Vision 2041 Strategic Review

September 2022

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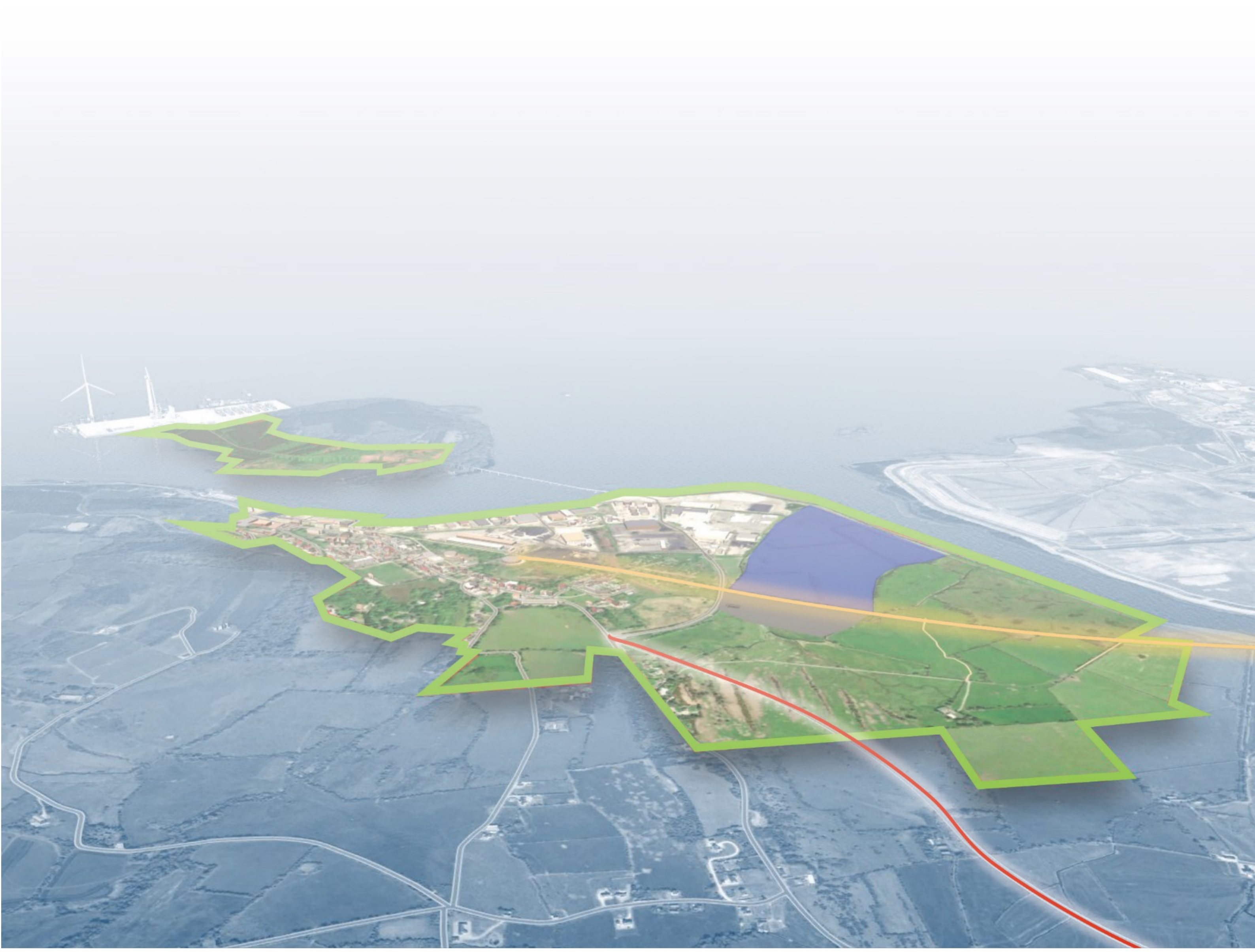
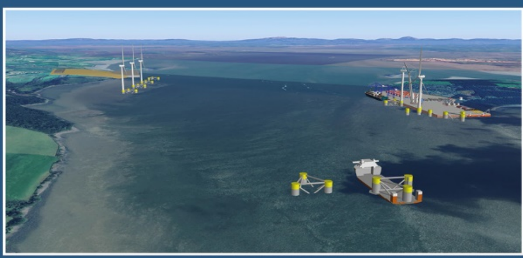
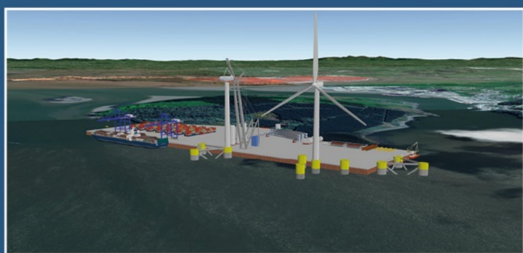
Foreword







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Foreword

Vision 2041 was launched in 2013 with its plan period entailing a 30-year time horizon. Vision 2041 committed to a review every 7 to 10 years and accordingly we are delighted to present this ambitious and comprehensive Review. This Review does not replace Vision 2041 and should be read in conjunction with it. In summary, the Review focusses very much on the sea change of opportunities and obligations around climate action as well as the extensive changes in national supply chain logistics. Climate action is grounded in our net zero obligations by 2050, and while significant associated uncertainties exist on how to achieve these obligations, plans to attain them must be devised and implemented in the immediate term as time is not on our side. Likewise, with regard to the logistics sector, events such as Brexit and Covid-19 with its acceleration of remote working, have fundamentally changed freight market dynamics. These changing dynamics coupled with strong Irish economic and population growth, require additional sustainable supply chain capacity particularly with regard to port infrastructure.

The approach to the Review has been to identify and address relevant change, either in policy or market dynamics, over the Vision 2041 period to date. Some areas, such as our approach to Limerick Docks remain unchanged from Vision 2041. We launched the Limerick Docklands Framework Strategy in 2018, and this Strategy is actively being implemented. Accordingly, and as mentioned above, this review does not replace Vision 2041 but provides further clarity and guidance on the sustainable development and expansion of our harbour, the Shannon Estuary, based on changing dynamics since its launch in 2013.

In order to fully inform the Review, a broad and extensive range of stakeholder consultations were undertaken, and these were supplemented by procuring expertise and experience in master planning for large scale infrastructure, particularly with regard to port and energy infrastructure.

As mentioned, this Vision 2041 Review, looks at the entire Shannon Estuary and is structured over three main themes or drivers for future growth and expansion:

- Deployment of Floating Offshore Wind (FLOW) at scale
- Green Industrial Development and Transition facilitating alternative fuels production
- Required port expansion to meet expanded, diversified and more sustainable logistics services

FLOW and alternative fuels

There has been much commentary concerning the readiness of Irish ports to service this sector, this Review demonstrates that the Shannon Estuary can provide capacity to facilitate a supply chain supporting an annual build out of up to 1,800 MW of FLOW per annum or up to 30 GW by 2050. In addition, a 2-GW electrolyser for hydrogen and downstream e-fuels production could be located on the Shannon Estuary. This review has approached FLOW and alternative fuels production from a holistic infrastructure perspective focusing on the numerous advantages of the Shannon Estuary such as its 500km^2 of deep water, its 1,400 ha of zoned deepwater Strategic Development Locations (SDLs), and its proximity to the Atlantic's abundant ORE resources to name some.

While the Shannon Estuary is considered the best port to develop the supply chain for FLOW, this Review finds that, with regard to infrastructure, a new deepwater terminal at Foynes Island and a strategy for the development of the offshore grid (potentially along marine cable corridors identified in this Review) are critical and should be in place by 2028 in order to enable the sector to mobilise and meet net zero obligations by 2050.

Port Capacity

As part of the Review, Shannon Estuary throughput projections were analysed and revised. The base, mid and high scenario framework was retained with projections to 2041 now ranging from 13m tons pa for the base scenario to 22m tons pa for the high scenario. These projections take account of the transition away from fossil fuels to zero carbon energy including e-fuels. This is particularly relevant for Shannon Foynes Port Company not only because of its existing strong characteristics as an energy port, where for example it facilitates over 20% of feedstock inputs for existing national electricity generation, but because it is the closest deepwater port to the Europe's best wind resource, Atlantic offshore wind.

In addition to becoming an integration port for FLOW, the Port of Foynes including the new deepwater quay at Foynes Island, will add substantial freight capacity on the national supply chain. Importantly, this capacity at Foynes will be situated at an uncongested point in the national road and rail network due to progress made on Vision 2041 transport objectives. The Limerick to Foynes rail connection and the Foynes to Limerick Road Scheme, are key requirements of Vision 2041. At the time of writing, Irish Rail have commenced procurement for the reinstatement of the rail line and planning consent has been granted by An Bord Pleanála for the Limerick to Foynes Road. These crucial hinterland connections together with the port infrastructure planned for Foynes, will transform the Foynes terminal into a major national freight and logistics hub. Its unparalleled maritime and land transport access, with its 180-hectare port estate, ensures Foynes can provide substantial capacity and resilience for the national freight sector.

Successful implementation of this review by delivering on the identified offshore wind, green industry and logistics opportunities will be transformational for the Shannon Estuary, the region and the country. The Atlantic wind resources can provide a significant zero carbon energy supply, in either electrical or molecular format for our grid or GHG intensive downstream sectors. Freight transport can be considerably decarbonised by using the planned Foynes logistics hub and by the production of ammonia and/or e-methanol for maritime transport bunkering, HGV fuelling and SAF for aviation. Resulting economic impacts will be in the order of tens of thousands of jobs created and billions of euros invested in supply chain and route to market infrastructure and facilities in the zoned SDLs around the Shannon Estuary.

To fully unlock these huge opportunities, significant national policies in a number of sectors require updating. Examples include more clarity around energy policy, enduring regime, alternative fuels and wider economic and social policies.

Finally, I would like to thank all those who contributed to this Review with a special thanks to Bechtel for their hard work and guidance during its compilation.

Patrick Keating

CEO Shannon Foynes Port Company

Acknowledgement

Many parties were consulted in the preparation of this Vision 2041 Strategic Review. Direct consultations were requested which focused on stakeholders including local businesses operating in the strategic development locations, local authorities, transmission system operators, windfarm and various renewable energy technology developers and representative bodies for the relevant industries.

In addition to these direct consultations, a public consultation was also conducted which was advertised in local media and was hosted on the Shannon Foynes Port Company's website[1]. Written submissions were received in response to this consultation.

We thank all those who provided their time and shared information with our team during our consultations.

We also thank HRA Planning and RPS for their collaborative assistance in this review.

SHANNON FOYNES PORT

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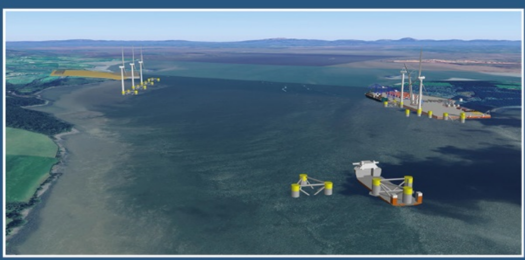

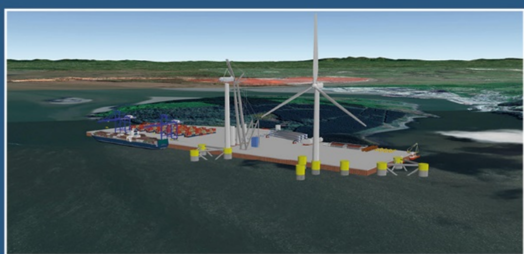

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Table of Abbreviations

AA	Appropriate Assessment
AC	Alternating current
AFSC	Atlantic Fuels Supply Company
AI	Artificial Intelligence
BAT	Best Available Technology
CCGT	Combined Cycle Gas Turbine
CCS	Carbon capture and storage
CCUS	Carbon Capture Utilisation and Storage
CHP	Combined Heat and Power
CRU	Commission for Regulation of Utilities
CTV	Crew Transfer Vessels
DAC	Direct Air Capture
EHB	European Hydrogen Backbone
EIA	Environmental impact assessments
EMS	Environmental Management System
ESPO	European Sea Ports Organisation
FOWT	Floating Offshore Wind Turbine
FSRU	Floating Storage and Regasification Unit-Ship
FTE	Full time equivalent
GDA	Greater Dublin Area
GDP	Gross domestic product
GHG	Greenhouse gas
GNI	Gas Networks Ireland
GW	Gigawatt
HFO	Heavy fuel oil
HGV	Heavy goods vehicles
HV	High Voltage
HVAC	Heating, ventilation, and air conditioning
HVDC	High voltage direct current
IDA	Industrial Development Agency
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
LNG	Liquified Natural Gas
LOHC	Liquid organic hydrogen carriers
LOLO	Lift on / Lift Off
MAC	Maritime Area Consents
MAP	Maritime Area Planning
MARA	Maritime Area Regulatory Authority
MaREI	Science Foundation Ireland Research Centre for Energy, Climate and Marine
MSFD	Marine Strategy Framework Directive
MW	Megawatt

NIR	Natura Impact Report
NORA	National Oil Reserves Agency
NREL	National Renewable Energy Laboratory
O&M	Operations and maintenance
OECD	Organisation for Economic Cooperation and Development
PCCC	Post Combustion Carbon Capture
RORO	Roll on / Roll off
ROV	Remote Operated Vehicles
SAF	Sustainable Aviation Fuel
SDL	Strategic Development Locations
SEA	Strategic Environmental Assessment
SFPC	Shannon Foynes Port Company
SIFP	Strategic Integrated Framework Plan
SOV	Service Operation Vessels
SPK	Synthetic paraffinic kerosene
STEP	Shannon Technology and Energy Park
TEU	Twenty-foot equivalent unit
TRUE	Total Resource Usage Effectiveness
UHVDC	Ultra-high-voltage direct current

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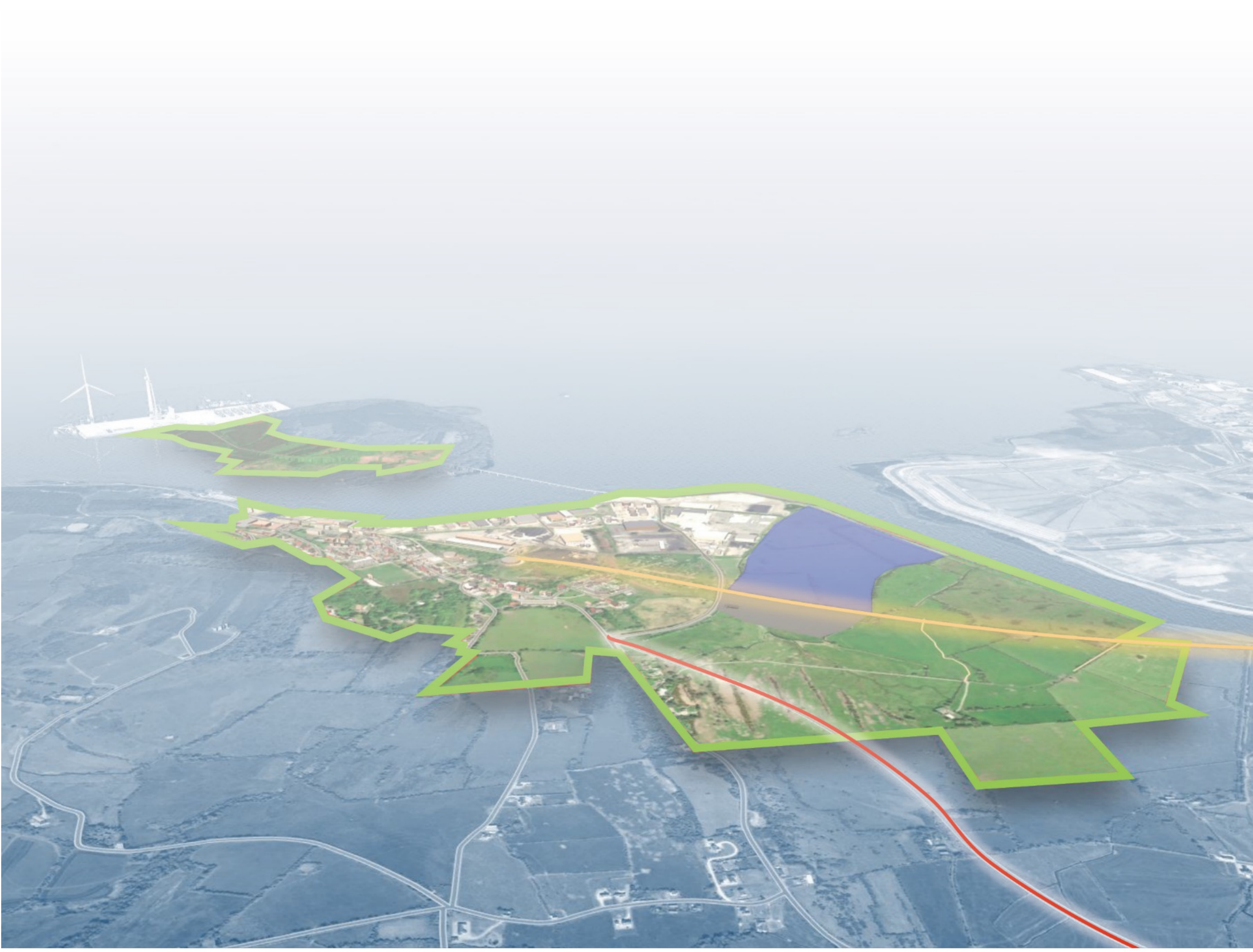
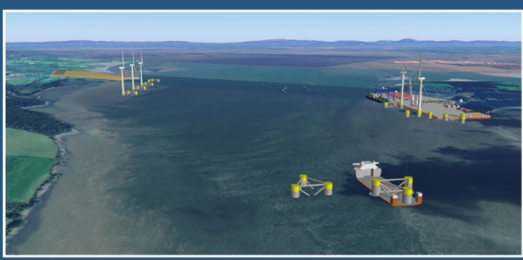
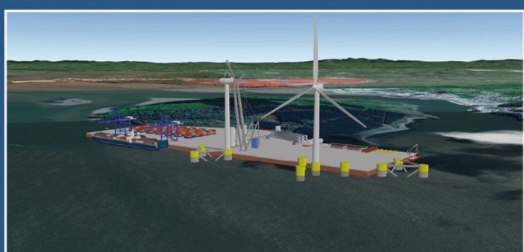
Executive Summary







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Introduction

Shannon Foynes Port Company (SFPC) is situated on the deepest watercourse in Ireland, and one of the deepest estuaries in the world, the Shannon Estuary. It extends to over 500 km^2 and has channel depths of up to 32 m. SFPC has statutory maritime jurisdiction over the entire Shannon Estuary and is designated as a Tier 1 Port at a national level and as a "core corridor port" on the EU's TEN-T network.

In 2013, SFPC published its 30-year Vision 2041 Strategy outlining the Port's future objectives for the medium to long term. This Strategy identified future port demand and associated landside and waterside capacity requirements such as port infrastructure and intermodal hinterland connectivity infrastructure.

The Vision 2041 Strategy indicated that a review would take place over a 7- to 10-year timeframe. Accordingly, this document represents such a review ("Vision 2041 Strategic Review") and is intended to refresh and re-affirm the Vision 2041 Strategy as well as inform a formal update in the future. For completeness, this *Vision 2041 Strategic Review* should be read in conjunction with the *Vision 2041* original document.

This Vision 2041 Strategic Review has set out to account for shifting political, environmental, and market dynamics since Vision 2041 was published. By far the most significant shifts relate to global climate change and the policy responses to combat its effects at a national and European level. The European Commission's European Climate Law and Ireland's Climate Action and Low Carbon Development Act were formally enacted in 2021 and set a legally binding target of Net Zero carbon emissions by 2050. As outlined in Ireland's Climate Action Plan 2021, the implications of these pieces of legislation are immense and far reaching, not least with regards to the Shannon Estuary, whose naturally occurring and expansive deep waters will play a pivotal role in delivering on the objectives therein.

First, achieving "Net Zero" will require a dramatic increase in renewable electricity generation capacity, and the European Commission recognises that – among the various renewable energy sources – offshore wind has the greatest scale-up potential. Sitting on the doorstep of the vast offshore wind potential of the Atlantic Ocean, opportunity knocks for the Shannon Estuary.

Second, delivering upon national and European climate objectives will necessitate the transitioning of existing industries as well as the formation of new, renewables-based ("green") industries. This includes the production of alternative, zero carbon, and carbon-neutral combustion fuels (i.e., "e-fuels") for use by those energy consumption areas that cannot be directly electrified. Already a major energy production and storage hub and with ready access to the major routes to market for e-fuels, the Shannon Estuary is well-positioned to lead a green industrial revolution for Ireland.

Lastly, the decarbonisation of supply chains will be central to realising "Net Zero" by 2050. Here the Shannon Estuary can again play a pivotal role as host to Ireland's only Tier-1 Neo-Panamax capable container terminal (at the planned Foynes Deepwater Port) with a dedicated rail connection, introducing a more efficient and lower carbon supply chain alternative.

The opportunities highlighted above represent the three main drivers of future growth for the Shannon Estuary, and will serve as the lenses through which the Estuary and its Vision 2041 Strategy will be reviewed:

1. Delivering Atlantic Offshore Wind at Scale
2. Green Industrial Development and Transition
3. Expanded, Diversified, and More Sustainable Logistics Services

The assessments performed in this Vision 2041 Strategic Review are aligned with the Strategic Integrated Framework Plan (SIFP), an inter-jurisdictional plan that was developed in parallel with the Vision 2041 Strategy. A key output of the SIFP was the identification of specific Strategic Development Locations (SDLs) as designated for marine-related industry. Since its publishing in 2013, the SIFP (and by extension, the SDLs) have been formally adopted by the respective development plans for Clare, Kerry, and Limerick County Councils. Figure 1 shows all the SDLs except for Limerick Docks, which is not included in this Vision 2041 Strategic Review.

Figure 1: Shannon Estuary SDLs, excluding Limerick Docks

Underpinned by a Strategic Environmental Assessment (SEA) and Appropriate Assessment (AA), both the Vision 2041 Strategy and the SIFP indicated that the development of these SDLs can be sustainably accommodated within the Shannon Estuary whilst safeguarding the natural environment. In turn, the land development recommendations contained within this Vision 2041 Strategic Review are broadly based around the SDL sites but also account for land demand arising from the renewables sector, developing new technologies, and the move toward larger ships.

The recommendations presented in this Vision 2041 Strategic Review are neither exhaustive nor prescriptive. Rather, they detail the possible options that will need to be further evaluated, including their relevant business case, environmental assessments, planning, and consent requirements at the appropriate time.

Driver 1: Delivering Floating Offshore Wind at Scale

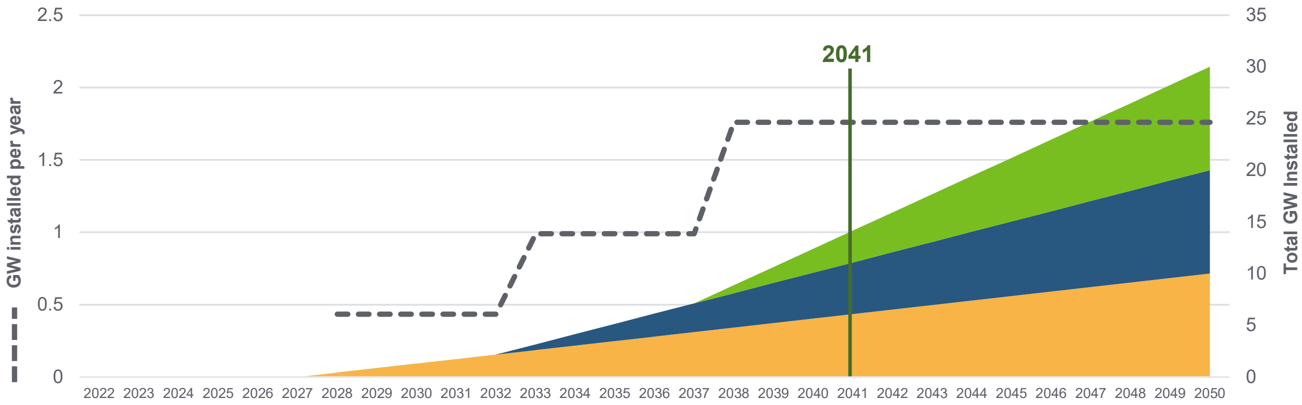
Since the Vision 2041 Strategy was published in 2013, perhaps the most consequential market development has been the accelerated emergence of the offshore wind industry, which was previously discounted due to the significant water depths not far off the Atlantic coast of Ireland, as well as fossil fuel's sustained global dominance. An increasing focus on combatting global climate change has induced rapid innovation in the offshore wind industry. As a result, the vast wind energy potential off the west coast of Ireland can now be viably harnessed through floating offshore wind turbines that can be deployed in much deeper waters.

By taking a closer look at Ireland's Atlantic domain and factoring in some key parameters, it is estimated that over 70 gigawatts (GW) of offshore wind potential is within the Shannon Estuary's reach. However, the vast wind energy potential within the Estuary's sights will remain just that – potential – unless this resource is connected to sources of demand, which can broadly be divided between domestic demand and European demand.

Domestically, the Climate Action and Low Carbon Development Act was enacted in March 2021 and commits Ireland to Net Zero carbon emissions by 2050, and as outlined by MaREI (the SFI Research Centre for Energy, Climate and Marine) in their "Zeroby50" study, this would require an approach involving (i) renewables-led electrification and (ii) the use of alternative, carbon-free combustion fuels ("e-fuels") for those energy consumption areas that cannot be electrified. In their 2021 report, Wind Energy Ireland adopted MaREI's outlook and calculated that a total of 27 GW of wind generation capacity will be required to satisfy Ireland's electricity and e-fuels requirements by 2050.

In Europe, the European Climate Law was enacted in July 2021 and – like Ireland – sets a legally binding target of "Net Zero" by 2050. Among the various types of renewable generation sources required to be brought online if this target is to be achieved, the European Commission recognises that offshore wind has the greatest scale-up potential and has stated that Europe will need up to 450 GW of offshore wind by 2050, presenting an enormous opportunity for the Irish Atlantic wind resource and the Shannon Estuary.[2]

Having surveyed the wind energy potential alongside prospective sources of demand and their possible routes to market, a set of generation capacity scenarios was developed that serve as a planning basis for this assessment. As shown in Figure 2, the low, medium, and high scenarios reflect different generation capacities delivered from the Shannon Estuary by 2050: 10 GW, 20 GW, and 30 GW.



Low Scenario	Medium Scenario	High Scenario
10GW by 2050	20GW by 2050	30GW by 2050
CAPACITY DEMAND IN 2050	CAPACITY DEMAND IN 2050	CAPACITY DEMAND IN 2050
Domestic electricity & E-fuels: (5GW - 10GW)	Domestic electricity & E-fuels: (5GW - 10GW)	Domestic electricity & E-fuels: (5GW - 10GW)
Electricity export: (0 GW – 5 GW)	Electricity export: (5 GW – 10 GW)	Electricity export: (10+ GW)
E-fuels export: (0 GW – 5 GW)	E-fuels export: (5 GW – 10 GW)	E-fuels export: (10+ GW)
CAPACITY SUPPLY PROFILE	CAPACITY SUPPLY PROFILE	CAPACITY SUPPLY PROFILE
~400MW per year from 2028	Increase to ~1,000MW per year from 2033	Increase to ~1,800MW per year from 2038
~25-30 turbines per year	~65 turbines per year	~120 turbines per year

Figure 2: Wind Power Generation Capacity Delivered by the Shannon Estuary – Scenarios for 2050

The demand cases for the scenarios are split into three components: domestic, electricity export, and e-fuels export. Whereas the domestic demand component carries the same range across all three scenarios, the two export components incrementally increase from the low to high scenarios. Simply put, the scenarios reflect three varying degrees of success in being able to tap Atlantic offshore wind into European demand.

Whilst the 2050 capacities vary greatly across the three scenarios, Figure 2 shows that they all share the same starting point, in terms of both start date (2028) and initial annual delivery capacity (~400 megawatts [MW] per year). Using a common starting point across the three scenarios reflects the realities of capital infrastructure development and of the likely rate of market uptake, both domestically and internationally. The three scenarios are shown as being achieved in a phased manner, which enables the formation of a long-term vision as well as a great degree of flexibility. Wind farm delivery-related infrastructure identified in this Vision 2041 Strategic Review can be deployed earlier or later in response to overriding market conditions and policy drivers.

