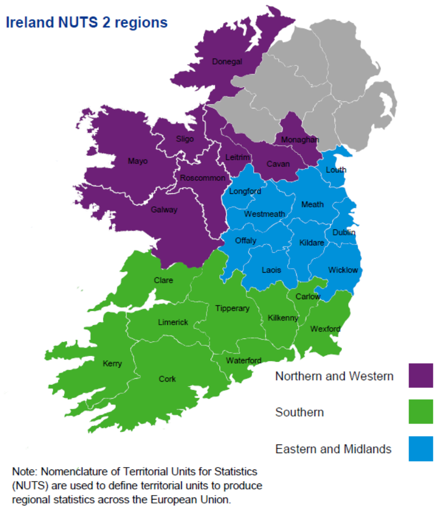


Figure 33: KPMG Report Regions

It has been reported that onshore wind creates a range of economic, social, and environmental impacts for communities across Ireland. These primarily arise as economic value add, job creation, additional Exchequer returns, reduced emissions, and a rolling and sustainable pipeline of capital investment. These impacts arise at each step of the sector's value chain: in project planning, manufacturing, transport, installation, grid connection, operations and maintenance, and decommissioning.

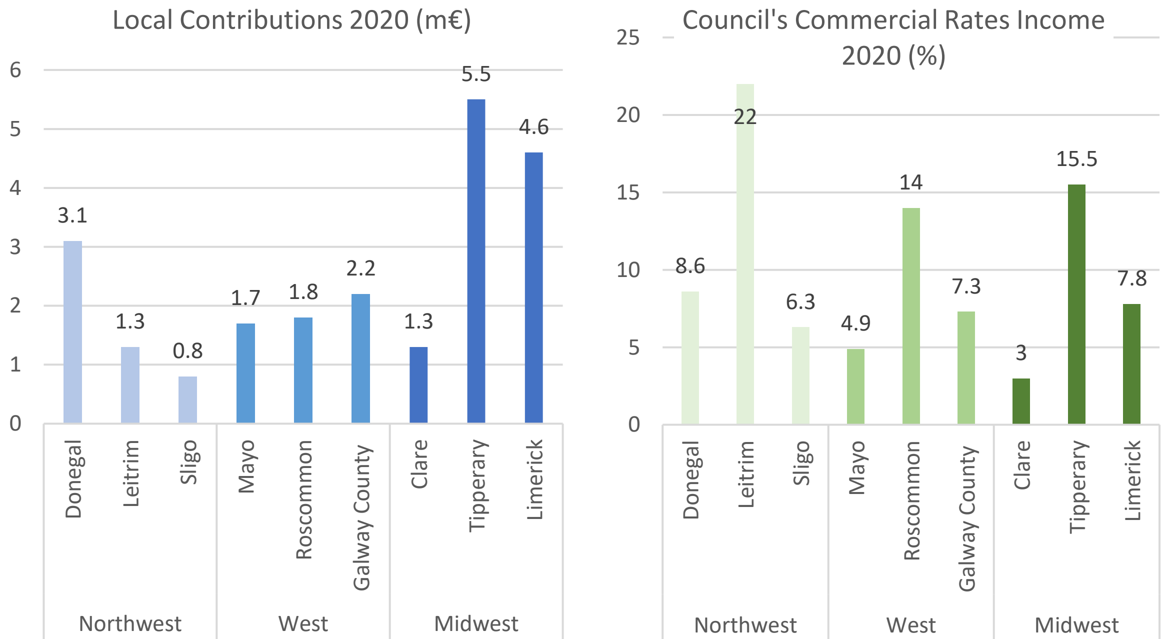


Figure 34: Wind Sector Contributions to Local Authorities (2020)

2.7.2 Onshore Wind Economic Impact in 2022

It is estimated that in 2022 across the Atlantic Region there are a total 3,550 MW of onshore wind in construction, development or operation, of which:

- 930 MW under development;
- 460 MW under construction; and
- 2,160 MW in operation.

Out of the total Irish capacity in development, construction and operations, it was estimated that around 15% of activity occurs within the North West of Ireland, 16% within the Midwest and 20% within the West. Onshore wind activity in the Atlantic Region accounted for around 50% of total activity within the Republic of Ireland, where there were 7,070 MW of capacity across the three phases.

To assess the economic impact generated by the onshore wind sector in 2022, it was first necessary to estimate the total expenditure associated with the development, construction and operation of onshore wind developments. Based on sectoral evidence on the spending per MW across a range of contracts, it was estimated that in 2022 the value of onshore wind contracts was around €1.2 million per MW. This is lower than previous estimates for expenditure per MW in Ireland, however, reflects the wider trend in cost reductions in the sector, including the moves to larger turbines.

Not all of this spending takes place within Ireland, as turbine components, for instance, are imported.

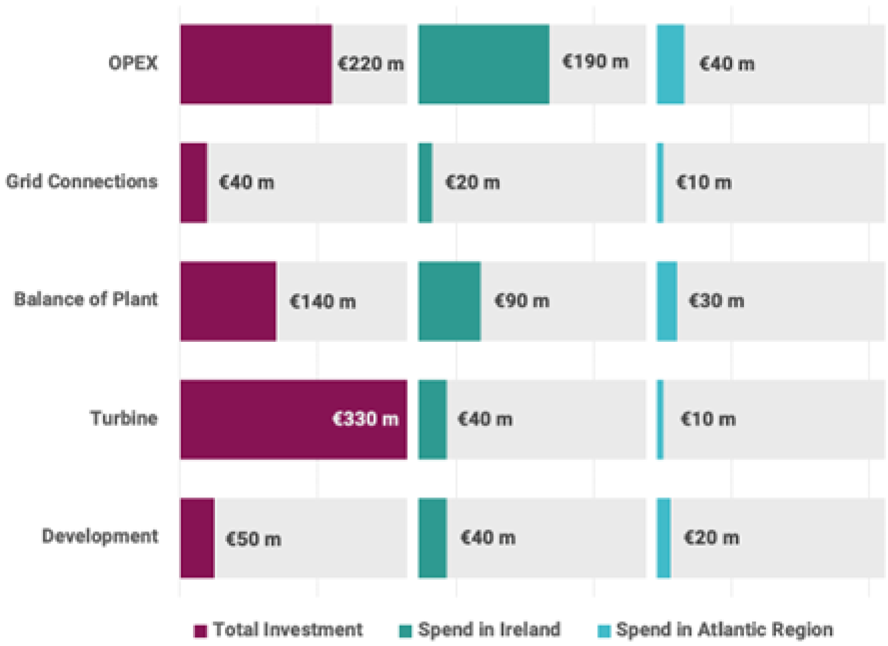


Figure 35: Spend in Ireland Onshore Wind Sector 2022

The total spend across the Atlantic region inclusive of any spending associated with developments not located within this area was estimated at €110 million. This is equivalent to 14% of the total expenditure on the onshore wind sector in the Republic of Ireland in 2022. In general, each region is expected to secure between 15 – 30% of the capital expenditure of projects built in their area. This is in line with supply chain assessments completed by SSE Renewables for Galway Wind Park [33]. In addition, some suppliers within each region will also work on onshore wind projects that are outside their region.

The largest area of spend is within the operations and maintenance contracts, which will service the 2.2 GW of onshore wind that is currently operational in the Atlantic region.

This is followed by balance of plant contracts linked with the construction of onshore wind farms. This includes:

- Civil engineering works;
- Construction of roads and hard standings;
- Plant hire; and
- Suppliers of aggregate, concrete and other building materials.

This spend will support employment and generate GVA in the companies that carry out wind farm related contracts. In addition, it will support businesses within their supply chains (indirect impacts). Those working on wind farm-related contracts will also generate an economic impact (induced impacts) through spending their salaries and wages in the economy.

Adding these impacts, it is estimated that in 2022 the onshore wind sector is responsible for:

- €8 million GVA and 130 jobs across the Northwest Region;
- €16 million GVA and 270 jobs across West Region;
- €21 million GVA and 350 jobs across Midwest Region;
- €45 million GVA and 750 jobs across Atlantic Region;
- €199 million GVA and 3,460 jobs across the Republic of Ireland.

2.7.3 Offshore Wind Economic Impact in 2022

The offshore wind sector in the Atlantic Region is in its infancy and there are no operational offshore wind farms off the west coast. There are project proposals such as Sceirde Rocks, which are in the development stage and generating economic activity.

During the development stage of an offshore wind farm, the largest opportunities are within professional, scientific and technical services. This work is often completed remotely from where the project shall be built. Within Ireland, the majority of employment (56%) in professional, scientific and technical services is within Dublin. Combined, the counties within the Atlantic Region account for 13% of all Irish employment in this sector .

In 2022, it was estimated that across the Atlantic Region there were a total 390 MW of offshore wind capacity that will generate economic activity. All of this is currently under development, rather than in either construction or operation. As discussed in Section 2.4, there are currently around 40GW of projects which are in some stages of development across Ireland. However, many of these projects will be dormant, or will be generating minimal activity at this stage. For the purposes of the analysis, it is assumed that the majority of the economic activity will occur during the active stages of development, such as the pursuit of planning applications in the years preceding construction. Across Ireland there is assumed to be approximately 3.9 GW of offshore wind projects at some stage of active development, as this is the level required to meet the targets outlined in this scenario.

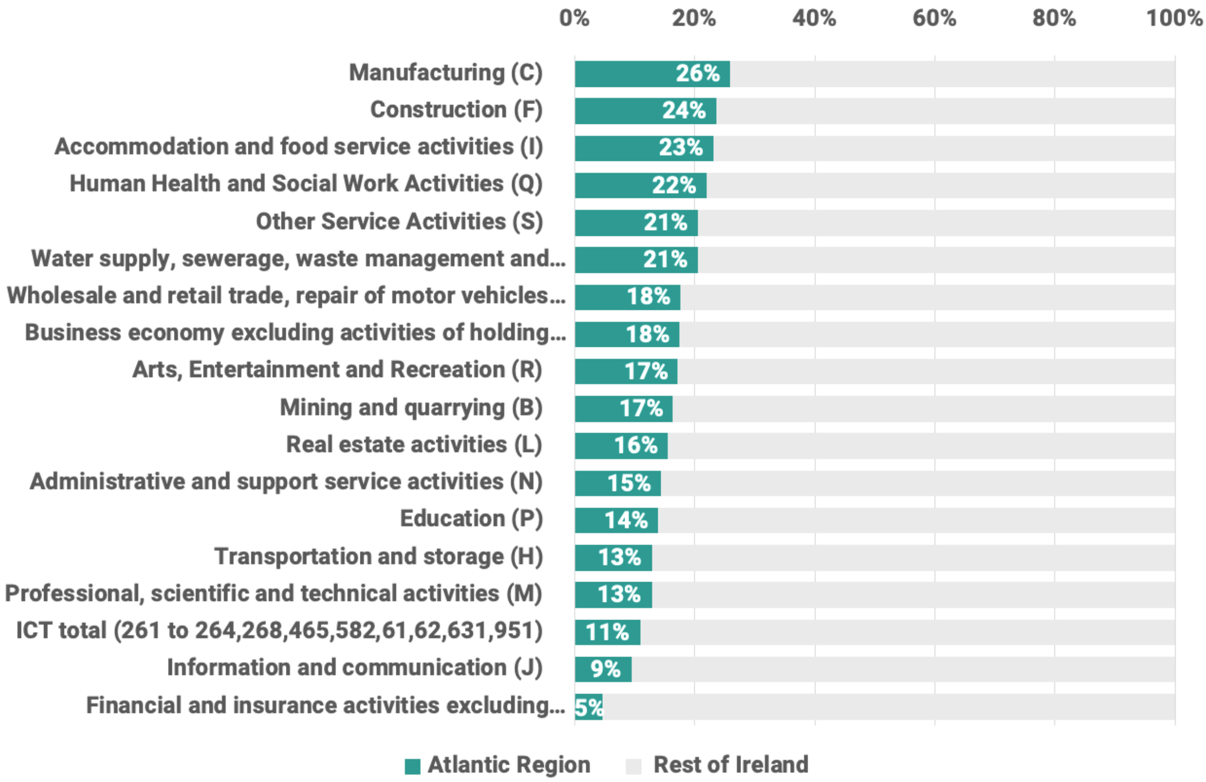


Figure 36: Share of Irish Employment in Atlantic Region by Sector

Based on this level of capacity, it was estimated that in 2022 a total €90 million were spent across the offshore wind sector in Ireland. The Atlantic Region attracted a total €10 million of spending.

A similar approach towards the estimation of economic benefits as for the onshore wind baseline was applied. By adding together direct, indirect and induced impacts, it was estimated that the offshore wind sector in 2022 supported:

- €1 million GVA and 10 jobs across the Northwest Region;
- €4 million GVA and 60 jobs across West Region;
- €2 million GVA and 20 jobs across Midwest Region;
- €6 million GVA and 90 jobs across Atlantic Region;
- €85 million GVA and 1,240 jobs across the Republic of Ireland.

3 The Opportunity

Ireland has ambitious plans for renewables, including offshore wind. The Irish Government wants to reduce emissions by 70% by 2030 and be carbon neutral by 2050. Government wants to see 5GW of offshore wind in operation by 2030 and has a long-term ambition of 30GW of floating offshore capacity for domestic use and export, although the policy framework to deliver this larger ambition is still in development.

The geopolitical situation in Europe, most notably the war in Ukraine, and the resulting deterioration of relations between the European Union and Russia have renewed and refocussed efforts to address the reliance of many European nations on imported hydrocarbons. The development of renewable energy projects is likely to accelerate in Europe due to rising energy costs and concerns over energy security that have emerged as a result of the war.

The focus on floating offshore wind in Ireland is highly appropriate. With rapid cost reduction seen in offshore wind, the offshore wind sector is increasingly confident over the role floating offshore wind can play, and Ireland has a competitive resource suitable for rapid growth.

However, there are challenges relating to the development of the Irish transmission grid to accommodate significant new connections, particularly along Ireland's west coast, and significant infrastructure and skills investment will be needed to ensure that economic benefit from the future pipeline of projects is maximised.

3.1 Global Context

Offshore wind as a whole is set to grow rapidly. Wind energy is a mature, low cost energy source that can be deployed at an industrial scale. In many locations offshore wind is more suitable for deployment than onshore wind due to wind speed, visual impact and competing land use. Currently there is 35GW of installed offshore wind capacity globally, but the Global Wind Energy Council (GWEC) forecasts that there will be approximately 300GW in operation by 2030 based on known project activity [34]. The IEA has recently updated its global energy scenarios to align with global net zero emissions targets and forecasts approx. 2,000GW of offshore wind by 2050. To deliver this would require between 70 and 80GW of offshore wind to be delivered each year between 2030 and 2050 – i.e. 2x the existing global capacity would need to be installed annually.

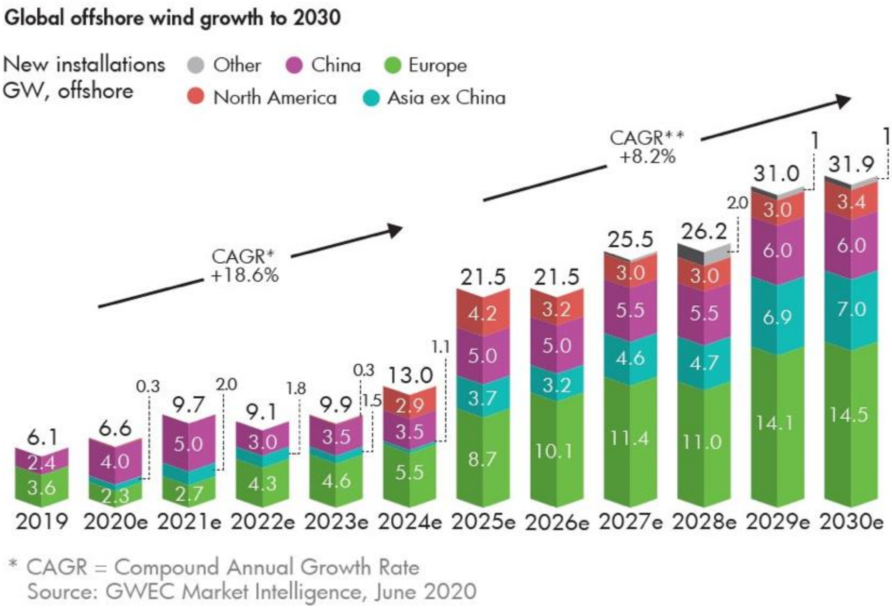


Figure 37: Global offshore wind market growth rate 2019 – 2030 [34]

While globally, there are only 128MW of floating offshore wind in operation across three floating offshore wind farms (Hywind and Kincardine in Scotland and Windfloat Atlantic in Portugal), the offshore wind sector is increasingly confident about the opportunity for development of large scale floating offshore wind projects. Rapid growth of floating offshore wind is expected globally as part of efforts to deliver this 2,000GW of offshore wind by 2050. Countries like the UK, Norway, France, Spain, Japan, South Korea and the USA (West Coast) all have multiple projects now in development.

The Carbon Trust has forecast that floating offshore wind will grow to 10GW by 2030 and 70GW by 2040 [35] as shown in Figure 38 (70GW is given as a mid-range forecast between a low of 30 and a high of 120GW).

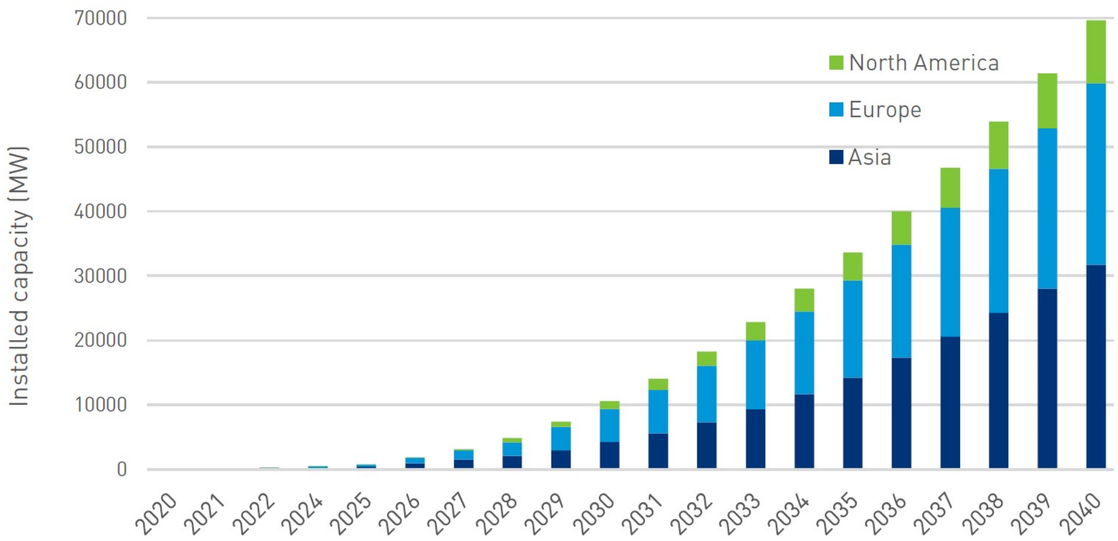


Figure 38: Global floating offshore wind market growth (2020-2040)

3.2 Targets

3.2.1 National Targets

The Programme for Government 'Our Shared Future' aims to take advantage of the "at least 30 GW of offshore floating wind power" off the Atlantic coast by 2050. Irelands Offshore Renewable Energy Development Plan (OREDP) outlines the possibility of 27 GW of floating wind in Irish waters (7GW of which is on the West Coast). Currently there are at least seven specific floating offshore wind farm projects in the Atlantic Region in the very early stages of planning. These projects are competing for less than 2GW of grid connection capacity available at Moneypoint. Future installed FOW capacity may be related to upgrades in grid connection availability, or potentially production of Green Hydrogen as a vector fuel. Combined fixed and floating offshore wind projects are also planned off the Sligo and Donegal coasts in the North-West region and are at an early stage of project definition and planning.

3.2.2 Regional Targets

County development plans for the nine counties in the region were generally aligned in stating objectives and policies to advance renewable energy generation, sustainable power generation and grid infrastructure improvements in the counties in this study. County development plans are relevant for a duration of six years, so while some counties have just released new development plans for 2022 - 2028, other development plans were written in 2017 and are relevant up until 2023. All counties mention the Government programmes including the Ireland's Transition to a Low Carbon Energy Future (2015 - 2030), and the Climate Action Plan (2021) for those written more recently, amongst other reasons for the increase in renewable energy generation, with wind energy cited as one option alongside solar energy and biomass power production. In general, however, county development plans did not set out concrete goals for the quantity of electricity generated from renewable sources or the capacity increases required. The Mayo County development plan mentions the aim of 100MW increase in wind energy over the plan period of 2021 – 2027, and Roscommon development plan sets out the current capacity of 112MW of wind energy, with a further 14MW already contracted and an aim to get to 262MW in total by 2030.

All councils note the importance of all wind energy developments being in accordance with the Department of Environment, Heritage and Local Government Wind Energy Development Guidelines, published in 2006 and revised in 2019. Along with wind energy development occurring in accordance with these guidelines, all county development plans noted the need to consider the impact of wind developments on local residents and communities, the local environment as well as the landscape and visual impacts of development. Some county councils and public bodies have indicated, during stakeholder interviews in the course of this study, that they may are reaching a saturation point with wind development being limited in areas.

Some counties are significantly reducing the space allotted to wind energy, an example of which is shown with the comparison between Galway County councils land earmarked for development from 2010 to 2022 versus the land for wind development from 2022 to 2028 and illustrated in Figure 39. If this approach continues, the land available for wind development needs to increase its productivity to meet climate goals.

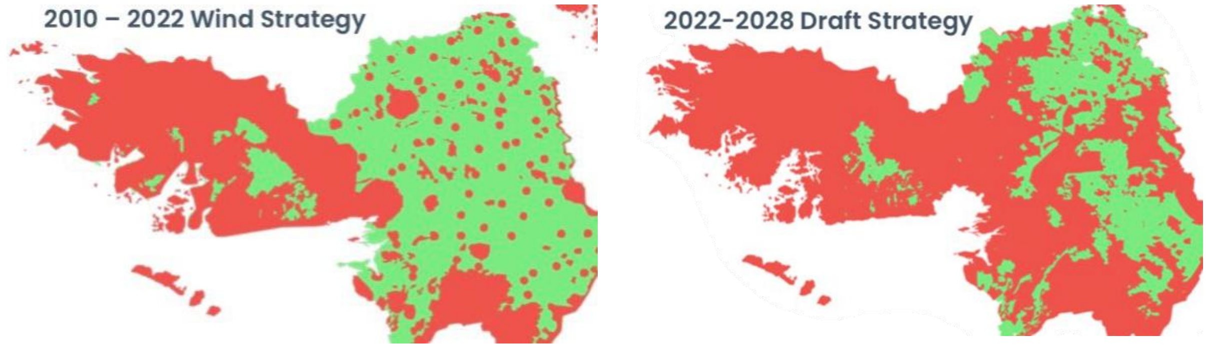


Figure 39: Galway Wind Strategy 2010 – 2022 (L) and 2022 - 2028 (R)

Table 23: High level summary of climate references in county development plans

	Donegal	Leitrim	Sligo	Mayo	Roscommon	Galway	Clare	Limerick	Tipperary
Support renewable energy	✓	✓	✓	✓	✓	✓	✓	✓	✓
Grid improvement	✓	✓	✓	✓	✓	✓	✓	✓	✓
Centre of Excellence/Cluster	✓			✓		✓	✓	✓	✓
DEHLG Wind Energy Development guidelines	✓	✓	✓	✓	✓	✓	✓	✓	✓
Consider residents/environments/landscape	✓	✓	✓	✓	✓	✓	✓	✓	✓
Support Government programmes	✓	✓	✓	✓	✓	✓	✓	✓	✓

The county development plans for some counties outline the intention of creating centres of excellence or development clusters, to support renewable energy with infrastructure such as ports and manufacturing centres along with business clusters. These include:

- Killybegs Port, Donegal
- Atlantic Marine Energy Test Site (AMETS) tidal & wave test site off Beal an Mhuirthead (Belmullet), Mayo
- SmartBay - Ireland’s national marine test site and observatory comprising a test site, data buoy, and subsea cabled observatory in Galway Bay

- Marine Resource Innovation Parks including Páirc na Mara at Cill Chiarán and Ros an Mhil Port, Galway
- Moneypoint and Cahiracon Strategic Development Locations, Clare
- Foynes Port and Atlantic Green Digital Basin, Limerick

Other supporting infrastructure such as the development of Sligo port to provide an O&M hub is mentioned without specific details or timelines.

3.3 Wind Build Out Scenarios

In order to quantify the scale of the opportunity that the development of onshore and offshore wind offers to the Atlantic region, it is necessary to look ahead to understand potential build out rates. Three scenarios are considered for the future development of wind energy in Ireland based on a range of information sources including the Programme for Government [3], the Climate Action Plan 2019 [4] and 2021 [5], Eirgrid's 'Shaping Our Electricity Future' report [6] with additional input from academic and industry sources [7] [8] and based on the pipeline of wind projects in the public domain.

There is often little clarity on specific details or timelines and in these instances detailed build out rates are predicted based on available literature supplemented by the author's experience.

Initially the project was intended to consider a high and low build out scenario however it was noted by the client team that the rapid build out scenario, while based on the well-established guidance and targets, did not capture the full scale of the opportunity for the Atlantic Region if the full potential for renewable energy generation was captured. For this reason, an '*Aspirational'* scenario was added to identify the full scale of the opportunity.

3.3.1 Steady Build Out

The 'Steady' build out scenario is based on the following assumptions:

- Onshore wind build out to 2030 limited by grid capacity to 5700MW
- Offshore wind build out to 2030 based on CAP 2021, Eirgrid grid capacity, and the Programme for Government
- Onshore wind to 2050 set at the maximum installed capacity target identified in CAP 2019
- Offshore wind capacity in 2050 based on Eirwind lower bound value
- Distribution of onshore wind in Ireland assumes the county breakdown for new capacity matches existing installed capacity
- Offshore wind project locations based on Eirgrid regional connection capacity to 2030
- First offshore connection in the Atlantic Region assumed to be in the West Region based on Eirgrid and 'relevant project' status
- Post-2030 the offshore wind locations are based on the Eirwind breakdown for 2050 scaled down from 25GW offshore wind installed capacity

- Subregional offshore locations are based on the declared pipeline of offshore projects in the public domain.