Delivering Floating Offshore Wind from the Estuary

The fundamental building blocks of the floating wind farm delivery chain and the process through which they come together are unpacked in detail in the main report. The discussion immediately below is limited to those delivery chain activities where proximity to the wind farm is essential, thus making the case for their establishment on the Shannon Estuary. These activities are: (1) Floating Offshore Wind Turbine (FOWT) integration, (2) substructure assembly, (3) wet storage, and (4) wind farm operations and maintenance.

FOWT Integration Base at Foynes Deepwater Port

The planned Foynes Deepwater Port is located at Foynes Island, directly across the main berthing channel from the Port of Foynes. It is proposed that Foynes Deepwater Port hosts an FOWT integration base, which entails the final assembly and pre-commissioning of the wind turbines prior to their departure for the wind farm. Subject to a detailed feasibility study, the targeted FOWT construction throughput will be approximately 400 MW per year, in line with the low scenario. Phased expansions of Foynes Deepwater Port could increase throughput to 1,800 MW per year (subject to detailed feasibility study), in line with the high scenario.

Substructure Assembly Base at Moneypoint

As part of its Green Atlantic project, ESB intends for its Moneypoint site to become a centre for the construction and assembly of floating wind turbine structures. The substructure assembly facility at Moneypoint would serve as one of the Estuary's core delivery bases for floating offshore wind and would complement the turbine integration port currently planned for Foynes Deepwater Port. ESB is targeting for its facility to be capable of a substructure throughput of 1,000 MW annually, and their targeted completion by 2028 coincides with the Foynes Deepwater Port plans, setting the Estuary up well for being able to deliver at least 10 GW by 2050 as per the low scenario.

Wet Storage Along the Estuary

Wet storage of both substructures and completed FOWTs will be necessary to minimise the impact of any supply chain disruptions and weather. Wet storage areas should have at least 15-m water depth and be suitably sheltered and separated from the main navigation channel. Potential wet storage areas have been preliminarily identified along the Shannon Estuary and total approximately 700 hectares, significantly exceeding the estimated requirements of even the high scenario, making the Shannon Estuary uniquely positioned to deliver floating offshore wind at scale.

Operations and Maintenance Base at Port of Foynes

Ongoing operational and maintenance support to the Atlantic offshore wind developments requires quayside laydown and frequent berth access to accommodate crew and equipment transfers. Deciding on a location involves many factors and ultimately rests with the wind farm operator but, given its current available capacity and its proximity to the integration base at Foynes Deepwater Port, the Port of Foynes is well-suited to serve as the starting point for wind farm operations and maintenance (O&M) activities.

Additional Delivery Chain Opportunities for the Estuary

The integration port at Foynes Deepwater Port, the substructure assembly yard at Moneypoint, the designated wet storage areas, and the O&M base at Port of Foynes together constitute the delivery chain activities where proximity to the wind farm – and therefore their establishment on the Estuary from the outset – is essential. Among those that are not so constrained by proximity, certain delivery chain activities have a higher likelihood of being established locally if annual turbine delivery rates increase to a point where colocation becomes an attractive investment for potential developers. This includes blade manufacturing facilities, blade recycling facilities, and miscellaneous steel fabrication facilities. The basic requirements of such facilities are discussed in the main report, with both Cahiracon and Port of Foynes as candidate locations for such facilities.

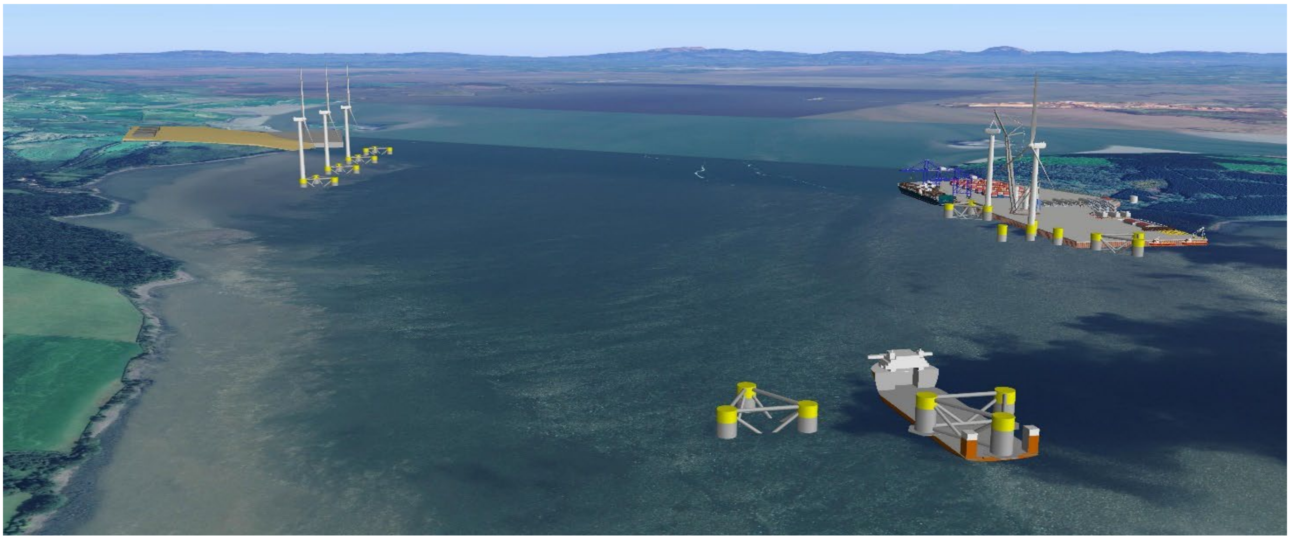


Figure 3. FOWT Integration Base at Foynes Deepwater Port and Wet Storage.

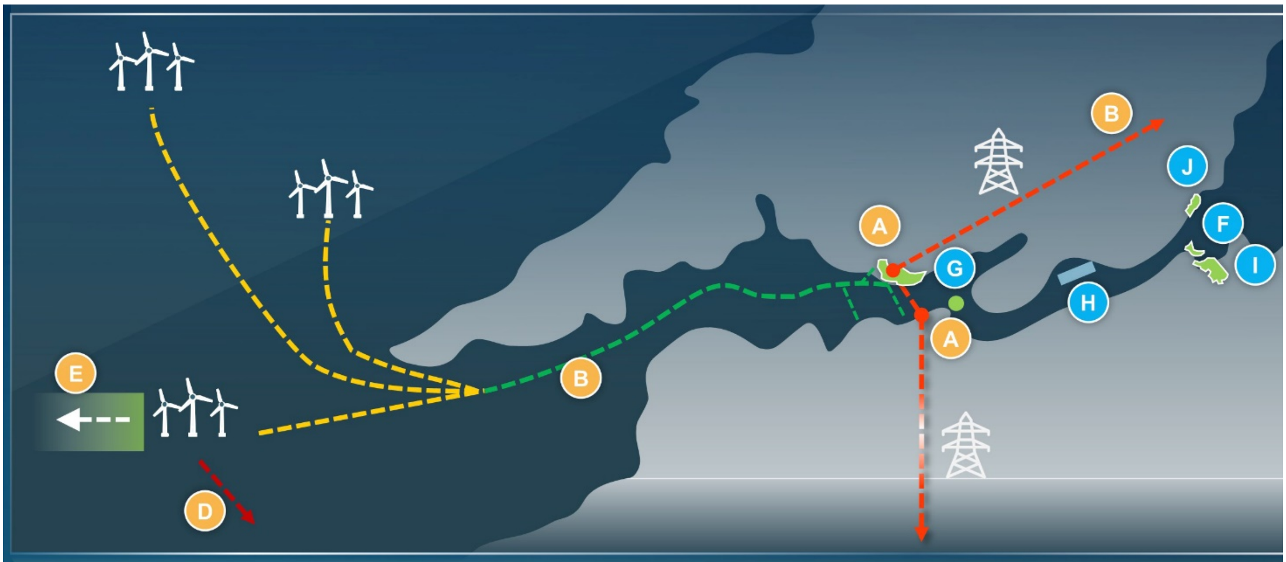
Estuary Transmission Infrastructure

Situated at the western end of Ireland’s main 400-kV cross-country transmission lines and with high-voltage substations on both its north and south shores, the Shannon Estuary is well-positioned to serve as the “go-to” destination for connecting west coast offshore wind power to domestic demand in the near term.

Multiple long-distance high-voltage direct current (HVDC) submarine cables will be required for 10+ GW of Atlantic offshore wind power to reach Ireland’s shores. Therefore, it is imperative that the initial cable deployments are planned with future expansion in mind. “Cable corridors” could be established that effectively reserve a route (allowing for sufficient width to accommodate spacing between cables) for additional HVDC submarine cables. Subject to detailed study, establishing such a “cable corridor” through the Shannon Estuary could be feasible given its water depth and overall width. This approach could more readily leverage existing grid infrastructure, whereas routing the cable elsewhere along the outer west coast would likely require the establishment of significant “greenfield” facilities shoreside and associated over-land transmission lines through potentially sensitive areas.

The Shannon Estuary can also act as a conduit delivering electricity to the European grid by connecting to one of Ireland’s high-voltage interconnects. Additionally, the hybrid project concept offers an alternative route through which electricity generated by Atlantic offshore wind could be conveyed directly to Europe without ever touching Ireland’s shores. It is imperative for the long-term future of Atlantic offshore wind that hybrid projects linking it directly to Europe be studied and advanced today.

One leap beyond the hybrid project is SuperGrid, a pan-European transmission network that would allow huge volumes of electricity to move across great distances. The SuperGrid offers great promise for the rapid development of renewable generation across Europe and, particularly, for Ireland considering the size of Ireland’s offshore wind resource compared to its domestic demand. Inherent in the realisation of the SuperGrid is the advancement of higher capacity transmission technologies, such as those using special superconducting materials. Though not ready for implementation today, the swift advancement and deployment of long-distance high-capacity superconducting cables would be a welcome boon for the SuperGrid and ultimately for Atlantic offshore wind.



	2022-2025	2026-2030	2031-2035	2036-2041
Route to Market	Substations Upgrades and Expansions	HV cable corridor through the Estuary Local / regional grid upgrades for Green Industry	Grid reinforcement to HV interconnects Direct HVDC Connection to Europe	SuperGrid connection
Estuary Facilities		Foynes Turbine Integration Base Phase 1 Substructure Assembly Base at Moneypoint Wet storage areas along Estuary	Foynes Turbine Integration Base Phase 2 Blade manufacturing at Cahiracon	Foynes Turbine Integration Base Phase 3

Route To Market Developments

A Estuary Substations Upgrades and Expansions: By upgrading and expanding the existing high-voltage substations at Moneypoint, Tarbert, and Kilpaddoge, the Estuary is well-positioned to serve as a major receiving node for offshore wind electricity.

B HV cable corridor through the Estuary: A high-voltage subsea "cable corridor" through the Estuary that accounts for future expansion can more readily leverage existing onshore grid infrastructure and minimise greenfield facilities shoreside, as well as streamline the planning process.

C Grid Reinforcements to HV Interconnects: Further grid reinforcements will be needed for Atlantic offshore wind electricity to access the existing and expanding HV interconnects from Ireland to Great Britain and France.

D Direct HVDC connection to Europe: Hybrid projects that combine offshore generation with HV interconnection can link Atlantic offshore wind power to European demand without ever touching Ireland's shores.

E SuperGrid connection: The SuperGrid is a large pan-European transmission network which would make possible to move huge volumes of electricity across great distances, offering significant promise for renewables generation across Europe, not least in the Irish Atlantic.

Estuary Facilities Required

F Foynes Turbine Integration Base: Located on Foynes Island directly across the main berthing channel from the Port of Foynes, Phase 1 of Foynes Deepwater Port will be capable of supporting both wind turbine integration and containerised cargo operations simultaneously.

G Substructure Assembly Base at Moneypoint: A key element of ESB's Green Atlantic project, this will serve as one of the core delivery bases for floating offshore wind and would complement the turbine integration port currently planned at Foynes Island.

H Wet storage: The Estuary's potential for wet storage space in sheltered deep water offers a crucial risk-mitigating solution for supply chain disruptions, enabling the full potential of Atlantic offshore wind to be realised.

I Windfarm O&M Base at Port of Foynes: Ongoing operational and maintenance support to the Atlantic offshore wind developments requires quayside laydown and frequent berth access to accommodate crew and equipment transfers, all of which can be provided at Port of Foynes.

J Blade manufacturing and EOL facilities at Cahiracon: Increases in the annual turbine delivery rate can attract additional supply chain activities, such as blade manufacturing and end-of-life recycling, which can be accommodated at Cahiracon through its available land and deepwater access.

Figure 4: Delivering Atlantic Offshore Wind at Scale from the Shannon Estuary

With respect to Driver 1 “Delivering Floating Offshore Wind at Scale”, the key findings are listed below.

Key takeaways…

- The Shannon Estuary is uniquely-positioned to deliver floating offshore wind at scale, given its (1) proximity to the resource, (2) deep water facilities, (3) ample space for wet storage, and (4) existing high voltage grid connections.

- The design and installation methods for floating offshore wind turbines require that certain assembly activities take place relatively close to the wind farm. It is estimated that over 70 GW of development potential is well within the Shannon Estuary’s reach.

- Having surveyed the wind energy potential alongside prospective sources of demand and their possible routes to market, a set of generation capacity scenarios was developed that will serve as a planning basis for this assessment. The three scenarios reflect different generation capacities delivered from the Shannon Estuary by 2050: 10 GW, 20 GW, and 30 GW.

- This assessment recommends the establishment of four core facilities on the Shannon Estuary to support the delivery of floating offshore wind at scale:
    1. FOWT integration and pre-commissioning at Foynes Deepwater Port,
    2. FOWT substructure assembly at Moneypoint,
    3. Wet storage at various locations along the Estuary, and
    4. O&M base at the Port of Foynes.

- The establishment of these four core facilities on the Estuary lays the groundwork for the potential development of additional delivery chain capabilities over the longer term, such as turbine blade manufacturing, blade recycling and miscellaneous steel fabrication.

- The Shannon Estuary’s unparalleled potential for deep water wet storage – totalling in the hundreds of hectares and suitably separated from the main navigation channel – offers a crucial risk mitigating solution towards realising the full potential of Atlantic offshore wind.

- Situated at the western end of Ireland’s main 400kV cross-country transmission lines and with high-voltage substations on both its north and south shores, the Shannon Estuary is well-positioned to serve as a major receiving node for Atlantic offshore wind electricity.

- For 10+ GW of Atlantic offshore wind power to reach the Estuary’s shores multiple long-distance HV submarine cables will be required. Therefore, initial submarine cable deployments must be planned with future expansion in mind.

- A “cable corridor” running through the Shannon Estuary could more readily leverage existing onshore grid infrastructure and minimise the need for significant “greenfield” infrastructure elsewhere along the outer western coast.

- The feasibility of hybrid projects that would link Atlantic offshore wind directly to Europe must be studied and advanced urgently.

- The swift advancement of the SuperGrid (a pan-European high-volume transmission network and underlying superconductor technology) would be a welcome boon for Atlantic offshore wind.

Driver 2: Green Industry and Transition

The Shannon Estuary's proximity to an abundance of renewable power from offshore wind provides the potential for significant production of Net Zero compatible fuels, such as green hydrogen and its various derivatives. In addition to transforming local industry and helping the country accelerate its transition to a Net Zero future, this will enhance Ireland's energy security as it reduces reliance on imported fossil fuels. Through green hydrogen production and export, Ireland can also become a net exporter of energy, providing it with a new revenue stream.

Green hydrogen production is fully consistent with the Net Zero route and is the most compatible option with the EU's climate neutrality and zero pollution goal in the long term and the most coherent with an integrated energy system.[3] It relies on technologies that have long been well known, based on water electrolysis powered by renewable electricity (see Figure 5).

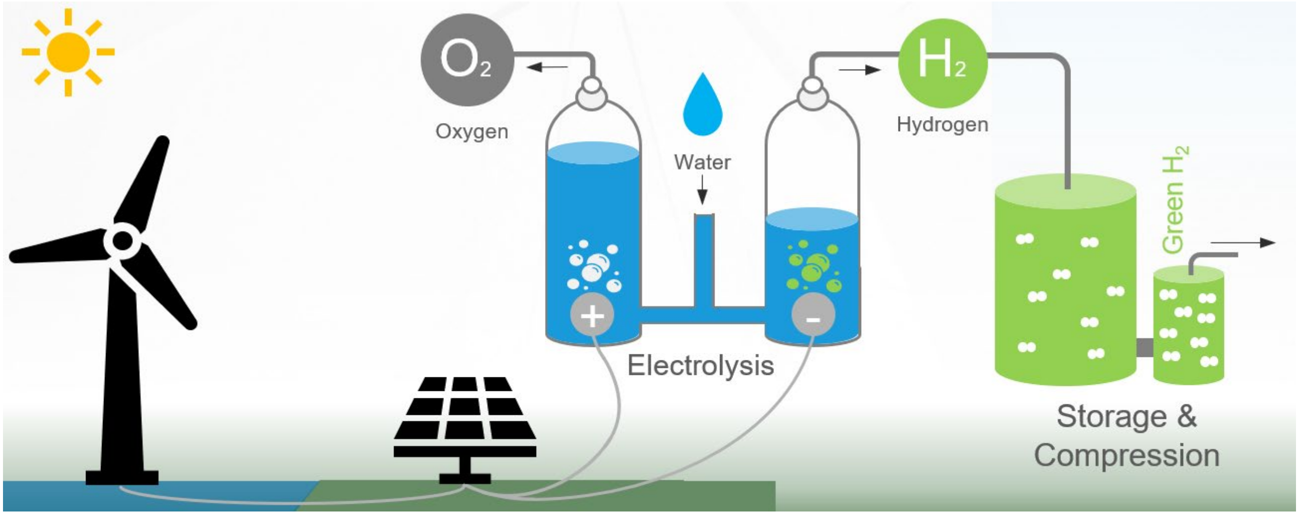


Figure 5: Production of Green Hydrogen

There is currently no industrial-scale production of hydrogen in Ireland. However, in July 2022, the Irish Government established a target for 2 GW of green hydrogen to be produced by 2030.[4] The development of a green hydrogen industry on the Shannon Estuary presents multiple opportunities:

- To store Ireland's offshore wind energy for use when the wind is not blowing.
- To decarbonise Ireland's industrial sectors through replacing natural gas with carbon-free green hydrogen.
- To decarbonise Ireland's transport sectors through green hydrogen or the production of e-fuels.
- To decarbonise Ireland's agriculture sector through the production of green ammonia for fertiliser.
- To become a net energy exporter through the Irish supply of green hydrogen to Europe.

The Shannon Estuary has long been an energy storage hub for Ireland, considering the coal stockpiles at Moneypoint, the National Oil Reserves Agency (NORA) reserves at Tarbert, and inventories at the Port of Foynes. Transitioning the Shannon Estuary away from fossil fuel storage and into a leading renewable energy storage hub through the production and storage of green hydrogen and green ammonia produced from offshore wind and through additional grid services such as the deployment of long-duration, large-scale battery storage facilities will play a key role in Ireland's transition to Net Zero.

There is a significant potential for the development of a green hydrogen ecosystem in the Shannon Estuary (see Figure 6). The region is already home to the largest electricity producers in the country along with some of the largest industrial energy and fuel consumers. A new industrial future powered by wind energy and fuelled by green hydrogen should be an obvious goal for the region; this will require significant collaboration between industry and the Government to ensure policy is in place to achieve this goal as soon as possible and to further accelerate the country's transition to Net Zero.

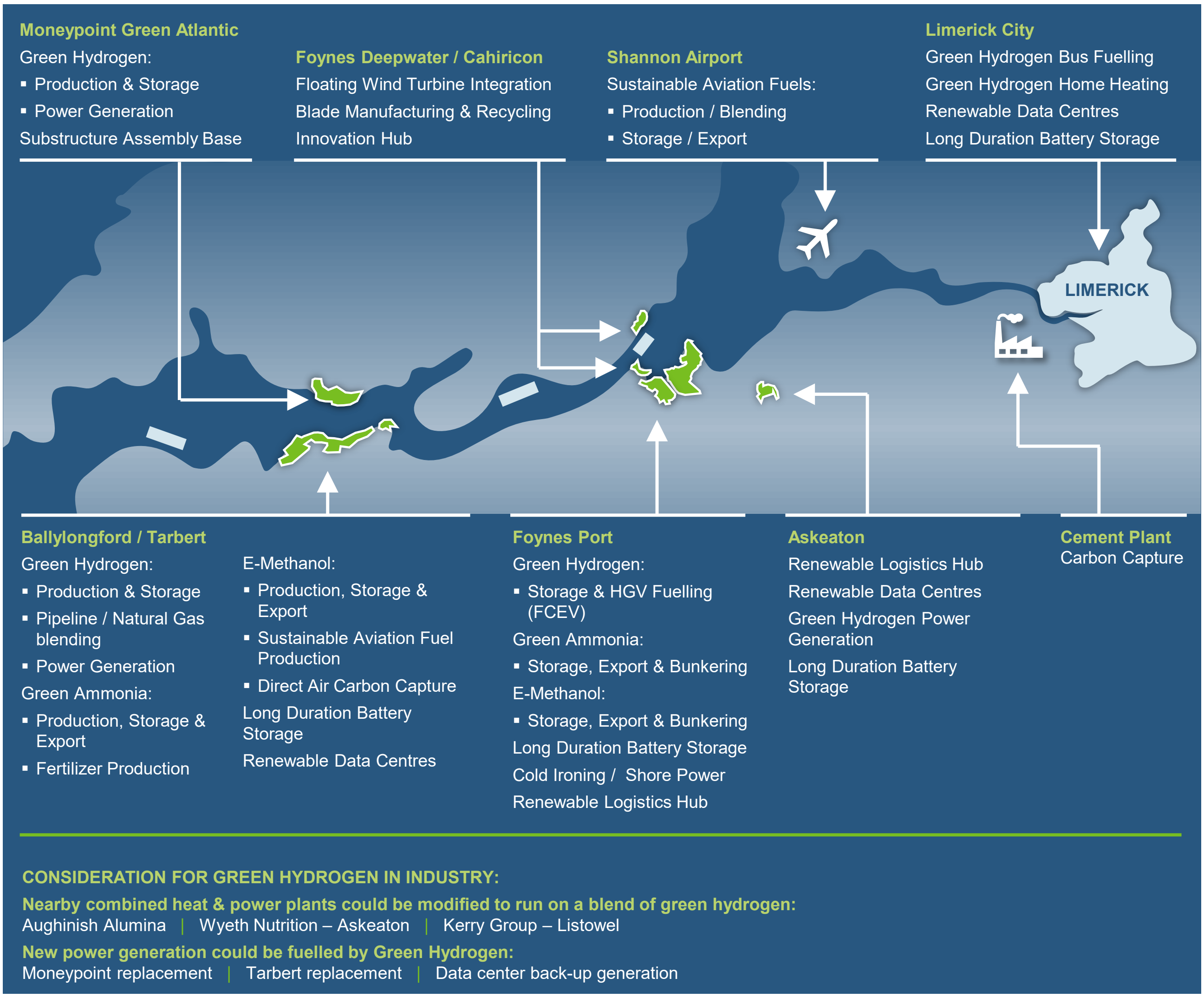


Figure 6: Shannon Estuary Green Industrial Ecosystem

Central to the establishment of a green hydrogen ecosystem on the Shannon Estuary is the development of a gigawatt-scale green hydrogen production facility. Among the various SDLs along the Estuary, the Ballylongford/Tarbert landbank emerges as an ideal location for such a facility considering the availability of land, the proximity to the offshore wind and the potential cable land fall location, the access to water for electrolysis and cooling and deep water for ship exports, the proximity to existing electrical grid and potential development of new gas grid for the Shannon Technology and Energy Park (STEP) project, and the existing Upper Tier Seveso site. The colocation of facilities could potentially reduce costs for the development of these plants and allow a shorter time frame for delivery of new facilities.

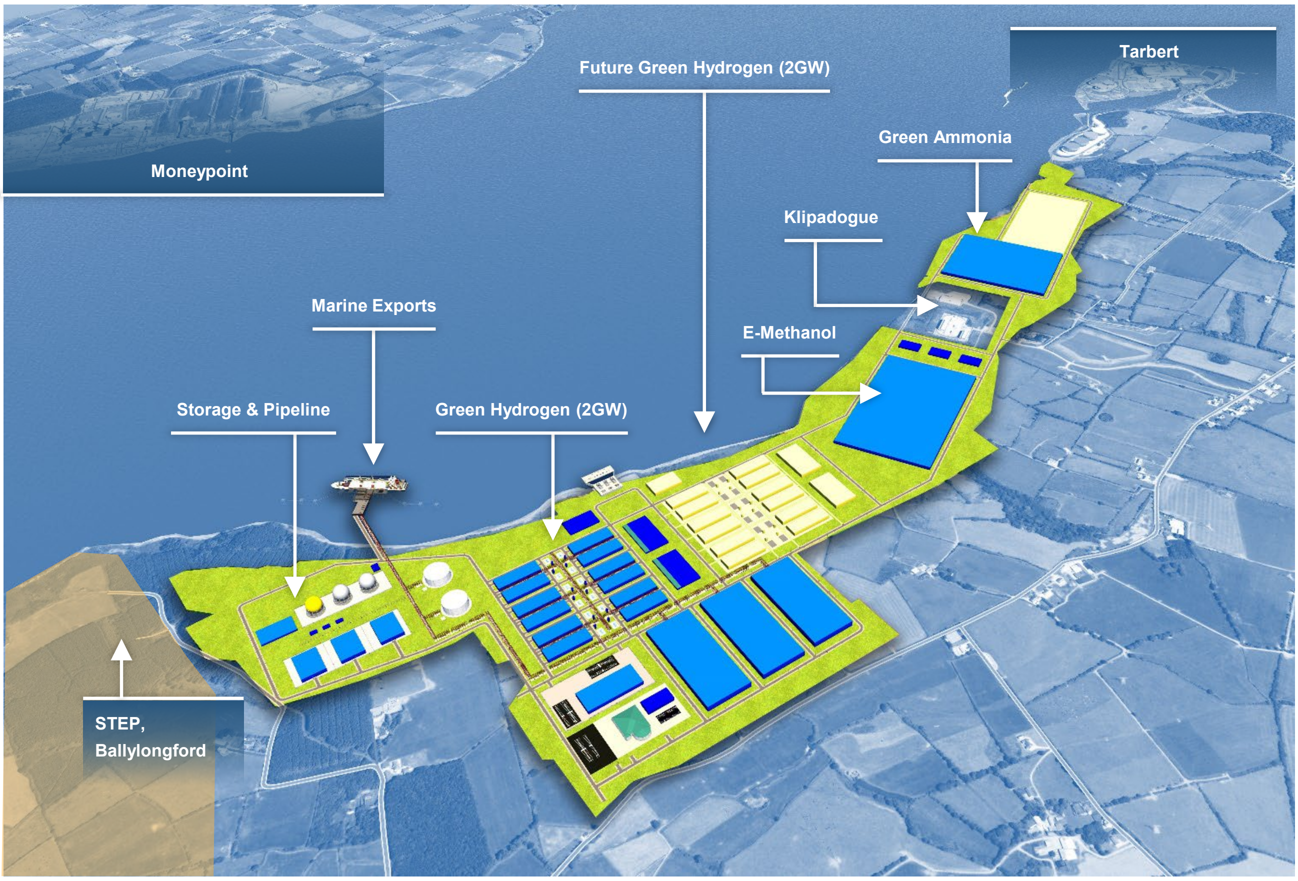


Figure 7: Green Hydrogen & Derivatives Production

From this location, hydrogen could be piped directly to industry along the Estuary should significant demands emerge. Quantities of hydrogen could also be trucked from this location directly to industry and to hydrogen re-fuelling stations that would power heavy goods vehicles at Shannon Foynes Port or the bus fleets operating from Limerick City and the surrounding region. At this location, hydrogen can also be further processed into ammonia for domestic production of fertilizer or for large-scale energy export via ships carrying ammonia to European markets that have a hydrogen deficit.

Production of e-methanol should also be considered at this location. This fuel can be bunkered for large-scale shipping, thereby further supporting decarbonisation of port operations at Shannon Foynes. The e-methanol can also be processed into synthetic kerosene, which can be used as a Sustainable Aviation Fuel (SAF). The production of e-methanol requires a supply of carbon dioxide (CO_2), this could be captured from the air through Direct Air Capture (DAC) at a new facility along the Estuary or, alternatively, it could be captured directly from the off-gasses produced by large CO_2 emitters in the region. A facility that produces or blends SAFs, supplied by green hydrogen and CO_2 pipelines, could also be accommodated with the facility being adjacent to the Shannon Airport, which would provide colocation benefits with existing fuel storage facilities and the existing marine terminal. The development of sustainable fuel facilities on the Shannon Estuary could serve as a production hub for the island of Ireland from where sustainable fuels could be transported via road, rail, or ship.