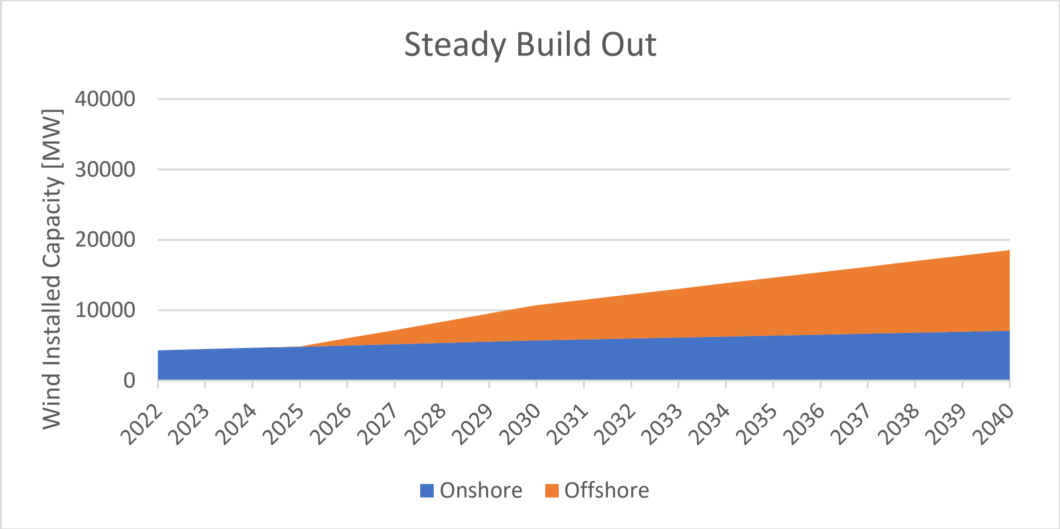


Figure 40: Steady Build Out Installed Wind Capacity, Ireland

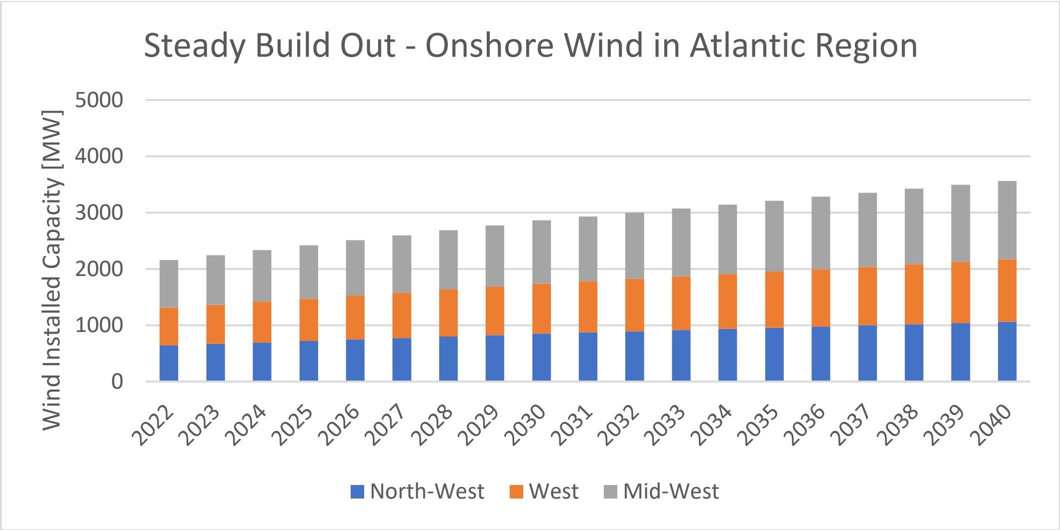


Figure 41: Steady Build Out - Onshore Wind Capacity, Atlantic Region

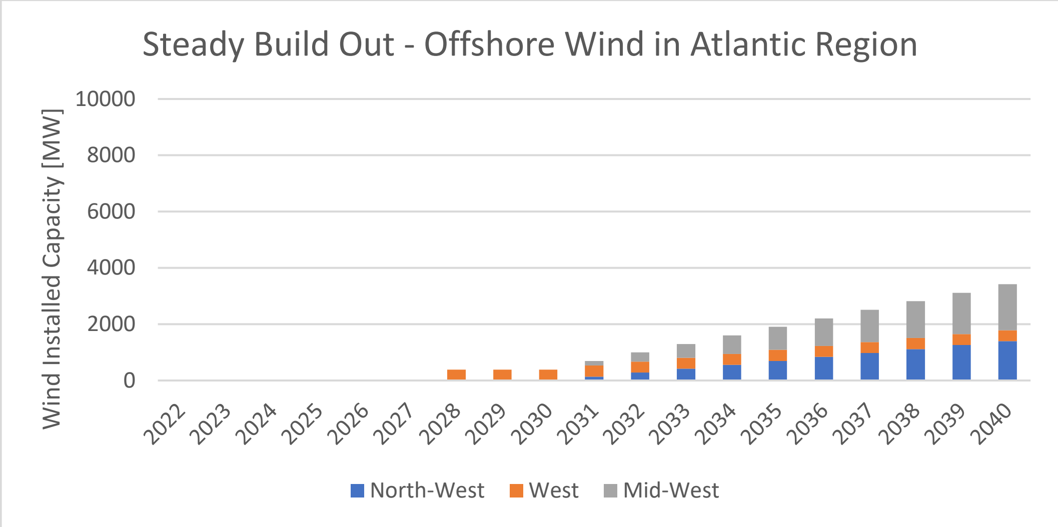


Figure 42: Steady Build Out Offshore Wind Capacity, Atlantic Region

3.3.2 Rapid Build Out

The ‘Rapid’ build out scenario is based on the following Assumptions:

- Onshore wind build out to 2030 based on PfG, CAP 2021 (exceeds Eirgrid capacity)
- Offshore wind build out to 2030 based on CAP 2021, Eirgrid grid capacity, PfG + Moneypoint Connection capacity
- Onshore wind to 2050 set at the maximum installed capacity target identified in CAP 2019
- Offshore wind capacity in 2050 based on Eirwind upper bound value
- Distribution of onshore wind in Ireland assumes the county breakdown for new capacity matches existing installed capacity
- Offshore wind project locations based on Eirgrid regional connection capacity to 2030 + Moneypoint
- First offshore connection in the Atlantic Region assumed to be in the West Region based on Eirgrid and ‘relevant project’ status
- Post-2030 the offshore wind locations are based on the Eirwind breakdown for 2050
- The post-2030 subregional offshore locations are based on the declared pipeline of offshore projects in the public domain.

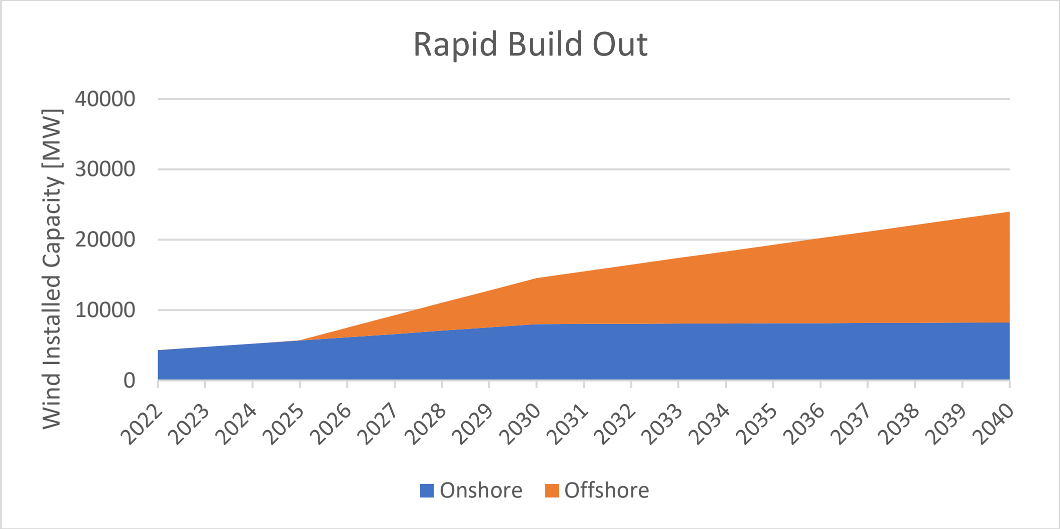


Figure 43: Rapid Build Out Wind Capacity, Ireland

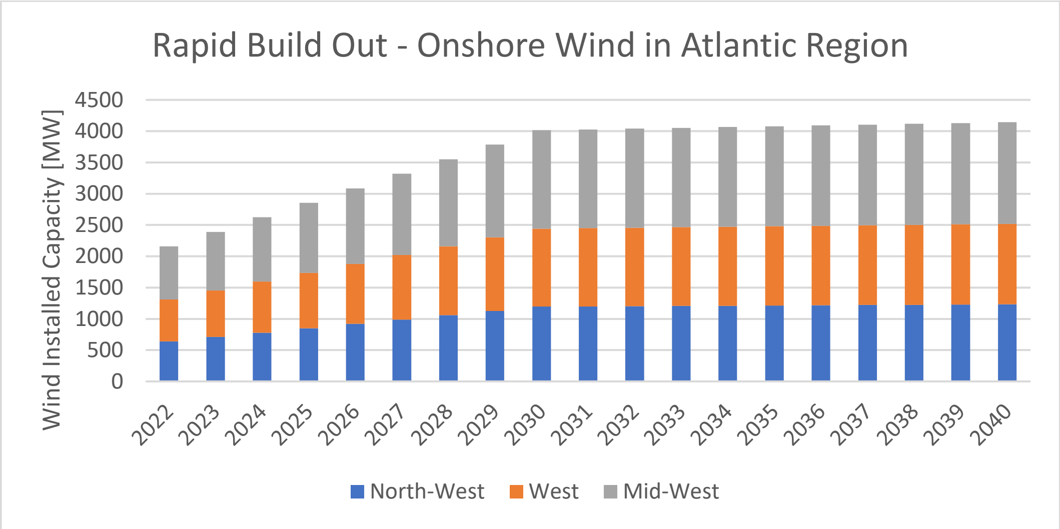


Figure 44: Rapid Build Out Onshore Wind Capacity, Atlantic Region

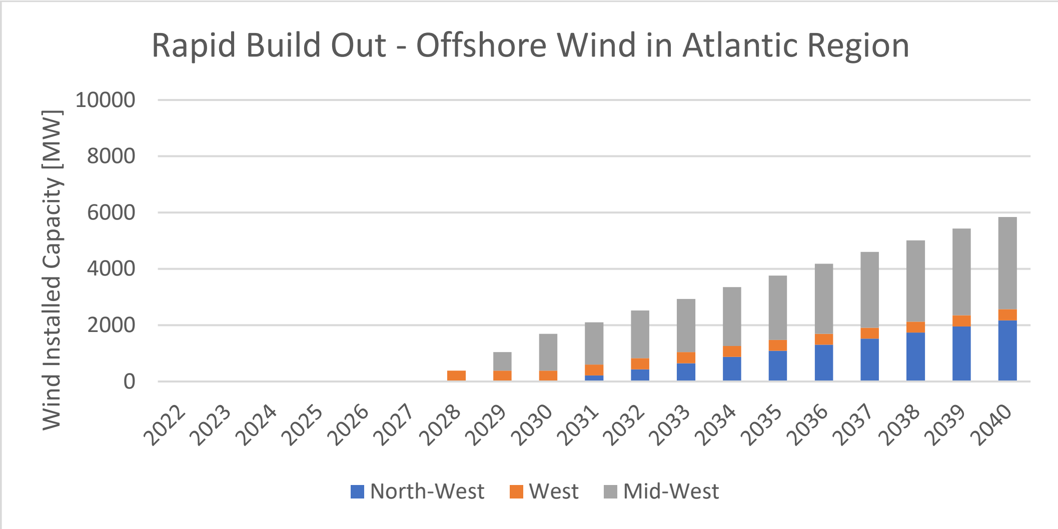


Figure 45: Rapid Build Out Offshore Wind Capacity, Atlantic Region

3.3.3 Aspirational Build Out

The 'Aspirational' build out scenario is based on the following assumptions:

- Onshore wind build out to 2030 based on PfG, CAP 2021 (exceeds Eirgrid capacity)
- Offshore wind build out to 2030 based on CAP 2021, Eirgrid grid capacity, PfG + Moneypoint Connection capacity
- Onshore wind to 2050 set at the maximum installed capacity target identified in CAP 2019
- Offshore wind capacity in 2050 based on Udaras value [8] of 35.6GW for floating wind by 2050. 25GW floating declared to date, this ratio used to scale up current floating projects in the Atlantic region.
- Distribution of onshore wind in Ireland assumes the county breakdown for new capacity matches existing installed capacity
- Offshore wind project locations based on Eirgrid regional connection capacity to 2030 + Moneypoint
- First offshore connection in the Atlantic Region assumed to be in the West Region based on Eirgrid and 'relevant project' status
- Post-2030 the subregional offshore wind locations are based on the declared pipeline of offshore projects in the public domain such as the 4c Offshore map of declared projects

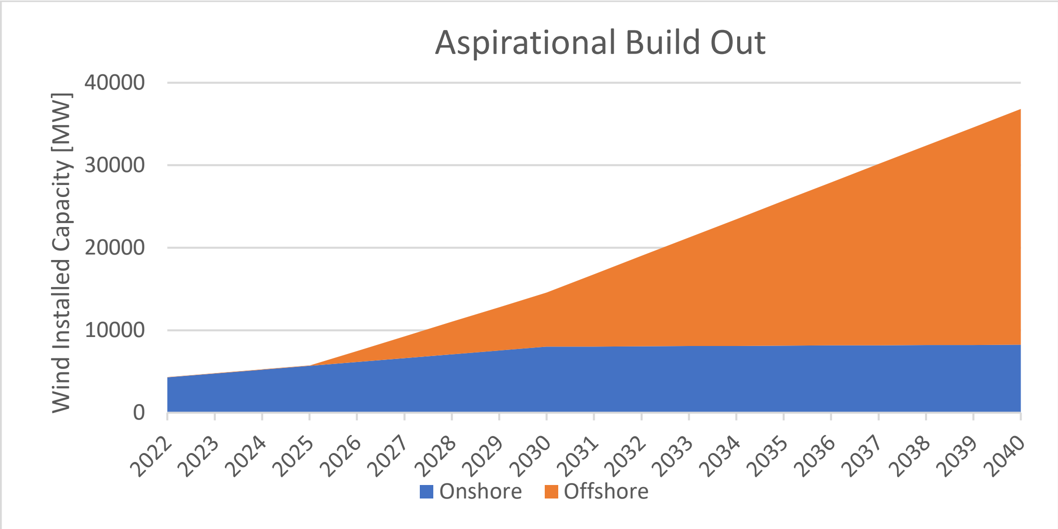


Figure 46: Aspirational Build Out Wind Capacity, Ireland

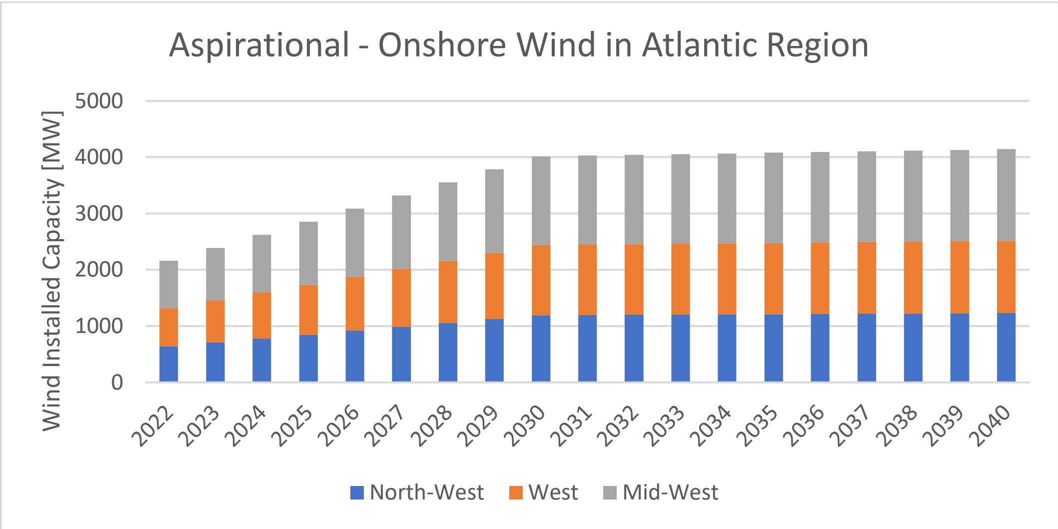


Figure 47: Aspirational Build Out Onshore Wind Capacity, Atlantic Region

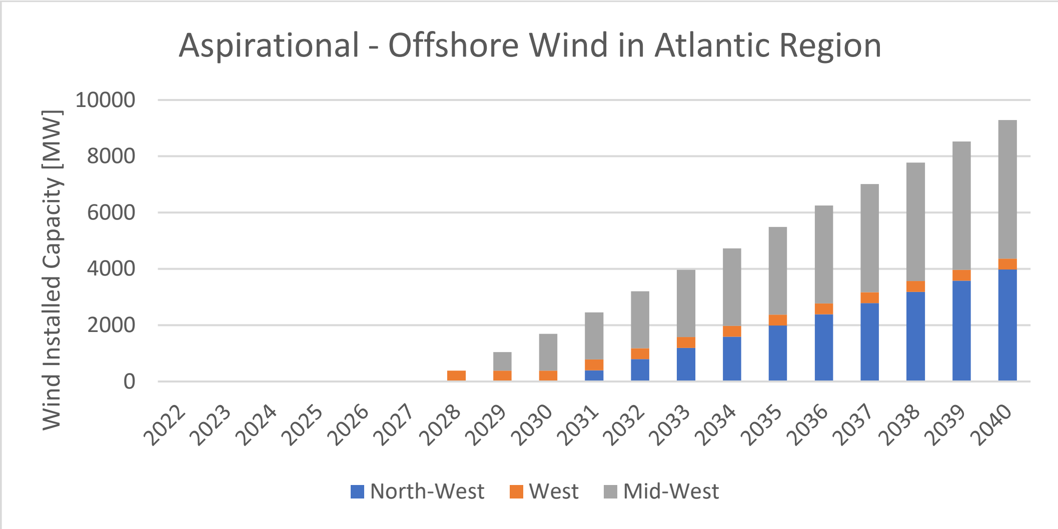


Figure 48: Aspirational Build Out Offshore Wind Capacity, Atlantic Region

3.4 Economic Impact

The future opportunities for the Atlantic region and its sub-areas have been modelled based on the rapid build-out scenario. Under this scenario, it was estimated that by 2037 the total generating capacity from onshore and offshore in Ireland could be 21 GW, of which 8.2 GW would come from onshore wind installation and 13 GW from offshore wind. The contribution from each energy source is considered separately below. The analysis is followed by a sensitivity analysis setting out the economic impacts under other two scenarios: the steady build-out and the aspirational scenario.

The impacts of the wind energy sector have been split into:

- economic impacts of the onshore wind sector; and
- economic impacts of the offshore wind sector.

3.4.1 Economic Impact of Onshore Wind in the Atlantic Region

It was estimated that under the rapid build-out scenario, by 2037 the development, construction and operations and maintenance of onshore developments across the Republic of Ireland will generate a total €1.9 billion.

The largest area of spending will be in balance of plant contracts, €860 million. This includes all the civil engineering works on the site and any enabling works, such as road widenings or port investments, that are required to build these sites. This is despite the large level of spending in turbines contracts (over €2.5 billion), which will however be carried out by companies based outside Ireland.

Assumptions were then made on the ability of companies across the study areas considered to perform these contracts. This was based on the relative levels of skills and specialisation required to carry out contracts. For onshore wind developments outside the Atlantic Region, it was assumed that a share of the contracts could be performed within the Atlantic Region depending on regional skills supply.

Table 24: Total Expenditure on Onshore Wind Contracts by Study Area, Rapid Built-Out Scenario

	Overall Spend	Ireland	Atlantic Region	Northwest Region	West Region	Midwest Region
Development	€260m	€220m	€70m	€10m	€30m	€30m
Turbine	€2,520m	€330m	€130m	€20m	€30m	€40m
Balance of Plant	€1,110m	€870m	€230m	€40m	€80m	€110m
Grid Connection	€340m	€190m	€90m	€20m	€30m	€40m
Total Capex		**€1,610m**	**€490m**	**€90m**	**€170m**	**€220m**
Operations and Maintenance	**€350m**	**€310m**	**€70m**	**€13m**	**€24m**	**€33m**

Based on these levels of spending, it was possible to estimate the direct employment supported over the period to 2037. This was done by allocating spending across each contract to the industrial sector of those businesses likely to be involved in its delivery. Spending by sector and area was then divided by sectoral Irish turnover per job ratios.

In this way, it was estimated that under the rapid built-out scenario, there will be a total 8,460 years of employment supported by the deployment of onshore wind. The two main opportunities for Irish businesses will be within civil engineering contracts for foundations and hard standings, and roads and onsite tracks. Across the Northwest, West and Midwest regions the main two supply chain opportunities will be around grid connection and substation construction and foundations and hardstandings.

In addition to the direct employment supported by contracts for the development, construction and operation of onshore wind farms, impacts across the supply chain (indirect impacts) and from the spending of those carrying out the contracts (induced impacts) were estimated.

By adding the direct, indirect and induced impacts supported by onshore wind, development, construction and operation, it was estimated that this activity could support a total:

- 1,700 years of employment in the Northwest Region;
- 3,290 years of employment in the West Region;
- 4,470 years of employment in the Midwest Region;
- 9,460 years of employment in the Atlantic Region; and
- 41,390 years of employment across the Republic of Ireland.

Table 25: Total Employment (Years of Employment) from Onshore Wind, Rapid Built-Out Scenario - Cumulative

	Northwest Region	West Region	Midwest Region	Atlantic Region	Republic of Ireland
Direct Employment (Years of Employment)	1,240	2,420	3,320	6,990	20,530
Indirect Employment (Years of Employment)	220	430	560	1,220	13,920
Induced Employment (Years of Employment)	230	440	590	1,250	6,930
Total Employment (Years of Employment)	**1,700**	**3,290**	**4,470**	**9,460**	**41,390**

Employment in the Atlantic Region (including from indirect and induced impacts) is highest in the period to 2028, peaking with 800 jobs. The majority of these jobs are associated with the development and construction of onshore wind projects in the area. After 2028 it is expected that the additional onshore wind capacity that is added to the grid will reduce significantly. This will result in a reduction of jobs supported by the industry, that may be partially mitigated by repowering activities not considered in the economic model. By 2037, it is expected that the onshore wind sector will support 400 jobs across the Atlantic region. The vast majority of this employment will be supported by the operations and maintenance of the 4.1 GW of onshore wind that is expected to be operational in the area.

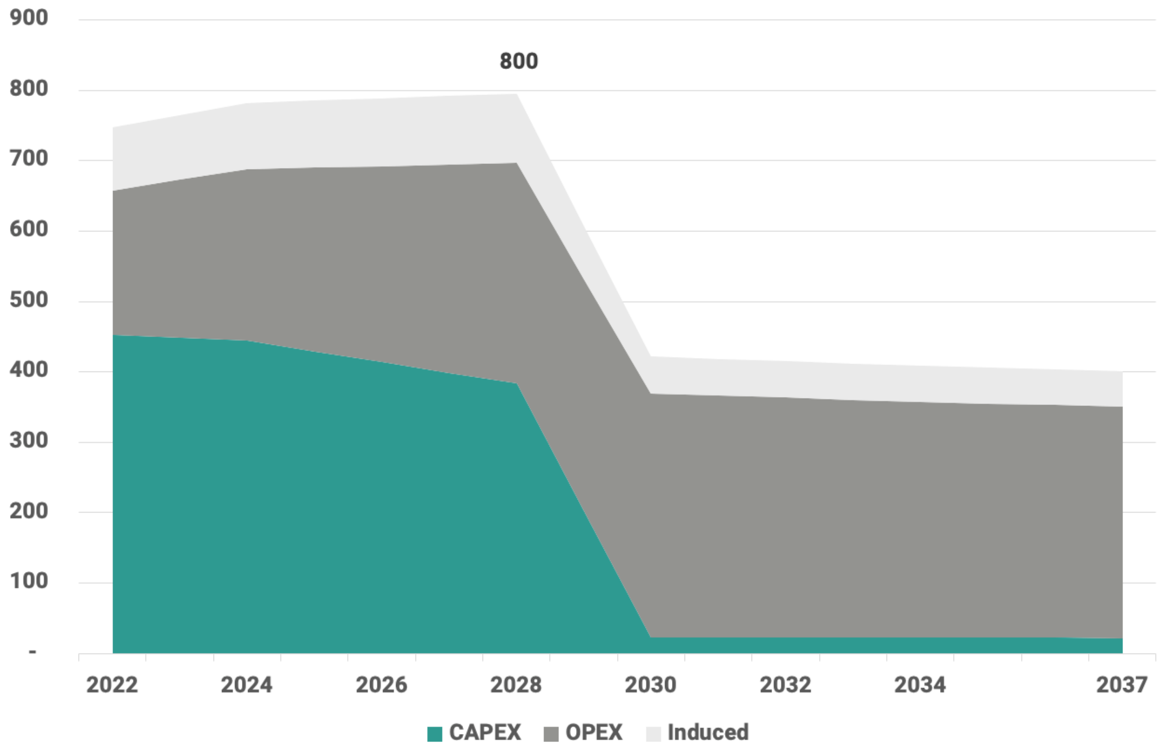


Figure 49: Atlantic Region Onshore Wind Employment over time – Rapid Build-Out

The long-term economic opportunities, under this scenario, for the onshore wind sector are therefore those associated with operational expenditure. In particular, the maintenance of turbines is expected to directly support 120 jobs across the Atlantic Region. These jobs will be different from those which are currently in demand in the civil engineering sector to support the construction of onshore wind projects.

To estimate the direct GVA supported by onshore wind, it was necessary to divide the turnover generated by each contract by a relevant industrial turnover per job ratio. Indirect and induced impacts were estimated by applying the relevant Type 1 and Type 2 Irish GVA multipliers.

Based on this, it was estimated that onshore wind activity could generate to 2037 a total:

- €110 million GVA in the Northwest Region;
- €200 million GVA in the West Region;
- €270 million GVA in the Midwest Region;
- €570 million GVA in the Atlantic Region; and
- €2.6 billion GVA across the Republic of Ireland.

Table 26: Cumulative GVA from Onshore Wind, Rapid Build-Out Scenario

	Northwest Region	West Region	Midwest Region	Atlantic Region	Republic of Ireland
Direct GVA (€ million)	€90m	€160m	€220m	€470m	€1,510m
Indirect GVA (€ million)	€10m	€20m	€30m	€60m	€790m
Induced GVA (€ million)	€10m	€10m	€20m	€40m	€260m
Total GVA (€ million)	**€110m**	**€200m**	**€270m**	**€570m**	**€2,560m**

The onshore wind development scenarios all anticipate a significant decline in new capacity coming online across Ireland. Therefore, this reduced demand for jobs in the sector is duplicated across Ireland, but at a larger scale. It is therefore unlikely that companies in the Atlantic Region will be able to significantly grow the demand for jobs by securing a greater share on the overall operations and maintenance market. To maintain, or grow, the economic impact of the onshore wind sector in the Atlantic Region there will need to be a much greater level of additional capacity added to the grid in the 2030s.

3.4.2 Economic Impact of Offshore Wind in the Atlantic Region

Under the rapid built-out scenario, it was estimated that by 2037 there would be around 13 GW of offshore wind energy operational across the Republic of Ireland. The level of activity across each study area was estimated based on the current planned developments across the Northwest, Midwest and West regions. Similarly, it was assumed that of the operational capacity installed by 2037, there would be 9 GW of fixed offshore wind and 4 GW of floating offshore wind across Ireland. In the Atlantic Region it is estimated that 90% of capacity will be floating. Accounting for the deployment of these different technologies was important since they are associated with different construction and development costs.

Based on BiGGAR Economics' experience working with both floating and fixed offshore wind developers, it was estimated that offshore wind contracts could result in a total expenditure of €48 billion. Irish businesses would be able to capture around 30% of this spending, equivalent to €15 billion. Spending across the Atlantic region could be almost €6 billion, as shown in the table below.

Table 27: Spending in Offshore Wind by Study Area

	Northwest Region	West Region	Midwest Region	Atlantic Region	Republic of Ireland
Project Development	€112m	€60m	€337m	€508m	€1,606m
Wind Turbines	€63m	€91m	€184m	€338m	€780m
Transmission System	€372m	€1,047m	€848m	€2,267m	€6,459m
Array Cabling	€52m	€161m	€64m	€277m	€642m
Floating Substructure	€497m	€190m	€1,231m	€1,917m	€3,651m
Foundations, monopile/jacket	€0m	€0m	€0m	€0m	€0m
Installation, Foundations	€3m	€16m	€8m	€27m	€279m
Mooring	€69m	€9m	€56m	€135m	€248m
Marine Works, incl. installation	€39m	€149m	€49m	€237m	€562m
Financing and Insurance	€10m	€24m	€24m	€58m	€471m
Total Capex	**€1,216m**	**€1,904m**	**€2,801m**	**€5,921m**	**€14,706m**
Operations and Maintenance	**€184m**	**€189m**	**€645m**	**€1,017m**	**€9,908m**

By applying the relevant sectoral turnover per GVA ratios, it was estimated that over the period to 2037, the development of the offshore wind sector could support a total 72,650 direct years of employment across Ireland. The activity associated with the sector will have implications for the demand for labour in the Atlantic Region.

Applying a similar methodology as for onshore wind contracts, it was possible to estimate the total employment supported by offshore wind contracts (direct, indirect and induced impacts). It was estimated that by 2037, the cumulative employment supported by the offshore wind sector under the 'Rapid' build-out scenario could be:

- 7,010 years of employment in the Northwest Region;
- 9,100 years of employment in the West Region;
- 18,750 years of employment in the Midwest Region;
- 34,860 years of employment in the Atlantic Region; and
- 160,690 years of employment across the Republic of Ireland.

Table 28: Total Employment (Years of Employment) from Offshore Wind, Rapid Build-Out Scenario

	Northwest Region	West Region	Midwest Region	Atlantic Region	Republic of Ireland
Direct Employment (Years of Employment)	4,980	6,610	13,360	24,960	72,650
Indirect Employment (Years of Employment)	880	1,040	2,360	4,280	56,560
Induced Employment (Years of Employment)	1,140	1,450	3,040	5,630	31,480
Total Employment (Years of Employment)	**7,010**	**9,100**	**18,750**	**34,860**	**160,690**

In a similar way, it was estimated that the total economic impact from the 'Rapid' roll-out scenario could be:

- €460 million GVA in the Northwest Region;
- €610 million GVA in the West Region;
- €1.2 billion GVA in the Midwest Region;
- €2.3 billion GVA in the Atlantic Region; and
- €13.1 billion GVA across the Republic of Ireland.

Table 29: Total GVA from Offshore Wind, Rapid Build-Out Scenario - Cumulative

	Northwest Region	West Region	Midwest Region	Atlantic Region	Republic of Ireland
Direct GVA (€ million)	€380 m	€500 m	€1,010 m	€1,900 m	€7,190 m
Indirect GVA (€ million)	€40 m	€70 m	€120 m	€230 m	€4,560 m
Induced GVA (€ million)	€40 m	€40 m	€100 m	€180 m	€1,310 m
Total GVA (€ million)	**€460 m**	**€610 m**	**€1,230 m**	**€2,300 m**	**€13,050 m**

Offshore wind related employment in the Atlantic Region (including from indirect and induced impacts) is highest in the period to 2028, peaking with around 4,000 jobs. This reflects the capacity added in the 'Rapid' scenario, which is expected to decrease from 1.3 GW in 2030 to 0.9 GW in the years after. This will result in a reduction of jobs supported by the industry, although in reality the development may be smoother over this period. By 2037, it is expected that the offshore wind sector will support 3,000 jobs across the Atlantic region. The vast majority of this employment will be supported by the development and construction of offshore wind projects, which is expected to continue well beyond 2037.