The availability of green hydrogen also supports the development of a digital ecosystem within the Shannon Estuary. The potential abundance of renewable energy from offshore wind, combined with green hydrogen as a fuel for back-up generation and the proximity to water for efficient and more environmentally friendly cooling, presents an ideal location for the development of a hyperscale data centre industry. This industry on the Shannon Estuary would be in line with the government's principles for future data centre development in Ireland as it would demonstrate the additionality of renewable energy use and ultimately provide Net Zero data services without impacting the existing grids.

With respect to Driver 2 “Green Industry and Transition”, the key findings are listed below:

Key takeaways…

- The Shannon Estuary can take advantage of the abundant Atlantic offshore wind energy to develop an industrial ecosystem centred around green hydrogen.
- There is land available on the Tarbert – Ballylongford landbank which could facilitate the development of at least 4 GW of hydrogen electrolysers and provide a suitable location for landfall of HVDC cables transporting electricity from floating offshore wind farms in the Atlantic.
- Green hydrogen produced on the Estuary can be used to fuel local power plants and the large local industry providing an accelerated path to decarbonisation.
- Green hydrogen produced on the Estuary can be used to fuel heavy goods vehicles (HGVs) at the Port of Foynes or transported to other locations such as Limerick City to fuel HGVs, buses and coaches.
- Green ammonia can also be produced on the Estuary and can be used for the future fuelling of ships, for the production of fertiliser or for seaborne exports.
- Sustainable fuels such as e-methanol can be produced on the Estuary. This can be used as bunker fuels for large ships and maritime transport benefiting the Shannon Foynes Port and other Irish ports.
- Sustainable Aviation Fuels (SAF) can be produced on the Estuary for use in Shannon Airport and other Irish airports.
- The production of e-methanol creates a circular economy on the Shannon Estuary as it requires captured CO_2 for its production. There is a potential to capture the CO_2 either directly from the air or from the large CO_2 emitters in the region.
- The circular economy on the Shannon Estuary is further supported through the development of large data centres in the area. These provide additionality for renewable energy and can reduce the demands on the Irish electricity grid.
- Green hydrogen produced along the Estuary can be blended into the gas network and can eventually be used as a source of green hydrogen for the European Hydrogen Backbone.
- The Shannon Estuary can fulfil Ireland’s target to produce 2GW of green hydrogen by 2030.
- The production of offshore wind energy, green hydrogen, green ammonia and sustainable transport fuels from the Shannon Estuary should be accelerated to achieve Ireland’s 2030 climate targets.
- The Shannon Estuary should be designated as a dedicated “go-to” area for renewables and the need for green industrial development on the Shannon Estuary recognised as an overriding public interest.

Driver 3: Expanded, Diversified, and More Sustainable Logistics

Adjacent to the world's busiest shipping routes, with current capacity to handle over 10 million tonnes annually and with water depths of up to 32 m, the facilities on the Shannon Estuary are uniquely positioned to expand as an international cargo hub serving the domestic, European, and worldwide markets. The turnover value of current trade handled by the Port is EUR €8.5 billion per annum, with associated economic impacts of EUR €1.9 billion pa supporting over 3,900 jobs. SFPC is an EU Core Corridor Port (TEN-T) and a Tier 1 Port in the National Ports Policy, effectively designating the Shannon Estuary as a commercial watercourse of international significance.[5]

As the largest bulk port in the country, approximately 20% of national maritime cargo tonnage travels through the Shannon Estuary across six terminals. The Port of Foynes, Limerick Docks, and Shannon Airport facilities are owned and operated by SFPC. The other three dedicated facilities at Aughinish, Moneypoint, and Tarbert are managed privately but serviced by SFPC.

Driven by base business growth as well as national climate objectives related to decarbonising both the energy and transport sectors, Estuary logistics will see a shifting mix in operations and growth that will necessitate port expansions and ground transport upgrades. Shannon Foynes stands today within a 2.5-hour drive of 75% of Ireland's gross domestic product (GDP) (see Figure 8), a catchment that is enhanced by the delivery of the planned road schemes for the region.

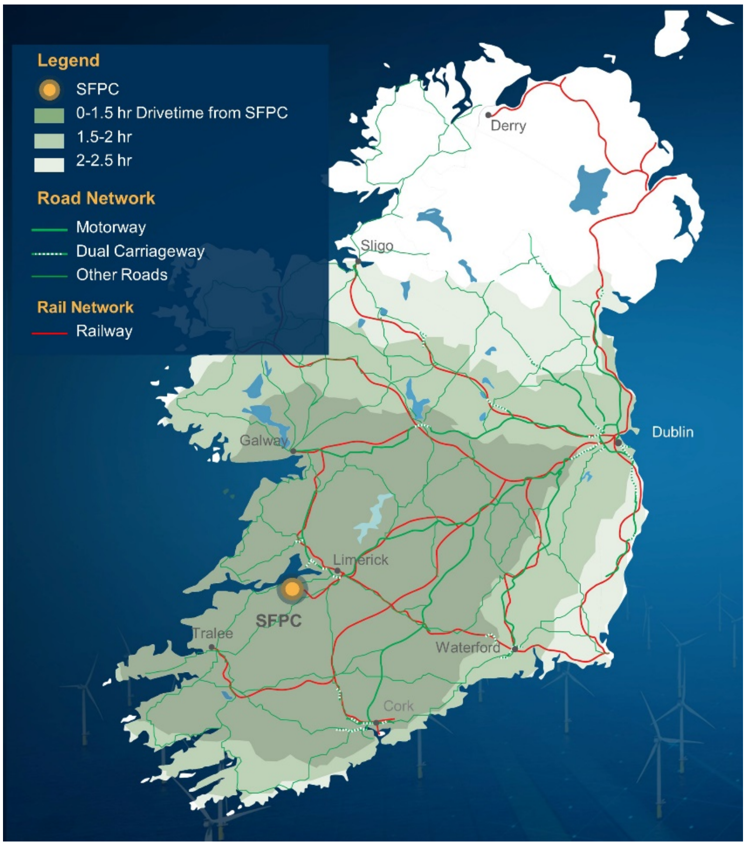


Figure 8: Travel time from Shannon Foynes

The expansions and upgrades to the Shannon Estuary's ground transportation links help facilitate the expansion in the logistics business. The Port of Foynes is linked to the national road network via the N69, and the planned Limerick-Foynes Road scheme will further enhance its access to the wider Irish market through improved connections to Ireland's motorways and upgrades to existing routes. This provides ground transport carriers the ability to leverage a motorway and dual carriageway to access the Port of Foynes, further cementing this Tier 1 Port in the national logistics network and provides best-in-class connectivity from quay to road.

Unique to the Port of Foynes and future Deepwater Port at Foynes Island is the direct access to the Irish Rail network. Recent announcements regarding the Limerick-Foynes rail link indicate that it will be reinstated and active by mid-2024.[6] The re-establishment of the Foynes rail link, along with rail investments at the national level, will deliver a network of freight transport options that relieves congestion and supports national decarbonisation objectives. With rail freight connections, the Port of Foynes will enhance national and international connectivity and will be the only Tier 1 Port in the country featuring direct rail access to a Panamax-capable port.

Investment in logistics infrastructure such as the Foynes Deepwater Port and expanded hinterland facilities at Foynes, new and re-purposed port facilities at Moneypoint and along the Ballylongford/Tarbert landbank, and nationally strategic road and rail projects, highlights the Estuary's offering of new services geared toward renewable energy and decarbonising the supply chain. This, in turn, enables it to play a significant role in the Government's Climate Action Plan over the years to come.

Figure 9: Foynes Deepwater Port and Port of Foynes Estate, Artist Rendering

The development of the Deepwater Port at Foynes Island (Figure 9) will provide both offshore wind integration services as well as a Neo-Panamax-capable container terminal. The container terminal will provide the required capacity to expand the container business at the inner Port of Foynes. Further complemented by its rail access, this terminal offers diversified and sustainable logistics.

The Port of Foynes and nearby SDLs are further advantaged in their capacity to offer cost-effective development of warehouses and distribution centres located at a major port. Irish businesses have an opportunity to locate their supply chain operations within a well-connected and uncongested Tier 1 Port.

	2021	2031	2041
Base Line	10,975,000	11,144,000	12,808,000
Mid Line	10,975,000	13,648,000	17,061,000
High Line	10,975,000	17,190,000	22,212,000

Table 1: Shannon Estuary Updated – Total (tons/yr)

	2021	2031	2041
Base Line	2,657,000	3,204,000	3,311,000
Mid Line	2,657,000	3,535,000	4,072,000
High Line	2,657,000	4,020,000	5,143,000

Table 2: General Cargo Ports Updated (tons/yr)

Moreover, warehouse rental rates in the Limerick area offer a lower cost option compared to the lettable facilities in the Greater Dublin Area (GDA). SFPC enhances their offering by establishing fully integrated port and logistics facilities and services to customers looking to develop or lease business park or warehouse property.

Throughout this expansion and growth of emerging businesses, the Estuary is facing a transition away from coal and heavy fuel oil (HFO) power stations to an Estuary with the potential to deliver offshore wind units, natural gas, and emerging renewable fuels. The proposed shutdowns of Tarbert and Moneypoint generating stations represent a near-term decrease in Estuary tonnage that will be more than offset by new offshore wind and container businesses.

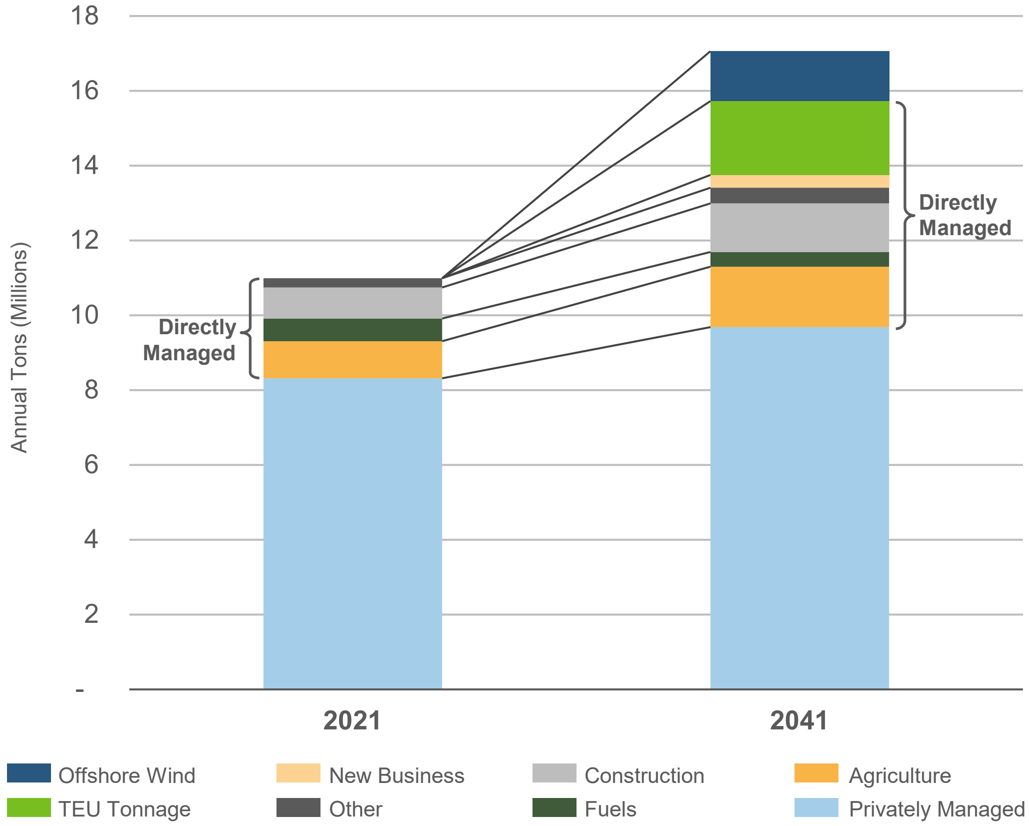


Figure 10: Projected Change in Throughput Composition (Mid Line), 2021–2041

The result of these shifts in operations across the Estuary brings about a greater proportion of forecasted Estuary traffic to be directly managed by the SFPC (Figure 10), with new businesses in container traffic and offshore wind driving the transition.

Overall, investments in the port's infrastructure and the national supply chain will further unlock latent capacity at Shannon Foynes. In line with Government priorities from the National Development Plan,[7] strengthening the required economic connections to this Tier 1 Port will enable Ireland to better leverage this important and needed node in the national logistics network. Specifically, this includes the delivery of the following key infrastructure developments:

- Limerick-Foynes road scheme,
- Limerick-Foynes rail reinstatement,
- Development of the Port of Foynes, and
- Development of Foynes Deepwater Port.

In summary, the SFPC offers businesses a unique opportunity to locate their supply chain operations and storage within a Tier 1 Port. There are also significant real estate pricing advantages in and around the Shannon Estuary for lettable industrial spaces, with strategic land available for development of conveniently located distribution centres, logistics facilities, and warehouses.

With respect to Driver 3 “Expanded, Diversified, and More Sustainable Logistics”, the key findings are listed below:

Key takeaways…

- Logistics are the cornerstone of SFPC today and will continue to be sustainable long into the future with the addition of more diverse markets.
- Strategic infrastructure investments in ground transport links and port expansions will allow this Tier 1 Port to develop further as a key node in the Irish logistics network and support Ireland’s overall economic growth.
- The Foynes-to-Limerick Road Scheme and reinstatement of the Foynes-to-Limerick rail line are essential hinterland connections that will enhance and improve resilience in the national supply chain by improving access to the deepwater port of SFPC.
- Located at an uncongested location on the national supply chain, the development of the Foynes Deepwater Port makes the Port of Foynes the only Tier 1 neo-Panamax-ready port with rail access.
- The establishment of container services and the emergence of new renewable business sectors, such as offshore wind and e-fuels, are expected to drive growth above and beyond the base cargo businesses.
- Distribution centres and light industrial park capacity at the Port of Foynes and Askeaton SDLs offers businesses a unique opportunity to cost-effectively locate portions of their supply chain within (or within close proximity to) a Tier 1 Port.

Energy Transition Skills Requirements

In November 2021, the Department of Enterprise, Trade and Employment published the Skills for Zero Carbon report.[8] This report recognised the need to urgently accelerate the transition to a Zero Carbon Economy and outlined recommendations for consideration with regard to the overall delivery of the Climate Action Plan. While it is difficult to give a definitive projection for the Shannon Estuary, considering all the potential for development, the below benchmarks provide some idea of the scale of new job creation.

The renewable energy targets set out as the basis in that report have since been increased for offshore wind (moving from a target of 5,000 MW to 7,000 MW) and now a dedicated target for green hydrogen (an additional 2,000 MW) has been established by the Irish Government. Therefore, the hydrogen economy was not envisaged in the Skills for Zero Carbon report and accordingly the skills demands for offshore wind must be scaled up by 40% (Table 3).

Table 3: Full Time Equivalent jobs per MW of installed capacity (Source: Skills for Net Zero & adapted)

Offshore Wind	Planning & Installation	Operations & Maintenance (Annual)
Skills for Zero Carbon (based on 5GW)	2.3	0.22

Scaling these same numbers as a basis for full time equivalent (FTE) for the Atlantic Offshore wind delivered at scale for the low scenario from the Shannon Estuary provides the following estimate (Table 4).

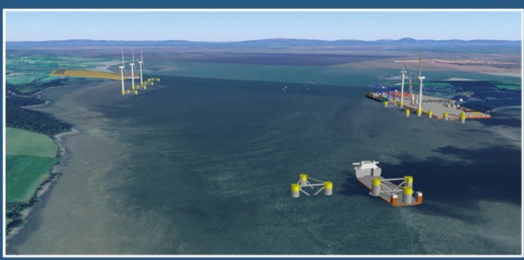
Table 4: Estimated FTE for the Atlantic offshore wind delivered at scale from the Shannon Estuary

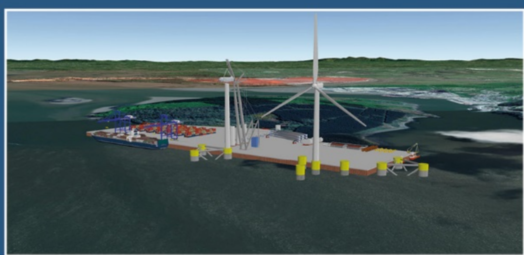
	Planning & Installation	Operations & Maintenance (Annual)
Low Scenario 10GW by 2050	23,000	2,200

With respect to hydrogen jobs, the Hydrogen and Wind Energy report published in January 2022 on “The role of green hydrogen in Ireland’s energy transition” commissioned by the Green Tech Skillnet in partnership with Wind Energy Ireland and Skillnet Ireland examined the likely role of green hydrogen in Ireland’s energy transition and the associated future talent and skills requirements. The report stated that if just heavy goods vehicles and buses were to switch from diesel to green hydrogen it would require at least 1.4 GW of dedicated wind energy generation. Synthesising just 50% of shipping and aviation fuels would require a further 6.6 GW. The construction of the required wind farms and the electrolysis alone would require an investment of c. €18.4 bn, resulting in the generation of approximately 16,000 direct and a further 32,000 indirect jobs. [9]

Therefore there is a considerable opportunity for new employment in the Shannon Estuary related to offshore wind development and green hydrogen and associated derivative production. Even just considering the low scenario of offshore wind development and the current government target for green hydrogen thousands of new jobs will be created. This will need to be supported by local and national development plans to ensure there is sufficient housing, utilities, transport and amenities provided in the region for the new workers and their families.

Setting the Scene





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1. Introduction

SFPC is situated on the deepest watercourse in Ireland, the Shannon Estuary, which is one of the deepest estuaries in the world. It extends to over 500 km^2 and has channel depths of up to 32 m. SFPC has statutory maritime jurisdiction over the entire Shannon Estuary and is designated as a Tier 1 Port at a national level and as a “core corridor port” on the EU’s Trans-European Transport network (TEN-T).

In 2013, SFPC published its thirty-year Vision 2041 Strategy outlining the Port’s future objectives for the medium to long term. This Strategy identified future port demand and associated landside and waterside capacity requirements such as port infrastructure and intermodal hinterland connectivity infrastructure.[10]

As well as guiding port development, Vision 2041 has been instrumental in influencing national, regional and local policy regarding the Port’s requirements. It has been a key document in securing recognition under EU TEN-T Policy such as the recent inclusion of SFPC in the North Sea Mediterranean Core Corridor grouping of ports (see Figure 11).

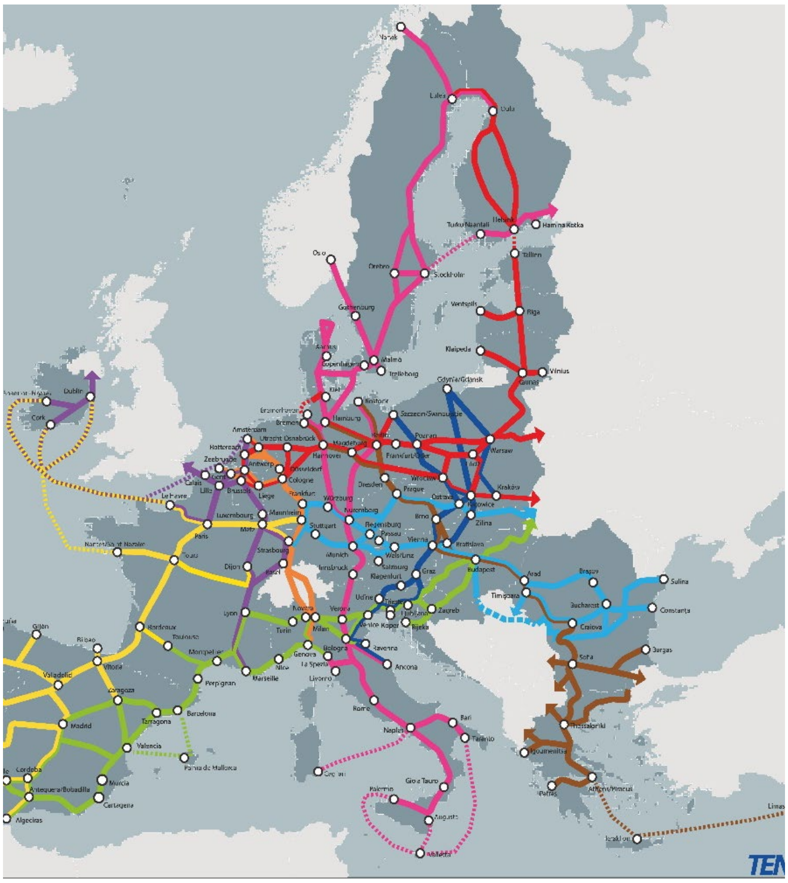

Figure 11: Trans-European Transport (TEN-T) Network Corridors Map[11]

The Vision 2041 Strategy indicated that a review would take place over a seven-to-ten-year timeframe. Accordingly, this document represents such a review (“Vision 2041 Strategic Review”) and is intended to refresh and re-affirm the Vision 2041 Strategy as well as inform a formal update in the future.

This Vision 2041 Review has set out to account for shifting political, environmental, and market dynamics since Vision 2041 was published. By far the most significant shifts relate to global climate change and the policy responses to combat its effects at a national and European level. Years in the making, both the European Commission’s European Climate Law and Ireland’s Climate Action and Low Carbon Development Act were formally enacted in 2021 and set a legally binding target of Net Zero carbon emissions by 2050. As outlined in Ireland’s Climate Action Plan 2021, the implications of these pieces of legislation are immense and far reaching, not least with regards to the Shannon Estuary, whose naturally occurring and expansive deep waters will allow it to play a pivotal role in delivering on the objectives therein.

First, achieving “Net Zero” will require a dramatic increase in renewable electricity generation capacity, and the European Commission recognises that – among the various renewable energy sources – offshore wind has the greatest scale-up potential. Sitting on the doorstep of the vast offshore wind potential of the Atlantic Ocean, opportunity knocks for the Shannon Estuary.

Second, delivering upon national and European climate objectives will necessitate the transitioning of existing industries as well as the formation of new, renewables-based (“green”) industries. This includes the production of alternative, zero carbon and carbon-neutral combustion fuels (i.e., “e-fuels”) for use by those energy consumption areas that cannot be directly electrified. Already a major energy production and storage hub and with ready access to the major routes to market for e-fuels, the Shannon Estuary is well-positioned to lead a green industrial revolution for Ireland.

Lastly, the decarbonisation of supply chains will be central to realising “Net Zero” by 2050. Here the Shannon Estuary can again play a pivotal role as host to Ireland’s only Tier-1 Neo-Panamax-capable container terminal (at the planned Foynes Deepwater Port) with a dedicated rail connection, introducing a more efficient and lower carbon supply chain alternative.

The opportunities highlighted above represent the three main drivers of future growth for the Shannon Estuary, and will serve as the lenses through which the Estuary and its Vision 2041 Strategy will be reviewed:

1. Delivering Atlantic Offshore Wind at Scale
2. Green Industrial Development and Transition
3. Expanded, Diversified, and more Sustainable Logistics Services

The assessments performed in this Vision 2041 Strategic Review are aligned with the SIFP, an inter-jurisdictional plan that was developed in parallel with the Vision 2041 Strategy. A key output of the SIFP was the identification of specific Strategic Development Locations (SDLs) as designated for marine-related industry. Since its publishing in 2013, the SIFP (and by extension, the SDLs) have been formally adopted by the respective development plans for Clare, Kerry, and Limerick County Councils. Figure 12 shows all the SDLs except for Limerick Docks, which is not included in this Vision 2041 Strategic Review.

Figure 12: Shannon Estuary Strategic Development Locations (SDLs), excluding Limerick Docks

Underpinned by a SEA and AA, both the Vision 2041 Strategy and the SIFP indicated that the development of these SDLs can be sustainably accommodated within the Shannon Estuary whilst safeguarding the natural environment. In turn, the land development recommendations contained within this Vision 2041 Strategic Review are broadly based around the SDL sites but also account for land demand arising from the renewables sector, developing new technologies, and the move toward larger ships.

The recommendations presented in this Vision 2041 Strategic Review are neither exhaustive nor prescriptive. Rather, they detail the possible options that will need further evaluation including their relevant business case, environmental assessments, planning and consent requirements at the appropriate time.

2. Relevant Policy

The development of an indigenous offshore wind integration port and green hydrogen ecosystem on the Shannon Estuary is in line with a number of national and European policies. A brief overview is provided below while there is a more comprehensive examination of national, regional and local policy in the final section of this report.

The objective of the deployment of offshore wind, zero-emissions gas and the production of hydrogen for use in other industries is set out in the Climate Action Plan 2021.[12]

The National Energy Security Framework published in April 2022 called for the prioritisation of the development of an integrated hydrogen strategy for Ireland and stated the position that long-term security needs take account of future hydrogen technologies. Hydrogen is also mentioned as a means of diversifying fossil fuel supplies.[13] It is hoped that the development of the National hydrogen strategy will also support the development of indigenous production of green hydrogen and the creation of holistic hydrogen ecosystems such as that laid out in this report for the Shannon Estuary.[14]

In May 2022, the European Commission launched the REPowerEU plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition by setting an enhanced European wide target of 10 million tonnes of domestic renewable hydrogen production and 10 million tonnes of imports by 2030, to replace natural gas, coal and oil in hard-to decarbonise industries and transport sectors. This plan also includes an EU Commission Recommendation to tackle slow and complex permitting for major renewable projects[15], and a targeted amendment to the Renewable Energy Directive to recognise renewable energy as an overriding public interest. The plan also calls for dedicated 'go-to' areas for renewables to be put in place by member states.[16]

The Government's commitment of a 2030 target to develop 7,000MW of offshore wind and 2,000MW of green hydrogen to further accelerate the reduction of overall economy-wide emissions was announced as part of the sectoral emissions ceilings, setting Ireland on a pathway to turn the tide on climate change at the end of July 2022.[17]

Government and EU policy also supports the deployment of alternative fuels such as hydrogen as mentioned in the National Policy Framework on Alternative Fuels Infrastructure for Transport in Ireland - 2017 to 2030[18] and the Renewable Fuels for Transport Policy Statement published in 2021.[19]

The greening of Aviation Declaration made at COP 26 that calls for an ambitious long-term goal for the reduction of aviation CO_2 was endorsed by Minister Eamonn Ryan. Ireland is also endorsing the so-called "Clydebank" Declaration which aims to establish green shipping corridors. The declaration will allow for innovative ports and shipping companies which are committed to environmental measures in their industry to promote green shipping channels and make meaningful changes.[20]

The Climate Action Plan 2021 established a stretch target to retrofit 2 out of 4 cement/lime plants in Ireland with carbon capture and storage (CCS) by 2030.[21] The production of sustainable aviation fuels also requires a source of carbon. The consideration of CCS in the Shannon Estuary combined with green hydrogen produced locally could serve as a great example of circular economy for the Shannon Estuary and Ireland.

Finally, the development of floating offshore wind and an associated hydrogen ecosystem will accelerate development in a clean Net Zero economy. This will provide not only the creation of new industry and jobs within the region but will also help Ireland achieve its legal commitment to achieving Net Zero emissions no later than 2050 as set out in the Climate Action and Low Carbon Development (Amendment) Act 2021.[22]

3. The Case for the Shannon Estuary

The Shannon Estuary is recognised not only at a national level as being fundamental to Ireland's economic prosperity and global trading links, but also at a European level as a designated core corridor port on the EU TEN-T network. Building upon its current strengths as an operating Tier-1 port moving approximately 20% of Ireland's cargo, this chapter will highlight the main strengths of the Shannon Estuary in the context of the three drivers of infrastructure development.

Driver 1: Delivering Floating Offshore Wind at Scale

The delivery chain for floating offshore wind farms is still taking shape globally, and not just in Ireland. Although there are many similarities between fixed and floating offshore wind farms, there are crucial differences that are explored thoroughly in Chapter 5.1. Now that deeper waters have been unlocked via the advancement of floating wind technology, the European Commission recognises that offshore wind has the greatest scale-up potential and has stated that Europe will need up to 450 GW of offshore wind by 2050 in order to meet its climate objectives.[23] This poses both an immense challenge to existing ports as well as generational opportunity for the establishment of purpose-built port infrastructure that will support the emerging delivery chain. For the west coast of Ireland to play its part and host such purpose-built infrastructure, there are four elements that are crucial to enabling the delivery of floating offshore wind at scale, and as demonstrated below the Shannon Estuary makes a strong case for hosting key delivery chain activities on its shores.