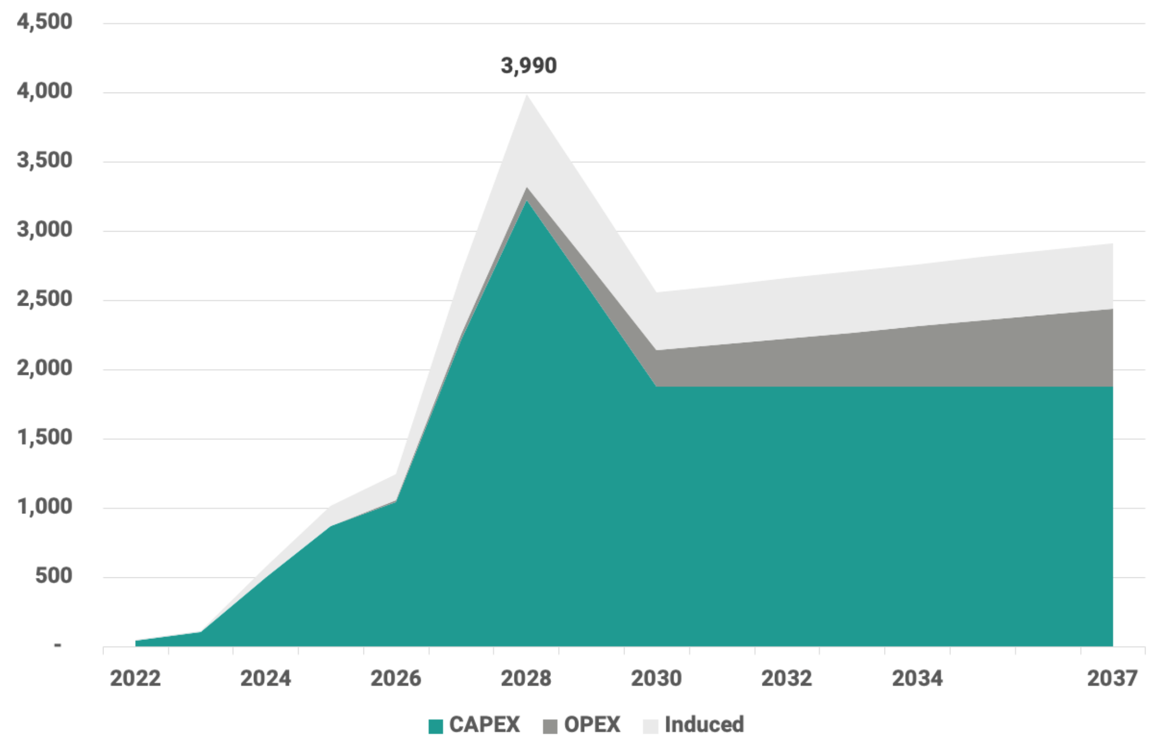


Figure 50: Atlantic Region Offshore Wind Employment over time – Rapid Build-Out

It should be noted that the ramp up of employment begins years in advance of the offshore wind capacity in the Atlantic Region coming online. The development of these projects is expected to take at least four years and the construction another two. Therefore, it is assumed that projects that come online in 2030 would have a demand for construction related employment from 2028, and for development related employment from 2024.

3.4.2.1 Scenario Analysis

The economic impact of the wind energy sector would vary significantly between scenarios.

In the 'Rapid' build out scenario, the level of development and construction activity is front loaded, which creates a significant peak in employment in the late 2020s. This level of employment reduces in the 2030s as the level of development and construction activity is scaled back.

In the 'Steady' build out scenario, there is an expectation that the level of development and construction activities will be greater in the 2030s than the late 2020s. As a result, the level of employment in this scenario grows more steadily. By 2037, it is expected that there would be around 2,100 jobs supported in the Atlantic Region in this scenario.

In the 'Aspirational' build out scenario, the significant level of activity that is seen in the 'Rapid' Scenario to 2030 continues throughout the decade. This includes a significant proportion of floating offshore wind, which utilises the ports and supply chain in the Atlantic Region. As greater capacity is added, the level of operations and maintenance activity also increases at a greater rate than in the other scenarios, which results in a higher rate of overall employment growth. In total, by 2037, it is estimated that there will be 5,400 jobs supported in the Atlantic Region from the development of offshore wind.

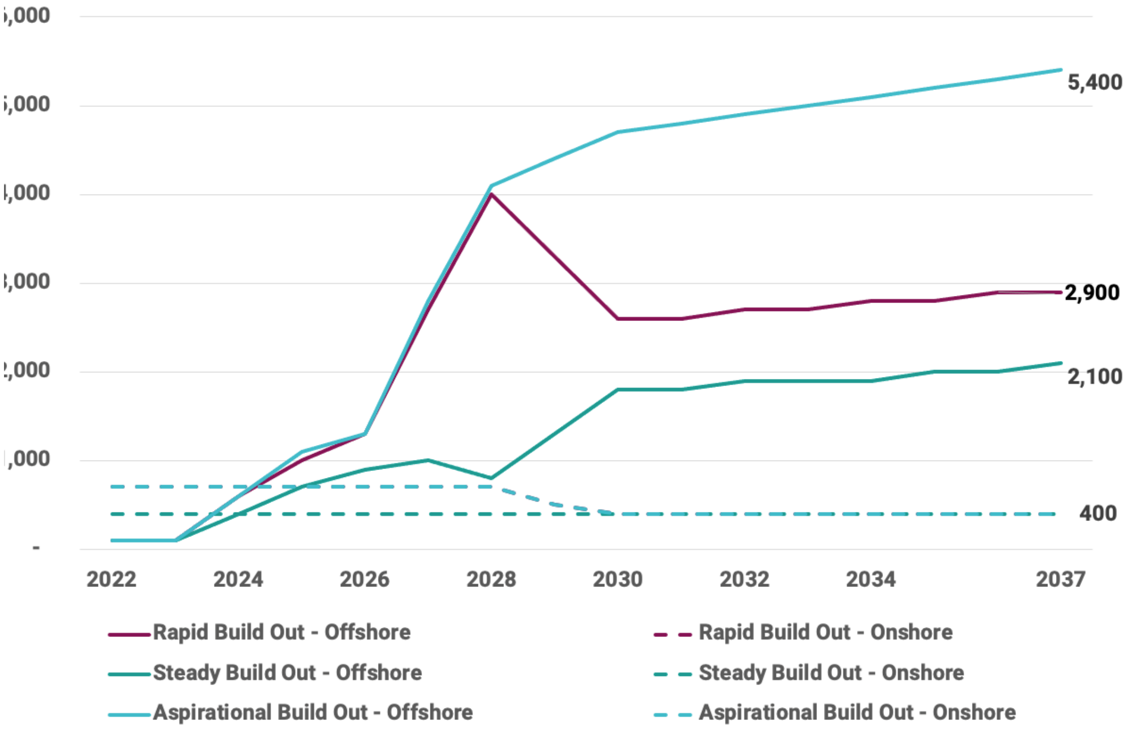


Figure 51: Jobs supported by the wind energy sector in the Atlantic Region

In all scenarios, the value and relative importance of the onshore wind sector declines. To meet the targets for 2030 set in each of the scenarios, the level of activity and employment in the offshore wind sector will increase significantly from 2024. Around this time, it is expected that the economic impact of the offshore sector will overtake that of the onshore wind sector in the Atlantic Region. The total employment in the onshore wind sector n 2037 in all scenarios is expected to be around 400 jobs. Therefore, by 2037 it is expected that there will be at least 5 offshore wind supported jobs for every 1 job supported by the onshore wind sector.

The differences in Gross Value Added in each sector are also driven by the offshore wind sector. As with employment, the level of economic activity in the region will grow throughout the 2030s. By 2037 it is expected that in the Atlantic Region the wind sector will annually generate:

- €170 million GVA in the ‘Steady’ build out scenario;
- €220 million GVA in the ‘Rapid’ build out scenario; and
- €400 million GVA in the ‘Aspirational’ build out scenario.

The cumulative impact of this difference highlights the scale of opportunity that could be reached in each scenario. In the ‘Aspirational’ scenario, the wind energy sector will generate over €4.2 billion GVA for the economy of the Atlantic region. This is over twice as much as could be created in the ‘Steady’ scenario. In each scenario, the economic value created by the offshore sector accounts for around 80% of the total.

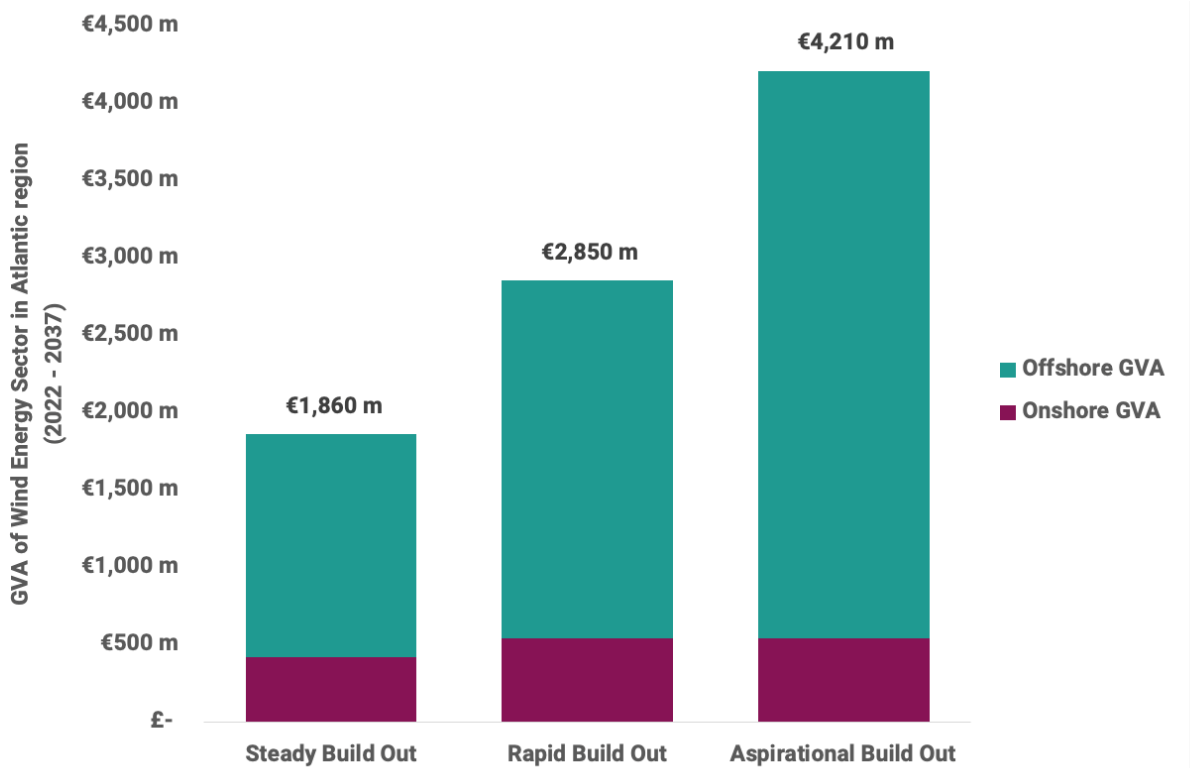


Figure 52: Cumulative GVA in Atlantic region from Wind Sector, by Scenario (2022 – 2037)

3.4.2.2 Industry Skills Demand

The skills that will be in most demand will vary between the technology and stage of each project. The potential skills and industry demand are discussed in this section, split between onshore and offshore wind.

The values discussed in this section reflect the ‘Rapid’ build out Scenario, however the activities and sectors which are most likely to be in demand in the Atlantic Coast are common across all scenarios.

3.4.2.2.1 Onshore Wind Skills Demand

The largest opportunity in the short term is linked with the development and construction of onshore wind projects. The largest demand in the Atlantic Region will be linked with civil engineering and electrical engineering contracts.

The grid connection and substation construction contracts are expected to generate a demand for 590 years of employment in the engineering sector in the Atlantic Region. This is followed by the Foundations and hardstandings, roads and on-site tracks. The skills required for these elements of the construction of an onshore wind farm are likely to be typical of the civil and electrical engineering sectors that are already active within the Atlantic Region.

The onshore wind contract activities that are expected to have the largest direct employment impacts in the Atlantic Region are shown in Figure 53.

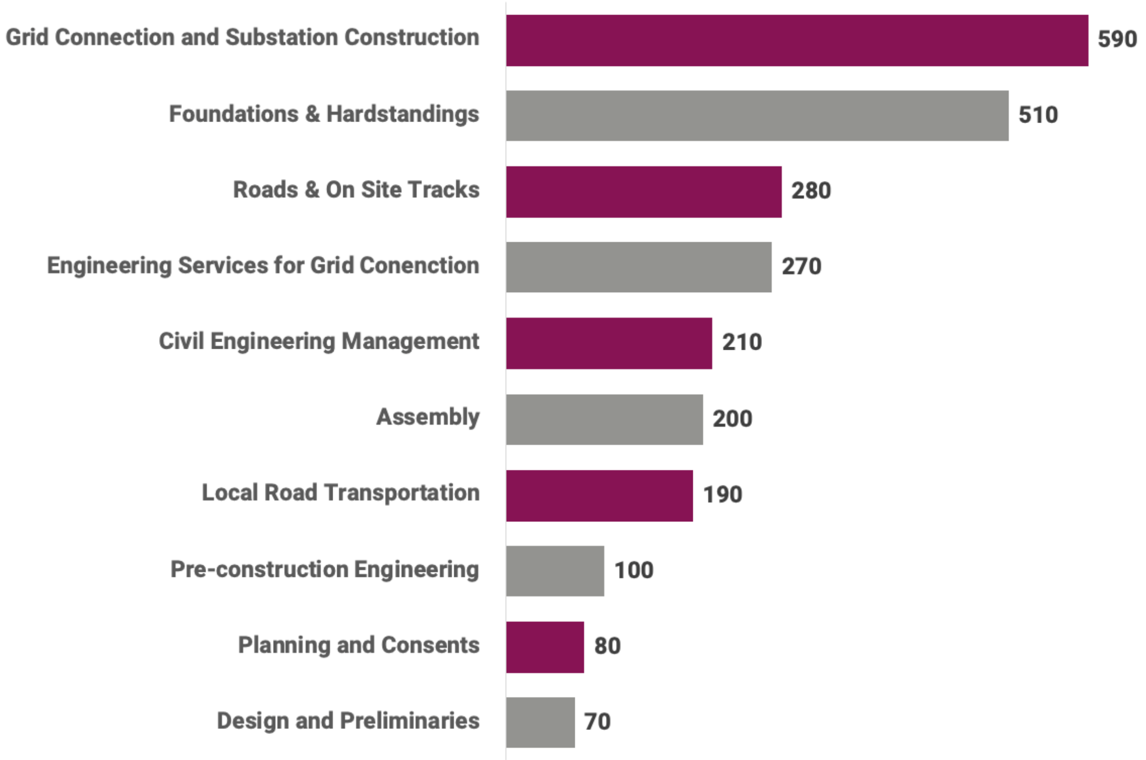


Figure 53: Years of Employment Demand in Atlantic Region - Onshore CAPEX

3.4.2.2.2 Offshore Wind Skills Demand

The largest opportunity in the medium to long term is linked with the development and construction of offshore wind projects. The largest demand in the Atlantic Region will be linked with civil engineering and logistics contracts.

The construction of floating turbine bases, particularly if concrete is used will be the most significant generator of employment demand within the Atlantic Region. This will include the civil engineering contracts associated with constructing the structures themselves and the works required to prepare the ports in the area to be able to facilitate this investment. This will include general and specialised civil and marine engineering skills to complete these contracts.

There will also be significant works required to construct specialised operations and maintenance facilities along the Atlantic Coast to service the growing offshore wind capacity.

The marine based opportunities will be linked with the provision of port and other services for the installation of the substation, turbines and the subsea cables.

The offshore wind contract activities that are expected to have the largest direct employment impacts in the Atlantic Region are shown in Figure 54.

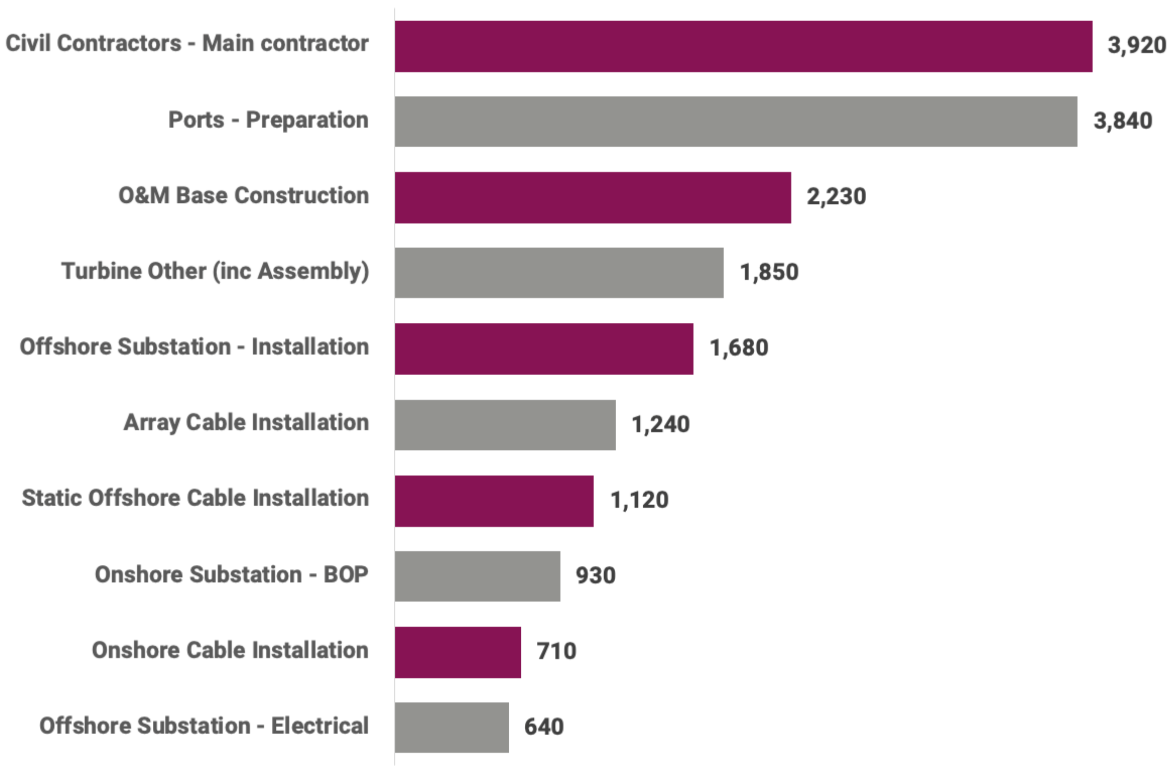


Figure 54: Years of Employment Demand in Atlantic Region - Offshore CAPEX

4 Creating a Supportive Ecosystem

4.1 Infrastructure Gap Analysis

4.1.1 Ports and Harbours

The gaps between the available port and harbour infrastructure and what is required to deliver different stages and activities within the development of wind energy projects in the Atlantic region are described in the following sections.

While markets like Norway, France and South Korea have significant port infrastructure that can be easily adapted, other markets such as Wales and Scotland must assess options for upgrading port facilities. The most developed has been the work to review port capability in Scotland, with different Government bodies supporting a number of relevant studies.

In 2020, Crown Estate Scotland commissioned Arup to look at port requirements for floating offshore wind platform marshalling. It modelled two scenarios – one at 10GW (delivery of existing projects plus current ScotWind round projects by 2030) and a more ambitious scenario of 35-45GW by 2040. This modelling highlighted that between 175 and 300 Ha of port space would be required, well above existing capacity of 50 Ha.

Subsequently, the capability of Scottish ports was reviewed in more detail to deliver this predicted 300 Ha of space [36]. While market conditions in Scotland and Ireland are different, this analysis highlights the significant space requirements needed for floating offshore wind delivery, and the opportunity this represents for ports in Ireland.

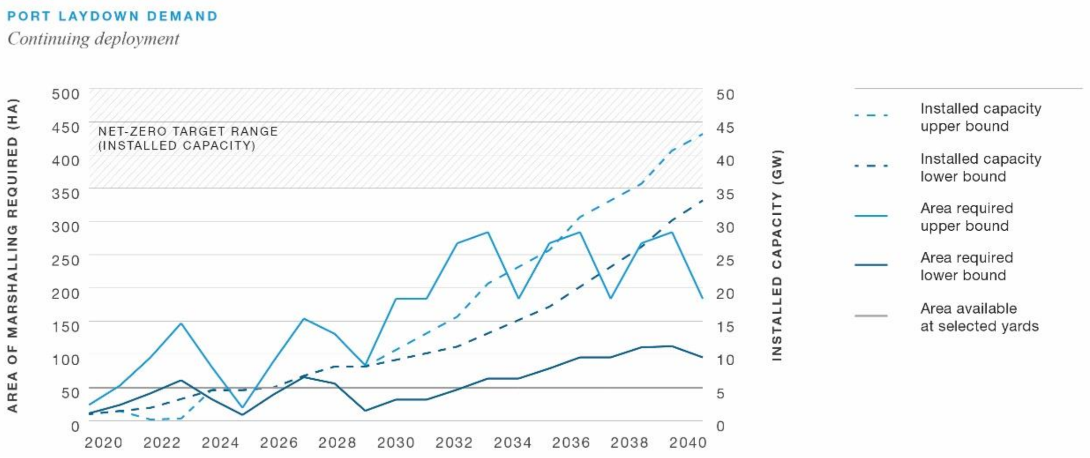


Figure 55: Projected port onshore area demand for foundation and turbine component marshalling, and cumulative installed capacity of offshore wind in Scotland

4.1.1.1 Onshore Wind Cargo

Wind turbine components are transported from OEM plants to a staging port before being installed offshore or on floating foundations. Due to the ever-increasing challenges associated with transport of increasingly long turbine blades, delivery of turbine components is typically by sea, and preferably to a location in close proximity to the project development location.

Shore side cranes will be required for offloading of equipment such as the blades. Roll on / roll off terminal may be required for the unloading of heavy components such as the nacelle and hubs to avoid large capacity cranes. Good road access is required within the port to the storage area for the components, and from the storage area to the assembly quayside from which load out will take place.

Figure 56: Nacelle offload options (Ro/Ro or Lo/Lo)

4.1.1.2 Quick Reaction O&M (offshore)

Once in operation wind farms will require ongoing O&M activities in order to maintain the assets, reduce production losses and ensure compliance with any environmental conditions that form conditions of the licence to operate.

This will require onshore support facilities for farm monitoring, and offshore operators who will be responsible for carrying out both planned and unplanned maintenance across the wind farm. Access alongside, and port berths will be required for various vessels that are used for surveys, equipment swaps, and crew access. Due to the metocean conditions in the Atlantic it is unlikely access to the platforms will be provided through traditional Crew Transfer Vessels (CTV). Service operation vessels (SOV) will provide a more appropriate weather window for personnel access to the platform, where on board maintenance can be performed by the technicians and therefore a suitable berth must be available for these vessels.

Quick Reaction Ports are intended to be the homeport for operations and maintenance vessels. The ports must be close enough to the wind farm to allow vessels to reach the site in less than two hours. These ports mostly offer services such as crew transfer, minor maintenance and repairs. Weather conditions can limit the O&M activities. The use of helicopters decreases the impact of harsh weather conditions, particularly high waves, and thus results in an increased available period for O&M and increased safety and security.

Figure 57: Service Operation Vessel (SOV) - Wind of Change owned by Orsted

4.1.1.3 Offshore Construction Support (fixed)

In fixed offshore wind, project developers look for ports that can simultaneously handle between 50-70% of all wind turbine components. Depending on construction strategy adopted by project developer, number of WTG required for a project, ability & speed of the manufacturer to deliver, spatial requirements for wind turbine components storage could be between 10 ha and 15 ha.

Typically, the construction support port will require laydown areas for wind turbine blades, nacelles, tower sections, monopiles with sufficient hard standing to allow transport of components from delivery quay to storage and from storage to assembly quay as required.

4.1.1.4 Offshore Construction Support (FOW)

Due to the complexity and specific requirements required for FOW platform mobilisation and turbine assembly, a separate construction support port may be advantageous if a suitable port is in close proximity to a proposed project. An offshore construction support port should have laydown space to accommodate storage of equipment including electrical array cables, anchors, chain, synthetic mooring lines and mooring jewellery such as buoys, clump weights and load reduction devices. Large staging areas should be accessible from both the point of delivery and the assembly quay.

4.1.1.5 FOW Assembly / Full O&M

Figure 58: Turbine Tower Assembly for FOW

The quay where the FOW assembly will take place has very specific requirements for water depth, quayside capacity, and access owing to the large structures to be assembled. The water depth must be suitable for the floating platform to be brought alongside the quay for 24-hour operations and ensure that the crane can reach for turbine assembly.

Turbine components are brought from a staging area to the immediate proximity of the load out quay using Self Propelled Modular Transporter (SPMT) in order for the platform mobilisation to be completed within a period of a few days. The assembly area must be fully accessible for all components. There must be enough space to allow the platform to be positioned alongside safely using multiple tugs. There must be road access for all components to be brought from the storage areas to where they will be picked up by the assembly team for the lift on.

The largest and most onerous lift will be the assembly of a turbine to the floating base. This will most likely be performed using a shore-based crane which will assemble the wind turbine tower in sections directly onto the floating platform. The crane requirements for these lifts are quite onerous and will require the top end of existing equipment, not readily available in Ireland.

Currently, full O&M for FOW imagines the disconnection of the platform from the site and return to port for any major maintenance such as a blade replacement. The ability of a port to handle major repairs with floaters towed in for work will be linked to their ability to support assembly activities (heavy lift, channel depth, depth at quayside, space & facilities for repair work and component storage).

4.1.1.6 FOW Platform Construction

The requirements of a FOW platform construction port are very onerous with few sites in the world suitable for serial platform production. FOW platforms can range in size up to almost 1 Ha, with structures weighing in the range of 5,000 – 20,000 tonnes depending on the platform type and construction (steel versus reinforced concrete). Typical loadout methodologies include construction in a dry-dock, use of a very large slipway and roll-on-float-off using a semisubmersible.

Only 4 – 5 dry-docks are available in Europe or the USA at the required scale, with a greater number available in China, South Korea and Japan. A roll-on-float-off operation may be carried out using a semi-submersible transport vessel however this imposes quay water depth requirements and may be costly for serial production.

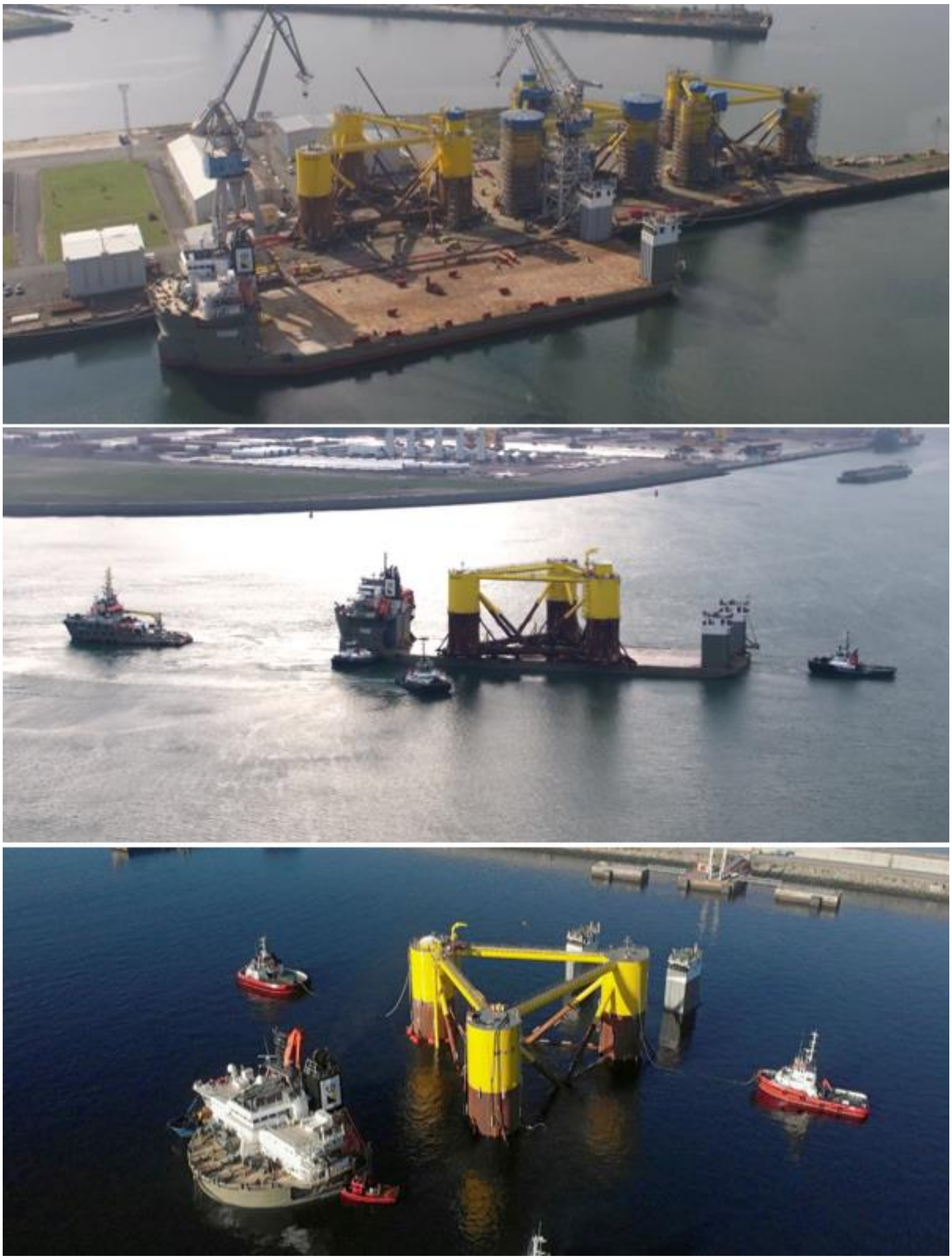


Figure 59: Platform loadout – Roll-on-float-off

4.1.1.7 Floating Foundation Wet-Storage

Due to the very large size of FOW platforms, storage within the port is impractical and it is necessary to manoeuvre the platform to wet storage at a seabed zone outside of the port to temporarily moor FOW platforms as relief storage during deployment and operational workflows until ready for Turbine Assembly & Load Out. A grid of pre-laid moorings is used for short term station keeping of platforms. The use of sheltered offshore areas which can function without the space restrictions of the Port allows the Port to effectively service a large volume throughput of FOW elements and avoid the capacity bottlenecks of the tighter harbour space. While the ability to service a constant throughput of platforms will also be critically constrained by the capacity and rate of craneage activities at quayside.