Proximity to the resource. The design and installation methods for floating offshore wind turbines require that certain assembly activities take place relatively close to the wind farm. Given its central location along the west coast, the Shannon Estuary is well-positioned to serve as a key delivery and operations base for floating offshore wind, with over 70 GW of development potential well within its reach.

Deep water facilities. Because a floating offshore wind turbine is completely assembled at port before wet-towing to the wind farm, the port facilities require very deep water alongside (at least 15m) in order to perform final assembly and integration. Extending over 500 km^2 and with channel depths of 32m, the Shannon Estuary is one of the deepest and most sheltered estuaries in the world. There are currently jetties with over 20m water depth alongside and the new Foynes Deepwater Port development will have 800m of quayside with 18.5m water depth alongside where turbines can be assembled.

Ample space for wet storage. Delivering floating offshore wind *at scale* requires the adoption of a mass-production mindset. Accordingly, buffer storage is required across the various steps in order to minimise the impact of any supply chain disruptions. Uniquely, the final activities in floating wind turbine assembly require buffer storage in water (aka “wet storage”) with at least 15m depth. The Shannon Estuary’s unparalleled potential for deepwater wet storage – totalling in the hundreds of hectares and suitably separated from the main navigation channel – offers a crucial risk mitigating solution towards realising the full potential of Atlantic offshore wind.

Strong grid connections. Situated at the end of Ireland’s main 400kV cross-country transmission lines and with major high-voltage substations on its shores, the Shannon Estuary is well-positioned to serve as a major receiving node for Atlantic offshore wind generated electricity. The advancement of projects such as the 400kV Cross-Shannon cable and ESB’s €50M Sustainable System Support facility at Moneypoint will enable higher volumes of renewables on the system and greater regional connectivity. Although substantial grid reinforcement and long-distance transmission infrastructure is still needed, the Shannon Estuary is nonetheless poised to be a “go-to” destination for connecting Atlantic offshore wind into the national grid.

Driver 2: Green Industry and Transition

In alignment with EU-wide targets, in March 2021 the Irish Government signed into law the Climate Action and Low Carbon Development Act, committing Ireland to Net-Zero carbon emissions by 2050. This important legislation will accelerate the transitioning of existing industries as well as encourage the formation of new renewables-based industries. The Shannon Estuary is ideally placed to help Ireland deliver on its commitments as outlined below.

Proximity to vast amounts of renewable electricity. On the supply side, given its central location along the west coast, a significant proportion of Ireland’s Atlantic offshore wind potential can be delivered from the Shannon Estuary. Similarly on the demand side, in order to access the national grid, the electricity generated by Atlantic offshore wind will likely initially travel through the existing substations and transmission infrastructure along the Shannon Estuary in order to access the national grid, offering significant opportunities for green industrial development. In future, provided there is reform in Irish private wire and planning legislation, renewable electricity generated in the Atlantic could be directly linked to large industrial consumers along the Shannon Estuary thereby relieving pressure on the existing transmission and distribution networks.

Existing industries can lead Ireland’s green transition. The Shannon Estuary currently hosts two of Ireland’s largest power stations at Moneypoint and Tarbert, as well as its third busiest airport. The alumina refinery at Aughinish accounts for ~11% of Ireland’s annual natural gas consumption.[24] Furthermore, a major cement producer (Irish Cement) and leading food ingredient supplier (Kerry Group) are also situated not far from the Estuary’s shores. As important regional anchors of industry and employment and with vast quantities of renewable electricity becoming increasingly available through Atlantic offshore wind, these large industrial facilities play a vital role in supporting the achievement of Ireland’s climate objectives.

Continuing its role as a leading energy storage hub. With its coal stockpiles at Moneypoint, its NORA reserves at Tarbert, and inventories at the Port of Foynes, the Shannon Estuary already serves as a leading – albeit *fossil-fuels-based* – energy storage hub for Ireland. Much of this existing infrastructure and available land within the SDLs can be (re)purposed to transform the Estuary into a leading *renewable* energy storage hub through the deployment of long duration large scale battery storage facilities and through the production and storage of zero carbon green hydrogen and green ammonia produced from offshore wind. These facilities will provide an additional means for balancing the electricity grid and will help provide a stable and secure supply of energy when power is not being generated by renewables.

Diversified access to potential routes to market for e-fuels. E-fuels are a CO_2-neutral alternative to conventional fossil energy carriers and therefore make a decisive contribution to the global energy transition – shifting the energy demand to the use of renewable sources. The production of e-fuels requires electricity from renewable sources such as solar or wind, as well as water to produce hydrogen through electrolysis processes and CO_2 extracted from the atmosphere.[25] The Shannon Estuary has all components required for the production of e-fuels in abundance. The full story of e-fuels – the extent of its role coupled with its preferred delivery model – has yet to be written and will depend on market dynamics and policy decisions over the coming decades. Which sectors will be the early adopters of e-fuels? Which will be the laggards? Diversification is key when faced with this degree of uncertainty, and in this sense the Shannon Estuary is fortunate given its access to all the major potential routes to market. No matter how (or how quickly) demand for e-fuels evolves – be it distributed broadly across the natural gas network or focused narrowly on dispatchable power or industrial heat generation; be it via road transport fuel, bunkering fuel for ships or aviation fuel; or be it via mass seaborne exports – underpinned by its existing and natural attributes, the Shannon Estuary stands poised to deliver.

Driver 3: Expanded, Diversified, and More Sustainable Logistics Services

Logistics and cargo operations are the backbone of Shannon-Foynes Port Company, where the Estuary moves over 10M tons of cargo per year, representing 20% of the national cargo traffic. Over the next 20 years, cargo activities will continue to expand – growing with the Irish economy. Port traffic and cargo composition will increase in diversify thanks, in part, to the emerging offshore wind business and green industries. Planned investments in road and rail will further improve Shannon-Foynes Port Companies ability to deliver as a Tier 1 Port, enable the Irish economy to realise growth efficiently, and to achieve the Port’s Vision 2041. Below are the key elements positioning the Port accomplish its logistics objectives:

Tier 1 Port with efficient ground transport links. Shannon-Foynes is one of three Irish Tier 1 ports and features national ground transport links connected to the N69. Planned upgrades and the new Limerick-to-Foynes road link will cement the Port of Foynes central position in the national supply chain. Furthermore, reinstating the Limerick-to-Foynes rail link will offer the opportunity to decarbonise and decongest the national supply chain through providing a rail freight option.

Planned Deep Water Terminal capable of berthing Neo-Panamax vessels. The deepwater terminal at Foynes will feature both offshore wind integration activities and 400m of dedicated quay for berthing container vessels. Once operational, the Foynes Deepwater Port will be the only Panamax-capable Irish container terminal with rail connectivity, unlocking optionality for Irish logistics traffic. This new container terminal will relieve congestion concerns at a national level and help install economic capacity in the region.

Capacity for supply chain development within a major port. SFPC is developing portions of the available land at the Port of Foynes to immediately address warehouse and laydown demands, and has over 100 hectares of additional space available for businesses to establish facilities that can optimise their respective operations and supply chains. Over the coming decades, as the port diversifies to also accommodate container traffic, offshore wind operations, and new renewables-led industries, the availability of development lands within a Tier 1 Port further strengthens the Shannon Estuary’s offering.

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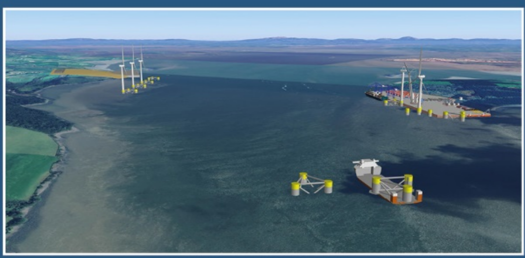
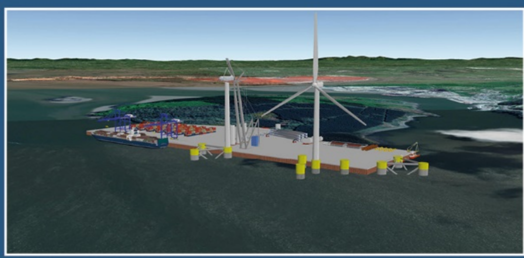
Driver 1: Delivering Floating Offshore Wind at Scale





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Since the Vision 2041 Strategy was published in 2013, perhaps the most consequential market development impacting the SFPC has been the accelerated emergence of the offshore wind industry. In 2013, this was discounted due to the significant water depths not far off the Atlantic coast of Ireland as well as fossil fuel's sustained global dominance. An increasing focus on combatting global climate change has brought rapid innovation in the offshore wind industry, such that the vast wind energy potential off the west coast of Ireland can now be viably tapped through *floating* offshore wind turbines, which can be deployed in much deeper waters.

The chapters in this section assess how the Shannon Estuary can best orient itself to serve the needs of floating offshore wind developments in the Irish Atlantic. Broadly speaking, the Shannon Estuary has two roles to play in supporting the delivery of floating offshore wind. First, it can serve as a base for the production, assembly, and final installation of the wind farm's major components, as well as for ongoing O&M support. Second, it can facilitate the conveyance of and act as a main receiving node for the electricity generated by the floating offshore wind farms. These two fundamental roles are explored in Chapters 5 and 6, which conclude by offering development options for the Shannon Estuary.

Before assessing how best to leverage the opportunities afforded by floating offshore wind, some initial consideration is required to quantify the scale of power generation capacity that can feasibly be delivered from the Shannon Estuary within the relevant timeframe. Chapter 4 examines this and concludes with the establishment of three generation capacity scenarios upon which any subsequent assessments are based.

4. Generation Capacity Delivered by the Estuary by 2050

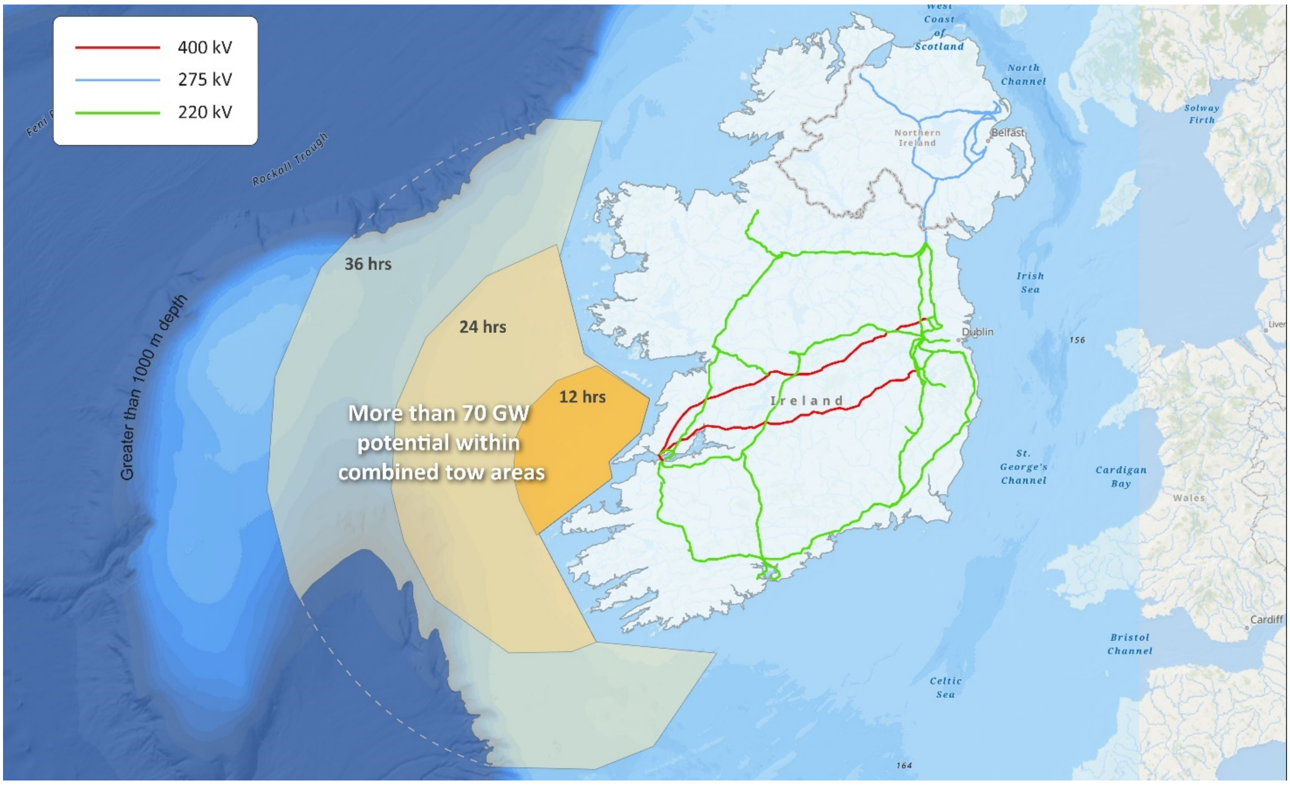


Figure 13: Area within a 36-hr wet-tow time from the Shannon Estuary

Much has been made in recent years of the vast wind energy potential off Ireland's west coast ever since floating offshore wind technology has become viable. And rightly so. When its seabed territory is accounted for, Ireland is one of the largest countries in Europe, with much of its marine territory extending out into the North Atlantic from its western shores.

This chapter takes a closer look at Ireland's Atlantic domain and quantifies the overall potential of the wind resource within the Shannon Estuary's reach. Once the overall wind resource potential is quantified, this chapter continues by evaluating potential routes to market and relevant policy considerations. This information is then integrated to establish three scenarios of wind power generation capacity delivered from the Shannon Estuary by 2050. These three generation capacity scenarios form the planning basis for subsequent assessments in this review.

4.1 The resource potential

As explained in greater detail in Chapter 5, one key aspect of floating wind turbines is that they are fully constructed in port (i.e., at an “integration port”) before being wet-towed to their final installation location. Due to the size and weight of a completed wind turbine, wet-tow speeds are typically limited to an average of around 4 knots. Using this 4-knot average speed, Figure 13 shows that approximately 80,000 km^2 of the Irish Atlantic with water depth less than 1,000m is within 36-hrs of the Shannon Estuary.

From a theoretical perspective, if the entire 80,000 km^2 area deployed 15MW floating wind turbines (using appropriate spacing between turbines), this would amount to over 175 GW of installed capacity, within 36-hrs wet-tow time of the Shannon Estuary. However, due to environmental considerations and other exclusion factors, such as vessel density and existing or new pipelines, cables and substations, full coverage is not feasible. In their report “Our Energy, Our Future”, WindEurope reviewed these exclusions and calculated that 42% of the Irish section of the Atlantic is available for offshore wind.[26] This calculation may include the vast expanses of the Irish Atlantic that are greater than 1,000m depth (and therefore not feasible for offshore wind), likely making the percentage much higher within the Shannon Estuary capture area. Nevertheless if this percentage is conservatively applied uniformly, the result is over 70 GW of offshore wind potential within a 36-hr wet-tow from the Shannon Estuary.

4.2 Potential Routes to Market for Atlantic Offshore Wind

The vast wind energy potential within the Shannon Estuary’s reach will remain just that – potential – unless this resource is connected to sources of demand. The following reviews both domestic and European demand opportunities and their respective routes to market.

4.2.1 Domestic Demand

In alignment with EU-wide targets, in March 2021 the Irish Government signed into law the Climate Action and Low Carbon Development Act, committing Ireland to Net-Zero carbon emissions by 2050.[27]

Released at the same time as Ireland’s new climate legislation, MaREI’s “Zero by 50” study outlined what a zero-carbon energy system could look like in Ireland by 2050. Broadly speaking, the study recommended an approach involving (i) renewables-led electrification, proposing renewable electricity in place of fossil fuel combustion, and (ii) the use of alternative, carbon-neutral combustion fuels (“e-fuels”) for those areas that cannot be electrified, such as portions of the heating, land transport, sea transport, and aviation sectors.

Largely driven by electrification, the MaREI study projected an almost doubling in electricity demand to 52 TWh in 2050, and envisaged wind energy providing over 90% of the electricity required. This translates into ~12 GW of wind power generation capacity required, according to Wind Energy Ireland in their August 2021 report. That same report combined the MaREI demand projections for e-fuels with aviation and shipping fuel demands to calculate that ~15 GW of wind power generation capacity will be required to satisfy Ireland’s e-fuel production requirements by 2050.[28]

Adopting MaREI’s and Wind Energy Ireland’s figures, brings the total wind power generation capacity required to meet domestic demand to 27 GW by 2050, a more than six-fold increase from today’s capacity.

Considering that wind power build-out will be distributed across Ireland’s onshore and offshore regions, the basis for this Vision 2041 Strategic Review is that between 5 and 10 GW of the capacity required to meet Irish demand by 2050 will be supplied from the over 70 GW of floating offshore wind potential situated within the Shannon Estuary’s reach.

4.2.2 European Demand

Formally enacted in July 2021, the European Climate Law sets a legally binding target of Net Zero greenhouse gas emissions by 2050[29]. This objective is at the heart of the European Green Deal and in line with the EU’s commitment to global climate action under the Paris Agreement.[30]

Achieving Net Zero carbon emissions will require several measures including significant ramp-up of power generation from renewable sources. Among the various renewable sources, the European Commission recognises that offshore wind has the greatest scale-up potential and has stated that Europe will need up to 450 GW of offshore wind by 2050.[31]

In their report “Our Energy, Our Future”, WindEurope estimated that 85% of this 450 GW capacity by 2050 would be developed in the North Seas (which includes the Atlantic off of France, Ireland and the UK, the North Sea, Irish Sea and Baltic Sea) based on the good wind resources, proximity to demand and supply chain efficiencies.[32] This is equivalent to around 380 GW of the 450 GW targeted by 2050, and presents an enormous opportunity for floating offshore wind and more specifically the Shannon Estuary.

However, given its location at the 'edge of the grid', there is considerable uncertainty around the routes through which Irish Atlantic offshore wind will access European demand and their associated timeframes. But fundamentally, Atlantic offshore wind can reach European demand in the form of either electricity or green hydrogen and its derivatives.

4.2.2.1 Delivering Electricity to Europe

If delivered as electricity, a significant expansion of the high-voltage transmission network will be required, both on- and offshore Ireland. The island of Ireland is currently connected to the European grid only via Great Britain, and these high-voltage interconnects will have a combined capacity of 1.5 GW by 2024 once the 500 MW Greenlink Interconnector is completed.[33] A planning application for a direct link between Ireland and France – the 700 MW capacity Celtic Interconnector – was recently approved by An Bord Pleanála and is anticipated to be built and energised by 2026.[34]

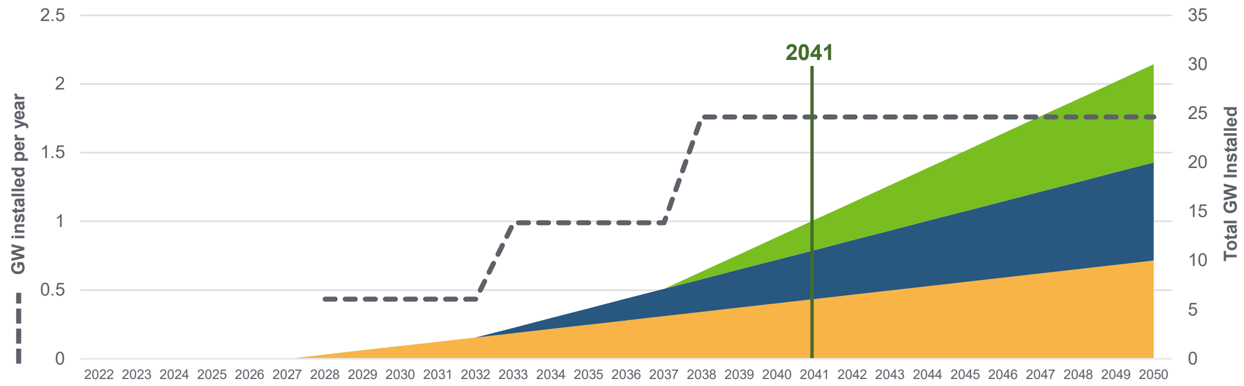
Whilst a more than doubling of Ireland's interconnection capacity (from 1 GW to 2.2 GW) within the next four years is promising, much more high-voltage transmission will need to be developed if Irish Atlantic offshore wind energy is to be delivered to Europe as electricity in any meaningful way over the coming decades. In addition to the installation of new submarine interconnects between Ireland and neighbouring countries, this could also entail the development of an offshore grid across Europe's North Seas that would allow electricity generated in the Irish Atlantic to supply the continent without that electricity ever landing on Ireland's shores. The transmission technology to deliver this scale-up exists today in the form of HVDC cabling, and new, higher-capacity transmission systems using superconductor technology are developing rapidly. These options are explored further in Chapter 6.

4.2.2.2 Delivering E-fuels to Europe

Unlike electricity which can only be delivered to Europe via high-voltage conducting cables, there are two modes through which e-fuels can be delivered to Europe. Once produced at a facility using renewable electricity, green hydrogen can be fed into a European pipeline network, or it can be loaded onto a ship in various forms and transported to Europe. This is further explored in Chapter 9.

4.3 Generation Capacity Scenarios

Having surveyed the wind energy potential alongside prospective sources of demand and their possible routes to market, a set of generation capacity scenarios was developed that will serve as a planning basis for this assessment. As shown in Figure 14, the low, medium, and high scenarios reflect different generation capacities delivered from the Shannon Estuary by 2050: 10 GW, 20 GW, and 30 GW.



Low Scenario	Medium Scenario	High Scenario
10GW by 2050	20GW by 2050	30GW by 2050
CAPACITY DEMAND IN 2050	CAPACITY DEMAND IN 2050	CAPACITY DEMAND IN 2050
Domestic electricity & E-fuels: (5GW - 10GW)	Domestic electricity & E-fuels: (5GW - 10GW)	Domestic electricity & E-fuels: (5GW - 10GW)
Electricity export: (0 GW – 5 GW)	Electricity export: (5 GW – 10 GW)	Electricity export: (10+ GW)
E-fuels export: (0 GW – 5 GW)	E-fuels export: (5 GW – 10 GW)	E-fuels export: (10+ GW)
CAPACITY SUPPLY PROFILE	CAPACITY SUPPLY PROFILE	CAPACITY SUPPLY PROFILE
~400MW per year from 2028	Increase to ~1,000MW per year from 2033	Increase to ~1,800MW per year from 2038
~25-30 turbines per year	~65 turbines per year	~120 turbines per year

Figure 14: Wind Power Generation Capacity Delivered by the Shannon Estuary – Scenarios for 2050

The demand cases for the scenarios are split into three components:

1. domestic demand (which combines electricity and e-fuels),
2. electricity export, and
3. e-fuels export (green hydrogen, green ammonia, e-methanol etc.)

Whereas the domestic demand component carries the same range across all three scenarios, the two export components incrementally increase from the low to high scenarios. Simply put, the scenarios reflect three varying degrees of success in being able to tap Atlantic offshore wind into European demand.

Figure 14 also shows that whilst the electricity export and e-fuels export demand components increase with each phase, their respective ranges are identical within a specific phase. This reflects the current uncertainties surrounding the pace and scale of the development of both export forms – uncertainties that will only resolve themselves with time as market dynamics and policy development at a national and international level converge.

By 2050, the wind power generation capacities delivered from the Shannon Estuary in the three scenarios will vary greatly, from 10 GW in the low scenario to 30 GW in the high scenario. However, given the current lack of offshore wind-oriented infrastructure within the Estuary, the three scenarios all share the same starting point, in terms of both start date for wind turbine deployment as well as initial annual delivery capacity. The start date has been fixed at 2028, which aligns with the proposed development timeframes for Foynes Deepwater Port and ESB's Green Atlantic program at Moneypoint, and the delivery capacity is based on being able to deliver the low scenario (10 GW by 2050) from the Estuary from 2028 onwards, which translates to ~400 MW annually.

Using a common starting point across the three scenarios reflects the realities of capital infrastructure development and of the likely rate of market uptake, both domestically and internationally. The three scenarios are shown as being achieved in a phased manner, with Figure 14 showing that the expansions required to deliver the medium and high scenarios will be deployed in 2033 and 2038, respectively, if and as market dynamics dictate. In addition to enabling the formation of a long-term vision, the phased generation capacity scenarios offer a great degree of flexibility, in that any wind farm delivery-related infrastructure expansions identified in this Vision 2041 Strategic Review can be deployed earlier or later in response to overriding market conditions and policy drivers.

5. Wind Farm Delivery Chain Assessment

This chapter explores and provides development recommendations as to how the Shannon Estuary can be best positioned to deliver this generation capacity within the targeted timeframes.

In addition to establishing a generation capacity profile that is grounded in a robust assessment that considers all the available options, providing *credible* infrastructure development recommendations for the Estuary requires a thorough understanding of the floating offshore wind turbine (FOWT) delivery chain. Each activity along the delivery chain has its own set of requirements and constraints. These requirements and constraints will be considered in providing a suite of infrastructure development recommendations for the Shannon Estuary.

When surveying what is needed across the various steps in the FOWT delivery chain, a consistent theme emerges: both a lot of space and a lot of deepwater access is required. With over 1,000 hectares of land designated (via its SDLs) for maritime development, and with water depths more than 15 m, the Shannon Estuary stands apart as the optimum delivery base for the floating offshore wind industry in Ireland.

5.1 Floating Offshore Wind Turbine (FOWT) Technical Overview

It is expected that most of the wind turbines deployed in the Irish Atlantic will be horizontal axis turbines with three blades in an upwind arrangement, as shown in Figure 15. Onshore and offshore wind turbines do not differ much above the foundation (or substructure), the main components of both being the tower, the nacelle, and the rotor blades.

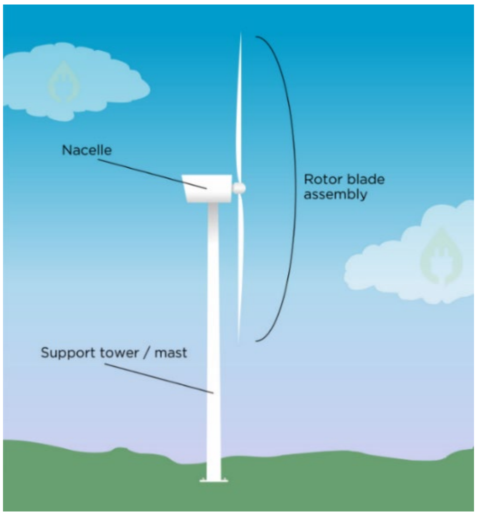


Figure 15: Main Wind Turbine Components[35]

The towers of most modern turbines are made of round steel tubes, atop of which sits the nacelle which houses the gearbox, driveshafts, generator, break, and control electronics. To withstand the very high stresses they experience, wind turbine blades are made from modern composite materials like carbon fibre or glass fibre to give the most amount of strength and rigidity for the least amount of weight.[35]

Offshore wind turbines are mounted on substructures that keep the base of the wind turbine tower above the crest of the highest waves, and these substructures may be either resting on the seabed (i.e., "bottom-fixed") or floating. Bottom-fixed substructures are generally preferred in water depths up to 50-60 m. As the water depth increases, bottom-fixed substructures must be made taller which makes their construction and installation more challenging and expensive. In water depths greater than 60m, which is the case for the vast majority of the Irish Atlantic, floating substructures become the more attractive alternative.

Among the different floating substructure types (see Figure 16), the semi-submersible is the most versatile as they combine a large payload capacity with good motion characteristics in waves. Their relatively deep draft allows them to operate even in the harshest environments. But they can also be de-ballasted to a shallow draft which allows them to enter port. This makes them suitable for quayside integration and pre-commissioning of the wind turbine, which is crucial for efficient wind farm development.

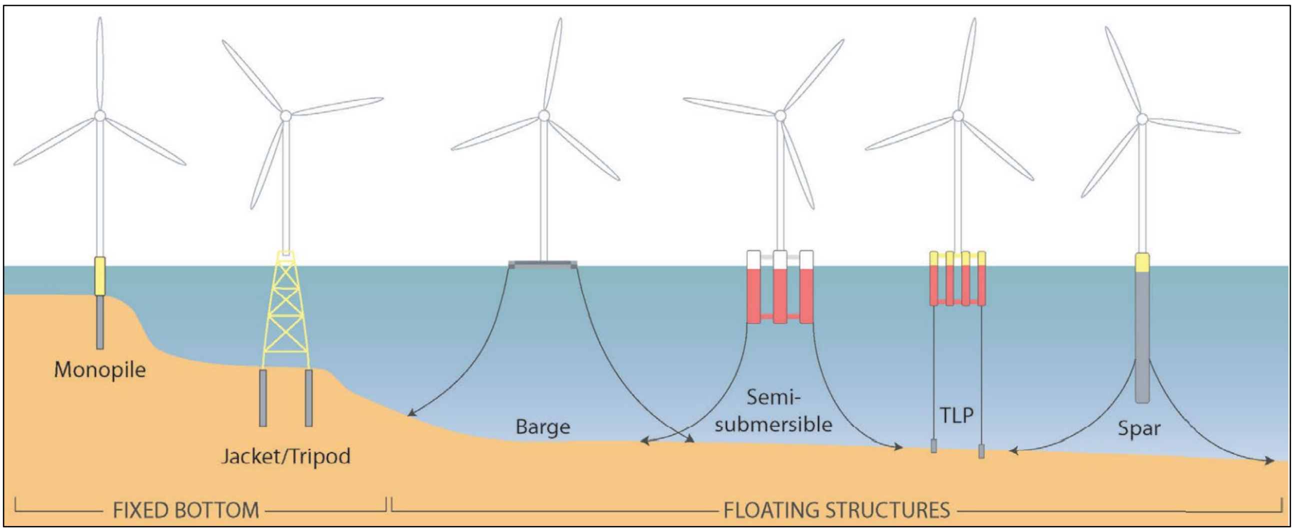


Figure 16: Common types of Wind Turbine Substructures for bottom-fixed and floating offshore Wind Turbines (Source: MaREI)[36]

As far as turbine size, it is expected that turbines with nameplate capacities of between 10 MW and 20 MW will dominate offshore wind farm developments in the coming years. Although the history of the wind industry shows a clear trend of increasing wind turbines over time [37], the growth of offshore wind turbine capacities beyond 15-20 MW will become increasingly more difficult as the supply chain infrastructure for such large turbines and the associated floating substructures is reaching its limits. The primary theme in the floating wind industry in the next two decades will more likely be the need for mass fabrication at lowest possible cost rather than the supersizing of wind turbines.

Assuming a representative average wind turbine size of 15 MW, the three scenarios translate into the annual throughputs shown in Table 5 below. Obviously, actual production numbers will vary depending on the timing of individual wind farm projects and on the actual turbine sizes deployed, but these throughputs will be used in this study as a guide for estimating the port capacities needed to support the projected wind farm development scenarios.

Table 5: Required Wind Turbine Production Scenarios

Wind Turbine Production Throughput			
Scenario	**Capacity / Year**	**Units / Year(1)**	**Cumulative Installed Capacity**
Low	400 MW / yr	27 / yr	10 GW by 2050
Medium	1,000 MW / yr	67 / yr	20 GW by 2050
High	1,800 MW / yr	120 / yr	30 GW by 2050
Note 1) based on 15 MW avg. turbine capacity			

Beside the representative 15 MW turbine[38], this assessment is based on two representative floating substructure designs, one constructed of a steel hull, the other a concrete hull (see Figure 17). While most substructures operating today are built from steel, constructing them from concrete can offer a series of advantages, such as the use of locally sourced and lower-cost materials that can be cast into shape at sites without requiring a high proportion of specialised labour or expensive machinery. As the floating offshore wind industry is still taking shape, it has yet to be seen which material is better suited for large scale production.

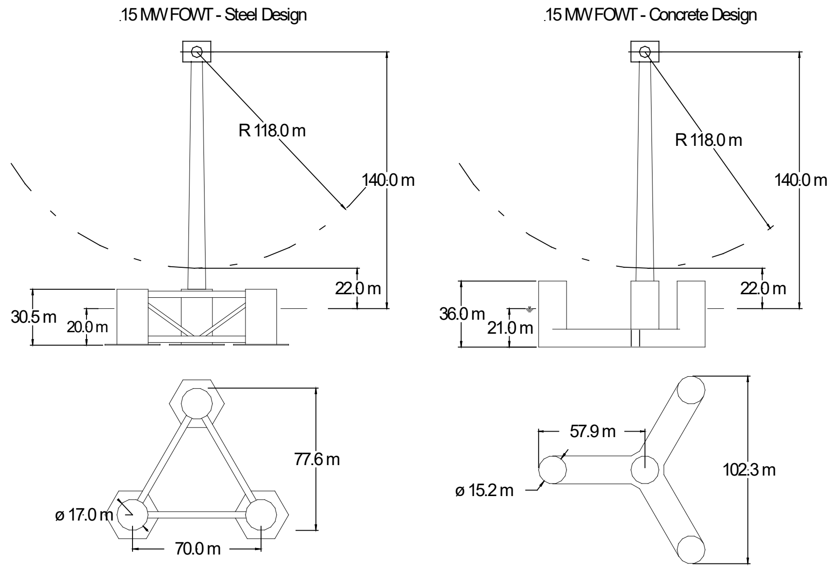


Figure 17: Two 15 MW Reference FOWT Configurations used for this Study

5.2 The Floating Offshore Wind Farm Delivery Chain

While floating wind farm developments may differ from project to project in a variety of ways, there are certain activities that are common to all floating wind farm developments. These fundamental building blocks of the floating wind farm delivery chain and the process through which they come together are illustrated in Figure 18 below and are described in detail in the following discussion. This information sets the stage for identifying specific opportunities for the Shannon Estuary in delivering offshore wind.

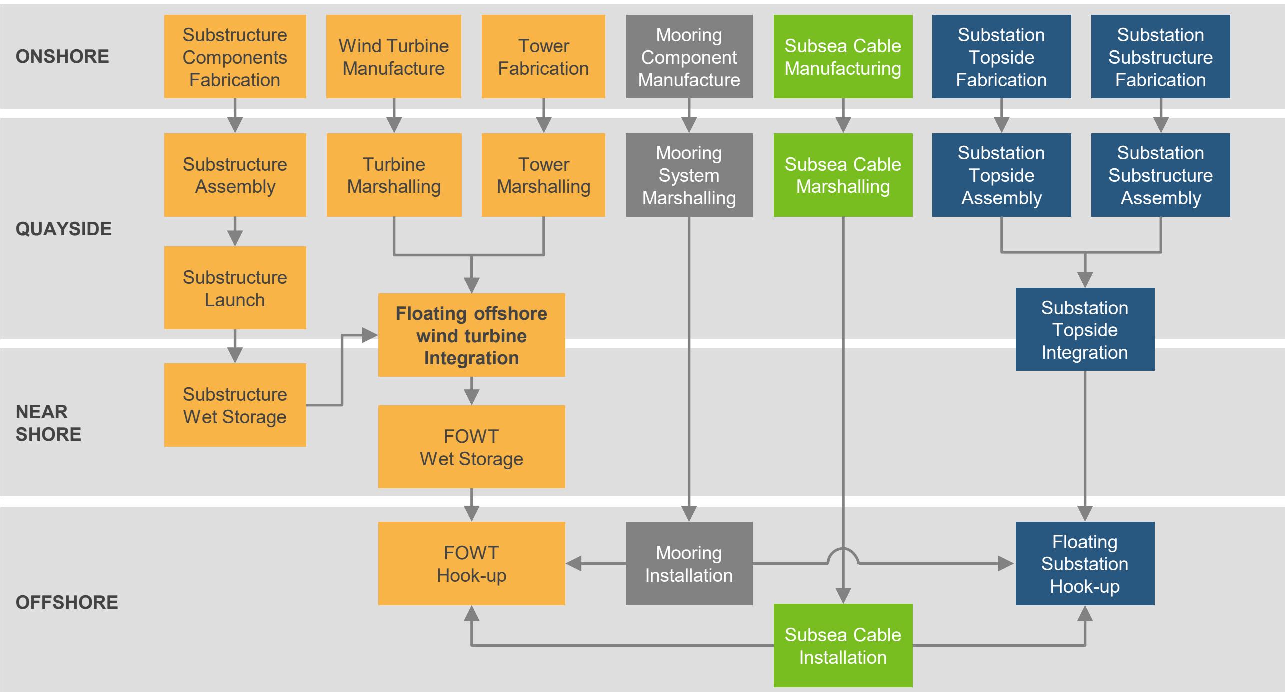


Figure 18: Floating Offshore Wind Farm Delivery Chain

5.2.1 Wind Turbine and Tower Production

Wind turbines are typically procured from a turbine provider and delivered to the integration site in a state substantially ready for installation. The assembled nacelles are shipped with the gearbox and the electric generator installed. The manufacturing of wind turbine blades is proprietary and takes place in purpose-built manufacturing facilities.

Wind turbine towers are made up from three or four rolled steel segments connected by bolted flanges and can be fabricated in any suitable steel fabrication yard.

Since these wind turbine and tower components are large, heavy, and cumbersome to move, their transportation method as well as their loading and unloading must be carefully evaluated from both a technical and commercial point of view (Figure 19[39]). The seaborne transport of the wind turbine nacelles, turbine blades, and tower sections will be either by flat deck carriers (so-called roll-on/roll-off, or RORO ships) or by project cargo vessels (so-called lift-on/lift-off, or LOLO ships) (Figure 20).

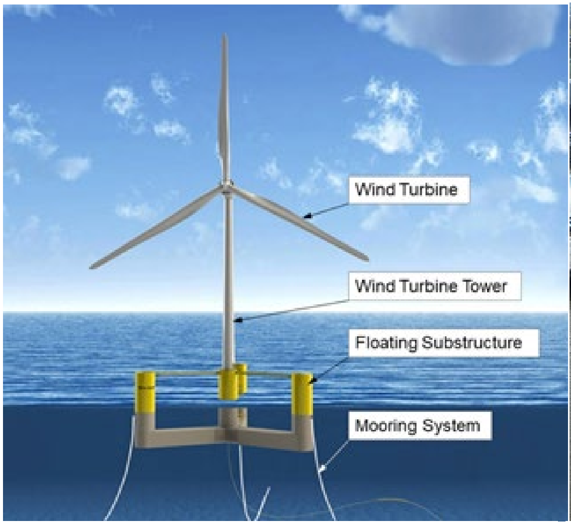


Figure 19: FOWT Components [39]

Figure 20: Off-loading of wind turbine blades at Foynes

5.2.2 Floating Substructure Production

Floating substructures resemble offshore platforms used in the oil & gas industry and may be made from steel or from concrete, or a hybrid of both materials. Most existing steel substructure designs are made up from tubular members and buoyancy compartments, their fabrication combines methods of offshore jacket fabrication with methods of ship hull fabrication. Substructures made from concrete may be cast in place or may be slip-formed. More innovative concrete fabrication methods using pre-cast and post-tensioned components have also been proposed but are not yet proven.

Assembled substructures can be transported either on the deck of heavy transport vessels (“dry-tow”) or by wet-tow. Wet-tows are performed with the substructure afloat and connected by towing lines to one or several offshore tugs. Because substructures are large objects difficult to transport in a single piece, minimizing the transport distance of the assembled substructures can significantly reduce the overall project cost. On the other hand, substructure fabrication at a distant but low-cost shipyard may also provide a significant cost advantage. To balance these factors, project developers may choose to fabricate the major substructure components at the most cost-effective fabrication yard but then assemble the components at a site close to the wind farm.

Substructure launch (i.e., the transfer from land into water) is a critical step in the construction of FOWTs. The launch can be done by several methods including:

- by slipway,
- by crane lift,
- by means of a dry-dock, or
- by float-off from a semi-submersible vessel.

Float-off is a convenient way for both substructure offloading and launch in a single operation, and for large-scale wind farm developments such as that envisaged from the Shannon Estuary, it’s likely the preferred option. Such an operation requires a sheltered float-off site with sufficient water depth (about 20+ m), something that the naturally deep water of the Shannon Estuary can accommodate at multiple locations.

Once floating in water, substructures must be brought to an integration site where the substructure, tower, and wind turbine are assembled. A launch site close to the integration site is desirable as this eliminates a long-distance transport of the substructure (Figures 21[40] and 22[41]).

Figure 21: Steel floating substructure assembly [40]

Figure 22: Floating substructure transported on a semi-submersible vessel [41]

5.2.3 FOWT Integration & Pre-commissioning

One key difference between the fixed and floating offshore wind farm delivery chains is that fixed wind turbines must be assembled at their final installation location – quite a major (and costly) operation requiring calm seas, large vessels with specialist equipment and heavy lift cranes. Conversely, floating wind turbines allow the units to be fully integrated and pre-commissioned in the port (i.e., at an "FOWT integration port") before being wet-towed to their final installation location.

FOWT integration starts with erecting the tower on the substructure by sequentially lifting all tower sections, followed by the nacelle, and then attaching the individual blades to the rotor hub. A FOWT integration port therefore requires a very large heavy lift crane as well as sufficient water depth alongside to accommodate the draft of the floating substructures.

Another advantage of quayside integration is the ability to pre-commission the FOWT prior to tow out. During pre-commissioning potential defects or malfunctions in the systems can be detected and corrected in a yard environment rather than offshore where operations are costly and generally more difficult.

The selection of the turbine integration site is a crucial decision for any wind farm development project. The integration site should

- be as close as possible to the wind farm to minimize the FOWT wet-tow distance for installation.
- provide unobstructed water-side access with sufficient water depth and air gap in the access channel.
- provide sufficient berth space and water depth at the quay wall to accommodate FOWTs as well as transport ships supplying wind turbines and other equipment.
- provide adequate offloading facilities, laydown areas, warehousing, and workspaces.
- have sufficient ground strength for a large crane and other heavy equipment.
- have adequate shore-side access and transport links for personnel and services.
- allow uninterrupted year-round operation.

As outlined in Chapter 5.3.1, the proposed Foynes Deepwater Port considers the above and is an ideal location for a FOWT integration site.

5.2.4 Wet Storage

The floating offshore wind farm delivery chain is no different to other delivery chains in their need for buffer storage across the various steps in order to minimise the impact of any supply chain disruptions. Uniquely, activities in the floating wind turbine delivery chain require buffer storage *in water* (aka "wet storage").

Wet storage will be required during two stages of the delivery chain. First, for assembled substructures (i.e., before integration). Second, for completed units (i.e., after integration but before final installation). Insufficient wet storage across these activities makes the delivery chain more vulnerable to disruptions, leading to downtime for equipment and crews involved and increased costs.

While disruption of the delivery chain could be caused by several reasons, weather-related downtime is guaranteed, as weather conditions in the Irish Atlantic will likely not permit continuous installation of FOWTs.

Hence, to prevent the entire delivery chain from stalling, both completed substructures *and* completed FOWTs will have to be put into wet storage. For the FOWT designs considered in this assessment, wet storage areas must have at least 15 m water depth and be suitably sheltered and separated from the main navigation channel.

The total wet storage space utilised will depend on the actual FOWT production rate as well as the quantity (in either days or number of units) of buffer required by the delivery chain. This is explored further and quantified in this section but given its vast area (over 500 km^2) and its channel depths of up to 32 m, the Shannon Estuary stands apart in being able to accommodate the wet storage needed to deliver floating offshore wind at scale in the Irish Atlantic.

5.2.5 Mooring Equipment Production and Installation

Mooring equipment of floating wind turbines are typically procured components from specialist vendors. The primary mooring components are mooring chains, synthetic mooring lines, shackles, connectors, buoyancy modules, clump weights, chain stoppers, and anchors. The marshalling site for the mooring equipment can be different from the FOWT integration site, although project developers may prefer executing all installations from one centralized location.

Prior to the arrival of a FOWT at its operating site its mooring system must be anchored to the seafloor. This operation is typically performed weeks or even months before the FOWT is installed. Depending on the anchor type this operation may require a specialized installation vessel. Installation of mooring systems are typically done with the help of dive robots, so-called Remote Operated Vehicles (ROVs). They are used for making up connections and to allow visual survey of the subsea operation.

5.2.6 FOWT Installation at the Wind Farm

FOWT installation entails the wet-tow of the integrated floater to the wind farm, its hook-up of the mooring system and the power cable, and the final commissioning of the FOWT (Figure 23[42])

FOWT wet-towing typically originates from the FOWT integration port (or nearby wet storage) and travels at speeds of about 3-5 knot. The hook-up to the mooring system requires a minimum of three tugs, whereby at least two will hold the FOWT in position while one tug connects the mooring lines. After all mooring lines are connected and tensioned the power cable will be installed with a specialized cable lay vessel. Once the FOWT is hooked-up to mooring lines and power cable, the final commissioning of the FOWT will be performed. Commissioning is done as a final check that all systems work correctly.

Figure 23: Wet-tow of integrated floater to wind farm [42]

Wet-tow and hook-up of FOWTs are weather restricted operations. This means they can only be performed when sea conditions are suitable. Due to their slow speed under wet-tow FOWTs are extremely vulnerable to sudden inclement weather conditions. Consequently, departure from safe berth will only take place when the weather forecast predicts enough good weather to reach the installation site and to make the FOWT “storm safe”. A storm safe condition is typically achieved when the FOWT is hooked-up to at least three mooring lines. The weather forecast must be monitored throughout this operation and if weather conditions worsen before the FOWT can be made storm safe, the operation must be abandoned, and the tow must return to port.

It is evident that with increasing distance between port and wind farm, the chance for encountering a long enough and suitable weather window becomes smaller. A study by Ramboll and the Hamburg University of Applied Sciences finds the choice of installation port crucial because “*shorter distances between port and wind farm simplify the installation process and reduce cost considerably. Larger distances, on the other hand, lead to additional and unpredictable problems, which directly increase both costs and duration of the installation process.*”[43]

The weather sensitivity of the wet-tow and hook-up makes the FOWT installation also dependent on the season. It is anticipated that weather conditions during winter months will not allow FOWT hook-up in the open Atlantic. Actual operating windows for different months will have to be confirmed by detailed metocean and operability studies. This will also drive the need for wet storage of FOWTs at the Shannon Estuary.

For the above reasons, the time needed between FOWT departure from port and achieving storm safe condition at its operating site has a significant impact on the ability to deliver Atlantic offshore wind at scale. Therefore, a FOWT integration port that is as close as possible to the wind farm is mission critical to the delivery of Atlantic offshore wind *at scale*, as the shorter wet-tow times increase the weather window availability rate.

5.2.7 Installation of Submarine Power Cables and Offshore Substation

Submarine power cables include both inter-array cables connecting wind turbines to the substation, and the export cables connecting the offshore substation to the onshore substation[44]. Once cables are installed on the seabed they will be tied-in to the substation and the wind turbines. Like the mooring equipment, power cables are procured from specialist providers.

Export power cables are installed from dedicated ships with carousel-type turntables that can hold more than 100 km of cable. They are typically spooled onto the installation ship at the cable fabrication site which makes intermediate storage at a marshalling port unnecessary. Array cables are significantly lighter than export cables and can be transported in shorter lengths which makes their handling less onerous. Array cables can be installed from on-board carousel tables or from individual drums. The use of drums has the advantage of easier handling. It also allows cable storage at a marshalling port, which affords more optionality for the installation campaign.

The installation of floating substations follows a similar installation procedure as FOWTs. They can be mated with their floating substructure at quayside and floated together to the installation site thereby reducing the offshore operations. This topic is discussed in greater detail in Chapter 6.1.

5.2.8 Wind Farm Operations & Maintenance

O&M activities for offshore wind farms are managed from an onshore operations base, which will typically consist of a port based marine operations facility and a central control room. The control room could be located off-site but colocating it with the marine operations port has obvious advantages. O&M activities can be categorized as either (1) continuous monitoring, (2) regular inspection, (3) scheduled maintenance and repair, (4) unscheduled minor repair, or (5) unscheduled major repair.

All work at the wind farm will require transfer of personnel and equipment between the wind farm and the shore base which will be performed either by Crew Transfer Vessels (CTVs) or by Service Operation Vessels (SOVs) (Figure 24[45] [46]).

Figure 24: Left- Crew Transfer Vessel (Atlantic Wind Transfers [45]); Right – Service Operation Vessel (Royal IHC [46])

CTVs are preferred for wind farms closer to shore. They are designed for daily transports of personnel to the wind farm and have no overnight facilities. CTVs have lengths of up to 30 m and space for about 10-20 service technicians, with drafts of 1.5-3 m so they can access shallow ports. CTVs may have service speeds up to 30 knot.

SOVs provide an offshore base with staff working from the vessel for two to four weeks at sea before returning to port. SOVs are preferred for maintenance of wind farms located far from shore. SOVs have overnight accommodation capacity for 40-60 service technicians and provide additional space for workshops and storage for spares. SOV have lengths of about 60-100 m, drafts of about 5-8 m, and service speeds up to about 15 knot.

The distance between the marine operations port and the wind farm has a significant impact on the O&M costs of the wind farm. Selecting a shore base close to the wind farm is beneficial because it reduces trip times and fuel cost. Less obvious, but equally significant is the impact on the available weather window for offshore operations. Maintenance activities of floating wind farms are weather restricted operations, similar to the FOWT installation as described previously. Above certain sea states O&M activities must stop altogether.

Proximity to the wind farms is even more important in cases where major repair requires tow to port. The slow speed during wet tow of approximately 3-5 knot makes this operation extremely vulnerable to bad weather and likely impossible during winter season. For these reasons wind farm operators prefer O&M ports closest to their wind farms.

An onshore O&M base typically consists of[47]:

- Operations control room and administrative facilities
- Lifting equipment (e.g., forklifts, small cranes)
- Workshop facilities and tool storage
- Small component stores
- Wet and dry rooms for personal protection equipment
- Oil store, gas bottles, and waste management facilities
- Fuel bunker
- Parking spaces

5.3 Floating Offshore Wind Delivery from the Shannon Estuary

Today, in both the onshore and the offshore wind industries, Ireland imports the vast majority of its components from overseas. Although a complete floating offshore wind farm delivery chain may eventually be developed in Ireland – and ideally in the Shannon Estuary – this Vision 2041 Strategic Review foresees this development as a gradual process starting first with the establishment of the necessary infrastructure to support those delivery chain activities where proximity to the wind farm is essential, specifically:

1. FOWT integration,
2. substructure assembly,
3. wet storage, and
4. operations & maintenance.

The following sections recommend locations along the Estuary for these four ‘essential’ activities and describe their key attributes and infrastructure requirements, followed by a short discussion on the opportunities for additional delivery chain opportunities for the Estuary over the longer term.

5.3.1 FOWT Integration and Pre-commissioning at Foynes Deepwater Port

Foynes Deepwater Port is located at Foynes Island, directly across the main berthing channel from the Port of Foynes. It is proposed that Foynes Deepwater Port serve as a FOWT integration and pre-commissioning base as well as a container terminal (see Chapter 15.2.2 for an overview of the container terminal) while supporting general cargo operations from the inner port at Foynes. The port will feature a quayside of about 800-m length with 15-m water depth alongside and approximately 20 hectares of reclaimed hardstanding behind.

Figure 25: FOWT Integration Base and Container Terminal at Foynes Deepwater Port

The initial 800-m quay wall will be divided into two equal sections with the south-western section used for wind farm development, whereas the north-eastern section will be used as container port. The 400 m of front-side quay wall and ~130 m of quay at the south end of the port provide space for three FOWT berths (see Figure 25). Subject to a detailed feasibility study, the targeted FOWT construction throughput capacity with this three-berth arrangement will be in the order of 400 MW per year, in line with the low development scenario of 10 GW by 2050.

FOWT substructures may be fabricated and assembled at any domestic (e.g., Moneypoint, see Chapter 5.3.2) or foreign yard and delivered to the Foynes Deepwater Port by a semi-submersible heavy transport ship. Delivering substructures by semi-submersible heavy transport ship will accomplish not only the transport but also their launch by float-off, thereby eliminating the need for a dedicated launch facility elsewhere.

Float-off from the heavy transport ship will preferably take place close to the Foynes Deepwater Port. A suitable location exists about 1,000 m west of Foynes Island where the Estuary has a water depth of more than 30 m. Immediately after float-off the substructure can be brought to the quayside at the Foynes Deepwater Port, or (if the port is occupied) to a wet storage location where it will be temporarily moored (Figure 26).

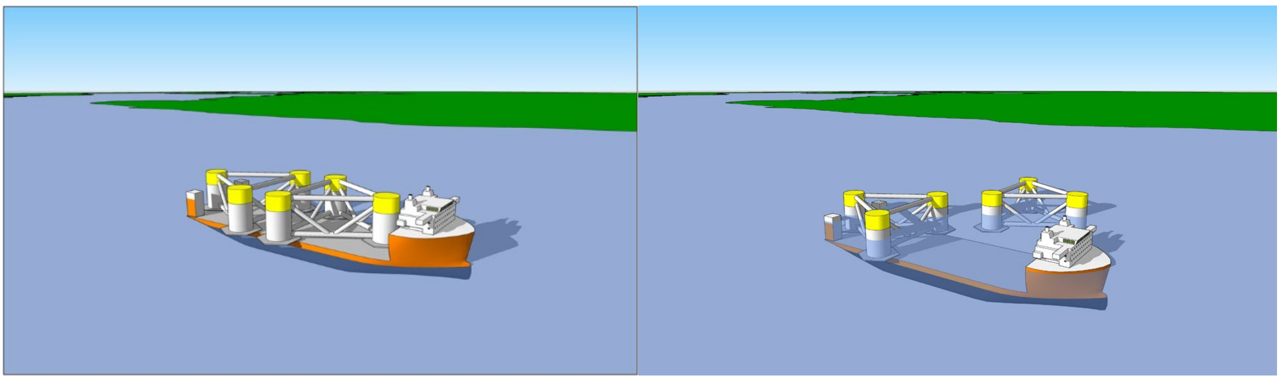


Figure 26: FOWT substructure float-off operation using a semi-submersible vessel

As shown in Figure 27, the Phase 2 expansion of Foynes Deepwater Port entails an additional 400 m of quay length and hardstanding, thereby making space for a fourth berth. This will allow completions and pre-commissioning activities to be performed at two berths simultaneously. Subject to a detailed feasibility study, the targeted FOWT construction throughput capacity with this four-berth arrangement will be in the order of 1,000 MW per year, in line with the medium development scenario of 20 GW by 2050.

Further enlarging the length of the quay by an additional 700 m could bring the FOWT throughput capacity of the Foynes Deepwater Port to about 1,800 MW per year (subject to detailed feasibility study), in line with the high development scenario of 30 GW by 2050.

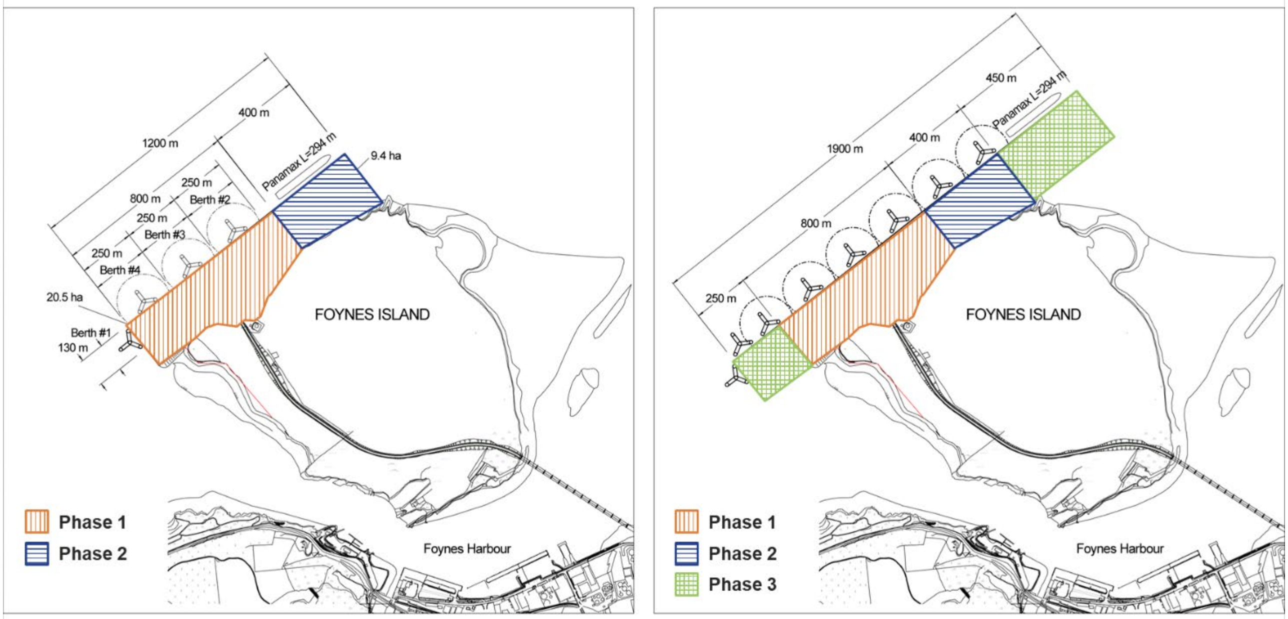


Figure 27: Conceptual Phase 2 (left) and Phase 3 (right) for Foynes Deepwater Port

5.3.2 Substructure Assembly Base at Moneypoint

The Moneypoint SDL currently hosts ESB's 915-MW coal-fired power generation facility, which includes a deepwater jetty and storage yard capable of storing 600,000 tonnes of coal. ESB has long signalled its intent to cease burning coal at Moneypoint, and in April 2021 it announced the Green Atlantic at Moneypoint project, which will transform the site into a green energy hub.