4.1.1.8 Port Suitability and Gap Analysis

The suitability assessment of the key ports in the Atlantic Region is presented in Table 30 and highlights the limited availability of suitable infrastructure, particularly for FOW platform construction and FOW turbine assembly, two areas with the largest potential for GVA in the region.

Table 30: Ports and Harbours high-level suitability assessment by construction phase or activity

Port	Onshore Wind Cargo	Offshore O&M Quick Reaction	Offshore (Fixed) Construction Support	Offshore (FOW) Construction Support	FOW Assembly / Full O&M	FOW Platform Construction	FOW Wet Storage
Killybegs	Green	Green	Green	Green	Green	Yellow	Yellow
Sligo	Yellow	Green	Red	Red	Red	Red	Red
Rossaveel	Green	Green	Green	Green	Red	Red	Green
Galway	Yellow	Green	Yellow	Yellow	Yellow	Red	Green
Kilronan	Red	Yellow	Red	Red	Red	Red	Yellow
Moneypoint	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green
Foynes	Green	Green	Green	Green	Yellow	Yellow	Green

Legend	Existing Capability / Planning Approved	Feasible subject to planning and finance	Major Challenges

The projected capability based on published plans is presented in Table 31.

Table 31: Ports and Harbours 2030+ projected high-level suitability assessment based on published plans

Port	Onshore Wind Cargo	Offshore O&M Quick Reaction	Offshore (Fixed) Construction Support	Offshore (FOW) Construction Support	FOW Assembly / Full O&M	FOW Platform Construction	FOW Wet Storage
Killybegs	Green	Green	Green	Green	Green	Green	Yellow
Sligo	Yellow	Green	Red	Red	Red	Red	Red
Rossaveel	Green	Green	Green	Green	Red	Red	Green
Galway	Green	Green	Green	Green	Green	Red	Green
Kilronan	Red	Yellow	Red	Red	Red	Red	Yellow
Moneypoint	Green	Green	Green	Green	Green	Green	Green
Foynes	Green	Green	Green	Green	Green	Green	Green

Legend	Projected Capability 2030+ (Green)	Feasible subject to planning and finance (Yellow)	Major Challenges (Red)

4.1.2 Grid Infrastructure

The Irish grid, as of March 2021, is shown in Figure 60. While 110kV connections are widespread around the country, areas of significant wind resource are left lacking without any connections of a higher capacity. Donegal, Leitrim and much of Mayo and Galway are without a larger capacity connection, limiting the wind generation possibilities in these areas, as well as limiting industry which requires significant energy resources. Donegal is particularly isolated from any significant grid connection, and the County Council has brought this to the attention of EirGrid during their 'Shaping Our Electricity Future' consultations. Increased grid capacity is essential for growth in the region, to enable the county to continue its renewable energy development growth, as well as increasing the prosperity and industrial feasibility of the county. The county council have also stated that the plans up to 2030 are not sufficient and will not provide the required capacity in the county, sub-regionally and nationally.

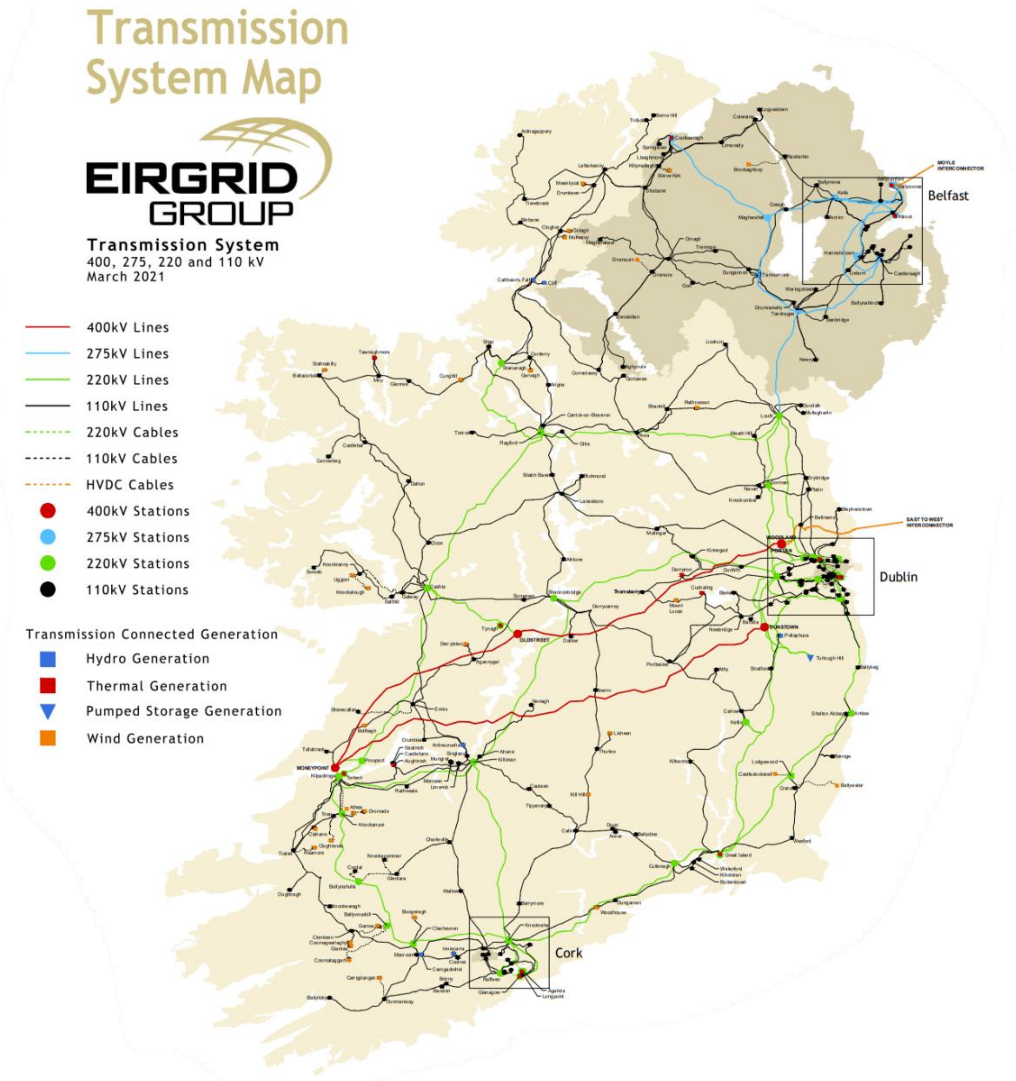


Figure 60: EirGrid Transmission Map (March 2021) [13]

As discussed previously, by 2030, the Irish government aims to have 8GW of onshore wind capacity, nearly double the current 4.3GW capacity. Current EirGrid plans up to 2030 target delivery of grid infrastructure to support 5.7GW of onshore wind, noted by Wind Energy Ireland in the stakeholder engagement, to be significantly below the required grid capacity to meet the Programme for Government and Climate Action Plan targets for onshore wind. An approximately 40% increase in capacity is required nationally to bring grid capacity up to match the 2030 onshore wind generation goals, with the grid capacity in the North-West and West particularly limited despite abundant wind resource. Overall, the entire Atlantic region does not have grid connections of sufficient capacity to support the growth out to 2030 and beyond.

Offshore development plans off the west coast have centred around the Clare coast, with numerous projects vying for the soon to be unused Moneypoint Coal Fired Power Plant 1,400MW grid connection.

Once this capacity is reached, without further infrastructural improvements, there is a real possibility that wind energy generation projects onshore and offshore on the west coast of Ireland will suffer. These projects require certainty and a route to market for the energy produced.

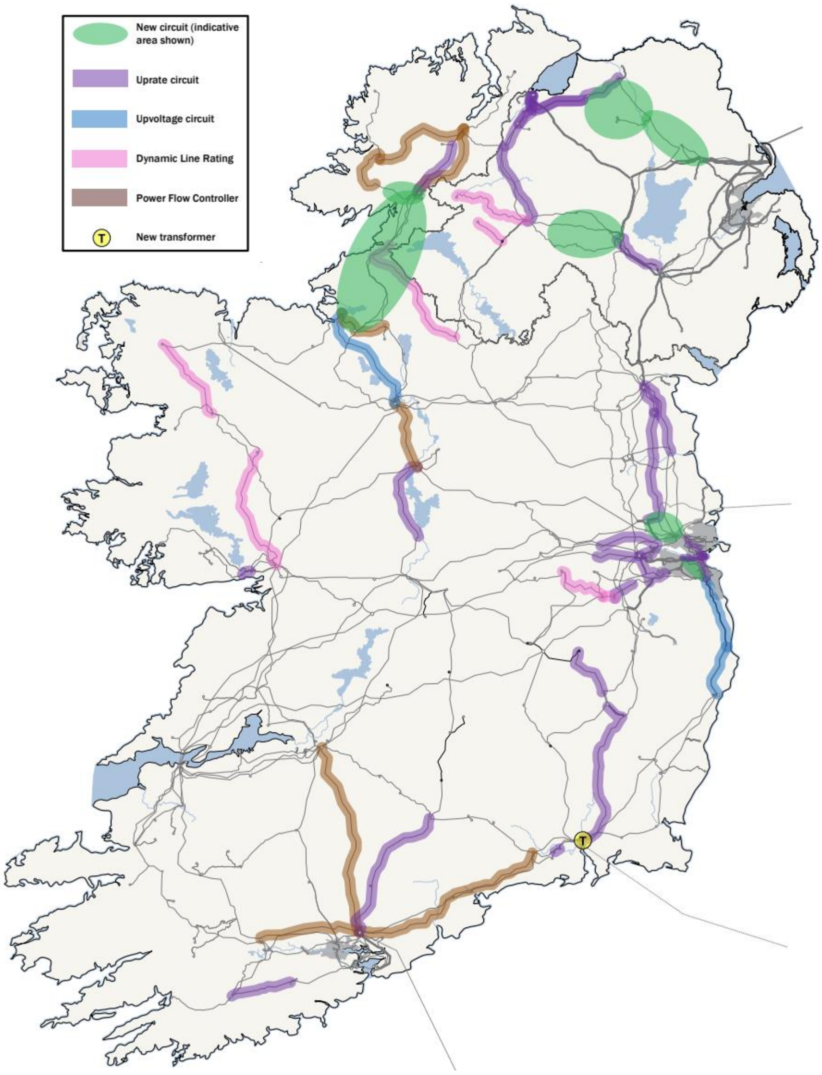


Figure 61: EirGrid Map of potential new electricity transmission network projects [6]

There is a lack of visibility on EirGrid's plans after 2030. This level of uncertainty makes development of onshore and offshore projects challenging, heightening the likelihood of delays or projects being abandoned entirely. The potential new electricity transmission network projects are shown in Figure 61. While there is growth here, it does not go far enough and needs to be expanded substantially to match the Programme for Government targets. Larger capacity grid connections are required in Donegal, Mayo, Galway and Clare to facilitate onshore and offshore wind projects and to maximise the opportunity for the region. Due to these grid constraints, alternative routes to market become more likely, particularly for large offshore projects.

4.1.3 Energy demand / use cases

Floating offshore wind in the Atlantic Region has the capacity to supply multiples of the current Irish electricity demand and therefore the long-term development of the industry cannot be based on a typical grid-connected solution alone. It should be noted that all scenarios considered in this study will require grid reinforcement along the west coast given existing grid capacity constraints, the 'Aspirational' scenario requires both major grid reinforcement as well as other uses for electricity produced by offshore wind.

For the longer-term ambitions, alternative routes to market are required for floating offshore wind and the potential for the manufacture and deployment of green hydrogen is seen as an exciting opportunity. At a domestic level, hydrogen is seen as a key enabler to decarbonise the Irish economy. In the short term, heavy vehicles such as trucks and buses will be powered by hydrogen rather than batteries and in the medium term, hydrogen is being investigated as an alternative to natural gas when it comes to heat and power.

In parallel, there is a growing demand for green hydrogen and hydrogen derivatives such as ammonia in mainland Europe. Development of this supply chain should commence now rather than waiting for other locations to capture the first international opportunities. Germany has already been vocal about its interest in utilising green hydrogen, generated by Irish wind energy, to decarbonise its heavy industry, for example with the establishment of the German-Irish Hydrogen Council.

Transport issues associated with hydrogen can be overcome by further converting the chemical into ammonia, simplifying transportation and reducing dangers. Ammonia itself could be a fuel source for powering vehicles and industry, however, this route is less developed than hydrogen and the fuel cells associated. Ammonia is of particular interest to the fishing fleet on the west coast of Ireland, particularly Killybegs, as current vessels could be modified to burn ammonia in place of heavy bunker fuels.

Figure 62: Proposed SuperNode interconnected renewable energy super grid [17]

The final route to market currently under consideration is to release potential capacity through the construction of a European grid to allow direct export to areas of high power demand through increased use of interconnectors however this is likely to become challenging beyond a low number of gigawatts. This could also be achieved using a super conducting connection system, allowing the transport of renewable energy across large distances and enabling a super-grid connection across Europe, with Irish wind energy powering parts of the continent thousands of kilometres away. When wind resources are low, electricity can flow back to Ireland from Spanish solar plants or wind farms in different areas of the continent experiencing different conditions. While this technology would be transformational for renewable energy and allow the wind resources in the Atlantic Region to be fully captured, it is still in an early development phase and is unlikely to be commercially viable until beyond 2030.

A number of technically viable use cases exist for power generation above the demand of the Irish network, but a significant gap remains to establish the economic viability and relative merits of the proposed solutions.

4.1.4 Building and office space availability

The offshore wind market will require significant onshore space for the long-term operation of farms. A typical Operations and Maintenance centre for an offshore farm will require office and welfare space for 30-80 people and warehousing for large scale components. This will result in significant centres of skilled personnel and can present an opportunity to co-locate facilities within supply chain and regional clusters to best maximise the economic potential. The early identification of locations with potential to support O&M activities in addition to construction port activities can guide location of supply chain development work. Port access, distance to the farm, and suitability of onshore facilities will be key, however through a combination of repurposing existing buildings, construction of new facilities or the use of temporary site offices it is not expected that buildings and office space will be a significant limiting factor for the ports identified in this study.

4.1.5 Civil Engineering

The existing port infrastructure on the Irish west coast is inadequate for the support of construction and operation of offshore wind farms. The significant upgrades required, such as being developed at Rossaveel with a new deep-water quay, will require extensive deployment of the marine civil engineering supply chain. These skills may be sourced from the existing Irish supply chain, with significant growth potential as ports expand to meet industry demand.

4.1.6 Manufacturing

The opportunities for local fabrication of major components for FOW will be limited to those components which can be competitively delivered through existing or readily developed capacity, and where barriers to entry into the global market for the component are challenging. For example, the floating platform can be made from steel or concrete, or a combination of both, and may be competitively fabricated through growth in local supply chain based on existing capabilities. The production of WTG turbines requires a significant and dedicated specialisation in supply chain and is less likely to be a candidate for local manufacturing.

For example, a requirement of the recent Scotwind leasing round in Scotland included a local supply ambition, with direct engagement with Scottish suppliers encouraged and resulting in approximately half of the proposed projects to commit to concrete platform fabrication to best align with local capabilities.

FOW Component	Manufacturing type	Local Delivery Requirements
Platform	Steel fabrication	Requires construction of fabrication facilities, and labour upskilling, greater than capacity of Irish market currently. The investment barrier to entry likely requires significant confirmed offshore project pipeline (>5GW) as a market pull.
Platform	Concrete fabrication	Requires leveraging and growth of existing Irish supply chain. Creation of bathing yards in proximity to port infrastructure. Investment by supply chain likely requires confirmed project pipeline >1GW.
WTG	Fabrication and assembly of completed nacelle	Significant confirmed project pipeline (expected >10GW) to be required to justify supply chain investment. The existing global supply chain allows efficient delivery and shipping of turbines from legacy OEM.
Blades	Moulding and assembly	Existing global supply chain is significant and has been developed to service onshore and offshore wind major market. The development of a blade factory dedicated to local market requires significant confirmed project pipeline (>5GW).
Anchor: Drag embedment	Steel casting and fabrication	Existing global suppliers may struggle with capacity as demand grows. Fabrication requires investment by supply chain into facilities and labour upskilling. The technical suitability of Irish FOW sites for drag embedment anchor types is not confirmed for all project locations, and their resulting obtainable market size may limit opportunities to justify investment for local supply.
Anchor: alternative (piled, gravity etc)	Steel fabrication, robotics	Alternatives to standard drag embedment anchors may vary significantly and include options such as drilled and grouted piles. As new technologies develop, the potential for local fabrication is greater as there is no existing global supply chain to compete with.
Mooring line: synthetic	Rope fabrication	The existing Irish supply chain (eg Swann Net Gundry) includes capabilities within synthetic line manufacture, albeit with focus currently not on FOW. There is a potential to support supply chain in accessing the market.
Mooring line: chain	Chain casting	The existing Irish supply chain cannot deliver mooring chain for the market. Chain at the scale required is manufactured globally in regions of low labour and material cost and is unlikely to be competitive if supply developed locally. In addition, mooring system are focussed on reducing chain requirements and maximising synthetic line integration.
Tower	Steel fabrication	The existing Irish supply chain cannot deliver towers at the scale required. Competition with existing steel fabricators in areas of low labour and material cost may be challenging. Significant project pipeline required to underpin investment.

4.1.7 Education and Training

The Atlantic Region is fortunate to have numerous third level institutions, training centres, apprenticeship pathways and resource centres. Currently, there are courses available to support the wind energy industry, and current training can be scaled up rapidly to provide a larger workforce. However, clear signals are required to set this in motion and ensure that training and upskilling in the wind industry will result in significant employment.

While a majority of training and education required is already available in the Atlantic Region through a combination of state-bodies, ETBs and private providers, there are some areas not covered. With the right indications of growth and development in the area, these can be provided for in the region, keeping employment within the region. Without this, employment will leak outside the region, along with the associated societal and financial benefits. Examples of this are the lack of energy systems engineering in the region or the complete lack of naval architecture or marine engineering courses on the island of Ireland. These major skills gaps are areas which can be filled, given the required notice and indications, and without this development represent a potential significant loss to the region.

It is clear from the discussions with stakeholders in the course of this study that there is a close relationship between education bodies and local industry, and that the third level institutions in the Atlantic Region are quite agile, and can deliver new courses, modules, and apprenticeships relatively quickly in response to industry need. The converse is also true, that courses will not be delivered without clarity on the prospects for students or apprentices at the end of their formation, and clear signals are required before dedicated offshore wind courses will be offered.

One of the suggestions from the stakeholder engagement was that an industry stakeholder group is needed to identify the skills requirements and to plan educational programmes including degrees and apprenticeships. This has already been developed in the Mid-West Region through the Mid-West Renewable Energy Research and Education Cluster, a group primarily comprised of the education and training providers and public sector bodies working with regional industry stakeholders to identify skills needs. It may offer a good template to replicate or extend to the wider Atlantic Region to capture emerging skills requirements. Replication may lead to duplication of effort, and it should be remembered that the regional subdivisions do not exist offshore or for a mobile workforce.

4.2 Industry Supports globally

The offshore wind industry, and especially the FOW industry, is a target for multiple countries as a potential future source of jobs and revenue, and the development of their supply chains. To support the early development of supply chains to have the capacity to deliver products and services into FOW and ensure economic benefit to the regions, significant support is being provided in key markets by government and local authorities to stimulate capacity. Support schemes include the development of proactive industry clusters connected to government enterprise departments, grant schemes for upskilling and new equipment, development of networks around significant port infrastructure in particular, and the re-orientation of industrial growth from legacy industries with compatible skill profiles.

4.2.1 Clusters

The use of industrial clusters, co-ordinated by both industry and public authorities, can be an effective way of leveraging combined impact and ensuring a clear interface between demand and supply. An effective cluster will enable each member to maximise their economic potential within the wind industry. Examples of relevant and active clusters and cluster initiatives are:

- Deepwind FOW Cluster

DeepWind is the shorthand for the North of Scotland Onshore Wind Cluster which started as a hub and spoke cluster based around the Moray Firth and the North of Scotland but has now expanded to include the whole of Scotland. Companies in Scotland, or who may in future establish operations in Scotland, are welcome. Its main aim is to develop a supply chain cluster around the offshore wind projects in the North of Scotland with a focus on deep water offshore wind including floating wind. Companies in the cluster are involved developing new products and services through innovation, increased access to training and upskilling of their workforce, advanced manufacturing techniques, through collaboration with academia and with other companies in the cluster. The cluster acts as a conduit for offshore wind dedicated public funding.

- Norwegian Offshore Wind Cluster

The focus of this cluster is to establish the Norwegian supply chain within the FOW market globally. A pro-active approach to establishing trade missions, bringing Norwegian suppliers directly to potential customers globally, supports the growth of the member companies. Members with significant experience in the oil & gas industry are supported to pivot into FOW and continue service and product offerings. They follow a co-ordinated approach with the network of Norwegian state ambassadorships globally.

- East of England Offshore Wind Cluster

This cluster bring together multiple suppliers across Norfolk and Suffolk to collectively advocate for the region and the investment and development funding required to build the offshore industry. A number of specialist task forces support specific focus areas. The cluster allows leveraging of the significant offshore pipeline on the east coast to underpin investment decisions.

- Celtic Sea Supply Chain Cluster

The cluster was established in support of the UK governments Offshore Wind Sector Deal. The cluster brings together numerous ports with the capability to support the offshore sector. Additional supports through the Offshore Wind Growth Partnership provide efficiently leveraged and highly targeted supply chain investments within the offshore wind sector, including and benefitting from significant expertise with industry bodies as delivery partners.

4.2.2 Transferable / complementary Skills

Numerous industries in the Atlantic region already provide complementary skills which may be efficiently transferred across to the wind industry. Those employed in the fishing industry provide extensive offshore experience, with these abilities centred around large fishing ports such as Killybegs and Rossaveel. The commercial fishing season very short, and the remainder of the year these skilled workers may be well suited to supporting O&M activities or other vessel-based activities required for fixed and floating offshore wind. Fishing support industries, such as net manufacturing in Killybegs, could be transferred to synthetic rope manufacture for FOW mooring systems.

Other areas of transferable skills include those employed in high precision manufacturing in the pharmaceutical industry in Sligo and Letterkenny. High precision manufacturing and control is also required for wind turbine components, particularly smaller parts within the nacelle that make up the gearbox or transformer. Investment and engagement with turbine manufactures would be required, but the highly qualified employees and high quality third level educational institutes would be an appealing option. Civil engineers working in the region would be suited to supporting onshore developments for foundation design and analysis, as well as port or road improvements needed to support offshore wind developments. With more visibility on project development and certainty, businesses and councils can make early moves to develop these areas which already have a competent workforce to transfer into.

A recent conference at the NMCI entitled “Our Offshore Renewable Energy Opportunity - Is Ireland Ready? - (Maritime Qualifications and Certification)” covered important topics relating to certification and qualification requirements across existing marine industries in Ireland and the future demands of the offshore wind industry. The significant opportunities for seafarers in transferring to the new industry were highlighted.

4.2.3 Local Content Clauses

In the UK, local content targets have been included in strategies and tenders by both the Westminster and devolved administrations.

The UK Offshore Sector Deal has included a target of 60% of UK content of offshore wind projects by 2030. This is a target for the sector as a whole and as part of the Supply Chain Plans (SCPs) submitted in support of the Contracts for Difference auctions, developers are requested to outline how they will maximise UK content. There are potential penalties for developers if they do not meet the commitment provided in the SCP. Recently, the EU has challenged this approach through the World Trade Organisation.

The Scottish Government has also introduced local content considerations into its offshore wind auctions through the Supply Chain Development Statements (SCDS) for the ScotWind Leasing Round. This also requested developers to outline the level of spending, by category, for Scotland, the rest of the UK, the EU and the rest of the world. Developers were also asked to outline what they felt the maximum expenditure potential could be if there was sufficient collaboration and supply chain development. This process was not officially scored as part of the leasing round but developers could also face penalties if they do not meet the expenditure levels outlined in their Commitments. Each successful developer completed this exercise and on average they committed to spending £800 million in Scotland per GW during the development and construction of these projects.

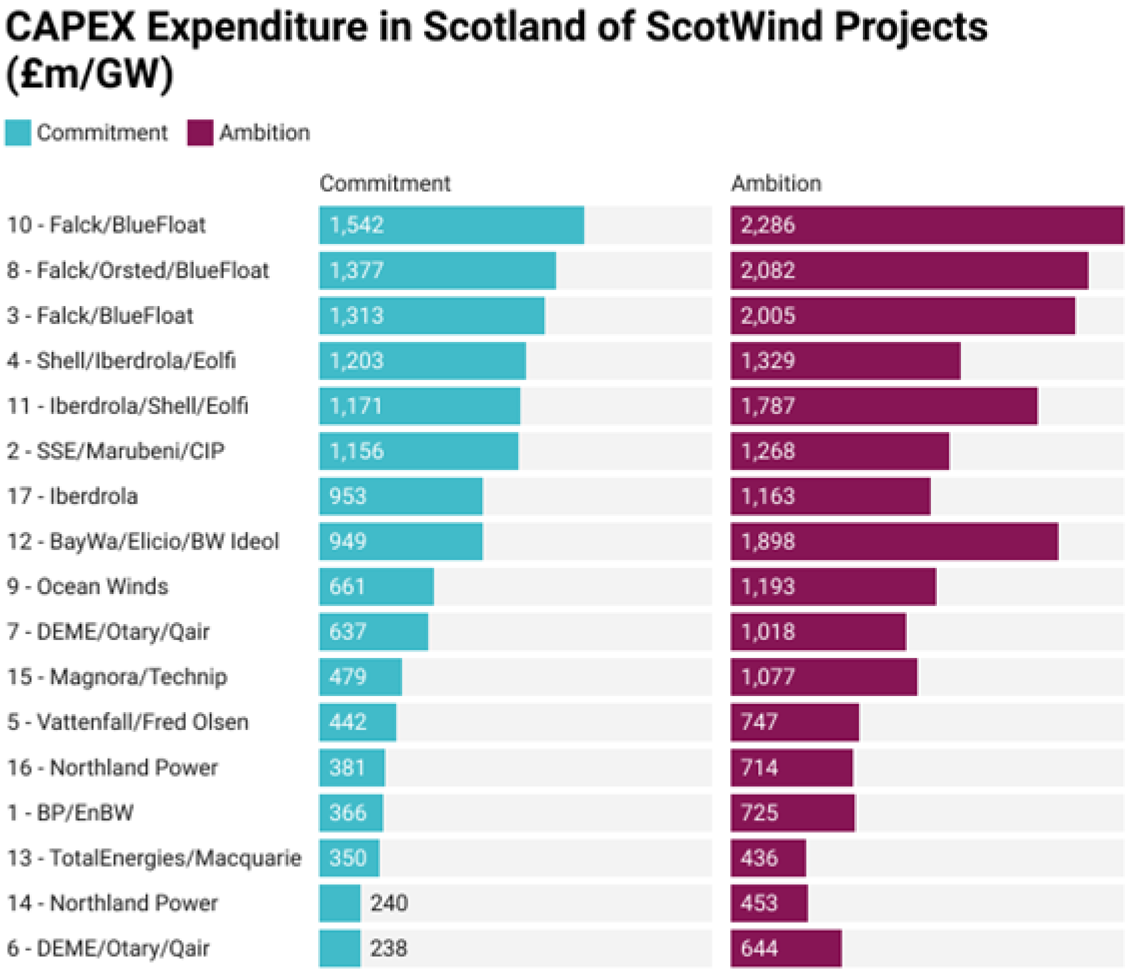


Figure 63: CAPEX expenditure in Scotland of Scotwind projects

Although this process was not scored it did force the developers to consider the potential for the development and use of a domestic supply chain. Developers engaged early with ports, and other Tier 1 suppliers and encouraged non-domestic Tier 1 contractors to consider how they would make best use of local supply chains.

4.2.4 Planning consideration and tourism impact

The relationship between the development of onshore wind and tourism has been the subject of numerous studies and debates across the world. In Scotland, this has included a review by the Scottish Parliament Economy, Energy and Tourism Committee in 2012 on the achievability of the Scottish Government's renewable energy targets. The Scottish Government had announced a target of achieving the equivalent of 100% of Scotland's gross annual electricity consumption by 2020. As part of this the Committee took evidence from tourism bodies, academics and economists and explored the issue of tourism and wind energy development. It concluded that the two sectors could develop simultaneously, and although the potential impacts of individual projects should be considered the planning assumption should not be that there were any detrimental impacts on the tourism sector from the development of wind energy. It concluded that:

> *"While some strongly held localised and anecdotal opinion exists, the Committee has seen no empirical evidence which demonstrates that the tourism industry in Scotland will be adversely affected by the wider deployment of renewable energy projects, particularly onshore and offshore wind.*
>
> *Whilst care always needs to be taken in terms of the planning process and decisions on the siting of individual projects in areas popular with tourists and in our rural and wild land areas, no one has provided the Committee with evidence, as opposed to opinion, that tourism is being negatively affected by the development of renewable projects."*

After Scotland (almost) reached its renewable energy targets in 2020, empirical evidence supported the conclusions of the Committee reached in 2012. In September 2021, BiGGAR Economics published new research [37] on windfarms and tourism in Scotland. The 2021 research was based on a similar methodology to the previous research and sought to provide more up to date analysis. The study was undertaken to understand the relationship between the development of onshore wind energy and the tourism sector in Scotland.

The study notes that since 2009, the onshore wind sector has expanded considerably in Scotland, from an installed capacity of 1,082 MW in 2009 to an installed capacity of 3,772 MW in 2019, with capacity increasing by 1159 MW between 2015 and 2019. Employment in tourism in Scotland also grew during these periods, by 19.7% between 2009 and 2019, including by 3.0% between 2015 and 2019.

The 2021 research identified 16 windfarms with a capacity of at least 10MW that became operational between 2015 and 2019. Analysis of trends in tourism employment in the locality of these windfarms (study areas were based on a 15km radius) found that 11 of the 16 areas had experienced more growth in tourism employment than for Scotland as a whole. For 13 of the 16 windfarms, trends in tourism employment in the locality had outperformed the local authority area in which they were based.

The research also re-examined the 28 windfarms considered in the 2017 report, again finding that the localities in which they were based had outperformed Scotland and their local authority areas in the majority of cases. Moreover, the analysis found that in the six areas which had underperformed their local authority areas in the 2017 study, all had done better than their local authorities in the 2015 to 2019 period.

However, it is likely that any impact of onshore wind energy on tourism would be most significant at the local level. Consequently, the study considered the evidence at not just the national level, but at the local authority level and in the immediate vicinity of operational wind farms.

The research has analysed trends in tourism employment in the localities of 44 windfarms developed in recent years, providing a substantial evidence base. The study found no relationship between tourism employment and windfarm development, at the level of the Scottish economy, across local authority areas nor in the locality of windfarm sites.

While the impact of onshore wind energy on tourism has not been quantified in the same way in Ireland, international evidence suggests that there is no significant negative impact.

4.2.5 Training and Upskilling

Ireland has a labour shortage in the area of offshore wind, and there are significant opportunities for growth in jobs and industry as demand develops. The challenge to provide the most effective and targeted training and refinement of offering is faced by all markets.

A good example of a targeted approach is the Offshore Wind Growth Partnership in the UK. This is a long-term business transformation programme that was established as part of the UK Offshore Wind Sector Deal promoting closer collaboration across the supply chain, implement structured productivity improvement programmes and facilitate shared growth opportunities between developers and the supply chain.

Delivery focusses on direct support to supply chain companies through a combination of strategic capability assessments, advisory services and grant funding. The Partnership is guided by a dedicated industry body with detailed supply chain understanding as the specialist delivery partner. The Partnership facilitates close collaboration between supply chain and potential future customers, which is key to establishing appropriate offerings and building in market demands to supply chain investments. Building new capacity within the existing supply is directly supported through grants and combined with market access programmes.

5 Discussion

5.1 Ambition – the Winds of Change

It is clear from all stakeholders that there is strong support and ambition in tackling climate change and that wind energy in the Atlantic Region can play a significant part. Wind energy is seen as an opportunity to deliver on climate goals, to deliver jobs, economic development, infrastructure, innovation and Foreign Direct Investment in the Atlantic Region.

The Climate Action Plan first set a commitment of 70% of electricity originating from renewable sources by 2030, later increased to 80% in 2021. This target requires significant infrastructure, including reinforcement of the grid with greater interconnection. The ambition stated in the Programme for Government is even more ambitious, identifying the potential for 30GW of floating offshore wind in the Atlantic alone. Whereas 2GW of onshore wind was built in the Atlantic Region in 20 years, 30GW of floating offshore wind could be built in 30 years. Local stakeholders recognise that FOW is an unprecedented opportunity for the Atlantic Region.

FOW is accelerating rapidly with cost reductions anticipated to achieve parity with fixed offshore wind and forecasts from Wind Europe and The Carbon Trust anticipate between 7 and 13GW respectively will be deployed globally by 2030. Given the depth of water off the west coast, FOW will be the technology of choice for most developers. It is a game changer for Ireland and in particular the Atlantic Region where it will unlock access to the majority of our national offshore resource.

FOW technology improvements have enabled the rapid maturing of the floating wind market. FOW has quickly progressed from demonstration to early-stage commercial projects and has already demonstrated confidence in technology concepts and scaled up to larger turbines along with significant cost reductions. It is no longer an emerging technology with countries such as UK, France, US (California), South Korea and Norway pushing ahead with leasing and tender rounds for commercial scale projects.

Delivering capacity targets irrespective of content and delivering targets with local impact have very different requirements. The pre-commercial Kincardine project developed in Scotland provides a warning of what may happen without a co-ordinated strategy to ensure infrastructure upgrades, skills pathways and project approvals share a common timeline. For the Kincardine project, the floating platforms were built in Spain, the turbine was built in Denmark, they were assembled in the Netherlands, and installed by a Dutch company. Similarly on the East Coast of Ireland due to a lack of capacity or capability in Irish ports, construction activities may be delivered from ports in the UK and Europe. If all of the major cost centres are delivered overseas the local impact is low.

However, in the recent ScotWind seabed auction round, 60% of successful projects used floating technology, and here Scotland outlines why FOW is an unprecedented opportunity – Floating projects identified 2 times more local content than Fixed offshore wind. The big differentiator is the floating platform which can account for one third of the CAPEX of a floating wind project. If built locally platform construction can deliver many thousands of jobs.

Ireland has clear targets to 2030 and ambitious goals to 2050. A national strategy is now needed to support their delivery. Stakeholders in both the public sector, through the county councils, and the private sector have a clear ambition to develop the wind industry locally and deliver the infrastructure and supports required to ensure that local communities benefit from the winds of change.

5.2 Clear Signals & Policy Cliffs

Clear signals from government are essential to deliver the full potential scale of the wind energy industry in Ireland and the Atlantic Region. This is plainly evidenced by the stakeholder engagement at all levels of the supply chain. Signals need to identify clearly, not just the pathway to Ireland's 2030 climate goals but to go further, to establish timeframes and intermediate targets along the route to 2050 and Net Zero.

Clear, definitive signals on a pipeline of wind energy activity in the Atlantic Region will enable port authorities to finance and commence upgrade works, project developers to develop construction schedules, educational bodies and training providers to tailor courses and ramp up activity to support industry needs and for strategy around the route to market to be implemented.

In the Atlantic Region clarity is needed on targets for installed capacity of wind post-2030.

- Is there appetite to exceed 8GW of onshore wind nationally or will the onshore industry peak this decade?
- Will the delivery of floating wind be supported through ring-fenced MAC and ORESS processes?

A number of stakeholders interviewed in the course of this study noted that public support for onshore wind is not guaranteed, that there is a possibility that a saturation point will be reached whereby further onshore wind development becomes increasingly challenging. It should be recognised that if this materialises the economic activity associated with onshore wind will peak this decade and reduce thereafter. The lack of clarity signalled beyond 2030 presents a challenging investment environment to local contractors that could invest in dedicated onshore wind equipment such as blade transportation, or turbine mobilisation equipment if the long-term market conditions were more favourable. Clear signals facilitate increased local economic impact.

One of the key challenges facing offshore wind developers is the lack of clarity at the transition between ORESS Phase 1, Phase 2 and Enduring Regime. The Offshore Wind Phase 2 Consultation document stresses that viable projects for Phase 2 must reach commercial delivery by 2030 in advance of the enduring regime [38]. Projects which cannot deliver by this date will have their Marine Areas Consent (MAC) rescinded. This cliff edge poses a significant risk for all projects, as timelines are immensely tight and investor confidence is hugely reduced by the risk of losing MAC. Some of the projects will be the biggest infrastructure projects ever commissioned in the State and they are being developed in an untested and evolving policy landscape.

In order to maximise local economic impact FOW projects will require a phased construction approach to accommodate the need to build supporting supply chain companies and infrastructure (in particular port and storage facilities) in tandem with the projects. Supply chains and training streams will only develop when it is clearly signalled that FOW is happening in the Atlantic Region.

5.3 Route to Market

Route to market was identified by most stakeholders as a key barrier to successful delivery of wind energy in the Atlantic Region. The challenge associated with delivering certainty on a route to market for Atlantic Region wind projects is multi-faceted.

The Eirgrid Shaping our Electricity Future document provides for only modest roll out of renewable energy and is insufficient to deliver the Programme for Government and Climate Action Plan 2021 targets and provides limited opportunity in the Atlantic Region. This is acknowledged in the Offshore Wind Phase 2 Consultation document [38]:

"the identified realisable grid capacity for offshore wind on the South and West coasts is extremely limited"

This statement could equally describe the limitations of the grid to support onshore wind developments in the West and Northwest Regions.

Eirgrid's Shaping our Electricity Future document aims to transform the power system in Ireland to facilitate an orderly transition to deliver at least 70% of electricity supply from renewable sources by 2030. It is anticipated that this document will be updated to reflect the increased targets agreed in the Programme for Government as the proposals do not match the target of 8GW installed capacity of onshore wind by 2030.

The Atlantic Region has one of the best wind resources in Europe and the world with an average of 7m/s onshore and 11m/s offshore. This has led to the significant harnessing of onshore wind energy in the region despite the limited availability of electricity grid infrastructure. Looking forward to the 2030 targets, the current grid connection is not sufficient. Continued development of onshore wind in the West and Northwest requires grid enhancements with stakeholders suggesting that upgrade to 220kva lines are needed. The enhancement of the grid infrastructure is essential to maximise the renewable energy generation potential of the Atlantic Region.

Making the necessary investments now will allow EirGrid to be in a position to avail of the huge opportunities in terms of clean renewable energy generation and the potential of the Atlantic Region in contributing significantly to achieving the national carbon neutral ambitions of 2050.

Taking Donegal as an example, grid infrastructure is currently limited to 110kva with the transmission avenue from the south of the County at Cathleen Falls in Ballyshannon, leading to the highest levels of curtailment in Ireland already. This limits the ability of power to be transported back to the grid, with wind energy generated not being delivered due to a lack of grid capacity. Upgrading the grid infrastructure to 220kva from Sligo to Donegal is imperative for the county to generate clean renewable energy for consumption across the island of Ireland in order to deliver the Region's climate action goals.

In order to get offshore projects established in Ireland Pre-2030, opportunities to connect to the grid will be required. Currently the ambition for grid development through Eirgrid's Shaping Our Electricity Future does not identify any real opportunities for FOW projects to connect off the west coast. There is a concern that this omission will lead to challenges for projects pre-2030.

Another factor that arose during stakeholder interviews relating to the route to market is timing. Achieving Ireland's climate action targets, in particular our carbon budget, the timing of renewable energy connections is significant. If the installed capacity targets in the Climate Action Plan are reached but are delivered in the last year of the plan the carbon budget will be significantly exceeded. Despite the criticality of connection timing, clarity on the timelines for grid connection availability from Eirgrid is not available. Beyond 2030 it is recognised that grid infrastructure will need to be upgraded to meet the vision of Net Zero by 2050 but there are no specifics on where or at what capacity upgrades will be provided.

A large number of project developers have published plans to deliver gigawatt scale offshore wind projects in the Atlantic Region with construction schedules beginning around the turn of the decade. A 10-year period from project initiation to construction is not uncommon for projects of this scale. In this context grid planning limited to a less than 10-year horizon presents another obstacle to the development of large scale renewable energy projects in the region. A longer-term vision is needed.

Floating offshore wind in the Atlantic Region has the capacity to supply multiples of the current Irish electricity demand and therefore the long-term development of the industry cannot be based on a typical grid-connected solution alone. This is the third of the challenges in delivering a route to market for wind energy in the Atlantic Region.

For the longer-term ambitions, alternative routes to market are required for floating offshore wind and the potential for the manufacture and deployment of green hydrogen is seen as an exciting opportunity. At a domestic level, hydrogen is seen as a key enabler to decarbonise the Irish economy. In the short term, heavy vehicles such as trucks and buses will be powered by hydrogen rather than batteries and in the medium term, hydrogen is being investigated as an alternative to natural gas when it comes to heat and power.

In parallel, there is a growing demand for green hydrogen and hydrogen derivatives such as ammonia in mainland Europe. Development of this supply chain should commence now rather than waiting for other locations to capture the first international opportunities.

5.4 Regional Port Strategy

There is a strong existing baseline of port and harbour activity in the Atlantic Region with demonstrated capability and capacity to support offshore projects and to support supply of onshore wind components.

However, there are significant gaps between existing port infrastructure and the requirements to support delivery of 30GW of offshore wind. It must be recognised that competition for contracts is not only within the Atlantic Region or the island of Ireland with competition also from UK and European ports.

There is precedent for FOW construction, assembly and installation to be carried out by international contractors remote of the project location limiting local economic impact. In this context Atlantic Region ports are competing internationally to support local projects. The recent Scotwind seabed auction provided evidence that local content can be delivered provided that adequate infrastructure is available.

There is a broad range of port activities associated with floating offshore wind development including construction support, FOW Assembly, platform fabrication and O&M activities. There is currently no or very limited infrastructure in the Atlantic Region to support assembly or platform manufacture, the activities that are likely to deliver the largest portion of project expenditure for local economies. Similarly large component O&M is likely to have the same quay and craneage requirements as the assembly stage and therefore may also not be supported with existing infrastructure.

A National or Regional Port Strategy is needed to ensure the required port infrastructure is delivered in time to capture the maximum local economic impact. It should identify the pipeline of offshore projects, to understand construction schedules, and to characterise the required port capacity and capability at each stage of construction and operation. Key questions the strategy should consider include how many platforms are required and when, what throughput of turbine assembly is required, what locations are suitable for quick reaction O&M hubs. With this information as input a Regional Port Strategy can be developed to specify the required capability, capacity and construction schedule for upgraded port infrastructure. Significant investment is needed to ensure the whole value chain can be captured to the maximum extent possible, to support regional development and local impact.

5.5 Industrial Strategy

The long-term target in the Programme for Government is 30GW of floating offshore wind. To build towards this target there is an urgent need to kick-start the development of FOW this decade by building a pathway for industrialisation in the Atlantic Region. Ireland must move fast to fully capture the benefits of FOW. There is an opportunity for Ireland to establish a strong indigenous industry to support the offshore sector but the window to become an early mover and attract FDI is closing as other jurisdictions ramp up their plans for FOW.

There are some strong positive investment signals emerging from the Atlantic Region, via recent announcements to upgrade Rossaveel harbour and plans for the Shannon Foynes port to develop to meet the requirements of the industry.

To build towards Ireland's long-term target of 30GW there is an urgent need to develop and implement an Industrial Strategy which will plan the development of the Irish and Atlantic Region supply chain to support the FOW sector. The plan should be delivered in tandem with a Regional Port Strategy and consider innovative transmission and storage technologies, such as high-voltage, direct-current interconnection, and green hydrogen.

The potential GVA associated with the major components of an offshore wind project are detailed in the economic impact assessment carried out in the course of this study. An industrial strategy should assess each of the major cost centres and identify the potential for delivery in Ireland.

The cost of the floating platform is estimated to be approximately one third of the overall FOW project CAPEX. Turbine components account for approximately another third of the CAPEX and while, in the short term, it is likely that the turbine components will continue to be manufactured in mainland Europe, there are solid reasons why the floating foundations should be manufactured in Ireland. The business case for manufacturing foundations becomes even more compelling for Ireland if they are built from concrete rather than steel.

In addition to platform fabrication there are additional components within a floating wind project that may be suitable for production in Ireland with a clear pipeline of projects and a supportive environment. These include the manufacture of fibre ropes, building on existing supply chain capability within the Atlantic Region, and the opportunity to manufacture inter-array and export cables as identified through the stakeholder engagement process.

The implementation of an industrial strategy aligned with clear signals on the build out of FOW and a regional port strategy would allow for the maximum capture of economic impact of FOW developments within the Atlantic Region.

5.6 Ramp up

The emergence of the FOW industry in Ireland is an unprecedented opportunity to deliver large scale heavy industry in the Atlantic Region but it is doing so from a standing start with little industrial activity in the region at the scale required to deliver the declared FOW projects. If the first FOW projects are built out to gigawatt scale directly it will leave little opportunity for the Irish supply chain to ramp up their capacity and capability to ensure FOW projects deliver local economic impact.

Project developers recognise the challenge of delivering straight to gigawatt scale as discussed during the stakeholder interviews, instead recommending a ring-fenced pot within the ORESS process for at least 3 projects of 300-400MW each and arguing that it will allow for sufficient competition within a FOW RESS auction. This could be facilitated through the overall State aid budget as Ireland has justified preferential treatment for offshore wind in RESS on the basis of the longer-term potential of these technologies for the country. Ramping up to FOW delivery would provide a kick start to the floating wind supply chain and provide significant GVA and jobs to help offset the additional cost associated with supporting floating wind.

Projects at the scale of 300-400MW represent a major financial commitment, requiring in the range of 20-30 FOW platforms. Project finance may dictate that suppliers are tried and tested both at scale and offshore. Few companies in the Irish supply chain will meet those requirements and therefore the ramp up to FOW may need to start at a smaller pre-commercial scale to allow the supply chain to establish their offshore credentials.

Currently, Ireland's planning means demonstration sites for innovative technologies must go through the same process as commercial projects. If Ireland wants to achieve 2030 and 2050 targets, innovation in both technology and energy system architecture is a necessity. Facilitating demonstrations sites this decade will ensure that Irish supply chain and innovative technologies are ready for full implementation as part of the Enduring Regime, where these technologies can assist in delivering higher targets.

Demonstration sites such as SmartBay and AMETS could play a key role for Irish contractors to explore opportunities in the FOW sector at relatively low cost, while continuing to support Irish technology companies operating in the space. The AFLOWT project at AMETS [39] promised to deliver a first demonstration of FOW in Ireland, an ideal opportunity from which the Irish offshore supply chain could learn, a starting point for the industry in Ireland to ramp up. The relocation of the AFLOWT project is a strategically tragic decision for the Atlantic Region that should be addressed urgently, through robust support for alternative FOW demonstrations.

The ramp up from demonstrator to pre-commercial to gigawatt scale projects provides the clear signals required by industry of what is happening and what is required. One of those requirements is skilled personnel. Operating FOW projects will showcase the potential for offshore wind in the Atlantic Region and promote career paths in renewable energy. Educational bodies in the Atlantic Region are relatively agile, practical and attuned to the needs of industry. New courses can be delivered quickly and tailored to ensure courses from apprenticeships to degrees deliver the skillsets required by industry. The corollary is that educational bodies in the Region will not deliver and tailor courses to support an industry without the confidence that graduates will be appropriately employed. Ramping up of FOW activity can help educational bodies to ramp up in parallel to deliver programmes to support this emerging sector.

6 Conclusion and Recommendations

The purpose of this study is to develop a report and briefings on how public and educational bodies can support the development and growth of the wind energy industry and supply chain from onshore to offshore in the Atlantic region and to develop specific and actionable recommendations.

The study identified a well-established onshore wind industry in the Atlantic Region with a total 3,550 MW of onshore wind in construction, development or operation, of which:

- 930 MW under development;
- 460 MW under construction; and
- 2,160 MW in operation.

Economic modelling and international benchmarking were used to establish an estimate of the value of onshore wind contracts at around €1.2 million per MW, for onshore projects in 2022. This is lower than previous estimates for expenditure per MW in Ireland, however, reflects the wider trend in cost reductions in the sector, including the moves to larger turbines.

The total spend across the Atlantic Region was estimated at €110 million, equivalent to 14% of the total expenditure on the onshore wind sector in the Republic of Ireland in 2022. The largest area of spend is within the operations and maintenance contracts, which will service the 2.2 GW of onshore wind that is currently operational in the Atlantic region. This is followed by balance of plant contracts linked with the construction of onshore wind farms.

This spend will support employment and generate GVA in the companies that carry out wind farm related contracts. In addition, it will support businesses within their supply chains (indirect impacts). Those working on wind farm-related contracts will also generate an economic impact (induced impacts) through spending their salaries and wages in the economy. Combining the direct, indirect and induced impacts, it was estimated that in 2022 the onshore wind sector was responsible for €45 million GVA and 750 jobs across the Atlantic Region.

In order to estimate the potential economic impact of the growth in wind energy in the Atlantic Region it was necessary to first establish build out scenarios for both onshore and offshore wind. A pipeline of declared offshore projects of 39GW was identified in Irish water, of which over 10 GW is located off the Atlantic Region. Onshore wind capacity nationally was estimated to reach a maximum of 8.5 GW. The build out scenarios identified installed wind capacity of up to 4 GW of onshore wind and up to 7 GW of offshore wind in the Atlantic Region for the Aspirational scenario in the 15 years to 2037.

The onshore wind industry in the rapid build out scenario is expected to deliver a peak of 800 direct jobs in 2028 and decline thereafter as the new capacity brought online after 2030 declines. The long-term economic opportunities for the onshore wind sector are therefore those associated with operational expenditure. In particular, the maintenance of turbines is expected to directly support 120 jobs across the Atlantic Region. The GVA supported by onshore wind up to 2037 is estimated at €570 million in the Atlantic Region.

Under the same scenario, it was estimated that by 2037 there would be around 4.5 GW of offshore wind energy operational in the Atlantic Region of which it is estimated that 90% of capacity will be floating. Accounting for the deployment of the different offshore wind technologies was important since they are associated with different construction and development costs, with floating delivering significantly larger local economic impact. It was estimated that offshore wind contracts could result in a total expenditure of €48 billion to 2037 for projects in Ireland. Irish businesses would be able to capture around 32% of this spending, equivalent to €15 billion. Spending across the Atlantic Region was estimated at €6 billion with an associated GVA of €2.3 billion and employment peaking at 4000 people.

While the scale of the opportunity is evident there are significant obstacles to overcome in order to develop the wind industry, in particular the offshore industry in the Atlantic. Not least is the lack of grid infrastructure, with limited grid capacity and the need to establish alternative routes to market for the energy produced. Similarly, port and harbour infrastructure requires substantial enhancement to support the offshore industry. While offshore wind projects could be developed from foreign ports, a substantial portion of the economic impact is associated with floating platform construction and turbine assembly and therefore port infrastructure upgrades are necessary to target these specific activities.

The scale of the challenges in addressing the structural gaps facing the wind industry in the Atlantic Region require a commensurate scale of response. Therefore, some of the key actions and recommendations to support the industry should happen at national level. Nevertheless, the study has leveraged international experience to present specific recommendations actionable by public and educational bodies to support the growth of wind energy from onshore to offshore.

Lobbying Government	
Upgrade grid in West and North-West to meet Programme for Government Targets	Lobby government and Eirgrid to ensure that grid enhancements to meet the onshore wind target of 8GW installed capacity by 2030 are delivered in the West and Northwest where 4 out of 6 counties are significantly below the national average wind energy generation despite low population density and strong wind resource.
Provide clear signals on post 2030 capacity – provide a roadmap to 2050 Net Zero	Lobby government to provide clear targets for offshore wind capacity post 2030 such as the auction of 2GW of new wind capacity per annum recently announced in France. Guidance on local content percentage should also be provided e.g. ScotWind minimum and ambition levels [40].
Ensure FOW benefits are captured within ORESS process	Lobby government to ensure ORESS targets and scoring criteria include blended financial, technology innovation, capacity factor, supply chain and local impact metrics. Non-financial metrics will help to support the inclusion of FOW and Atlantic Region projects and allow them compete with East Coast wind.

Enable Industry	
Identify opportunities in the offshore wind value chain for new industrial development in the Atlantic Region	Local manufacture of floating platforms, secondary structures, fibre rope moorings, export and array cables, blades can deliver significant local impact.
	Quantities and timelines for component delivery should be established for the existing pipeline of projects as part of a sectoral demand and supply chain analysis. Identify existing suppliers with scale-up or diversification potential. Establish appropriate support mechanisms.
	Where significant value is identified, and supply chain does not exist in Ireland identify international suppliers with the potential to establish in the Atlantic Region through engagement of EI/IDA to develop new industrial activity.
Identify supply chain ramp up opportunities in the Atlantic Region	Make suitable and promote the use of offshore test sites for FOW i.e. at SmartBay and AMETS. Make consenting, cabling, technical and financial support available to developers as in EMEC, Scotland or MetCentre, Norway. Councils can support consent, foreshore and grid process and lobby government to provide financial support.
	Lobby for ring-fenced pre-commercial scale FOW projects of 4 x 25 – 100MW in ORESS at the earliest possible opportunity (such as INTOG or French demos). This allows the potential for developer feedback loop and bid lessons learned. At this scale it is more likely that Irish and regional suppliers can deliver a substantial portion of activities.
	Organise supply chain trade missions to visit FOW facilities and projects internationally targeting high value areas such as platform construction and turbine assembly.
Establish Route to Market	Identify potential energy end-users with significant energy demand and assess suitability for establishing a presence in the Atlantic Region in locations where grid limitations persist, or significant curtailment is necessary.
	Investigate the suitability of combined offshore wind and hydrogen hybrid power plants to balance periods of low wind with periods of curtailment to deliver enhanced capacity factor for offshore wind projects.
	Develop a regional strategy to address the emerging hydrogen and ammonia production market to assess quantity, co-location requirements, infrastructure assessment to facilitate bulk export and to establish planning guidance and supports as required, and to ensure bulk export requirements are captured in any port and harbour upgrades carried out for FOW.

Cluster Formation & Support	
	Ports are the key driver of economic activity in offshore wind. A regional port strategy is required to:

Develop an Atlantic Region offshore wind port strategy	• Quantify pipeline in FOW i.e. the number of platforms required in the Atlantic Region and how much activity on the south coast can be captured. • Identify potential fabrication location(s), steel and concrete – is one site enough? • Identify potential assembly ports – can one assembly port service the Atlantic Region? • Identify O&M rapid response, marshalling, heavy O&M bases.
	Develop port upgrade options and timelines to ensure all construction phases are addressed in a co-ordinated approach, appropriate to pipeline project locations and ensure land banks are protected through appropriate zoning.
Cluster and Clustering Initiatives Support	Establish or support existing wind energy clusters co-located with strategically important wind energy ports with an umbrella Atlantic Wind Cluster to co-ordinate activities.
	Promote cluster expertise. Organise industry events including B2B, meet the buyer, and trade missions.
	Exploit synergies in the digital and data analytics domain between wind energy activities and established specialisations within the regions.
	Support relevant start-up and SMEs to locate within clusters through provision of office and workshop space and co-ordination with LEO and EI supports.

Educational Supports	
Raise awareness of offshore wind industry in the Atlantic Region	Public awareness campaign for offshore wind and FOW in public, schools, apprentice schemes, universities – 'can't see it can't be it'.
	Promote technical career paths to address potential labour market shortages due to port upgrades, FOW, Housing for All and NDP all competing for same resource pool.
Develop new courses and centres targeted at wind energy sector	Develop wind energy micro-credentials or diplomas targeted at professional services including legal, accounting, planning to support upskilling within the region to support offshore wind and mitigate leakage of economic activity to Dublin and overseas.
	Develop masters or degree programmes in Offshore Engineering and Naval Architecture. These are key areas of technical specialty in the development of an offshore industry, but programmes in these fields are not available on the island of Ireland.
	Deliver wind energy modules within all relevant degree courses and apprenticeships to ensure visibility of opportunities in the sector.
	Link research and training institutes to strategic wind port clusters. Establish Centre of Excellence benchmarked internationally to include provision of an offshore simulator and advanced modelling capability.
Recognition of transferable skills	Develop criteria for the mutual recognition of fishing, offshore wind and oil & gas training certificates. Fishing and offshore wind construction in the Atlantic are likely to occur in opposite seasons resulting in significant crossover in offshore personnel between the industries. Streamlining of training requirements would support local workforce utilisation.