Central to ESB's Green Atlantic project is a new floating offshore wind farm of 1,400 MW off the coast of Counties Clare and Kerry, to be delivered in two phases (see Figure 28). In addition, ESB intends for Moneypoint to become a centre for the construction and assembly of floating wind turbines, leveraging its deepwater access and significant land area that would be made available upon decommissioning of the coal-fired power station.

The substructure assembly facility at Moneypoint would serve as one of the Estuary's core delivery bases for floating offshore wind and would complement the turbine integration port currently planned for Foynes Deepwater Port. Operations at Moneypoint could be integrated with the Foynes Deepwater Port activities by transporting substructures fabricated at Moneypoint to Foynes Island where the FOWTs could be completed.

Though subject to confirmation during the initial planning and design stages, ESB is targeting for its facility to be capable of a substructure throughput of 1,000 MW annually. Their targeted completion by 2028 also coincides with the Foynes Deepwater Port plans, setting the Estuary up well for being able to deliver at least 10 GW by 2050 as per the low scenario defined in Chapter 4.3.

Figure 28: ESB's Green Atlantic at Moneypoint project concept[48]

As reviewed in Chapter 5.1, substructures can be constructed of steel, concrete, or a combination of the two. ESB intends for its substructure assembly yard to cater to any substructure type, though it should be noted that concrete substructures will likely rely more on the local supply chain as compared to steel, which can more readily source pre-fabricated and sub-assembled components from overseas yards. Regardless of whether substructures are constructed of concrete or steel or both, given that each (15 MW) substructure weighs thousands of tons and will approach 90 m in width and 30 m in height, substructure construction is a major operation that will generate a significant number of local jobs.

5.3.3 Wet Storage

As explained in Chapter 5.2.4, wet storage of both substructures and completed FOWTs will be necessary to minimise the impact of any supply chain disruptions along the delivery chain. Weather conditions in the Irish Atlantic will likely not permit continuous installation of FOWTs. Hence, both completed substructures and completed FOWTs will have to be put into wet storage. The expected installation downtimes will need to be assessed by detailed metocean and operability studies, but in lieu of such studies the approximate required wet storage areas for assumed downtimes of 14, 30, and 60 days are listed in Table 6.

Table 6: Estimated Wet Storage Areas dependent on Construction Buffer

Wet Storage Area Requirement [hectares]							
Scenario	**Capacity / Year**	**For Assembled Floaters Construction Buffer**			**For Substructures Construction Buffer**		
		14 days	**30 days**	**60 days**	**14 days**	**30 days**	**60 days**
Low	400 MW / yr	7	15	30	2	4	9
Medium	1,000 MW / yr	17	37	75	5	11	22
High	1,800 MW / yr	31	67	134	9	20	39

Wet storage areas should have at least 15-m water depth and be suitably sheltered and separated from the main navigation channel. Potential anchor zones for wet storage in the Shannon Estuary are depicted in Figure 29. The identified areas amount to a total wet storage area of approximately 300 hectares, significantly exceeding the requirements of even the high scenario at 60 days storage, making the Shannon Estuary uniquely positioned to deliver floating offshore wind at scale.

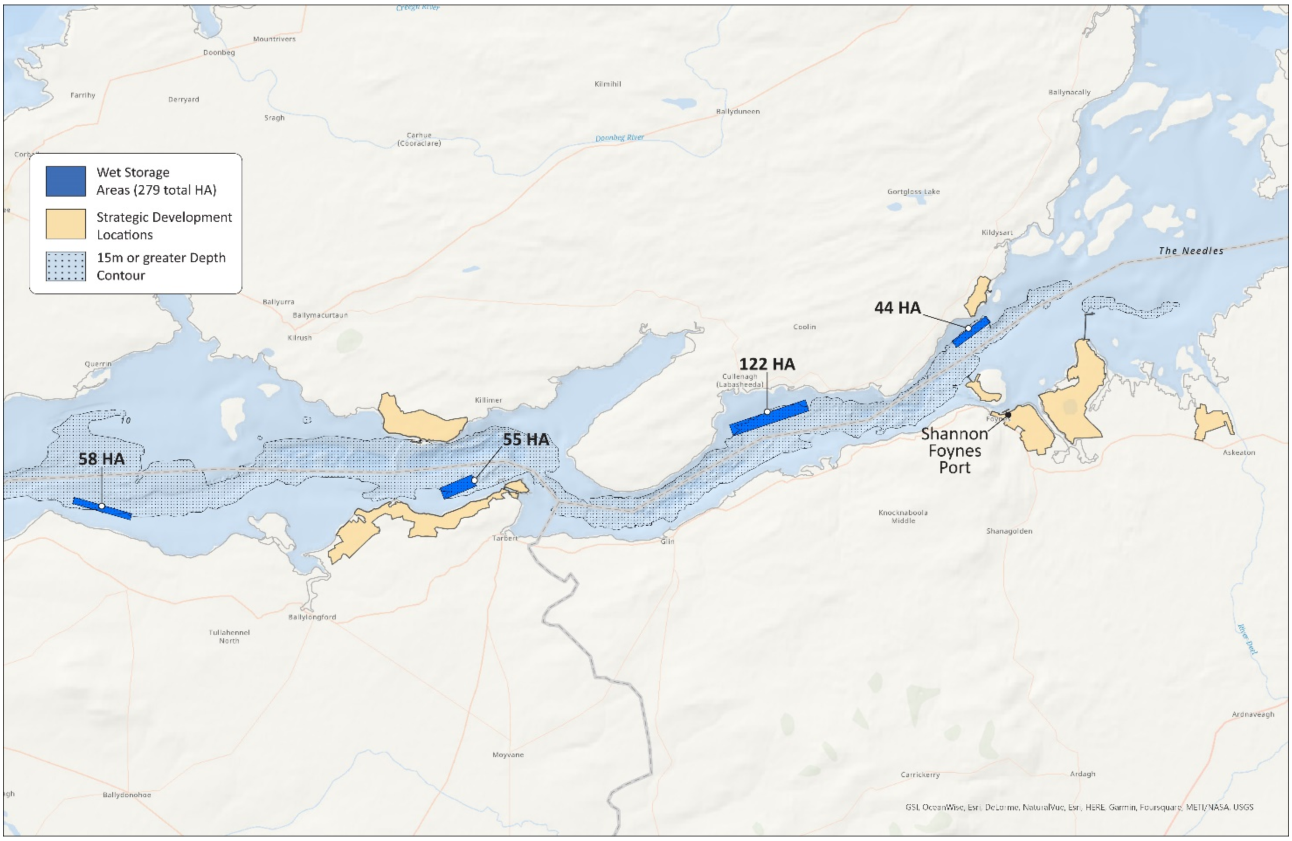


Figure 29: Identified FOWT Wet Storage Areas in the Shannon Estuary

Figure 30: Foynes Deepwater Port with wet storage of completed units in the background

5.3.4 O&M Base at Port of Foynes

Ongoing O&M support to the Atlantic offshore wind developments requires quayside laydown and frequent berth access to accommodate crew and equipment transfers. In general, requirements for the O&M port will depend on the distance to the wind farm. This is because wind farms far from shore will require larger SOVs, whereas wind farms close to shore will more likely be serviced by much smaller CTVs. In either case, port access in all tidal conditions must be assured to allow service crews taking full advantage of weather windows without being constrained by tide.

The Shannon Airport presents an additional differentiator for SFPC with respect to O&M services. Having an international airport nearby further enhances the value of this O&M base as it again reduces the overall travel time of any international specialists that need to travel to the wind farms. This will be particularly of benefit as the industry develops with many technical specialists from overseas needing to visit the region.

The throughput of material and personnel as well as the overall ship traffic at the O&M base will scale in proportion to the installed wind farm size. Initially, two berths, a laydown area of 0.5–1 ha, and warehousing facility of about 500–1,000 m^2 can suffice, and this can be provided at the Port of Foynes. As the installed wind farm capacity increases it is expected that the size of the operation will outgrow the capacity at the Port of Foynes, necessitating the establishment of an additional O&M port elsewhere. Since the distance between port and wind farm is an important cost factor for O&M, wind farm operators may prefer siting their O&M base at a location closer to their wind farm. Given that an O&M port does not require significant water depth alongside, their location may or may not be within the Shannon Estuary. This decision involves many factors and ultimately rests with the wind farm operator, but, given its current available capacity and its proximity to the integration base at Foynes Deepwater Port, the Port of Foynes is well-suited to serve as the starting point for wind farm O&M operations.

Table 7: Typical Sizes of Wind Farm Operations & Maintenance Vessels

Vessel Type	Length [m]	Bean [m]	Draft [m]	Speed [kt]
Crew Transfer Vessel (CTV)	18-30	6-11	1.5-3	20-30
Service Operations Vessel (SOV)	60-100	16-20	5-8	9-14
Survey Vessel	30-70	10-15	3-6	10-12
Geochemical Survey Vessel	60-100	16-20	4-7	10-12

5.3.5 Additional Delivery Chain Opportunities on the Estuary

The integration port at Foynes Deepwater Port, the substructure assembly yard at Moneypoint, the designated wet storage areas, and the O&M base at Port of Foynes together constitute the delivery chain activities where proximity to the wind farm – and therefore their establishment on the Estuary from the outset – is essential. Among those that are not so constrained by proximity (as described in Chapter 5.2), certain delivery chain activities have a higher likelihood of being established locally if and as annual turbine delivery rates increase to a point where colocation becomes an attractive investment for potential developers. These activities and their associated infrastructure requirements are described below.

5.3.5.1 Blade Manufacturing and Recycling Facilities

Colocation of the offshore wind supply chain within the Estuary can provide improved efficiency for operators and represents an opportunity for SFPC to offer a differentiated product to developers. Specifically, the manufacturing of components to support integration operations should be considered, with Cahiracon representing the most optimal location for these operations due to the proximity of the Cahiracon SDL to the Foynes Deepwater Port.

Analysis of the offshore wind supply chain, industry benchmarks, and local content capabilities highlights blade manufacturing as one of the most suitable opportunities for the Cahiracon SDL site. Turbine blade manufacturing requires large, custom facilities for fabrication and ample laydown space – totally up to 32 ha. Projects such as the Coastal Virginia Wind Project (in Norfolk, Virginia, USA), are prime examples of colocating blade manufacturing with an integration port. Depending on local blade demands, a proposed blade-manufacturing facility at Cahiracon may also find opportunities to export blades to other regional and even global projects.

As technology progresses, blade-recycling facilities will also be required to support the wind industry. Colocation of manufacturing and recycling facilities would make sense from a logistics perspective as the quay side will be developed to receive blades.

5.3.5.2 Miscellaneous Steel Fabrication Facilities

The Estuary may also look to colocate steel fabrication facilities for miscellaneous steel fabrications in support of the offshore wind units. Whilst the fabrication of large structural steel elements such as the turbine towers and floating substructure members is likely to take place at already established large-scale steel fabrication yards overseas, there is a strong rationale for the establishment of a local facility centred around ad hoc fabrication modifications as well as the production of lightweight items such as ladders, railings, and other miscellaneous and secondary steel support structures. In addition, there could also be a potential for fabrication of certain steel mooring components. Suitable locations for such a fabrication facility include the immediate hinterlands within the Port of Foynes SDL as well as Cahiracon.

5.4 Conclusion

Wind turbines with floating substructures are needed for wind farms in water depths greater than 50–60 m, which is the case for the vast majority of the Irish Atlantic. A key difference between the fixed and floating offshore wind farm delivery chains is that floating wind turbines are fully integrated and pre-commissioned in the port (i.e., at an "FOWT integration port") before being wet-towed to their final installation location. This installation method means that distance to port is a major cost driver for offshore wind farms. Long travel times to the wind farm reduce the available operating window for FOWT installation as well as maintenance. The generally harsh environment in the North Atlantic further exacerbates these challenges, and considering weather windows ports far away from the wind resource are significantly handicapped if not disqualified as a floating offshore wind farm integration, installation, or operations base due to the diminishing weather window. Accordingly, the Shannon Estuary is ideal for serving the floating offshore wind industry in the Irish Atlantic.

While a complete floating offshore wind farm delivery chain may eventually be developed in Ireland – and ideally in the Shannon Estuary – this assessment recommends an incremental development process starting first with the establishment of the necessary infrastructure to support those delivery chain activities where proximity to the wind farm is most essential:

1. FOWT integration and pre-commissioning at Foynes Deepwater Port,
2. FOWT substructure assembly at Moneypoint,
3. Wet storage within the Estuary, and
4. Operations & maintenance at the Port of Foynes.

The establishment of these four core facilities on the Estuary lays the groundwork for the potential development of additional delivery chain capabilities over the longer term, such as turbine blade manufacturing and miscellaneous steel fabrication.

All told, given its proximity to the resource, deep-water access, and ample space for wet storage, the core facilities recommended in this assessment will enable the Shannon Estuary to deliver floating offshore wind at a scale that will make an indispensable contribution toward achieving both Ireland's and Europe's climate objectives.

6. Estuary Transmission Infrastructure

The Shannon Estuary is well-positioned to serve as a major receiving node for offshore wind electricity generated off the west coast, situated at the western end of Ireland's main 400-kV cross-country transmission lines and with high-voltage substations – Moneypoint, Kilpadogue, and Tarbert – on both its north and south shores. The advancement of projects such as the 400-kV Cross-Shannon cable and ESB's Sustainable System Support facility at Moneypoint will enable higher volumes of renewables on the system and greater regional connectivity. Although substantial onshore grid reinforcement in the west and southwest regions is still needed and must be accelerated, the Shannon Estuary is nonetheless poised to be a "go-to" destination for connecting west coast offshore wind power to domestic demand in the near term.

Over the longer term, as the additional generation capacity off the west coast is increasingly being delivered to satisfy demand beyond Ireland's shores in Europe, there is considerable uncertainty around the routes to market that will eventually be utilised, and therefore around the role that the Estuary's transmission infrastructure will play. It is outside of SFPC's remit to answer the questions of exactly how Atlantic offshore wind would be connected to the national grid in the near term, as well as how it will supply European demand over the longer term, but they will be explored here only in the context of infrastructure planning and preparedness for the Shannon Estuary.

6.1 Offshore Wind Farm Transmission Infrastructure Overview

Figure 31 shows the schematics of the electricity transmission infrastructure for offshore wind farms. Its principal components for are (1) inter-array cables, (2) offshore substation, and (3) export cable. Of the currently existing floating wind farms only one – the Fukushima FORWARD – has a floating offshore substation. As floating wind farms are increasingly deployed at greater distances from shore and with greater capacities (e.g., >300 MW), offshore substations will be needed more regularly in order to keep transmission losses low.

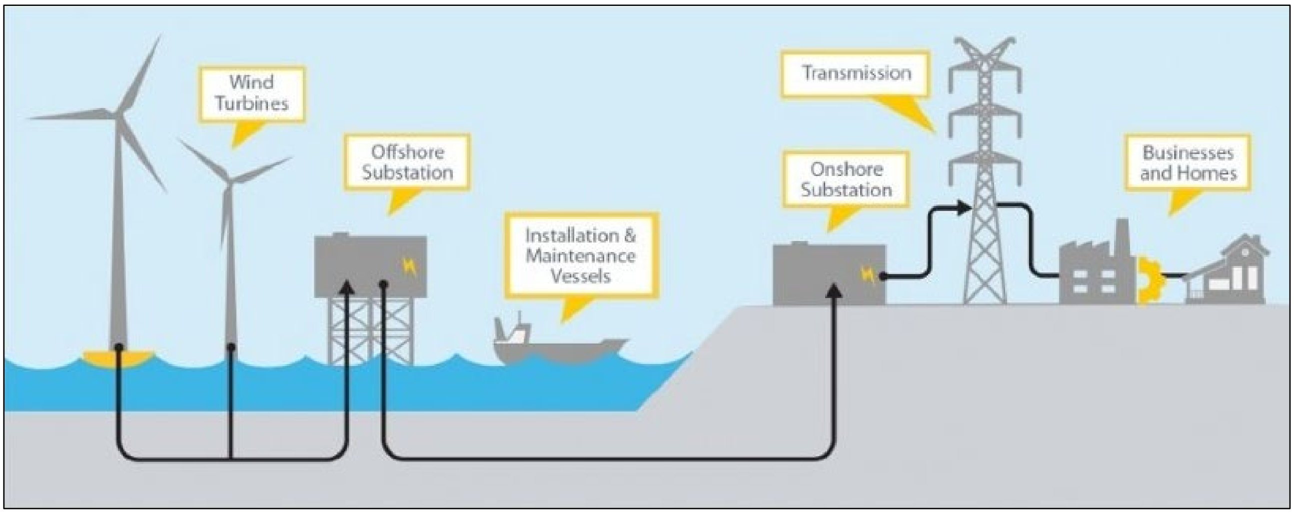


Figure 31: Major Offshore Wind Transmission Infrastructure[49]

Inter-array cables provide the interconnection between the wind turbines and the offshore substation. The top section of an inter-array cable (also known as "dynamic cable") is free hanging from the FOWT to the seafloor, while the remaining portion of the cable rests on the seafloor where it is preferably buried or protected by cable mats.

Offshore substations consolidate alternating current (AC) power from individual wind turbines and transform the output from medium voltage to high voltage for export to the onshore substation. Their purpose is to reduce electrical losses during export to shore. Existing offshore substations (for bottom-fixed wind farms) are supported either on mono-pile substructures or jacket-type substructures. Future offshore substations may be either bottom-fixed or floating, depending on the water depth at their locations. Floating substations can have any of the floating substructures shown in Figure 16. Instead of a wind turbine they will carry a topside that houses the electric transformers, switchgear, and control system.

A single heating, ventilation, and air conditioning (HVAC) substation can support wind farms up to about 500 MW. Large wind farms of 1 GW are likely to have two or three substations. Export cables provide the transmission connection between the offshore substation and the onshore substation. They can be designed for either AC or DC transmission, whereby the latter has less power loss but requires DC converter stations on both ends. AC export cables are typically rated at 132–245 kV, allowing for power export up to 400 MW per cable. DC cables currently achieve voltages up to 600 kV and power capacities up to 1.2 GW. High-voltage DC technology is currently still evolving and is predicted to ultimately enable the efficient long-distance transmission of power across Europe (see Chapter 6.3.2).

6.2 Connecting Atlantic Offshore Wind to the National Grid

In many instances, offshore wind farms are developed such that each project – each array – has its own individual submarine connection to the onshore grid. These individualised, project-specific transmission approaches are often called radial configurations. Although radial configurations can have an advantage in that offshore wind developers can move their project forward without having to wait for other projects or larger transmission plans, the industry is also exploring a shared transmission approach, whereby a high-capacity HVDC connection is developed offshore to which multiple wind farms can connect.[50] This approach would limit the number of onshore connections as well as the associated costs and environmental impact, though it typically requires the transmission system operator (TSO) – EirGrid to take more of a lead in coordinating the overall development.

The Government's latest target is for Ireland to deliver 7 GW of offshore wind by 2030, and according to Wind Energy Ireland, given the current connection regime this capacity will be connected using the conventional approach of radial connection schemes. However, it is expected that a new connection regime will be developed and implemented for post-2030 projects to strengthen the Irish grid while facilitating an increase in capacity of offshore wind.[51]

Currently, submarine HVDC power cables can be fabricated to a rating of 600 kV and deliver capacity up to 1.2 GW, though plans and proposals are discussed for standardisation of 2GW+ HVDC grid connection solutions to accelerate offshore wind development.[52, 53] This capacity limitation means that, for 10+ GW of Atlantic offshore wind power to reach Ireland's shores, multiple long-distance submarine HVDC cables will be required between the substations and shore, even if a shared transmission approach is pursued.

Therefore, it is imperative that the initial submarine cable deployments are planned with future expansion in mind. "Cable corridors" should be established that effectively reserve a route (allowing for sufficient width to accommodate spacing between cables) for additional HVDC submarine cables.

Subject to detailed study, establishing such a "cable corridor" through the Shannon Estuary (see Figure 32) could be feasible given its water depth and overall width. This approach could more readily leverage existing grid infrastructure – such as those substations along the Shannon Estuary – whereas routing the cabling elsewhere along the outer west coast would likely require the establishment of significant "greenfield" facilities shoreside, as well as associated over-land transmission infrastructure through potentially sensitive areas to connect to the grid. In either case, it is likely that Atlantic offshore wind power must – by land or by sea – travel through the existing substations and transmission infrastructure along the Shannon Estuary to access the national grid, offering significant opportunities for green industrial development.

Figure 32: Generation and Transmission Infrastructure, including potential submarine cable corridor through the Estuary

6.3 Electrically Connecting Atlantic Offshore Wind to Europe

As mentioned in Chapter 4, there is considerable uncertainty around the routes through which Irish Atlantic offshore wind will access European demand. But fundamentally, Atlantic offshore wind can reach European demand in the form of either electricity or e-fuels (i.e., Net Zero compatible fuel produced using renewable energy). This chapter will explore the options for *electrical* transmission to Europe and consider the high-level implications for the Shannon Estuary.

The island of Ireland is currently connected to the European grid only via Great Britain, and these high-voltage interconnects between the two islands will have a combined capacity of 1.5 GW by 2024 once the 500-MW Greenlink Interconnector is completed.[54] A planning application for a direct link between Ireland and France – the 700-MW capacity Celtic Interconnector – was recently approved by An Bord Pleanála and is anticipated to be built and energised by 2026[55]; this would bring Ireland's total interconnection capacity to 2.2 GW (see Figure 33).

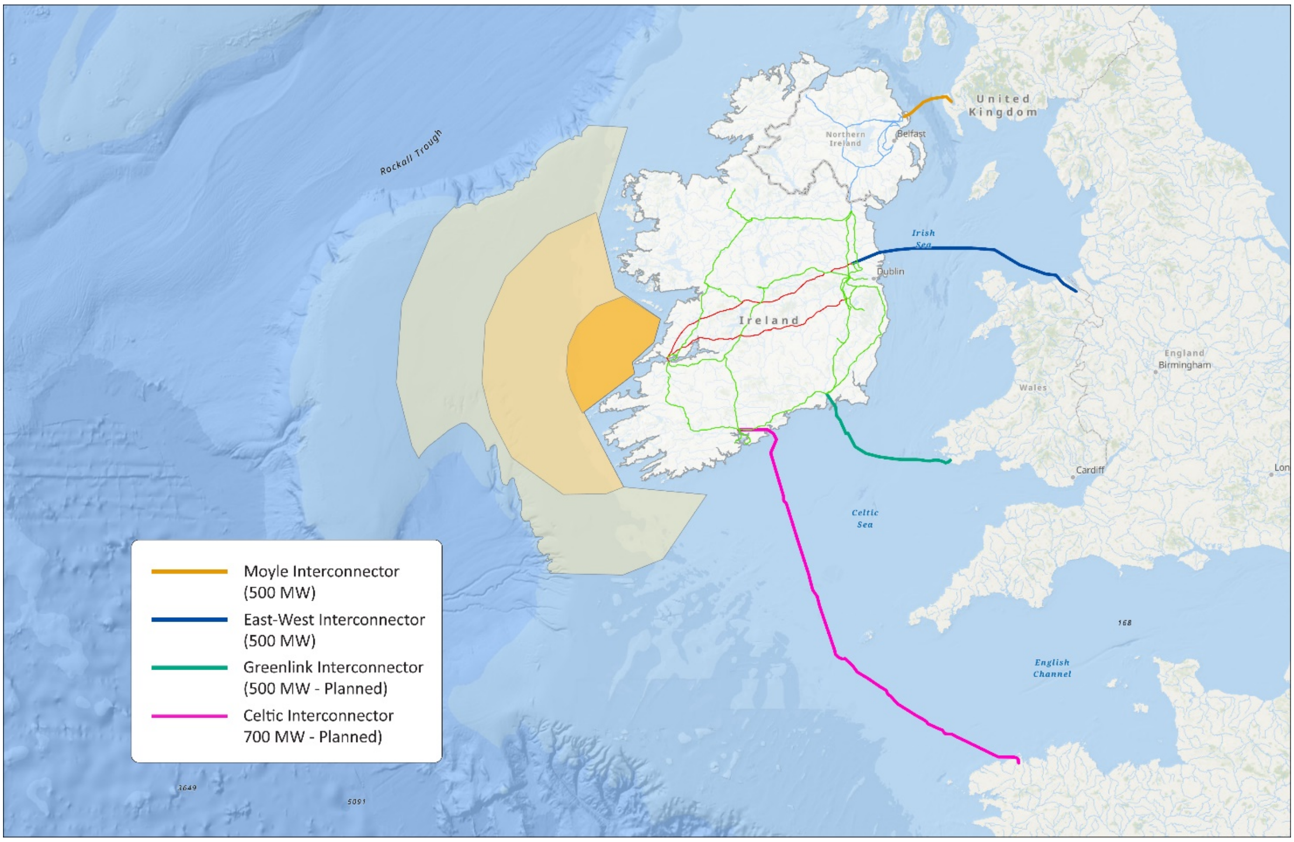


Figure 33: Existing and Planned high-voltage interconnects from Ireland

In their 2021 report on future power system needs, ENTSO-E (an association of European transmission system operators, including EirGrid) projected that Ireland will require an additional 1.2 GW of interconnection capacity by 2040, split as 500 MW to Great Britain and another 700 MW to France.[56] This would bring Ireland's total interconnection capacity to 3.4 GW by 2040, which clearly is not enough to offer a meaningful conduit to Europe from Irish Atlantic offshore wind over the coming decades.

6.3.1 Hybrid Offshore Wind Projects

In parallel with the conventional approach to international transmission system planning where country-to-country interconnections are developed independently of new generation assets, EU member states are also pursuing an alternative approach to accommodate and encourage the development of offshore wind. A *hybrid project* combines HV interconnection with offshore generation into a single project, linking two or more countries and providing a platform for further coordination between them.[57] In Germany and Belgium, there are already shared offshore connection points where multiple farms connect offshore and use the same link back to shore.[58] And many more hybrid projects are being advanced across Europe's northern seas.

With respect to Irish Atlantic offshore wind, fundamentally there are two routes through which it can access the European grid as electricity: one route that first lands on Ireland's shores and traverses across its (and potentially Great Britain's) onshore grid before arriving on the continent, or alternatively a route that is (by means of hybrid project development) conveyed directly to Europe without ever touching Ireland's shores. Presently there are no known hybrid projects proposed that include Ireland's western or southern seas. Unless Ireland's planned interconnection capacity via the conventional approach dramatically increases from the current forecast of 3.4 GW by 2040, it is imperative for the long-term future of Irish Atlantic offshore wind that hybrid projects linking it directly to Europe be studied and advanced today.

6.3.2 The SuperGrid

Taking the concept of a hybrid project one step further, the SuperGrid is the name given to a large pan-European transmission network that would allow the movement of huge volumes of electricity across great distances, using HVDC or ultra-high-voltage direct current (UHVDC, above 800 kV) power lines (Figure 34). From an Irish context the case for developing a SuperGrid is clear, considering the size of Ireland's offshore wind resource compared to its domestic demand.