Stakeholders & Planning Support	
Stakeholder support	Establish a working group to facilitate dialogue between project developers, fisheries representatives and other marine stakeholders to mitigate impact during development, construction and operation.
	Lobby government to ensure that ORESS provides a ring-fenced allocation of community benefit funds for the fishing industry and/or fishing communities.
Planning Framework	Establish a supporting framework for the grant of planning permission for the construction of onshore substations to ensure developers have clarity on the process to successful award.
	Establish a supporting framework for the grant of planning permission for cable routes at both foreshore and national grid level to provide developers clarity on the process to achieve successful award.
	Act on the proposed regional port and harbour strategy to ensure identified port activities are supported through appropriate land use zoning, the support of necessary port upgrades and activities, the protection of necessary land banks for laydown and storage and support of cluster development activities.

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Appendix B: Anatomy of a Wind Project

Wind energy can be located anywhere that the wind resource can be efficiently exploited to generate and deliver power. The supporting structures and infrastructure vary significantly with location and scale, from onshore with direct access to road networks and grid connections, to offshore requiring marine construction operations and subsea power cables. Onshore and offshore wind have some common project elements, and also areas of significant difference in supply chain, skills requirements, financing and technology.

6.1 Onshore Wind

Onshore wind turbines are typically mounted on gravity-based reinforced concrete foundations to provide stability. In the development of wind turbine technology, manufacturers strive to generate more power with larger rotor diameters and higher towers in order to capture a greater wind resource. The subsequent growth in wind turbine size, tower heights, and farm output has been significant since the initial farm developments in Ireland.

The first commercial wind farm in Ireland, commissioned in 1992 in Bellacorrick, Co. Mayo, consisted of 300kW wind turbines with a 31m rotor diameter and 31m hub height. In recent years rotor diameters of 70m or more at hub heights in excess of 80m are common. Figure 64 shows the growth in wind turbines onshore since the 1980's [41]. The first and only community owned wind farm so far is Templederry in Tipperary which has two 2.3MW turbines installed [42].

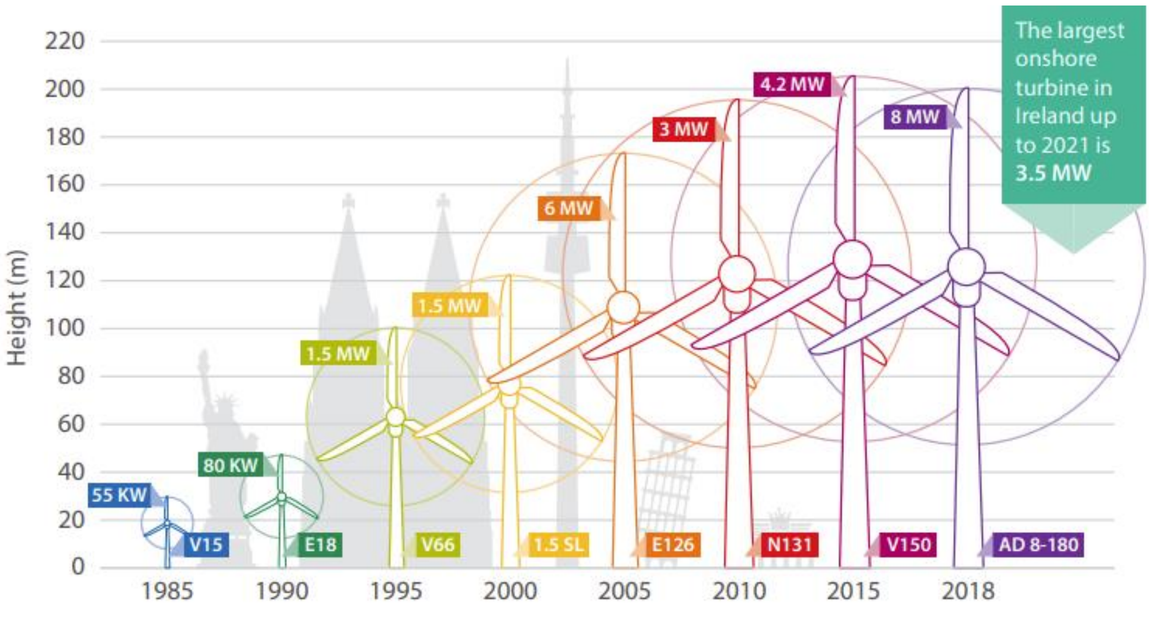

Figure 64: Growth in Wind Turbine Size and Power [41]

6.1.1 Onshore Wind Farm Life-Cycle Stages

An onshore wind farm is developed through multiple phases, with each stage corresponding to variations in supply chain requirements. Contributions from stakeholders and supply chain are progressed through each step, with the construction and commissioning phases requiring the most significant mobilisation of capital, resources and personnel. The lifecycle of a wind farm involves four main stages:

- Development;
- Construction;
- Operations and maintenance; and
- Decommissioning and repowering

Each of the four stages and the main types of activities that occur within each one are overviewed in Figure 65, which also shows the likelihood of the activity occurring locally. There are a wide variety of jobs involved in each of these activities and examples of these are given in the rest of the chapter along with further discussion of what activity occurs locally.

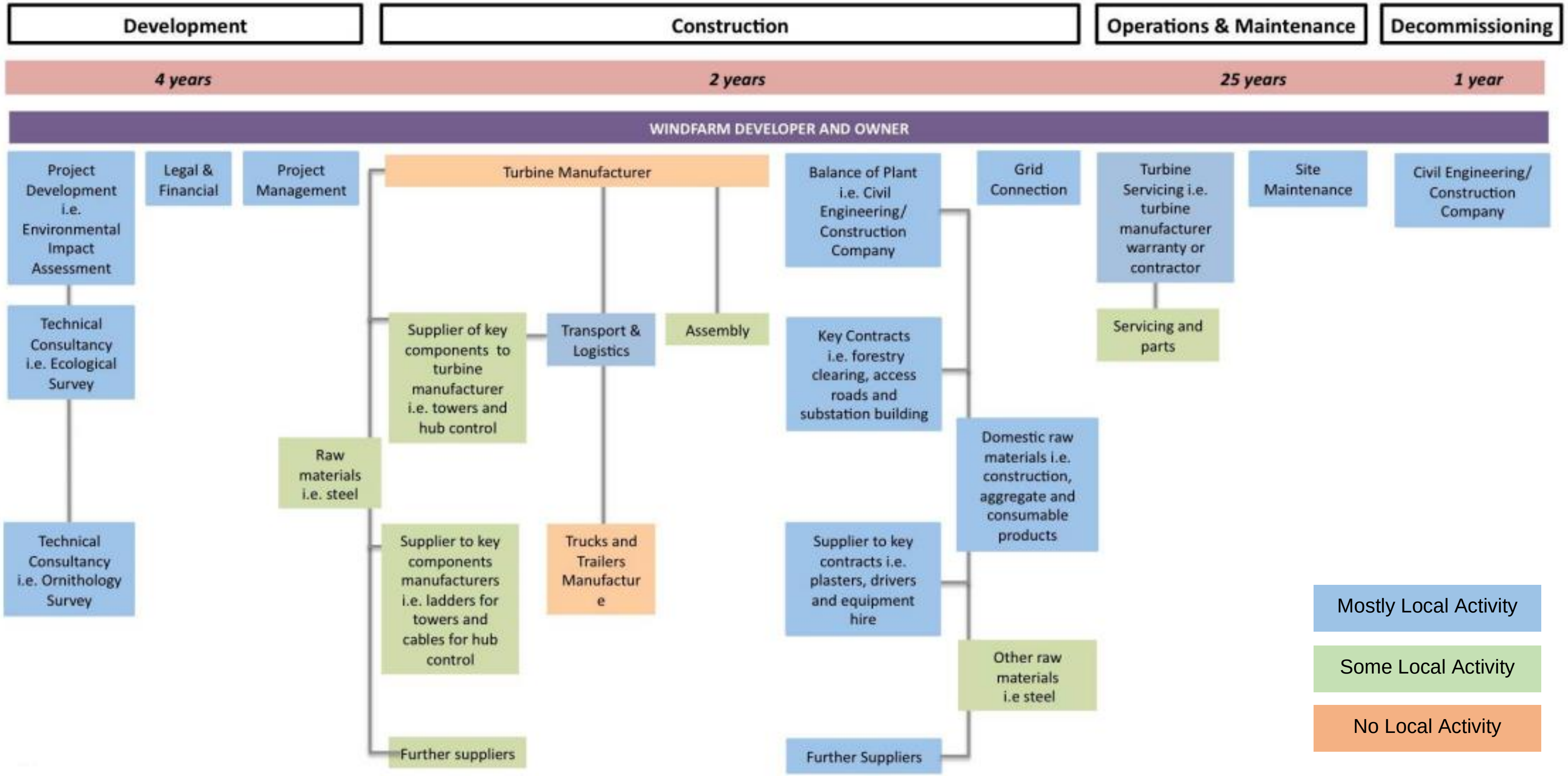

Figure 65: Onshore Wind Farm Life-Cycle Stages, Ref. [43]

6.1.1.1 Development Stage

The development phase involves three main types of activity, listed below. The specialist and highly skilled jobs required can be done by the wind farm developer itself or contracted out to specialist consultancies. For example, a utility firm may have the expertise to develop an onshore wind project while a community wishing to develop their own project may have to buy in expertise. In either situation this activity is usually undertaken in the locality due to the need to have local knowledge such as local planning laws and an understanding of processes such as community consultation and scoping studies. There are opportunities in these areas for small and medium sized businesses as well as larger companies:

1. Project development, which includes planning, technical consultancy, environmental impact assessment, stakeholder engagement, and technical testing and analysis;
2. Legal and financial, which includes legal and accounting activities; and
3. Project management, which includes management consultancy activities and civil engineering.

6.1.1.2 Construction Stage

The construction phase involves three main types of activity:

1. Turbine manufacture – including the tower, blades and internal components;
2. Balance of plant – activity and supplies required to install completed turbines; and
3. Grid connection – to connect installed turbines to the electricity grid.

The turbine manufacture does not currently occur in Ireland, and all components are imported. Balance of plant and grid connection activities are undertaken locally, with opportunities for medium and larger companies in proximity to the farm.

Balance of plant activities cover everything else that needs to be done to construct the wind farm other than the turbine activity. These activities include:

I. Civil and project management;
II. Roads and access;
III. Substation buildings;
IV. Turbine foundations and hard standings;
V. Forestry, logging and landscape service activities; and
VI. Electrical installation and installation of industrial machinery and equipment.

This can involve a wide variety of trades from plasterers, bricklayers, electricians, crane operators, HGV drivers, stone crushing machine operators, timber harvester operators, chainsaw operators and fibre optic networking technicians.

Figure 66: Onshore Wind Foundation: Reinforced Concrete Gravity Base (Image Courtesy Ramboll)

The type of activities usually involved in grid connections contracts include:

I. Engineering services, which includes engineering activities and related technical consultancy and technical testing and analysis;
II. Construction services including civil engineering; and
III. Electrical components, which includes manufacture of electric motors, generators transformers etc., manufacture of wiring and wiring devices and the manufacture of electronic components and boards.

These are significant contracts as many wind farms deliver connection to the grid using underground lower voltage infrastructure, which creates additional expenditure and economic impact when compared with using overhead lines.

6.1.1.3 Operations and Maintenance Phase

During the operations and maintenance phase there are two main areas of activity: turbine maintenance and site maintenance. Turbines can be operated and maintained by the turbine manufacturer for a warranty period, or they can be maintained by contract or by technicians working for the owner of the wind farm.

Given that technicians, both those working for turbine manufacturers and those working for maintenance providers, tend to live locally, this is an important source of economic impact at the local level, not only in terms of generating local jobs, but also in terms of spending their wages in the local economy.

Figure 67: Wind Turbine Maintenance at Minsca Wind Farm

Site maintenance activity includes routine tasks such as maintaining site access tracks and bridges, maintaining drainage ditches and repairing gates and fences. From time to time, site maintenance may also involve tasks such as snow clearing or tree clearance. This will also include improvement and maintenance of the grid connection including cable jointers and overhead lines technicians, building maintenance and habitat management. Locally based companies usually undertake this activity because the work-flow is unpredictable and often requires the contractor to attend the site at short notice. Much of the site maintenance work also requires plant to be brought on site and the transportation costs of moving this plant are minimised if the contractor is based locally.

6.1.1.4 Decommissioning and Repowering Phase

At the end of the operation phase, onshore wind sites will either be decommissioned or repowered. The operation phase is typically 25 years, and the re-powering of legacy wind farms is therefore a large potential future activity as farms age. Where sites are repowered, there will be opportunities for companies in the development phase since repowered proposals will require feasibility studies and planning approvals. While the costs of new turbines account for a large proportion of investment costs, there will be opportunities for cost savings in repowered sites, compared with new sites, during the construction phase since there will be existing access to the site and an existing grid connection. There will be work involved in decommissioning wind farm developments in the future. The exact nature of the work required will depend on the planning conditions attached to each wind farm and is therefore likely to vary from site to site. However, at a minimum, this phase will involve taking down and disposing of the wind turbines. Disposal may either involve scrapping the turbines or selling them second hand but either way, it will require civil engineering expertise to dismantle the towers and transportation services to remove them from the site. This work is likely to be undertaken by Irish based businesses.

6.1.2 Onshore Wind Farm CAPEX

An onshore wind farm comprised multiple elements, with variation in supply chain and project implications.

Table 32: Onshore Wind Farm CAPEX Cost Items

Scope	Cost Item	Description	Supply Chain Location
Civil Engineering Scope	Road access	Creation of internal farm roads, and connection to road network.	Local
	Site preparation	Land reclamation, including drainage, fill ground engineering	Local
	Turbine Foundation	Reinforced concrete construction	Local
	Met Mast	Foundation, tower and wind measurement unit.	Global
	Control Buildings	Construction of units to house farm control.	Local
	WTG Assembly	Activities to assembly WTG and tower on turbine foundation, including transportation and craneage	Local
	Export Cables	Trenching on project and public roads, potentially extensive road opening permit requirements. Installation of underground cable networks (medium voltage cables, copper cables and optical fibre cables)	Local
	Switch gear / transformers	Installation and connection of equipment at WTG and farm level.	Local. Support form WTG manufacturer
	SCADA Equipment	Installation of supervisory control and data acquisition system	Local. Support form WTG manufacturer
Project Procurement	WTG	Procurement of turbine from new or second-hand market. Engagement with local representative of global supply chain	Global
	Tower	Procurement from new or second-hand market. Engagement with local representative of global supply chain	Global
	Cable and electrical components	Procurement of all required equipment. Occasionally accounted for within civil or electrical contract.	Local

6.2 Offshore (fixed)

Fixed bottom offshore wind refers to wind turbines located offshore in shallow waters, assembled on fixed foundations. These turbines work on the same principle as onshore turbines, turning the kinetic energy of the wind into mechanical energy and then to electricity via an electric generator, but have a more complicated foundation in water depths of around 50m [44]. The Arklow Bank Wind Park is Ireland’s first and only offshore wind development, 10km off the coast of Wicklow. The wind park was commissioned in 2004 and was the first erection of turbines larger than 3MW in the world. The park has seven GE 3.6MW generators giving a total capacity of 25MW. Since its commissioning in 2004, there has been no further offshore developments in Ireland.

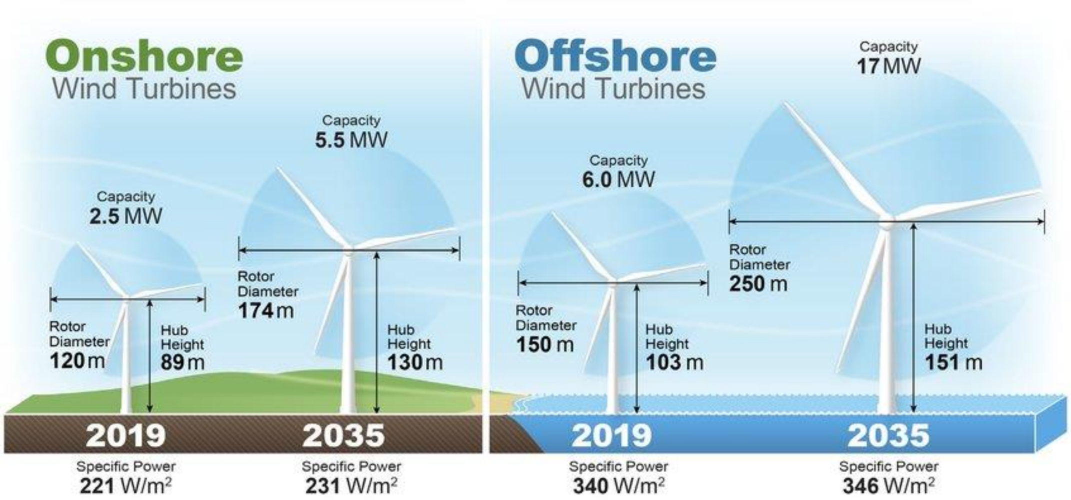

Figure 68: Size comparison of onshore vs offshore wind turbines [45]

Placing wind turbines offshore allows the use of larger turbines than are possible onshore, visible in Figure 68. The wind resource is more reliable offshore due to the lack of impediments such as buildings, trees and hills, as well as being stronger. The energy generated from a wind turbine is a function of the wind speed cubed, along with the turbine blade length squared. This means that a small advantage in wind speed offshore compared to onshore, along with the use of larger turbines, mean that wind resources are much greater offshore than onshore. As an example, an increase in wind speed from 22km/h to 25km/h results in an increase in energy of 50%.

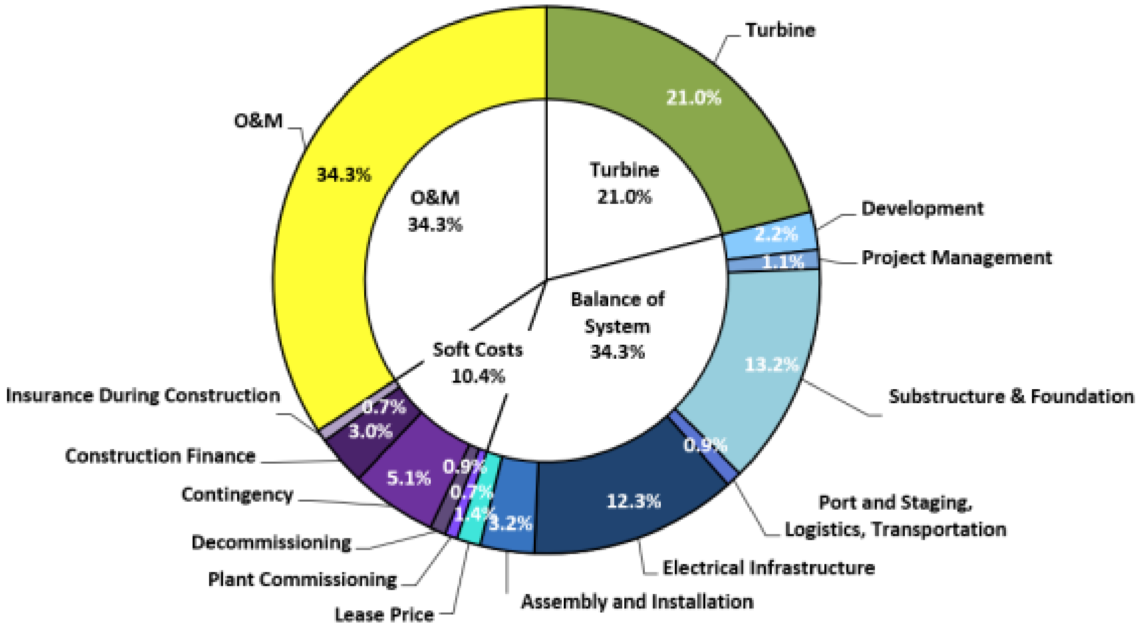

Figure 69: LCOE contribution for fixed bottom offshore wind project [46]

Projected cost breakdown for a 25-year lifespan fixed offshore wind project are shown in Figure 69. This is for a representative wind farm of 200MW, using 6.1MW fixed bottom turbines. The 4 major areas cost is split between are Finance CAPEX, Turbine CAPEX, Balance of System CAPEX, and O&M costs. Turbine and Operations & Maintenance costs are singular costs, with Balance of System and Finance CAPEX consisting of numerous sub-headings. Balance of Systems along with O&M accounts for the largest share of an offshore fixed bottom wind farm, with balance of system costs impacted by increased assembly, infrastructure and construction costs due to the offshore nature of the project.

6.2.1 Offshore Wind (Fixed) Foundation types

Fixed offshore wind projects typically use one of the three foundation types, illustrated in Figure 70. The foundation selection is based on a combination of water depth, geotechnical conditions, vessel availability and suitability, supply chain considerations and cost.

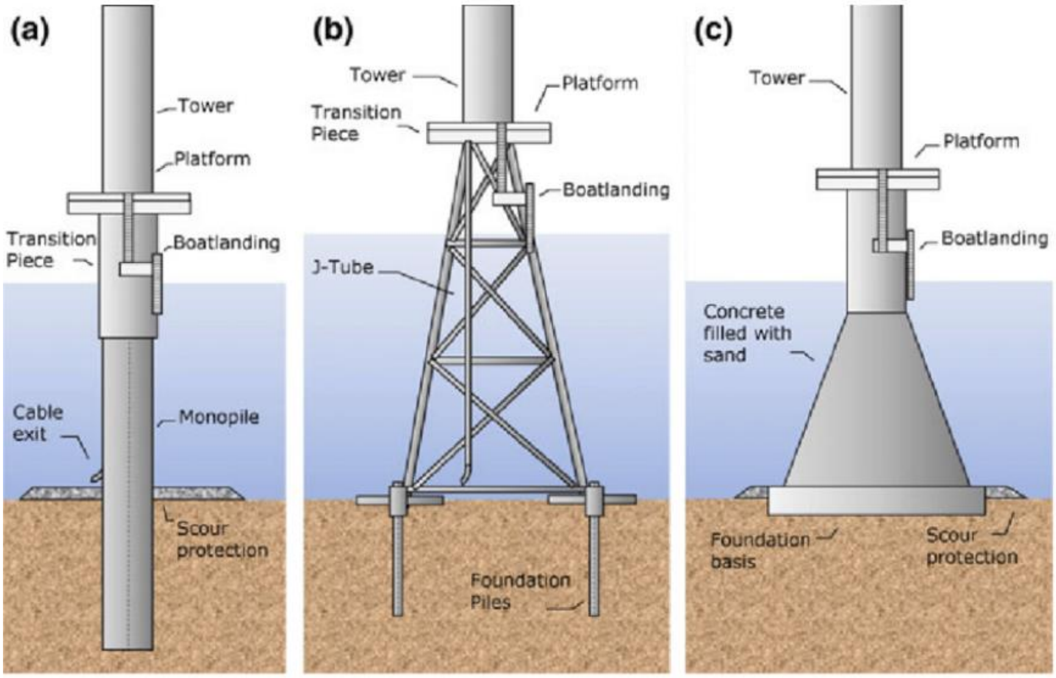

Figure 70: Fixed Offshore Wind Foundations [47]

6.2.1.1 Monopile Foundations

Monopile foundations are widely used for offshore wind turbines. This foundation type consists of a single, typically large diameter, steel tube that supports the wind turbine above the sea surface. These steel tubes are installed either by driving the pile into the seabed using a hammer or vibrator tool or by drilling a socket, installing the pile and grouting the pile in place. Typically, monopiles are installed at a depth (below seabed) of around 30m-40m, depending on seabed type. A transition piece is placed on the top of the monopile foundation, with boat landings and ladders attached to the transition piece to allow safe access. The turbine tower itself is connected to the top flange of the transition piece. The maximum economic water depth for monopile foundations is approximately 40 meters, but varies with seabed type, turbine loading and site conditions.

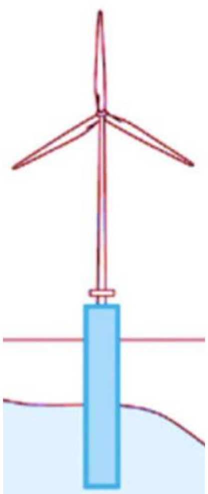

Figure 71: Monopile Foundation

Monopiles are transported to wind farm sites from the manufacturing location by vessel as they are too large for road haulage and are either taken directly to the site for installation or taken to a suitable port or harbour facility prior to transport to the site. The vessel which transports the monopile from the manufacturing location may not necessarily be used as the installation vessel, and piles may be transferred to another installation vessel either at sea or at the port facility. The installation vessels are typically self-propelled Jack-Up Barges (JUB) with the crane capacity to support installation of major components.

Figure 72: Jack-Up-Barge installation of Monopile - Credit: Van Oord

Once on site, the JUB legs will be lowered and deployed. The legs of the JUB will need to be on the seabed and suitable for weight bearing before operations can commence.

To provide context for the farms' construction operations, the following process would likely be followed for the installation of the monopile foundation (the example describes the methodology for a drilled and grouted pile but the process for a driven pile is similar):

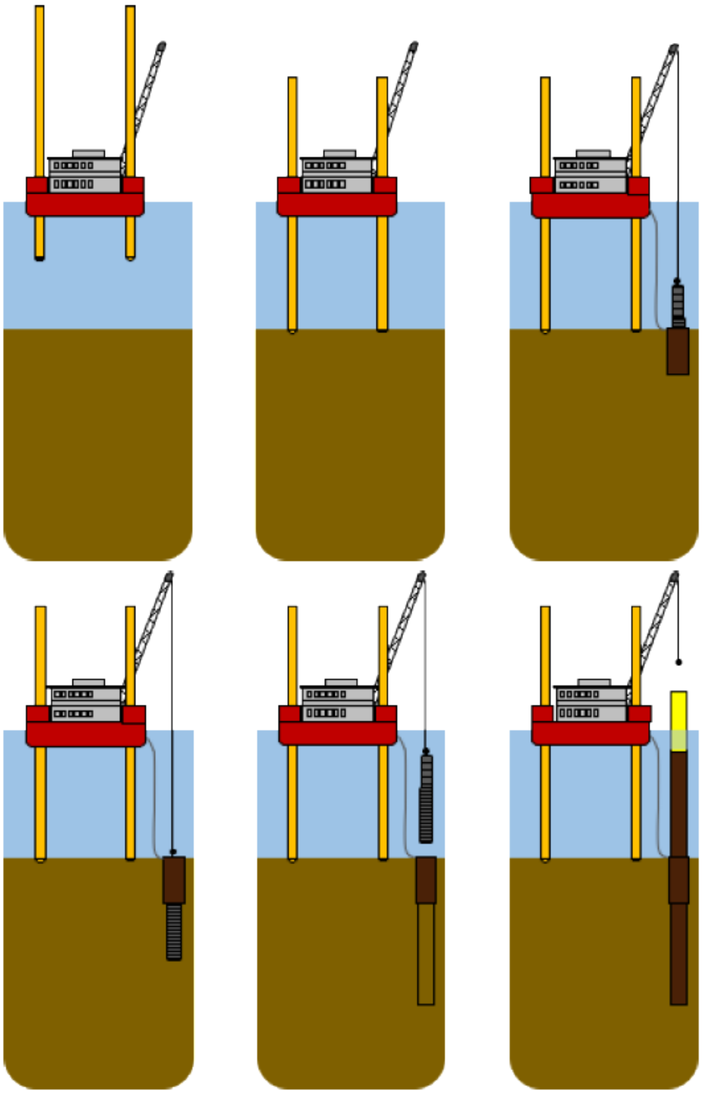

Figure 73: Typical Installation Sequence for Monopile Foundation

1. Installation vessel arrives on site.
2. Jack-up legs lowered onto the seabed and the vessel lifted to provide a suitable airgap.
3. Seabed preparation is undertaken prior to piling operations and includes clearance of debris and levelling of the piling area.
4. The drill string shall be assembled on the vessel.
5. A pile sleeve or casing is drilled into the seabed at the required location for the insertion of the monopile to ensure stability and prevent collapse.
6. Drill fluids are used to lubricate the drill as it penetrates the seabed. The use of drill fluids is managed, and the fluid is biodegradable and non-toxic, and is likely to consist of water-based mud.
7. A pile socket will be drilled into the seabed from the JUB for each foundation piece, using a single drill bit. The drilling methods make use of sea water and the drilling fluid, and all drill cuttings are left offshore.
8. A steel pile is lifted into place by the lifting vessel, inserted into the pile sleeve and grouted in place.
9. Cement grout will be injected through tubes in the casing or monopile structure into the small space between the monopile and the pile sleeve. The grout used for this purpose is cement based grout and is dispensed using a grout line from the JUB.

Installing the foundations is anticipated to take in the order of 60 days for a typical commercial farm. Up to three support vessels are required during installation as guard vessels, with an additional survey vessel potentially required as part of the operations.

6.2.1.2 Jacket Foundations

Jacket foundations consist of a lattice framework with multiple seabed anchoring points. Jacket foundations have a relatively wide base and taper in size as they approach the water surface and have a transition piece to connect to the turbine tower as well as providing boat landing and ladder for access and safety. They are made of steel sections that are welded together using straightforward manufacturing methods. Jacket foundations are typically used in deep waters, of between 40 and 60 meters, where their broad base, and truss form can deliver a more structurally efficient design than a monopile foundation. Jacket structures for offshore wind turbines can weigh more than 5,000 tonnes and typically are moved by barge.

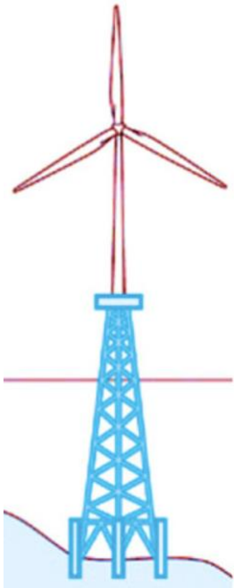

Figure 74: Jacket Foundation

The jacket is attached to pin piles embedded into the seabed. Suction caissons can also be used but only in stiff clays or medium-to-dense sands. Pin piles use a similar process to the monopile foundation installation, but pin piles are smaller and more numerous, with one or more placed at each corner of the jacket base. A pile installation frame is used in this installation phase to ensure correct pin pile placement.

Pin-pile foundation installation typically uses a JUB which will be mobilised to site under its own power. Once on site, the legs are lowered and deployed. The legs of the JUB will need to be on the seabed and suitable for weight bearing before operations can commence. There is the potential that temporary grout bags will be positioned beneath one or more of the jack-up legs to ensure the barge is stable. Once the barge is stable the drilling of the piles, or placement of the installation frame will commence. JUB suitability is one of the factors limiting the economical installation of jacket foundations to water depths of less than 60m.

The following process would likely be followed for the installation of pin-pile foundations for a jacket structure:

1. Installation vessel arrives on site.
2. Jack-up legs are lowered onto the seabed and the vessel is lifted to provide a suitable airgap.
3. Seabed preparation is undertaken prior to piling operations and includes clearance of debris or levelling of the piling area.
4. The drill template is placed on the seabed.
5. A pile sleeve is drilled into the seabed at the required location for the insertion of the pin pile.
6. Drill fluids are used to lubricate the drill as it penetrates the seabed. The use of drill fluids is managed, and the fluid is biodegradable and non-toxic, and is likely to consist of water-based mud.

7. A pile socket is drilled into the seabed from the JUB for each foundation piece, using a single drill bit. The drilling methods make use of sea water and drilling fluid, and all drill cuttings are left offshore.
8. A steel pile is lifted into place by the lifting vessel, inserted into the pile sleeve and grouted in place.
9. Cement grout is injected through tubes in the legs of the tubular jacket substructure into the small space between each pin pile and pile sleeve. The grout used for this purpose is cement based grout and is dispensed using a grout line from the jack up barge/vessel.
10. The process is repeated at each pin pile and jacket leg location required.

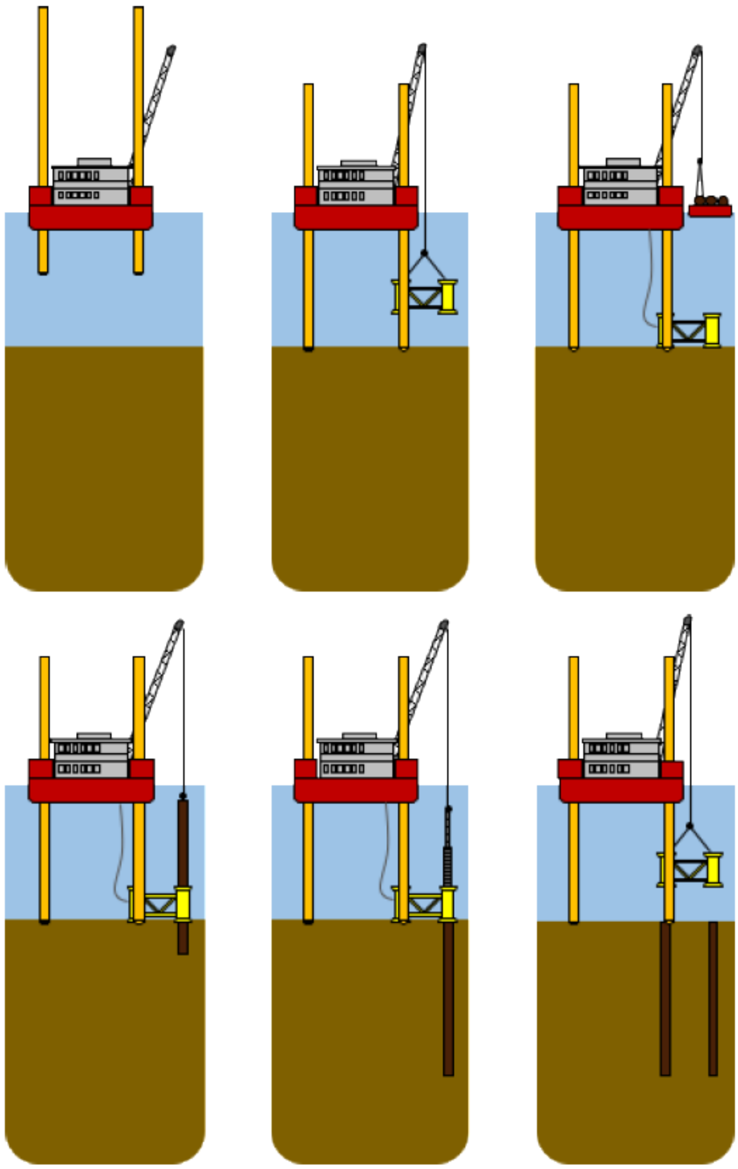

Figure 75 - Typical Installation Sequence for Pin-Piled Foundation

Installing the foundations can be a seasonal installation campaign. Up to three support vessels may be required during installation as guard vessels, with an additional survey vessel potentially required as part of the operations.

6.2.1.3 Gravity Based Foundation

Figure 76: Gravity Based Foundation [48]

Gravity based foundations (GBFs) are made from precast concrete and suitable for sites up to 30m in depth. GBFs can be floated to site and ballasted with gravel, sand or stones to sink the foundation to the seabed. The seabed is prepared prior to sinking to ensure a flat base, with engineered fill used to distribute the load of the GBF. Soft soils or undulating rocky seabeds are unsuitable for this foundation type. GBFs can make use of cheaper and more durable concrete and can use more basic vessels for installation. However, GBFs do have a larger installed footprint compared to monopiles or jackets, increasing foundation environmental impact in terms of size, but removing the need for subsea drilling or pile driving. GBFs will typically have a base diameter of 30 – 40m and a weight of 1900 to 4500 tonnes, requiring significant quayside space and load bearing capacity. 15,000 – 40,000 tonnes of ballast are required for the GBF – aggregate, sand or other dense waste materials such as waste metals can be used for ballast [49]. However, GBFs are being designed to be floated to site, simplifying installation and removing the need for heavy lift vessels.

The following process would likely be followed for the installation of gravity-based foundations:

1. Seabed preparation is undertaken prior to operations and includes clearance of debris, levelling of the foundation area and reinforcement with engineering fill.
2. GBF towed to site.
3. GBF arrives on site and 2 – 3 vessels used for positioning.
4. Ballast operation begins, ballast transferred from a barge to the GBF.
5. Ballasting continues until the GBF has reached the seabed and is on the prepared foundation pad.
6. Once ballasting has been completed, a scour protection skirt is filled around the circumference of the GBF.

Installing the foundations can be a seasonal installation campaign. Up to three support vessels may be required during installation as guard and station keeping vessels, with an additional survey vessel potentially required as part of the operations. The barge transporting ballast to site may require a tow or move under its own power. While there are several vessels required for this operation, they are basic vessels with good availability.

6.3 Floating Offshore Wind

Floating Offshore Wind is a recently developed technology that replaces the fixed monopile, jacket or gravity-based structures and foundations of offshore fixed-bottom wind generation with floating platforms, held in position by moorings. The unique selling point of FOW is the ability to develop offshore wind farms in deeper water depths and with more consistent wind resources resulting in increased capacity factors. The environmental impact of floating platforms is less than fixed bottom foundations and installation and maintenance has the scope to be more efficient, with turbines assembled on floating platforms quayside and towed to site with AHTS vessels, with the possibility of towing platforms back to port for major turbine repairs and maintenance. This removal of costly and limited jack up barges and offshore heavy lift vessels allows for significant cost savings. The use of smaller, local vessels and the potential to fabricate the floating platform locally can have a favourable impact on the local economy.

By 2030, FOW capacity worldwide is predicted to be 11GW, with a total capital expenditure of €34 billion up to 2030 and approximately €5 billion per annum thereafter [50]. As it stands, floating wind has only been deployed at pre-commercial or demonstration project scale, with projects such as Hywind Scotland [51], WindFloat Atlantic [52] and the IDEOL FloatGen [53] examples of these small deployments. These floating projects have proven the feasibility of the technology, identified issues in the development, deployment and operation of the turbines, and signify the start of rapid growth in the industry. This growth in capacity, up to January 2022, is shown in Figure 77. The increase in capacity would likely be more consistent if not for the disruption caused by Covid-19, with the 48MW Kincardine project delayed from 2020 to 2021, and the 3.6 MW TetraSpar demonstration delayed by a year.

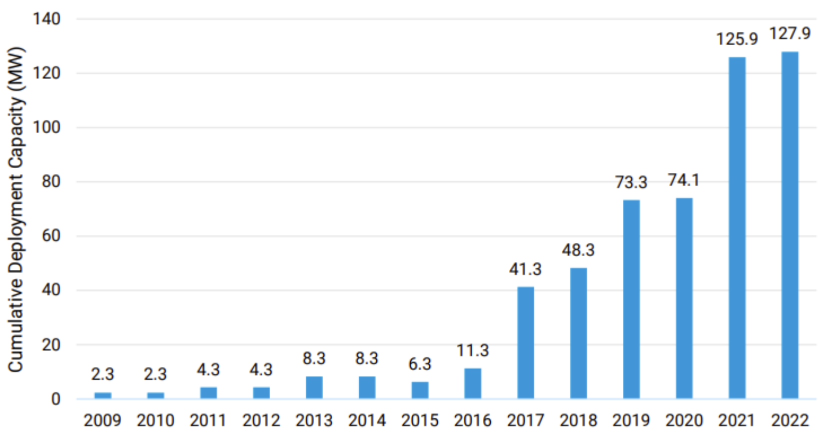

Figure 77: Cumulative global development of floating offshore wind [54]

6.3.1 Floating Foundations

There are four main floating foundation concepts currently being designed for future deployment of floating offshore wind. Spar-Buoys, Semi-subs, Barges and Tension Leg Platforms, as illustrated below.

Each platform type can be configured to support the same turbine capacity. At this stage in the development of the nascent floating wind industry no clear type or concept of design has proved it will become an industry standard. With the exception of Spar foundations, all other foundation concepts can theoretically be towed into ports with relatively shallow channels and quayside water depths in order to allow the Wind Turbine Generator (WTG) to be installed using cranes or other lifting concepts such as a Jack-up vessel.

This is the preferred assembly concept within the floating offshore wind industry as it allows for safer and cheaper installation of the WTG to the foundation by removing the requirement to install the WTG on to a foundation already in place offshore at the wind farm site, thereby removing the need for expensive heavy lift vessels operating offshore.

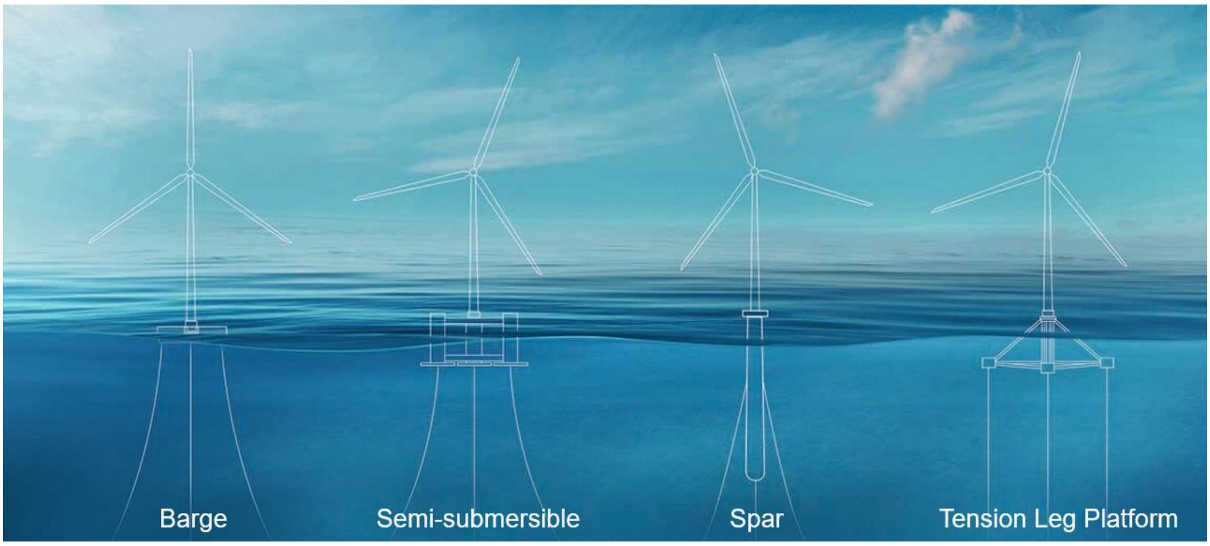

Figure 78: FOW Foundation Types [Image Credit : DNV GL]

Although not possible to predict which floating foundation types will be chosen for future FOW in Ireland, given that that there are no ports in Ireland with the water depth required to upend a spar and install the WTG at a quayside, it is expected that the market in Ireland will be dominated by Semi-Sub, Barge and TLP foundation designs, with potential hybrid options also being developed.

It is also worth highlighting potential evolution in the floating offshore wind platform market. As projects mature, cost reduction will become increasingly important, requiring ongoing innovation. This evolution in part explains the variety of platform types and companies active in the market. At present the market is structured around the construction of platforms in a single location, though as the market matures it is expected that the sector will shift to a strategy of pre-fabrication of platform components which are then shipped to nearer ports for assembly and final fabrication. Concepts such as the TetraSpar and TetraSub from Stiesdal Technologies are good examples of the drive to industrialise platform production [55].

6.3.1.1 Semi-Submersibles

Semi-submersible platforms (semi-subs) are platforms which float in a semi-submerged state, with ballast countering the structure's buoyancy forces, creating a stable platform. They have a low waterplane area relative to barges or vessels of similar displacement, and the design is influenced by the offshore oil & gas industry. Semi-subs are large and heavy platforms; a large volume of steel or concrete is required to construct a semi-sub platform however, industry action on industrialised processes is ongoing, and serial fabrication is the target of multiple semi-sub developers – e.g., Principle Power, Stiesdal TetraSub, and Ocergy.

Figure 79: Principle Power WindFloat Atlantic Semi-Sub [56]

For ports that can accommodate the draft of a semi-sub, turbine assembly dockside is possible using shore mounted cranes, as well as the possibility of O&M occurring dockside for major repairs. To reduce motion, semi-subs may use active ballast systems where water is pumped to different tanks in the semi-sub to counteract hydrodynamic and aerodynamic forces on the system. These systems can add complexity to the platform. Semi-subs may have heave resonance issues, which is the vertical movement of the platform. These can likely be addressed through the addition and refinement of heave plates. Semi-subs can be towed to site with AHTS vessels, which can be used for hook-up also, reducing vessel requirements.

6.3.1.2 Spar-Buoys

Figure 80: Hywind Tampen Spar-Buoy Platform [57]

Spar-buoys are long cylindrical structures which use ballast to bring the centre of gravity below the centre of buoyancy, creating a stable structure. The spar-buoy structure is highly stable, but with a draft of >80m it is not suitable for water depths <100m. The spar-buoy needs to be assembled in sheltered and deep water, as the spar is ballasted and turned from horizontal to vertical in the water. This means assembly is limited to locations such as fjords or other unique areas with high water depths and sheltered met-ocean conditions. The spar-buoy design is an elegant design and has been proven extensively as being extremely stable, originally in the oil & gas industry but more recently in floating wind demonstrations in Norway and Scotland.

Figure 81: Hywind Tampen Spar-Buoy Serial Fabrication in Norway [58]

The relative simplicity means that serial fabrication of spars is readily achievable, and the lack of active ballast systems further de-risks the system. The draft of spar-buoy platforms limits its deployment feasibility to deep water locations. Heavy-lift cranes and dynamic positioning vessels are required for assembly and the large draft means that spar-buoys are unable to be towed back to port for major repairs.

6.3.1.3 Tension Leg Platforms

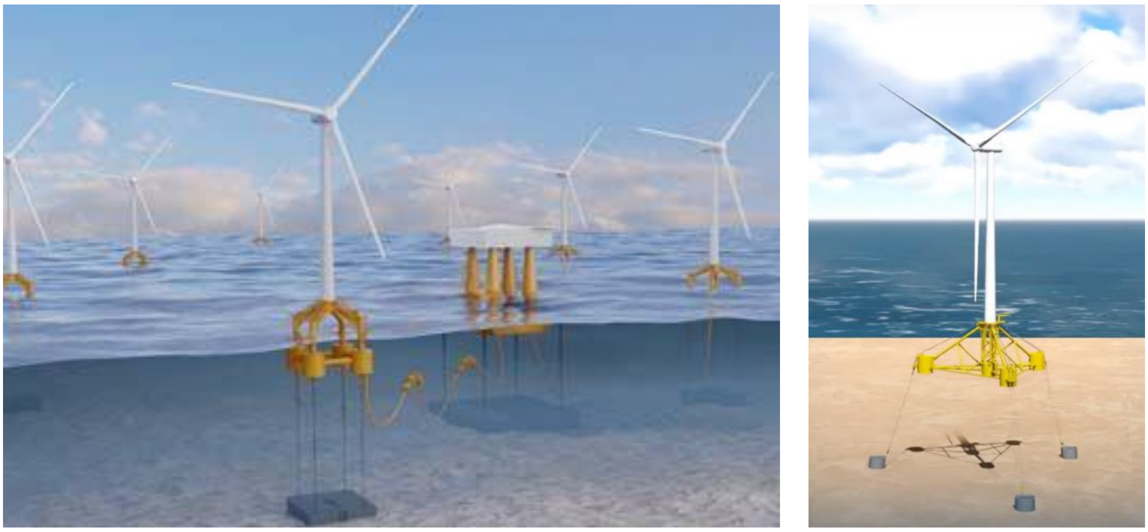

Figure 82: GICON (L) and SBM (R) Tension Leg Platform Renders [59] [60]

Tension Leg Platforms (TLPs) are buoyant structures which are semi-submerged and anchored in this position using mooring lines under tension, with the tension and buoyant forces in balance to provide stability. These platforms have a shallow draft and are smaller and lighter than other platform types due to the high-level of stability provided by the tensioned mooring lines. The low waterplane area and tension in the mooring lines results in low platform accelerations and the tension legs mean that the platform does not require active ballast, reducing complexity.

These mooring lines are under constant tension, and this creates significant mean stress on the mooring tendons as well as the anchoring systems. The installation process is more complex than for catenary or semi-taut systems and the operational risk can be higher due to the imbalance created if a tendon or connection fails. Synthetic mooring lines or steel wire may be used in these high tensile scenarios. Without the mooring forces balancing out the buoyancy forces of the TLP, the TLP may be unsteady so towing the platform and turbine assembly to site may require a bespoke installation barge to ensure stability.

6.3.1.4 Barges

Barge platforms consist of displacement hull vessels, which have a high waterplane compared to alternative platforms. They have the lowest draft of all floating foundation types, allowing them to access many ports and enabling in port assembly as well as O&M. The large waterplane area of barge platforms mean they have the potential for greater wave induced motion, which can impact turbine performance as well as requiring larger mooring systems. Initial barge designs were heavy steel based structures; however, design improvements have delivered reduced weight and cost. Concrete based designs enable increased local content in the construction of floating offshore wind platforms. The two most advanced designs are the IDEOL and Saitec platforms. The IDEOL Floatgen project is a concrete barge structure incorporating a damping pool, which is a central pool within the barge, designed to reduce wave induced loading through the hydrostatic forces on the barge. The Saitec SATH is a concrete barge which has two concrete cylinders to provide buoyancy, along with heave plates to reduce platform motion.

Figure 83: Saitec Swinging Around Twin Hull (SATH) Barge Platform [61]

6.3.1.5 Hybrids

Hybrid platforms use a combination of characteristics from the previously discussed platforms, attempting to utilise the positives of numerous platform designs, in particular semi-subs and spars. Platform draught, manufacturability, and the ability to return to port for O&M are some of the major areas that hybrid platforms address. The advantages and disadvantages of a hybrid platform are unique to each design and dependent on the wind farm design driving constraints. Examples include:

Figure 84: Stiesdal TetraSpar []

- The Saipem HEXAFLOAT uses a standardised substructure floater which can accommodate any turbine up to 15MW and a counterweight suspended with synthetic fibre tendons.
- The Stiesdal TetraSpar uses metal tube sections which can be serially manufactured and assembled in port. This design uses a floater with a ballast substructure suspended subsea.

6.3.2 Mooring Equipment

There are numerous anchoring methods available with the decision depending on the mooring configuration, seabed conditions and the holding capacity required. The horizontal loads experienced by an anchor in a catenary system mean that drag embedded anchors are often the best options, but depending on seabed conditions driven, drilled or suction piles, or gravity anchors could be used with different sized solutions for various holding needs. The vertical loading of anchors in tension leg systems mean that drag embedment anchors are not feasible, with suction piles, driven piles or gravity anchors managing the large vertical forces instead.

The knowledge and development of these anchoring methods comes from the oil & gas industry, where these anchor types have been tested extensively in real world applications.

6.3.2.1 Drag Embedment Anchor

Drag embedment anchors (DEAs) are designed for horizontal loading and generally used in catenary mooring systems. DEAs consist of a fluke, which embeds into the seabed and provides the majority of the anchors holding capacity, the shank rises perpendicularly from the fluke, at the end of which is the padeye, which connects the anchor to the mooring line. Best suited to cohesive sediments such as hard clay or sand, DEAs can struggle in soft sands or clay as well as ground that is too hard to penetrate. The installation process for the drag embedment anchor is straightforward and the anchor is recoverable during project decommissioning.

Figure 85 - Stevshark Rex DEA from Vryhof [22]

Vertical load anchors (VLAs) are a form of drag embedment anchor configured to withstand vertical loading. They are installed with a similar technique to DEAs. VLAs are dragged by the shank along the seabed to embed the fluke (the lower part of the anchor). Once the fluke is embedded and a designed tension force experienced, the angle of the shank is changed to the anchors holding position. VLA's can offer holding power 3.5 times the pull-in load [62]. These anchors can be used for catenary, ITM or tension-leg mooring systems and are designed so that the force being applied to the anchor is normal to the orientation of the fluke.

Figure 86 - Stevmanta Vertical Load Anchor from Vryhof [22]

6.3.2.2 Gravity Anchor

Sometimes referred to as a clump anchor, a gravity anchor is usually used in vertical loading applications but can handle horizontal loading also. This anchor requires medium to hard soil conditions and consists of a large clump of mass. The gravity anchors are low complexity. The large weight and size of the anchor makes it difficult to handle and increases installation costs, as well as making the anchor difficult to remove during decommissioning. Modular gravity anchors can address installation and retrieval issues but add to the overall anchor complexity.

6.3.2.3 Suction Anchor

Suction anchors or suction caissons consist of a long steel cylinder, capped at one end. The open end is placed on the seabed and a vacuum is created by pumping water out of the cylinder, embedding the anchor into the seabed. Suction anchors are most effective in soft silt up to stiff clay seabeds. Suction anchors require a sufficient depth of insertion to generate the necessary resistive forces to provide reliable holding strength in operation. These anchors are unsuitable for sites where tidal stream or current flow is greater than 2m/s as the seabed may be scoured clean. Suction anchors offer rapid installation and retrieval during decommissioning and have been developed and extensively proven in the oil & gas industry.

Figure 87 - Suction Anchor from Acteon

6.3.2.4 Pile Anchor

Drilled or driven piles can be used to deliver a mooring solution capable of withstanding a combination of vertical and horizontal loading. Driven piles are typically used for dense clay or sediment seabeds which allow penetration during installation. Hammer piling is required for installation, which necessitates specialist vessels and wider weather windows than DEA or VLA anchor installation. This installation method also results in subsea noise, affecting the surrounding environment and creating operational restrictions during installation.

Figure 88: BAUER BSD 3000 Subsea Drilling Rig

Drill and grouted pile moorings consist of a hole drilled into bedrock on the seabed, with a pile placed into the drilled hole and grouted into place. Drilling can occur from the surface however the water depths for FOW sites are likely to necessitate a subsea drilling rig placed on the seabed. Subsea drilling involves placing a subsea drilling rig on the seabed, attached to an offshore construction vessel (OCV) with an umbilical. The OCV maintains position above the subsea rig. Once the hole is drilled, the pile is placed into the hole and grouted into place.

6.3.2.5 Micropiles

Micropile anchors consist of numerous small piles drilled in close proximity acting in unison, with pile and template specification varying with ground and loading conditions. The piles are surrounded by grout to fill the drilled holes, allowing adequate load transfer to the seabed. The grouping of smaller piles creates a higher holding capacity as loads are distributed over an extended ground section. Micropiles can accept loading from horizontal and vertical lines and are suitable for most mooring configuration types. Micropiles have limited track record and are at a mid-level Technology Readiness Level for FOW.

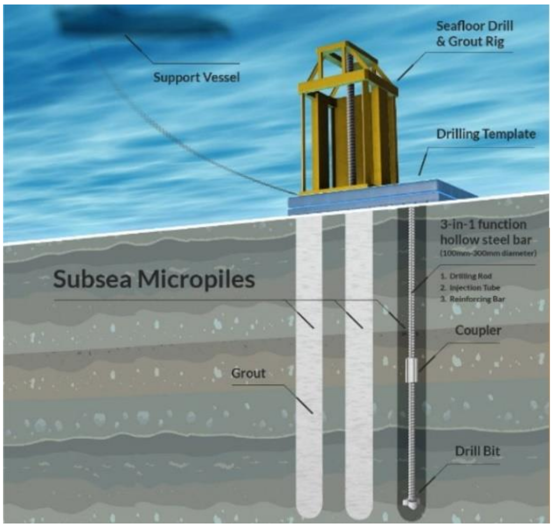

Figure 89: Micropiles. Credit: Subsea Micropiles

6.3.3 Specific Requirements of Floating Offshore Wind

Certain elements of manufacturing will most realistically take place at dedicated, specialist manufacturing plants already in existence outside of Ireland with finished products being shipped directly to the offshore wind farm site offshore, including:

- Export & Array Cables,
- Offshore substations including foundations.

Additionally, the following items are considered to be manufactured at dedicated plants already in existence outside of Ireland and shipped to an Irish port before being installed at the offshore wind farm site, including:

- Wind Turbine blades,
- Nacelles,
- Towers,
- Prefabricated steel components for floating foundations,
- Mooring chains.

Potential components that may be manufactured at an Irish port include:

- Concrete pre-fabrication of components for floating foundations,
- Slip-formed concrete foundations.
- Additionally, assembly of prefabricated components for both concrete and steel foundations may be performed at an Irish port.
- Ancillary wind turbine and platform components such as secondary steelworks, lifting devices, and secondary electrical systems.
- Anchors,
- Mooring lines (steel or synthetic).

Assembly of the Tower and WTG on to the floating foundation is expected to be performed at an Irish port in the case of semi submersibles (steel & concrete), and certain TLP concepts depending on the ability to be towed to the offshore wind farm site with WTG in place.

6.4 Shared and industry specific activities

Onshore wind and offshore wind have some overlapping supply chain requirements, and several areas of significant difference. A key difference between onshore and offshore projects is the average project size, with onshore wind focussing on individual projects <200MW installed capacity and offshore wind considering projects >500MW. This is for reasons of scale benefits, and the relatively lower development and mobilisation costs associated with onshore projects.