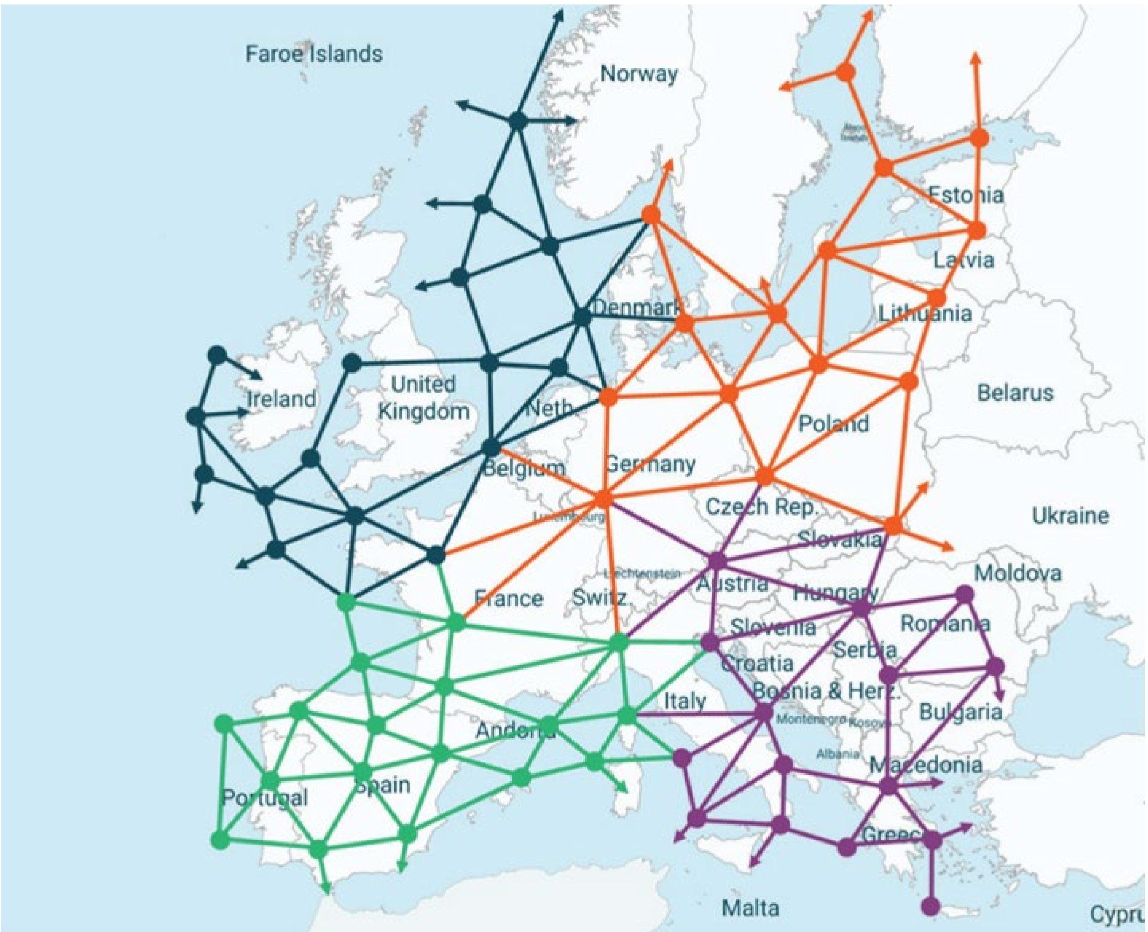


Figure 34: Representative Map of what a SuperGrid could look like[59]

From a European context, one of the main benefits to the SuperGrid would be in realising the seasonal complementarity between its wind resources in the north and its solar resources in the south. As shown in Figure 35, the energy outputs of the two resources are inversely related. When wind power output is high in the winter, solar power output is low, and vice versa. As Wind Energy Ireland states in their 2022 report entitled "Ireland and the SuperGrid", this complimentary relationship can only be taken advantage of with a grid big enough to connect areas of wind and solar generation to where the power is needed.[60]

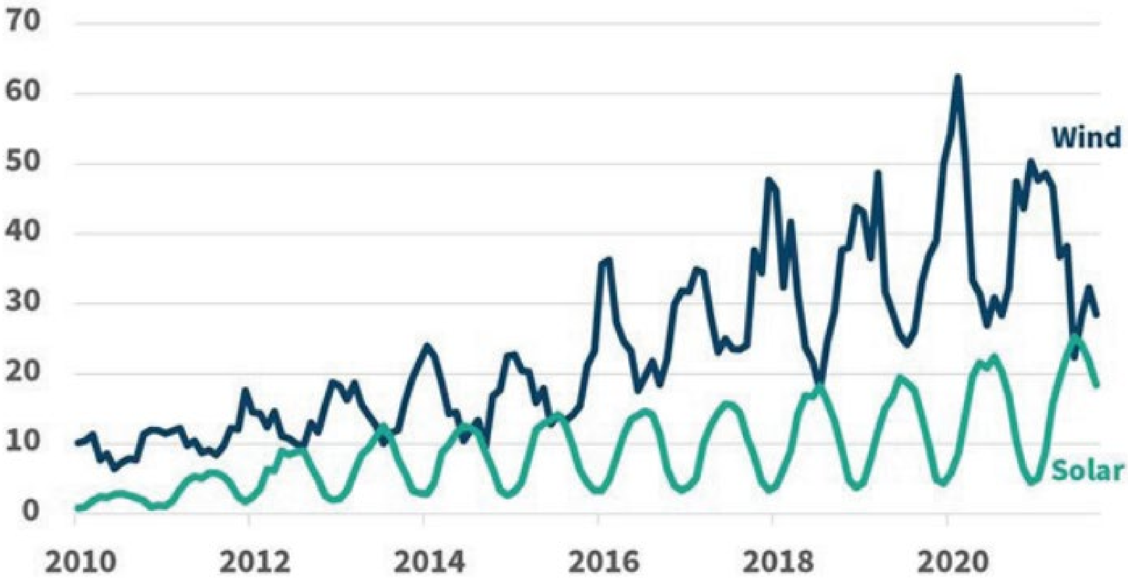


Figure 35: Seasonal Variability of Wind and Solar Generation in Europe (TWh) – The Complementary Relationship[61]

Inherent in the realisation of the SuperGrid is the advancement of higher capacity transmission technologies. As mentioned in Chapter 4, submarine HVDC power cables can currently be fabricated to a rating of 600 kV and deliver capacity up to 1.2 GW. Higher capacity cables are currently being deployed in China, with one in particular capable of delivering up to 12 GW.[62] However, these are over-land cables, which are not subject to the same conditions and constraints as submarine cables.

Cables composed of special superconducting materials may offer a solution to the capacity problem. These cables can carry higher currents than conventional cables meaning they can operate at lower voltages while still carrying several GWs of power, using a much smaller surface area and requiring significantly less infrastructure, materials, and space than conventional cables.[63] Long-distance, high-capacity superconducting cables are not ready for implementation today, but the technology is advancing rapidly.

6.4 Conclusion

The Shannon Estuary is well-positioned to serve as a major receiving node for offshore wind electricity generated off the west coast, situated at the western end of Ireland's main 400-kV cross-country transmission lines and with high-voltage substations on both its north and south shores. How exactly all this electricity will reach the Estuary remains to be seen, but present cable capacity limitations means that – for 10+ GW of Atlantic offshore wind power to reach Ireland's shores – multiple long-distance submarine cables will be required. Therefore, it is imperative that the initial submarine cable deployments are planned with future expansion in mind. "Cable corridors" should be established that effectively reserve a route for additional submarine cables, and such a corridor running through the Shannon Estuary could more readily leverage existing grid infrastructure, whereas routing the cable elsewhere along the outer west coast would likely require the establishment of significant "greenfield" facilities shoreside and associated over-land transmission lines.

Over the longer term, as the additional generation capacity off the west coast is delivered to satisfy demand beyond Ireland's shores to Europe, there is uncertainty around the routes to market that will be utilised. Interconnects, which are HVDC transmission cables between two countries' national grids, are likely to play a key role. However, the 3.4 GW of total interconnection capacity projected by ENTSO-E for Ireland by 2040 is clearly not enough to offer a meaningful conduit to Europe for Irish Atlantic offshore wind. Hybrid projects, which combine HV interconnection with offshore generation into a single project, may offer a solution, and it is imperative for the long-term future of Irish Atlantic offshore wind that hybrid projects linking directly to Europe be studied and advanced today.

One leap beyond the hybrid project is the SuperGrid, a pan-European transmission network that would move huge volumes of electricity across great distances. The SuperGrid offers great promise for the rapid development of renewable generation across Europe, and particularly for Ireland considering the size of Ireland's offshore wind resource compared to its domestic demand. Though not ready for implementation today, the swift advancement and deployment of long-distance, high-capacity superconducting cables would be a welcome boon for the SuperGrid and ultimately for Irish Atlantic offshore wind.

7. Driver 1 Key Takeaways

Key takeaways…

- The Shannon Estuary is uniquely-positioned to deliver floating offshore wind at scale, given its (1) proximity to the resource, (2) deep water facilities, (3) ample space for wet storage, and (4) existing high voltage grid connections.

- The design and installation methods for floating offshore wind turbines require that certain assembly activities take place relatively close to the wind farm. It is estimated that over 70 GW of development potential is well within the Shannon Estuary's reach.

- Having surveyed the wind energy potential alongside prospective sources of demand and their possible routes to market, a set of generation capacity scenarios was developed that will serve as a planning basis for this assessment. The three scenarios reflect different generation capacities delivered from the Shannon Estuary by 2050: 10 GW, 20 GW, and 30 GW.

- This assessment recommends the establishment of four core facilities on the Shannon Estuary to support the delivery of floating offshore wind at scale:
    1. FOWT integration and pre-commissioning at Foynes Deepwater Port,
    2. FOWT substructure assembly at Moneypoint,
    3. Wet storage at various locations along the Estuary, and
    4. O&M base at the Port of Foynes.

- The establishment of these four core facilities on the Estuary lays the groundwork for the potential development of additional delivery chain capabilities over the longer term, such as turbine blade manufacturing, blade recycling and miscellaneous steel fabrication.

- The Shannon Estuary's unparalleled potential for deep water wet storage – totalling in the hundreds of hectares and suitably separated from the main navigation channel – offers a crucial risk mitigating solution towards realising the full potential of Atlantic offshore wind.

- Situated at the western end of Ireland's main 400kV cross-country transmission lines and with high-voltage substations on both its north and south shores, the Shannon Estuary is well-positioned to serve as a major receiving node for Atlantic offshore wind electricity.

- For 10+ GW of Atlantic offshore wind power to reach the Estuary's shores multiple long-distance HV submarine cables will be required. Therefore, initial submarine cable deployments must be planned with future expansion in mind.

- A "cable corridor" running through the Shannon Estuary could more readily leverage existing onshore grid infrastructure and minimise the need for significant "greenfield" infrastructure elsewhere along the outer western coast.

- The feasibility of hybrid projects that would link Atlantic offshore wind directly to Europe must be studied and advanced urgently.

- The swift advancement of the SuperGrid (a pan-European high-volume transmission network and underlying superconductor technology) would be a welcome boon for Atlantic offshore wind.

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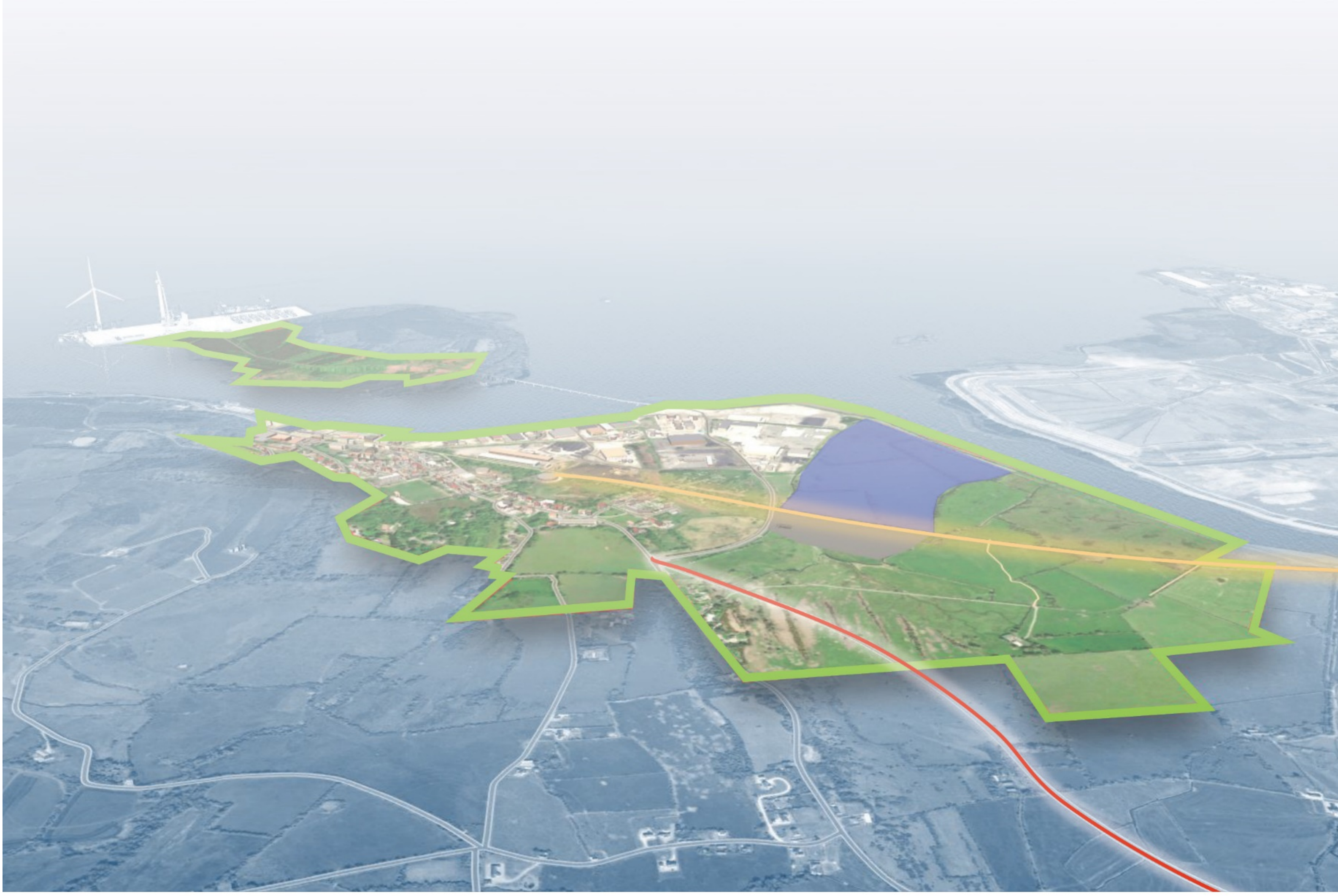
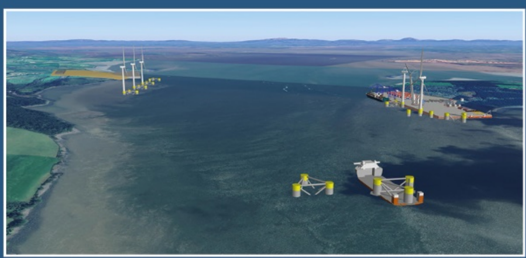
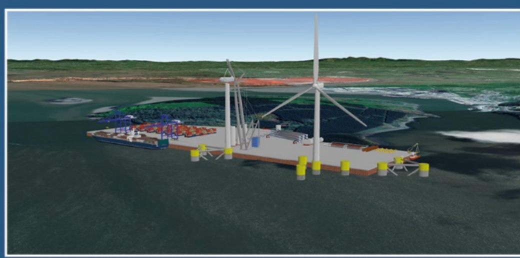
Driver 2:
Green Industrial Development and Transition







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As the world focuses on transitioning to Net Zero, renewable energy has become a large part of the solution. However, direct electrification using energy from renewable sources can only take Ireland and the world so far in its journey to Net Zero. For the remaining, difficult-to-electrify sectors of the economy, alternative Net Zero compatible fuels and feedstocks will be needed.

The Shannon Estuary's proximity to an abundance of renewable power from offshore wind provides the potential for significant production of Net Zero compatible fuels, such as green hydrogen and its various derivatives. In addition to transforming local industry and helping the country accelerate its transition to a Net Zero future, this will enhance Ireland's energy security as it reduces reliance on imported fossil fuels. Through green hydrogen production and export, Ireland can also become a net exporter of energy, providing it with a new revenue stream.

Ireland has just launched its consultation to develop a hydrogen strategy for the country.[64] This strategy will likely help develop a national demand for hydrogen across all industries. Hydrogen Mobility Ireland has also recently launched a report on the benefits of hydrogen as a transport fuel, which further highlights the need to consider hydrogen fuelling for bus and heavy vehicle fleets.[65]

The technology for producing green hydrogen has been in existence for centuries and is well proven, requiring only renewable electricity and water. The following chapters provide a technical overview of green hydrogen and its derivatives and show how the Shannon Estuary can – when supplemented by carbon capture technologies and renewables-ready data centres – leverage Atlantic offshore wind energy to develop an industrial ecosystem centred around green hydrogen.

9. Green Hydrogen

9.1 Introduction

Hydrogen offers much promise in the search for Net Zero compatible alternatives to fossil-based fuels and feedstocks. Not only does it produce zero harmful emissions when consumed, but pound for pound, hydrogen contains almost three times as much energy as fossil fuels.[66] However, unlike fossil fuels, there are no vast deposits of hydrogen in its molecular form (H_2) that can be extracted from the ground. Hydrogen must therefore be produced through a chemical process involving other molecular compounds. And unfortunately, the most prevalent hydrogen production process today results in significant carbon emissions. In other words, whilst hydrogen's *consumption* is carbon-free, it's *production* currently is not. However, there are alternative hydrogen production methods that are not as carbon-intensive, and these are categorised using a colour code system as illustrated in Figure 36[67].

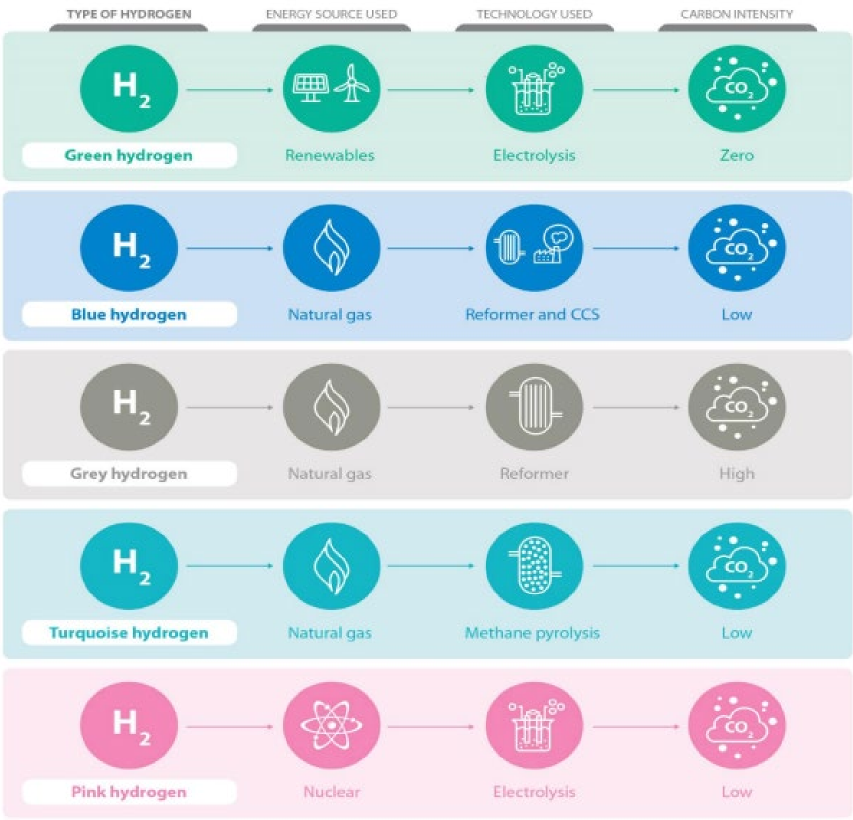


Figure 36: Types of hydrogen, source, technology & carbon intensity [67]

As alluded to above, most hydrogen today is "grey" hydrogen, which is produced using fossil fuels, notably through the processing of natural gas or coal. These fossil fuel-based production methods, which account for 95% of today's hydrogen supply, result in a substantial CO_2 footprint (900 Mt of CO_2 emissions per year[68]) and are not compatible with moving toward Net Zero emissions.[69]

Blue, turquoise, and pink hydrogen are lower (though not zero) emission alternatives, but they are not relevant from an Irish perspective because their prerequisite is the availability of an abundant supply of natural gas or nuclear power, neither of which Ireland has. Green hydrogen emits no carbon during its production and is powered entirely by renewable electricity, which Ireland could have in abundant supply in the form of offshore wind.

Green hydrogen production is fully consistent with the Net Zero route and is the most compatible option with the EU's climate neutrality and zero pollution goal in the long term and the most coherent with an integrated energy system.[70] It relies on technologies that have long been known, based on electrolysis, which combines water with electricity to form hydrogen (see Figure 37). [71]

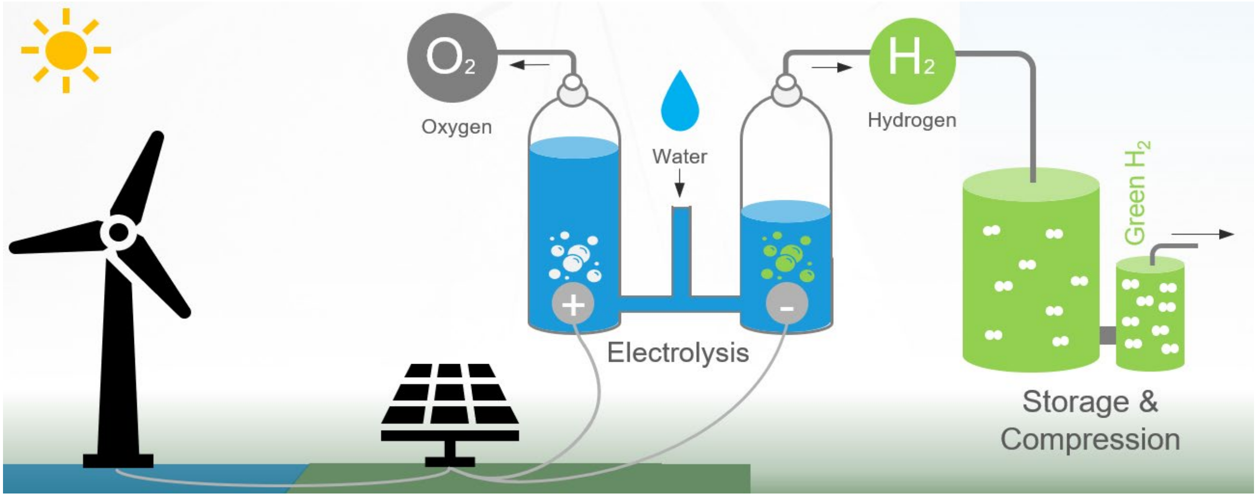


Figure 37: Production of Green Hydrogen

Water is a key feedstock in the production of green hydrogen with about 20 kg of water needed to produce about 1 kg of hydrogen via electrolysis considering losses. Water can be obtained from fresh water sources, or from sea water where it would need to be desalinated. The water needs to be as pure as possible as any impurities will have a major impact on the life of the electrolyser, therefore water treatment plants will be required for any green hydrogen production facility.

In addition to being used as feedstock for the hydrogen production process, water can also be used to cool the plant equipment. Access to significant amounts of water is therefore a key consideration for the siting of a green hydrogen production facility.

Green hydrogen will therefore be most economical in locations that have the optimal combination of abundant renewable resources and access to water, along with the capability to export to large demand centres.[72] New nodes, such as the Shannon Estuary, could arise that exploit these factors to become centres of hydrogen production and use.

9.2 Plans for Green Hydrogen

Currently, hydrogen production from renewable sources is limited (global electrolyser capacity today stands at just over 0.3 GW[73]), but this is set to change with the global focus on its development. In July 2022, the Irish Government set a target for 2 GW of green hydrogen production capacity to be established by 2030.[74] Though quite an ambitious target, green hydrogen production is being accelerated across the EU and its prospects are evolving quickly due to various initiatives, discussed below.

Both the 2020 EU Hydrogen Strategy and the (May 2022) RePowerEU plan target the installation of at least 40 GW of electrolyser capacity across Europe and the production of 10 million tons per annum of green hydrogen by 2030, and both recommend the development of local/regional ecosystems or “Hydrogen Valleys” where both hydrogen production and associated local demand centres are advanced in tandem.

From 2030 and toward 2050, the EU Hydrogen Strategy indicates that renewable hydrogen technologies should reach maturity and be deployed at large scale to reach all hard-to-decarbonise sectors. In particular, green hydrogen, green ammonia, and green hydrogen-derived synthetic fuels could penetrate more largely across a wider range of sectors of the economy, from aviation and shipping to hard-to-decarbonise industrial and commercial buildings.

In addition to the hydrogen-focused strategies put forward by the European Commission, there are further plans developing via the European Hydrogen Backbone (EHB) initiative, which aims to accelerate Europe's decarbonisation journey by establishing a pan-European hydrogen pipeline network using both existing and new pipelines.[75] Gas Networks Ireland is a member company of the EHB, and the Shannon Estuary will be connected to the EHB through the repurposing of the existing gas network by 2040 as can be seen in the map in Figure 38.

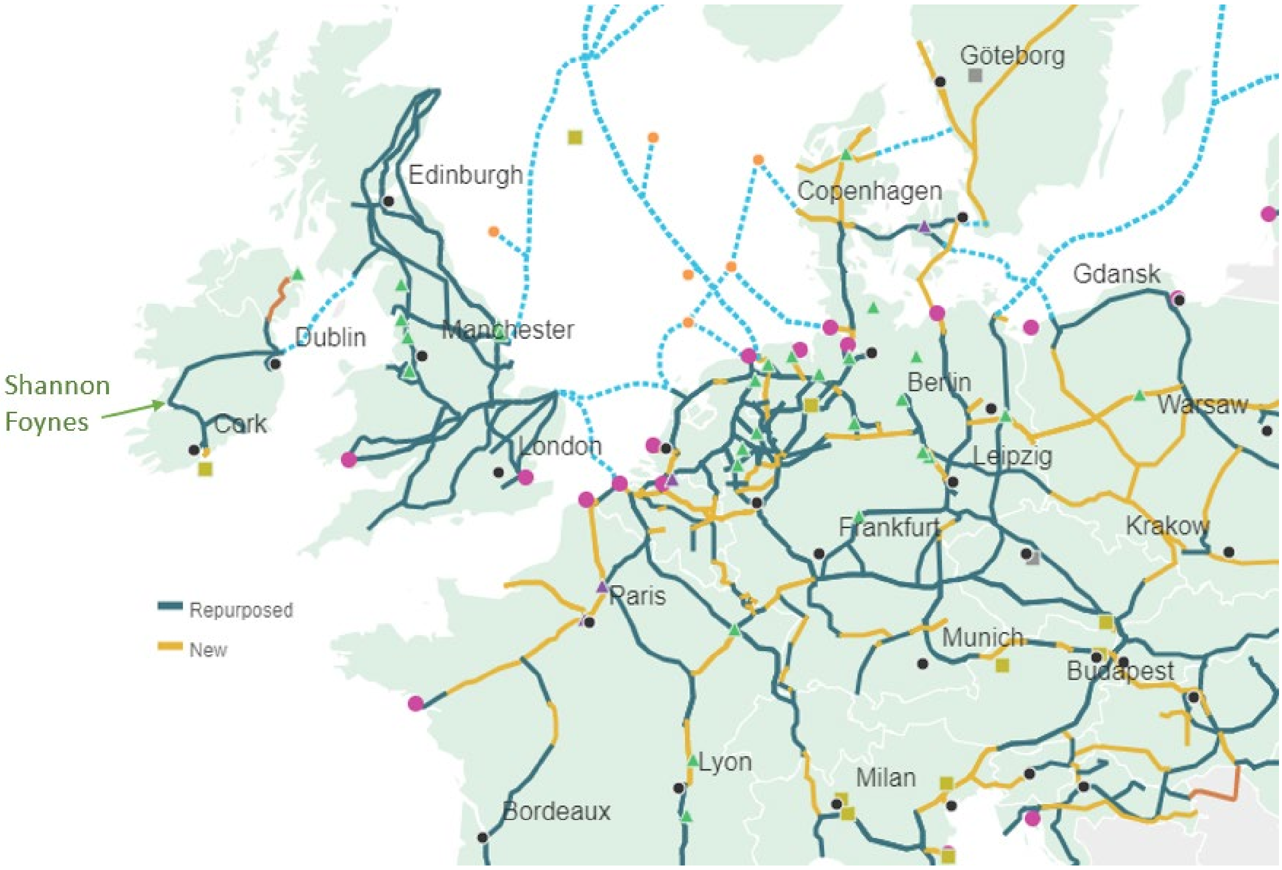


Figure 38: European Hydrogen Backbone Map 2040[76]

Considering Ireland's and Europe's 2030 targets as well as the longer-term green hydrogen plans set by both the European Hydrogen Strategy and the EHB, Table 8 below provides a high-level projection for associated production capacities of green hydrogen from the Shannon Estuary. This considers the domestic supply of green hydrogen, as well as the potential for export by 2050 and is aligned with the offshore wind generation capacity scenarios (10/20/30 GW by 2050) set out in Chapter 4.