Table 33: Wind Farm Activities

<table>
<tr><th>Phase</th><th></th><th>Onshore Wind</th><th>Fixed Offshore Wind</th><th>Floating Offshore Wind</th></tr>
<tr><td rowspan="2">Development</td><td>Shared Activities</td><td colspan="3">Grid Feasibility
EIA
Legal and Financial
Yield Assessment
Stakeholder engagement</td></tr>
<tr><td>Industry Specific</td><td>Landowner engagement</td><td colspan="2">Metocean
Bathymetry Survey
Offshore Site Investigation
Marine Foreshore / MAC Application</td></tr>
<tr><td rowspan="2">Construction</td><td>Shared Activities</td><td colspan="3">Nacelle, blades and tower procurement, import and logistics</td></tr>
<tr><td>Industry Specific</td><td>Land clearance
Road access construction
Onshore Foundation Construction
Onshore craneage</td><td>Port Operations
Marine Operations
Offshore Foundation Installation</td><td>Port Operations
Marine Operations
Quayside construction and Assembly
Mooring Installation
Platform Installation</td></tr>
<tr><td rowspan="2">Operation</td><td>Shared Activities</td><td colspan="3">Large component storage
Control Centre</td></tr>
<tr><td>Industry Specific</td><td></td><td>O&M Port</td><td>O&M Port
Tow to Port Maintenance</td></tr>
</table>

Appendix C: Installed Capacity in the Region

Table 34: Wind Farm Installed Capacity in the Region

Generator	Installed Capacity (MW)	Feeding Station	Feeding 110kV Station	County	No. of Turbines
Acres Wind Farm	17.5	N/A	Cathaleens Fall	Donegal	6+1(+1)
Anarget Wind Farm (1)	1.98	Donegal	Cathaleens Fall	Donegal	3
Anarget Wind Farm (2)	0.02	Donegal	Cathaleens Fall	Donegal	2
Anarget Wind Farm (3)	0.5	Donegal	Cathaleens Fall	Donegal	1
Beam Hill Wind Farm	14	N/A	Trillick	Donegal	8
Burtonport Harbour Single Turbine	0.66	Dungloe	ARDNAGAPPARY	Donegal	1
Cark	15	N/A	Letterkenny	Donegal	25
Clogheravaddy Wind Farm (Phase 1)	9.2	N/A	Binbane	Donegal	
Cooly Wind Farm	4	Moville	Trillick	Donegal	2
Corkermore Wind Farm Phase 1	9.99		Binbane	Donegal	5
Corvin Wind Turbine	2.1	SORNE HILL		Donegal	1
Crockahenny	5	Buncrana	Trillick	Donegal	10
Cronalaght Wind Farm 2	17.96	N/A	Ardnagappary	Donegal	5
Culliagh Wind Farm (Meenbog)	11.88	N/A	Letterkenny	Donegal	18
Drumlough Hill (2) (Lough Doo)	9.99	N/A	Trillick	Donegal	12
Drumlough Hill Wind Farm	4.8	Buncrana	Trillick	Donegal	8
Enros - Sorne Hill Single Turbine	2.3	N/A	Sorne Hill	Donegal	1
Flughland	9.2	N/A	Sorne Hill	Donegal	4
Glackmore Hill (1)	0.6	N/A	Sorne Hill	Donegal	1
Glackmore Hill (2)	1.4	N/A	Sorne Hill	Donegal	0
Glackmore Hill (3)	0.3	N/A	Sorne Hill	Donegal	0
Killin Hill Wind Farm	6	Binbane		Donegal	3
Killybegs Wind Farm	2.55	Killybegs	Binbane	Donegal	3
Loughderryduff Wind Farm	7.65	Glenties	Binbane	Donegal	9
Lurganboy Wind Farm	4.99	Milford (NR)	Letterkenny	Donegal	6
Meenachullalan Wind Farm	11.9	Killybegs	Binbane	Donegal	5
Meenadreen Wind Farm	3.4	Donegal	Cathaleens Fall	Donegal	4
Meenanilta (3)	3.4	Stranorlar	Letterkenny	Donegal	4
Meenanilta Wind Farm (1)	2.55	Stranorlar	Letterkenny	Donegal	3
Meenanilta Wind Farm (2)	2.45	Stranorlar	Letterkenny	Donegal	3
Meenaward Wind Farm (Formerly Beam Hill 2)	6.9	Trillick		Donegal	3

Meenkeeragh Wind Farm	4.2	N/A	SORNE HILL	Donegal	2
Meenkeeragh Wind Farm (2)	0.4	N/A	Sorne Hill	Donegal	2
Mossedge Wind Farm	0.5	N/A	SORNE HILL	Donegal	1
Mount Cronalaght	4.98	N/A	ARDNAGAPPARY	Donegal	8
Shannagh (Kilcar)	2.55	Kilcar	Binbane	Donegal	3
Sorne Hill (2)	7.4	N/A	Sorne Hill	Donegal	3
Sorne Hill Wind Farm	31.5	N/A	Sorne Hill	Donegal	16
Three Trees	4.25	N/A	Sorne Hill	Donegal	2
Golagh	15			Donegal	25
Meentycat	72.4			Donegal	38
Meentycat	16.1			Donegal	7
Mulreavy	5			Donegal	2
Mulreavy	90			Donegal	36
Black Lough Wind farm	12.5	N/A	Glenree	Sligo	6
Carrane Hill Wind Farm	3.4	N/A	Corderry	Sligo	4
Derrysallagh Wind Farm (Formerly Kilronan 2)	34	N/A	Garvagh	Sligo	
Geevagh Wind Farm	4.95	N/A	Corderry	Sligo	6
Lackan Wind Farm	6	Enniscrone	Moy	Sligo	3
Kingsmountain	25			Sligo	10
Kingsmountain	11.05			Sligo	13
Altagowlan Wind Farm	7.65	N/A	Corderry	Leitrim	9
Black Banks (1)	3.4	N/A	Corderry	Leitrim	4
Black Banks (2)	6.8	N/A	Corderry	Leitrim	8
Carrickeeny Wind Farm	7.65	Manorhamilton	Sligo	Leitrim	4
Corrie Mt.	4.8	N/A	Arigna	Leitrim	8
Faughary Wind Farm	6	Manorhamilton	Sligo	Leitrim	3
Moneenatieve Wind Farm (1)	3.96	N/A	Corderry	Leitrim	5
Moneenatieve Wind Farm (2)	0.29	N/A	Corderry	Leitrim	0
Spion Kop Wind Farm	1.2	N/A	Arigna	Leitrim	2
Tullynamoyle	9	N/A	Corderry	Leitrim	4
Tullynamoyle 2 Wind Farm	10.225	CORDERRY		Leitrim	5
Tullynamoyle Wind Farm 3 (Carrane Hill Merged Capacity)	1.598	N/A	Corderry	Leitrim	2
Tullynamoyle Wind Farm 3 (Formerly Geevagh 2)	11.98	N/A	Corderry	Leitrim	4
Garvagh	26			Leitrim	13
Kilronan	5	N/A	Arigna	Roscommon	10
Largan Hill	5.94	Ballaghaderreen	Tonroe	Roscommon	9
Roosky Wind Farm	3.6	Ballaghaderreen	Tonroe	Roscommon	2
Seltanaveeny Wind Farm	4.6	N/A	Arigna	Roscommon	3
Skrine Wind Farm	4.6	Roscommon	Lanesborough	Roscommon	2

Garvagh	22			Roscommon	11
Sliabh Bawn	64			Roscommon	20
Bellacorrick Wind Farm	6.45	N/A	Bellacorick	Mayo	21
Bunnahowen Wind Farm (Temp)	2.55	Belmullet	Bellacorick	Mayo	3
Bunnyconnellan Wind Farm	28	N/A	Glenree	Mayo	12
Carrowleagh Wind Farm (1)	34.15	N/A	Glenree	Mayo	16
Carrowleagh Wind Farm Ext. (2)	2.65	N/A	Glenree	Mayo	1
Cuillalea Wind Farm	3.4	Kiltimagh	Castlebar	Mayo	4
Cuillalea Wind Farm (2)	1.59	Kiltimagh	Castlebar	Mayo	2
Derrynadivva Extension	6.8	N/A	Castlebar	Mayo	3
Derrynadivva Wind Farm (prev. sd)	8.5	N/A	Castlebar	Mayo	10
Grady Joinery Wind Farm	2.5	Charlestown	Tonroe	Mayo	1
Killala Wind Farm (Phase 1)	19.2	N/A	Tawnaghmore	Mayo	Phase 1 (6) Phase 2 (TBC)
Lenanavea (Burren) Wind Farm	4.65	Windsor	Castlebar	Mayo	6
Mace Upper Wind Farm	2.55	N/A	Dalton	Mayo	3
Magheramore and Cloontooa Wind Farm	40.8	N/A	Dalton	Mayo	18
Raheen Barr Wind Farm	18.7	N/A	Castlebar	Mayo	22
Oweninny	92.8			Mayo	29
Cloonlusk Wind Farm	4.25	N/A	Cloon	Galway	2
Knock South Wind Farm (2)	0.69	Spiddal	Screeb	Galway	
Knock South Wind Farm (Inverin)	2.64	Spiddal	Screeb	Galway	4
Leitir Guingaid Wind Farm	40.9	N/A	Salthill	Galway	4, 6, 7
Rossaveel Wind Farm	3	Carraroe	Screeb	Galway	1
Sonnagh Old Phase 1	7.65	Loughrea	Somerset	Galway	9
Derrybrien	59.5			Galway	70
Knockalough	35.2			Galway	11
Seecon	108			Galway	36
Uggool	64			Galway	22
Boolynagleragh (1)	36.98	N/A	Booltiagh	Clare	16
Cahermurphy Wind Farm	6	N/A	Booltiagh	Clare	3
Carrownaweelaun Wind Farm	4.6	Kilkee	Tullabrack	Clare	2
Kiltumper Wind Farm	4.99	Greygrove	BOOLTIAGH	Clare	2
Lissycasey Wind Farm	13.399	N/A	BOOLTIAGH	Clare	
Moanmore Wind Farm	12.6	N/A	Tullabrack	Clare	7

Sorrell Island (Glenmore) WF Ext	8	N/A	Booltiagh	Clare	3
Sorrell Island (Prev Glenmore)	24	N/A	Booltiagh	Clare	9
Tullabrack Wind Farm	13.8		Tullabrack	Clare	6
Boolinrudda	45			Clare	18
Booltiagh	19.5			Clare	13
Booltiagh	12			Clare	6
Knockalassa	27.5			Clare	11
Moneypoint	17.25			Clare	5
Ballagh Wind Farm	4.6	Abbeyfeale	Trien	Limerick	2
Carrons (A&B) Wind Farm	4.99	Dunmoylan	Rathkeale	Limerick	3
Dromdeeveen Wind Farm (1)	10.5	N/A	Glenlara	Limerick	6
Dromdeeveen Wind Farm (2)	16.5	N/A	Glenlara	Limerick	8
Gortnacloghy Wind Farm	4.4	Abbeyfeale	Trien	Limerick	2
Grouse Lodge Wind Farm	15	Ballydoorlis	Rathkeale	Limerick	6
Kilmeedy Wind Farm	4.7	Milford (MWR)	Charleville	Limerick	2
Knockawarriga Wind Farm	22.5	N/A	Trien	Limerick	9
Mauricetown (Glenduff) Wind Farm	13.8	N/A	Glenlara	Limerick	6
Rathcahill West Wind Farm	12.5	Newcastlewest	Rathkeale	Limerick	5
Tournafulla (2) Wind Farm	17.2	N/A	Trien	Limerick	17
Tournafulla Wind Farm (1)	7.5	N/A	Trien	Limerick	5
Athea	34.35			Limerick	16
Dromada	28.5			Limerick	19
An Cnoc	11.5	Blanchfield	Thurles	Tipperary	5
Ballincurry Wind Farm Ltd (Glengoole)	4.6	Glengoole	Thurles	Tipperary	2
Ballinlough Wind Farm	2.55	Toomevara	Nenagh	Tipperary	3
Ballinveny Wind Farm	2.55	Toomevara	Nenagh	Tipperary	3
Bruckana	39.6	N/A	Lisheen	Tipperary	14
Cappawhite A Wind Farm (Gate 2)	2.92	Parkroe	Cauteen	Tipperary	1
Cappawhite A Wind Farm (Gate 3)	49.08	Parkroe	Cauteen	Tipperary	17
Cappawhite B Wind Farm (Cappagh White)	13.18	N/A	Cauteen	Tipperary	4
Carrig Wind Farm	2.55	Birr	Dallow	Tipperary	3
CURRAGHGRAIGUE (2) Wind Farm	2.44	N/A	Nenagh	Tipperary	3
Curraghgraigue Wind Farm	2.55	N/A	NENAGH	Tipperary	3

Garracummer (2)	1	Multeen	Cauteen	Tipperary	0
Garracummer Wind Farm	36.9	Multeen	Cauteen	Tipperary	17
Glencarbry Wind Farm	33	Piperhill	Cauteen	Tipperary	12
Glenough Wind Farm	33	Croughmarke	Cauteen	Tipperary	14
Gortnahalla	0.499	Holycross Road	Thurles	Tipperary	1
Gurteen Lower Wind Farm	2.3	Glengoole	Thurles	Tipperary	1
Hollyford(Holyford) Wind Farm	9	Multeen	Cauteen	Tipperary	3
Knockastanna Wind Farm	7.5	CAPPAMORE	Ardnacrusha	Tipperary	5
Monaincha Bog Wind Farm (Gate 2)	3.4	N/A	Ikerrin	Tipperary	15
Monaincha Bog Wind Farm (Gate 3)	32.55	N/A	Ikerrin	Tipperary	15
Mounvaun (Mienvee) Wind Farm	0.66	Cappamore	Ardnacrusha	Tipperary	1
Mounvaun (Mienvee) Wind Farm (2)	0.19	Cappamore	Ardnacrusha	Tipperary	1
Patrick Costello Wind Turbine	0.495	Cashel	Cahir	Tipperary	1
Skehanagh Wind Farm	4.25	Birr	Dallow	Tipperary	5
Slievereagh Wind Farm (1)	3	Garryspillane	Tipperary	Tipperary	1
Slievereagh Wind Farm (2)	1.6	Garryspillane	Tipperary	Tipperary	1
Templederry Wind Farm	3.9	N/A	Nenagh	Tipperary	2
Kill Hill	36			Tipperary	16
Lisheen	36			Tipperary	18
Lisheen	24			Tipperary	12

Appendix D: Proposed Offshore Wind Projects on the Island of Ireland

Table 35: List of Proposed Offshore Wind Projects on the Island of Ireland [20]

Project Name	Size (MW)	Foundation Type	County	Region	Owner
Arklow Bank	800	Fixed	Wicklow	East	SSE Renewables
Dublin Array	900	Fixed	Dublin	East	Saorgus Energy, RWE Renewables
Oriel Wind Park	330	Fixed	Louth	East	Parkwind NV, ESB
Codling Wind Park	1500	Fixed	Wicklow/Wexford	East	Fred Olsen Renewables, EDF Energies Nouvelles Group
Shelmalere	1000	Fixed	Wicklow/Wexford	East	DP Energy Ireland, Iberdrola
Sea Stacks	800	Fixed	Dublin/Wicklow	East	ESB
Greystones	1000	Fixed	Dublin/Wicklow	East	Cobra Instalaciones y Servicios, SA, Flotation Energy
n/a	1000	Floating	Donegal	North	n/a
Cooley Point	500	Fixed	Louth	East	Hibernian Wind Power
Clogher Head	500	Fixed	Louth	East	ESB, Parkwind NV
Braymore Point	800	Fixed	Louth	East	SSE Renewables
North Irish Sea Array	500	Fixed	Meath/Dublin	East	Statkraft
Latitude 52	1000	Fixed	Wicklow	East	DP Energy Ireland
Cailleach	1600	Fixed	Wicklow	East	Ocean Winds
Inis East 1	1000	Floating	Dublin/Wicklow	East	Cobra Instalaciones y Servicios, SA, Flotation Energy
Inis East 2	500	Floating	Wicklow	East	Inis Offshore Wind
South Irish Sea	1330	Floating	Wicklow/Wexford	East	Energia Renewables
Kilmichael Point	500	Fixed	Wicklow/Wexford	East	ESB
Shearwater One	3000	Floating	North/Scotland	North-East	Shearwater Energy Limited
North Channel Wind 1	300	Floating	Antrim	North-East	SBM Offshore
North Channel Wind 2	100	Floating	Antrim	North-East	SBM Offshore
Aniar Phase 1	500	Fixed	Sligo	North-West	Aniar Offshore
Aniar Phase 2	500	Floating	Sligo	North-West	Aniar Offshore
Inis Elga	1000	Floating	Cork/Waterford	South	DP Energy, Iberdrola

Emerald	1300	Floating	Cork	South	Simply Blue, Shell
Celtic Offshore 1	750	Fixed	Cork	South	ESB
Celtic Offshore 2	750	Floating	Cork	South	ESB
Celtic Sea Array	800	Floating	Cork	South	SSE Renewables
Inis South	1000	Floating	Cork	South	Inis Offshore Wind
Helvick Head	800	Fixed	Waterford	South-East	Energia Renewables
Loch Garman	800	Fixed	Wexford	South-East	ESB
Urban Sea	4000	Floating	Cork	South-West	Enterprize
Blackwater	1500	Floating	Wexford/Waterford	South-East	Cobra Instalaciones y Servicios, SA, Flotation Energy
Sceirde Rocks	400	Fixed	Galway	West	Green Investment Group
Western Star/Ilen	1350	Floating	Clare	Mid-West	Simply Blue, Shell
Inis West 1	1000	Floating	Kerry	Mid-West	Inis Offshore Wind
Inis West 2	1000	Floating	Clare	Mid-West	Inis Offshore Wind
Clarus	1000	Floating	Clare	Mid-West	DP Energy, Iberdrola
Moneypoint 1	400	Floating	Clare	Mid-West	ESB
Moneypoint 2	1100	Floating	Clare	Mid-West	ESB

Appendix E: Economic Impact Methodology

7.1 Key Terms and Definitions

7.1.1 Measures of Economic Impact

The economic impact analysis focussed on the following measures of impact:

- Gross Value Added (GVA): a measure of economic activity expressed as the difference between an organisation's turnover and its non-staff operational expenditure;
- Years of Employment: a measure of employment used in the context of cumulative impacts over a defined period of time. As an example, a job lasting for 24 months is equivalent to two years of employment; and
- Jobs: a measure of employment used to report on annual impacts.

7.1.2 Economic Impact Types

The Input-Output model considered three types of economic impact:

- direct economic impact: economic impact associated with the contracts carried out by primary contractors;
- indirect economic impact: economic impact arising from primary contractors' spending across their supply chains; and
- induced economic impact: spending in the economy of those workers directly employed in onshore and offshore wind projects.

The relationship between these types of impact is shown in the figure below.

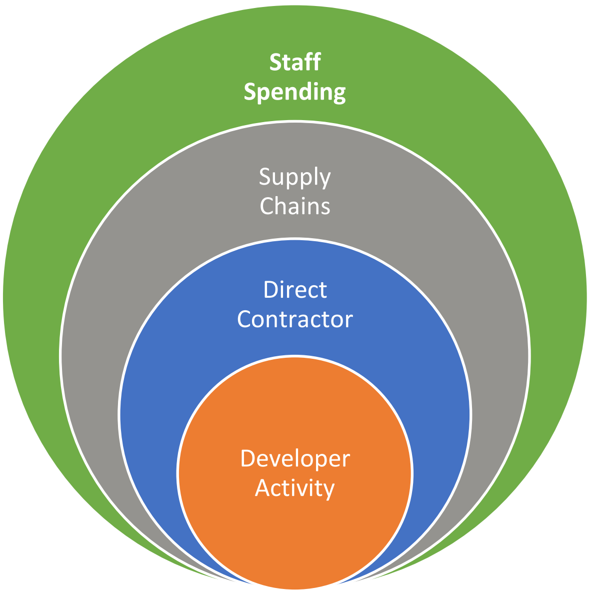

Figure 0-1 Levels of Economic Activity and Impact

7.2 Mapping Economic Impacts over Time

The first step in estimating the economic impacts from the onshore and offshore wind sectors over the period to 2037 was to establish how many MW would be under development, construction and operation each year.

To do so, it was first necessary to establish under each scenario the total generating capacity of operational developments over the period between 2022 and 2037. On that basis, it was then possible to estimate the generating capacity that would be added each year. The next step involved making assumptions on the likely duration of development and construction phases. Based on BiGGAR Economics experience working with both onshore and offshore developers, it was assumed that four years would be required for wind farm development and a further two years for construction. These assumptions and the estimates on capacity added each year made it possible to estimate the number of MW under development and construction.

The generating capacity across Ireland by project phase and development type under the Rapid Build Out scenario is shown in Figure 0-2 and Figure 0-3.

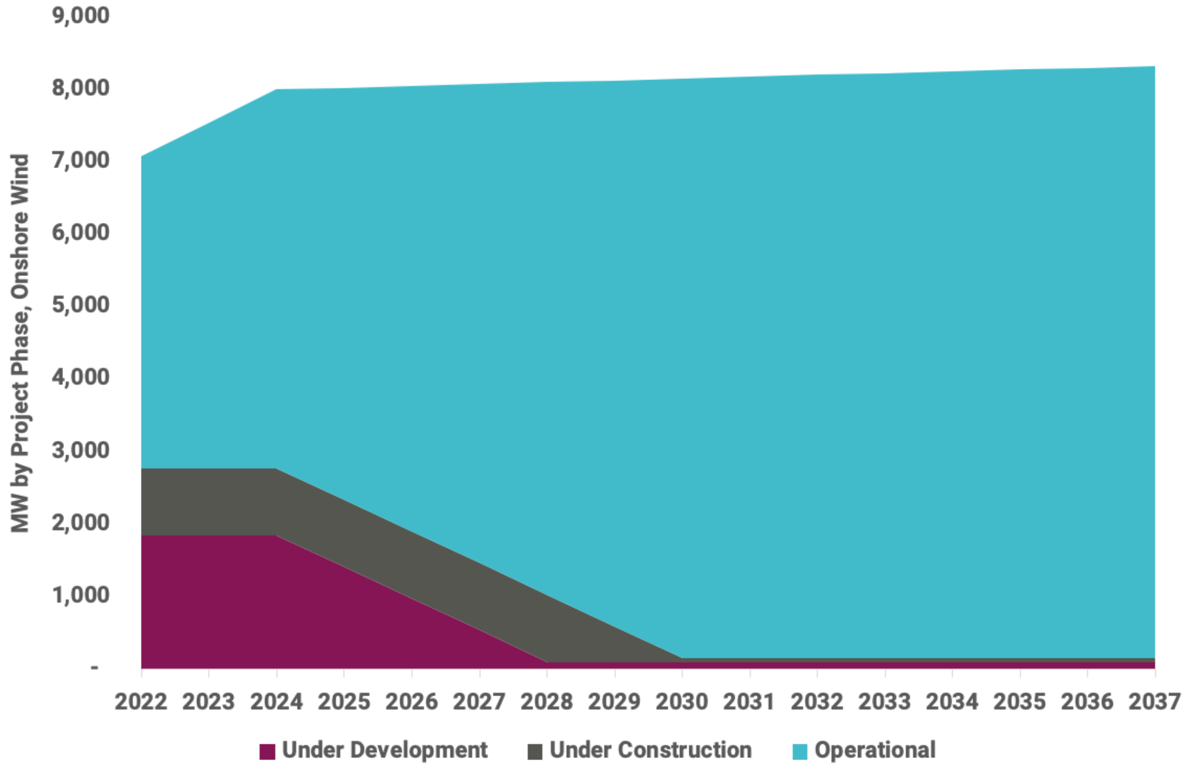

Figure 0-2 Onshore Wind Generating Capacity by Project Phase across Ireland, Rapid Build Out Scenario

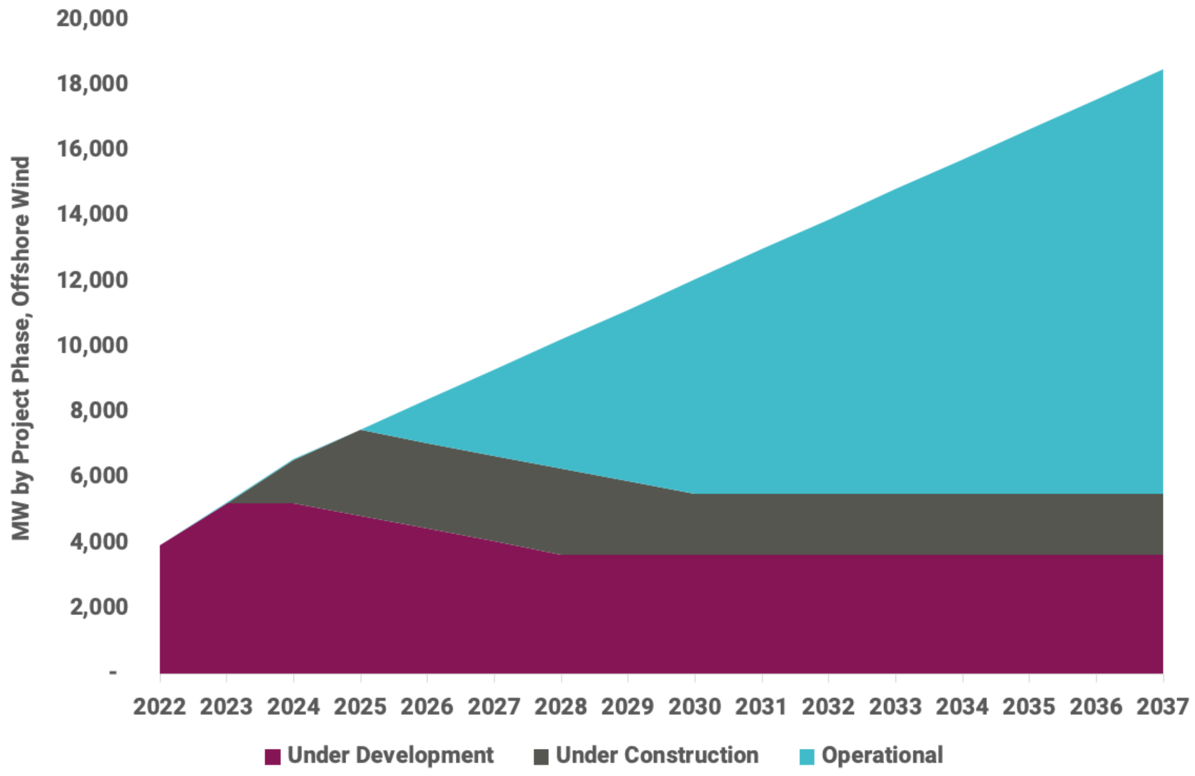

Figure 0-3 Offshore Wind Generating Capacity by Project Phase across Ireland, Rapid Build Out Scenario

For the purposes of the calculations, the turnover from the wind farms under development and construction was then divided by the time required to carry out those phases. Based on the total generating capacity by project phase, it was then possible to estimate the total expenditure occurring in a given year.

Once the turnover associated with each project phase was estimated, Input-Output Economic Modelling was adopted.

7.3 Input-Output Economic Modelling

Estimates of economic impacts across the three scenarios considered were based on Input-Output economic modelling.

As discussed in the economic analysis, the first step in estimating economic impacts involved making assumptions on the ability of businesses to fulfil development, construction and operational contracts. It was then possible to establish the direct GVA and direct employment supported by the onshore and offshore wind sectors over the period to 2037. This was done by applying sectoral turnover per job and turnover per GVA ratios, sourced from the OECD STAN[1], to the expenditure occurring in each study area, as shown in the figure below.

[1] OECD (2021), STAN Industrial Analysis (2020 ed.).

Figure 0-4 Direct GVA

The economic activity supported by a development, or a series of developments is not limited to the direct contribution that contracts awarded make to the turnover of recipient companies. Contract-related spending has also an impact on the supply chain of those businesses involved in the construction, development and operations of onshore and offshore wind farms (indirect impacts). In addition, those working on the development, construction and operation of onshore and offshore wind developments have an impact through their spending in the economy (induced impacts).

Indirect impacts were estimated by applying Type 1 GVA and employment multipliers, as derived from the Irish Input-Output Tables[2], to the direct GVA and employment supported by construction and development contracts. Similarly, induced impacts were estimated by applying Type 1 and Type 2 GVA and employment multipliers to the direct GVA and employment supported.

As the Irish Input-Output Tables reflect transactions taking place at the level of the Irish economy, it was necessary to make adjustments when considering indirect and induced impacts occurring in the Northwest, West and Midwest regions. In particular, it was assumed that indirect impacts in the three regions are 25% of those for the Irish economy and induced impacts 50%.

The calculations involved are shown in the figures below.

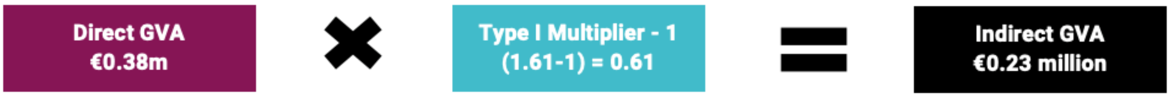

Figure 0-5 Indirect GVA

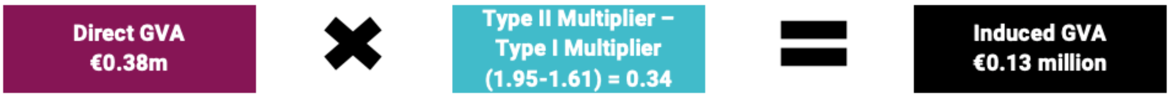

Figure 0-6 Induced GVA

The total construction, development and operational impact associated with the onshore and offshore wind sector is given by the sum of direct, indirect and induced impact, as shown below.

[2] Supply and Use and Input Output Tables for Ireland 2011

Figure 0-7 Total GVA

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