Table 8: Green Hydrogen Production Capacity from the Shannon Estuary

	Low Scenario (GW)	Medium Scenario (GW)	High Scenario (GW)	Assumptions
2022	0	0	0	▪ E-fuel demand: Ireland domestic 40%, Export 60% ▪ Electrolysers efficiency of 90%, Operating @ 8400 hrs. per year ▪ E-fuel export demand is based on meeting European demands as per EHB hydrogen supply report issued May 2022.[77] Considering – 5% for Low scenario – 1 GW – 15% for Medium scenario – 4 GW – 20% for High scenario – 6 GW
2030	2	2	2	
2050	3	6	10	

For the Shannon Estuary to be successful in reaching toward the scenarios depicted in Table 8, at least two things will be crucial. First is the promotion of an estuary-based regional ecosystem that links green hydrogen production directly with demand from local industry and transport; this concept is outlined in more detail in section 12. Second is the promotion of a pan-European green hydrogen market that encourages collaboration between countries and connects the Shannon Estuary to European hydrogen demand through the establishment of both pipeline networks and marine export terminals. The EHB projection is that, by 2050, Ireland will produce ~70 TWh of green hydrogen and this will include ~40 TWh of excess supply, which can be sent to Europe to reduce the large deficit in countries like Germany and Belgium. Considering these projections, the high scenario developed for the Shannon Estuary in this review would just supply less than 20% of Ireland's total needs for 2050. Therefore, there is much green hydrogen development required.

9.3 Producing Green Hydrogen from Offshore Wind

With the production capacity scenarios established, this section will explore the ways in which this capacity could be developed. Because it is still an emerging industry, there is still much debate about the most efficient way for the offshore wind-to-hydrogen value chain to take shape. The current strategies include (see Figure 39):

- Onshore green hydrogen production
- Decentralised offshore green hydrogen production
- Centralised offshore green hydrogen production

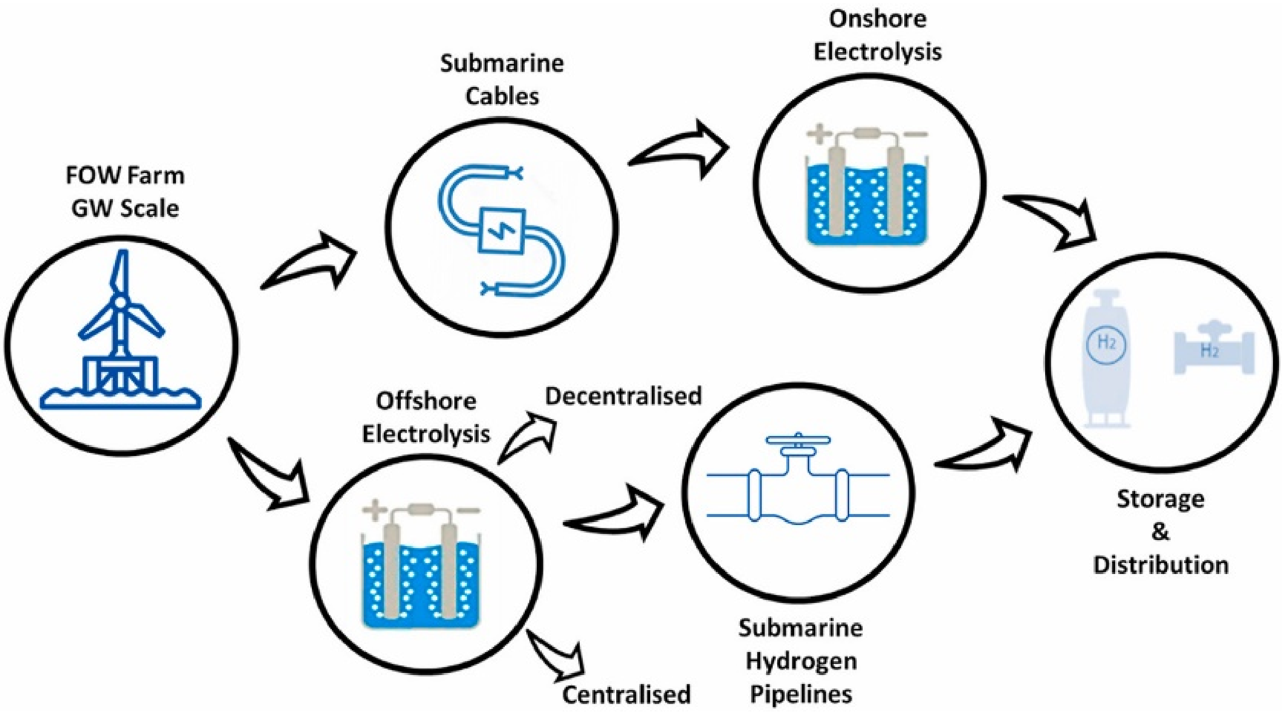


Figure 39: Offshore wind to hydrogen strategies [78]

9.3.1 Onshore Green Hydrogen Production

The most conventional arrangement for the development of a green hydrogen production facility is to locate it onshore as close as would be practical to the renewable power source where there is complementary infrastructure (i.e., grid connections and marine terminals).

As shown in Figure 40, the floating offshore wind power output is sent to shore using submarine electric cables where it is then converted to hydrogen through electrolysis. Ideally, the facility should be located close to the shore to minimise any further required electricity transmission on land.[78] Connecting the facilities to the onshore electrical grid could be leveraged for exporting electricity and for the provision of plant and emergency facilities.

This arrangement would be the most suitable for production of hydrogen in the Shannon Estuary as the technology is well developed, and there is available land within the SDLs that have access to water, the electricity grid, the natural gas grid, and deep-water marine terminals.

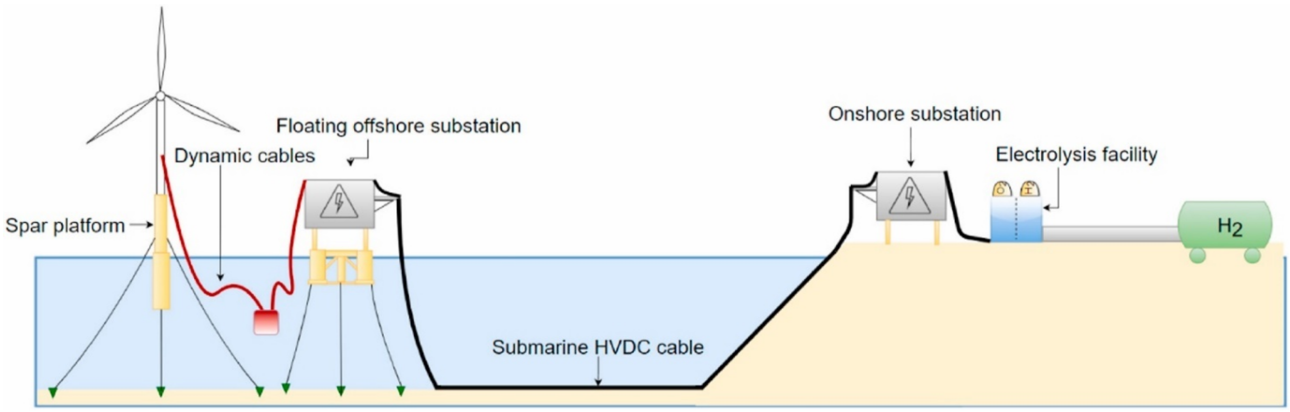


Figure 40: Onshore electrolysis system using both an offshore and onshore substation. [78]

9.3.2 Offshore Green Hydrogen Production

Another way of producing green hydrogen is to position the electrolyser facilities offshore in the wind farm and then transport the hydrogen onshore via pipeline or even in a ship. Offshore green hydrogen production can take place through either decentralised or centralised electrolysis.

Decentralised electrolysis (see Figure 41) entails the mounting of electrolysers on each turbine structure, effectively creating an array of electrolysers whose hydrogen output is marshalled via a manifold to an export pipeline. Centralised offshore electrolysis entails a single, larger, electrolysis facility mounted on a separate platform that gathers electricity from the wind turbines array to produce green hydrogen and then send it to an export pipeline.

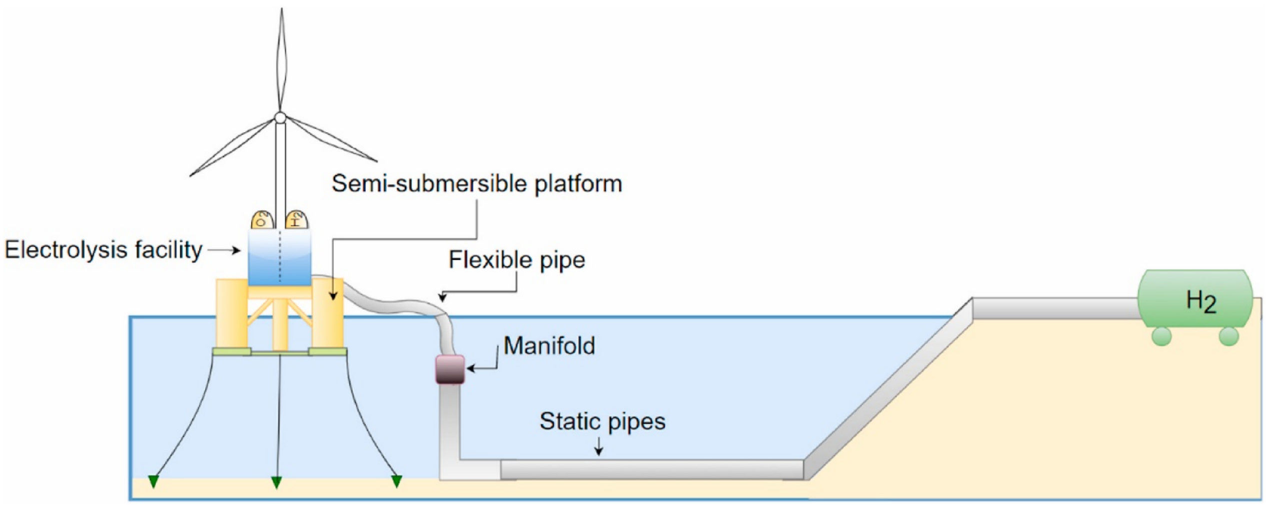


Figure 41: Decentralised offshore electrolysis typology layout using a semi-submersible platform with a flexible pipe connected to static submarine pipelines. [78]

The main difference between onshore and offshore green hydrogen production lies in how energy is evacuated from the offshore wind farm. In onshore green hydrogen production, energy is exported as electricity via a high-voltage submarine cable, whereas in offshore green hydrogen production it is exported as hydrogen via a pipeline or ship. In general, hydrogen pipelines can offer advantages over high-voltage submarine cables, because a hydrogen pipeline can accommodate a wind farm bigger than the current maximum capacity of a submarine HVDC cable, which offers considerable scale-up flexibility. However, submarine hydrogen pipelines are not yet commercially mature. [79]

Alternatively, hydrogen could be exported from the offshore electrolyser(s) via ship, either as molecular hydrogen in liquefied form, or as other hydrogen carriers such as ammonia. Regardless of whether it is exported via pipeline or ship, a major consideration for *offshore* green hydrogen production is the logistics of O&M for the electrolysers which – just like the O&M of the FOWTs discussed in Chapter 5.2.8 – will likely be a weather-restricted operation that can only be carried out when sea conditions are suitable. No matter how this challenge is addressed, it is likely that O&M for an offshore green hydrogen facility will entail more risk and cost than for an onshore facility.

9.4 Green Hydrogen Derivatives

In addition to direct use as a fuel for combustion or in fuel cells, green hydrogen can be used as a feedstock to produce other commonly used industrial chemicals and fuels such as ammonia, methane, methanol, and other liquid fuels such as gasoline, diesel, and kerosene (see Figure 42). The main advantage of these green hydrogen derivatives is that they can be used to replace their fossil fuel-based counterparts, and as such can be used in the transition to Net Zero. This section will focus on the production of ammonia and methanol as they are considered to provide the best potential for the Shannon Estuary.

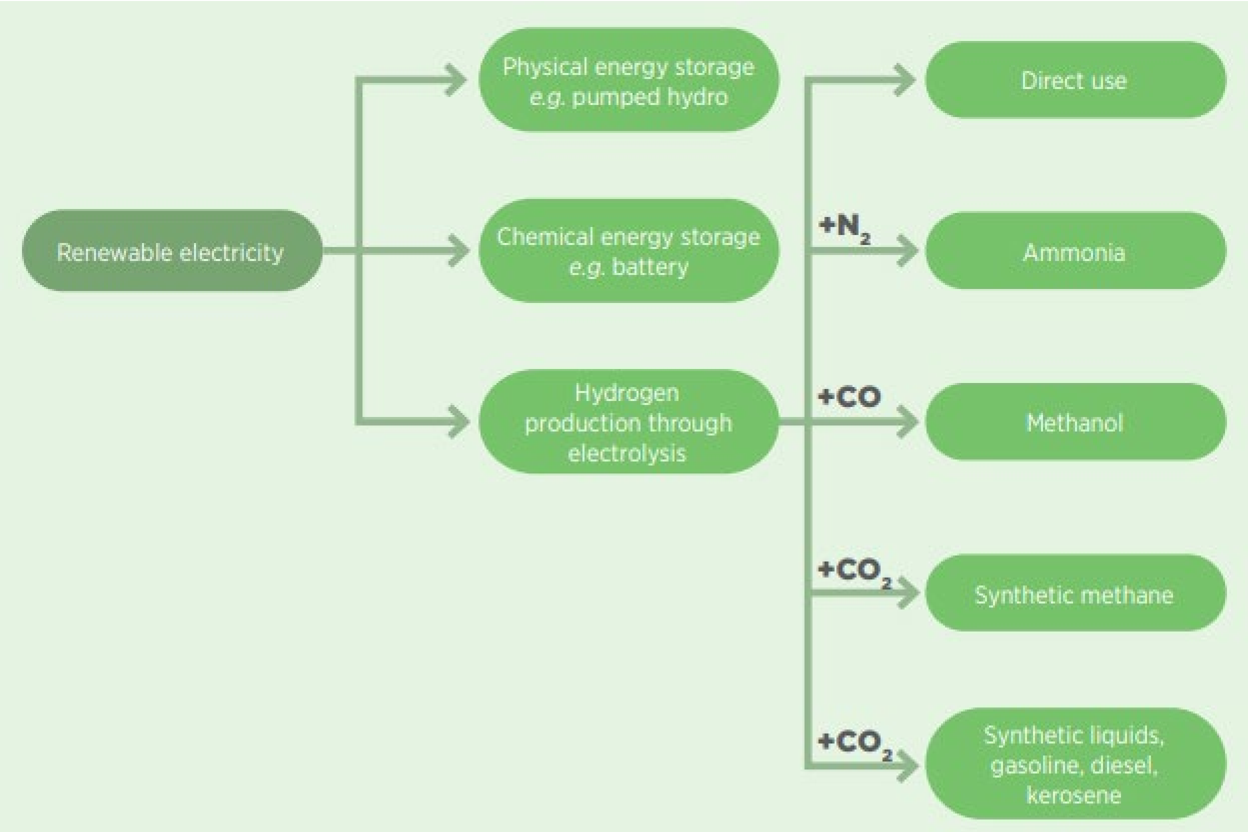


Figure 42: Schematic representation of green hydrogen derivatives [80]

9.4.1 Green Ammonia

Ammonia is the main ingredient in synthetic fertilisers, of which Ireland is a major user, consuming 560,000 tonnes in 2020. At present, this fertiliser is manufactured across the EU using “grey” hydrogen, and as such its replacement with green hydrogen presents a significant opportunity to reduce the associated emissions. Producing sufficient green hydrogen to satisfy Ireland’s fertiliser demand is estimated to require 780 MW of dedicated wind generation capacity.[81]

In addition to its longstanding role as a feedstock for fertiliser production, green ammonia can also be used as a fuel that could contribute to the decarbonisation of many sectors currently dependent on fossil fuels. Ammonia-powered ships are expected to be in operation by 2025 after the development of an ammonia dual-fuel engine. Moreover, ammonia can also be co-fired with hydrogen in power plants using gas turbine technology. In the future, combined-cycle power plants employing ammonia or a mixture of ammonia and hydrogen could be used instead of natural gas with hydrogen.[82]

Considering how its various potential uses match up well with existing industries in the area (e.g., agriculture, shipping, and power generation), the domestic production of green ammonia in the Shannon Estuary should be considered as a large opportunity for Ireland’s path to Net Zero.

9.4.2 E-Methanol

Methanol is a versatile fuel that can be used in internal combustion engines and in hybrid and fuel cell vehicles and vessels. It is a liquid at ambient temperature and pressures, and so is straightforward to store and distribute. The combustion of methanol does result in carbon emissions. However, if it is produced by synthesising green hydrogen with “captured” carbon (see Chapter 10), its combustion would in principle have net-zero carbon emissions. Methanol produced in this manner is commonly called “e-methanol”.

Production of e-methanol does not involve experimental technologies. Almost identical proven and fully commercial technologies are used to make methanol from fossil fuel-based syngas and can be used for e-methanol production.[83]

E-methanol is considered a likely candidate for shipping fuel in the future. Bunkering of methanol for marine applications is similar to existing marine fuels and is already widely available in many ports around the world. Domestic production of e-methanol therefore creates an opportunity for Shannon Foynes Port to provide re-fuelling services for shipping.

In the case of aviation, SAF can play an important role in helping the industry transition to a Net-Zero future. Synthetic paraffinic kerosene (SPK, also known as synthetic kerosene) is a type of SAF that is produced from e-methanol and can be chemically identical to fossil kerosene, the main ingredient in aviation fuel. Though SPK's production pathway has not yet been approved for use, it could in theory meet all aviation performance and safety specifications, offering the potential to be used as a straight replacement fuel (also known as "drop-in fuel"), and not just in blends. Domestic production of synthetic kerosene can be developed to produce SAFs for the Shannon Airport and other Irish airports.

9.5 Hydrogen Transport

As indicated in Chapter 4.2.1, although domestic demand will be a very important driver for Atlantic offshore wind developments in the near term, the key to tapping its full potential lies in accessing demand beyond Ireland's shores – in greater Europe. This section will provide a technical overview of the avenues through which green hydrogen and its derivatives produced from the Shannon Estuary can potentially access European demand.

9.5.1 Pipeline

There are about 4,600 km of dedicated hydrogen transmission pipelines operating in north-western Europe, the Russian Federation, and the United States of America. As discussed in Chapter 9.2, the EHB initiative aims to establish a pan-European hydrogen pipeline network using both existing and new pipelines, and under this plan the Shannon Estuary will be connected to the EHB through the repurposing of the existing gas network by 2040 (see Figure 38).[84]

In Ireland, the current code of operations does not allow for the injection of hydrogen into the gas network. However, Gas Networks Ireland (GNI – Ireland's gas network operator) believes that hydrogen will play a critical role in decarbonising the gas network and that the re-purposing of existing gas network infrastructure to transport hydrogen is a cost-effective model. GNI operates one of the most modern gas networks in Europe and – in line with Ireland's Climate Action Plan – is currently investigating the impacts of introducing hydrogen onto the gas network, either as a blend of up to 20% hydrogen by volume, or as a near 100% hydrogen.[85]

9.5.2 Shipping

Marine terminals, with multimodal transportation connections, conversion, and other facilities, will be key to connecting centres of production with demand in Europe and beyond, contributing to the EU's security of supply.[86] There are currently three main ways to transport hydrogen by ship, reviewed briefly below.

Liquid Hydrogen. Hydrogen must be cooled down to –253°C before being loaded in liquid form onto highly insulated tanker ships. The liquefaction process is energy-intensive, consuming the equivalent of 25–35% of the initial quantity of hydrogen. Currently, only one ocean-going ship can transport pure hydrogen, the Suiso Frontier, built by Kawasaki in late 2019 (Figure 43[87]).

Figure 43: Suiso Frontier – The world's first vessel to be officially classified as a liquefied hydrogen carrier.[87]

Liquid Organic Hydrogen Carriers (LOHCs). A slate of different organic compounds can absorb and release hydrogen through a chemical reaction. LOHCs can serve as a storage and transportation medium for hydrogen and can be transported as liquids without cooling. LOHCs are very similar to crude oil and oil products, so the existing oil transport infrastructure could even be adapted to transport LOHCs.

Ammonia. Ammonia is a promising hydrogen carrier which can be efficiently transported in liquid form. Hydrogen can be turned into ammonia by reacting with nitrogen from the air, using nothing but electricity, water, and air. Ammonia has a much higher energy density than hydrogen, meaning that a much higher amount of energy can be transported on a single ship. There is a well-established international trade in ammonia that can be leveraged.[88]

Ammonia is expected to become the largest carrier for hydrogen due to the technically simple storage and transportation conditions and well-established logistics.[89] The technology is mature and the cost to ship over large distances is favourable (Figure 44).

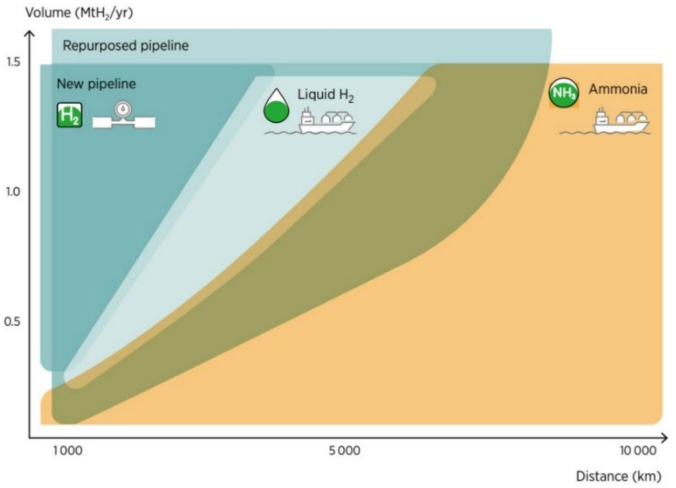


Figure 44: Cost efficiency of transport options when considering volume and distance [88]

9.6 Conclusion

Green hydrogen is likely to play a vital role in the journey to Net Zero, and demand for it is projected to increase dramatically. Considering its immense untapped renewable sources – particularly in offshore wind – there is a significant opportunity for Ireland to become a major producer of green hydrogen and its sustainable derivatives. It is important to think forward and employ solutions that are "future-proof" especially in a rapidly changing world. With Europe's recent energy crisis brought on by the dependency on imported gas, it is more critical than ever to seek energy independence and secure energy supply by investing in diversified and indigenous energy resources while becoming more sustainable.[90]

The processes for producing green ammonia and e-methanol are straightforward and well-proven. The storage and shipping methods for these products are also well established; therefore, the risks can be adequately assessed and the plants should be straightforward to construct at scale. Green ammonia produced in Ireland has the potential to help decarbonise the agricultural sector. Green ammonia and e-methanol can also be used to power ships, and this is a consideration for the development of green bunker fuels at Shannon Foynes Port. E-methanol can also be converted to make synthetic kerosene, which is a sustainable aviation fuel (SAF). This should also be a consideration for the Shannon Airport and all Irish airports and airlines.

10. Carbon Capture Utilisation and Storage (CCUS)

Because certain sectors such as aviation and heavy industry are difficult to decarbonise, carbon capture methods can offset their emissions and support a faster transition. Once captured, the CO_2 can either be permanently stored in deep geological formations or used, for example in food processing or combined with hydrogen to produce synthetic fuels, as described in Chapter 9.4.2.[91]

The Irish Government's Climate Action Plan has mentioned that the development of CCS by 2030 is challenging, but it could remove further emissions. There is also an established key performance indicator for the retrofit of CCS for two of the four cement/lime plants in Ireland by 2030.[92]

Along the Shannon Estuary there are facilities that could benefit from the implementation of CCS, and there is a further opportunity to consider DAC for the region, both of which could be used to support the production of sustainable shipping and aviation fuels produced from e-methanol. The Westküste 100 project in Germany is pursuing such an endeavour, with plans to synthesise green hydrogen (produced from offshore wind) with CO_2 (captured from cement production) to produce synthetic kerosene.[93]

10.1 Post Combustion Carbon Capture

There are a number of technologies that specialise in Post Combustion Carbon Capture (PCCC), or carbon capture from the gases emitted by power plants, boilers, kilns, and chemical facilities (Figure 45). This can still be considered an emerging industry as many technologies have yet to be successfully deployed at scale. PCCC requires significant capital investment and also increases operational costs of the facilities where installed. A trial project of CO_2 capture has been deployed in Irving Oil's Whitegate Refinery as part of the REALISE-CCUS project.[94] However, no commercial-scale CCUS plants currently exist in Ireland.

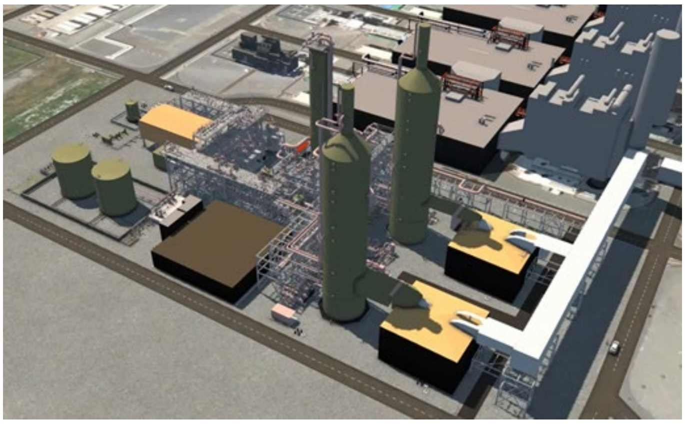


Figure 45: Post Combustion CO_2 Capture Plant

10.2 Direct Air Carbon Capture

Direct Air Carbon Capture is a nascent technology that captures carbon directly from the atmosphere (Figure 46[95]). The technology is rapidly improving and plants are currently being constructed at a mega-tonne scale. There are currently 19 DAC plants operating worldwide, capturing more than 10,000 t of CO_2/year, and a 1 Mt of CO_2/year capture plant is in advanced development in the United States.[96]

Figure 46: The world's largest direct-air capture facility, Orca, at the Hellisheidi geothermal power site in Iceland [95]

10.3 Carbon Transport and Storage

Where captured carbon is not being utilised locally, additional infrastructure is required to transport carbon to suitable sites for long-term storage or sequestration. Transport of carbon can be done via pipeline or via ship. Shipping of carbon currently exists only in small quantities for the food industry. However, the CO_2 shipping industry is advancing rapidly and there are multiple projects investigating the development of CO_2 import and export terminals.

10.4 Opportunities for the Shannon Estuary

Carbon capture will likely become more prevalent as Ireland moves toward Net Zero. The technologies are improving and as a result the costs will become less prohibitive. In the Shannon Estuary, there are some large CO_2 emitters that could be suitable for the implementation of carbon capture technology. Irish Cement's facility in Castlemungret is a potential candidate, seeing as its carbon emissions are (like all cement plants) primarily process-related and therefore cannot be significantly reduced through either electrification or green hydrogen fuel replacement, thus bringing carbon capture to the fore.

Should the production of e-methanol for sustainable shipping and aviation fuels become a reality on the Shannon Estuary, the production facilities will require a supply of carbon as a necessary constituent. The potential for locally captured CO_2 to provide this input is a significant opportunity for the Shannon Estuary to further establish itself as a green hydrogen ecosystem leading Ireland in its journey toward Net Zero.

11. Data Centres

Data centres are now a very significant feature of Ireland's electricity demand, and they are also a core infrastructure enabler of a technology-rich, innovative economy.[97] However, there are currently concerns that data centres are placing too much demand on the electricity grid. In its Shaping our Electricity Future 2021 report[98], EirGrid indicated that 300 MW of additional new data centre connections could be accommodated on the transmission network contingent on the developments proposed in their roadmap, and advised that data centre demand beyond this would necessitate significant reinforcements which would need to be balanced against wider grid investment and decarbonisation objectives.

To alleviate these grid concerns, in November 2021 the Commission for Regulation of Utilities (CRU) issued a direction (CRU/21/124)[99] that new data centre connections are required to have onsite generation (and/or battery storage) that is sufficient to meet their own demand and – to assist in full decarbonisation of the power system – this generation should be capable of running on renewable fuels when supplies become more readily available.

Building upon this CRU direction, the Irish Government's July 2022 report "The Role of Data Centres in Ireland's Enterprise Strategy" sets out principles intended to inform and guide decisions on future data centre development.[100] Prominent among the principles include preferences for data centre developments that:

- Make efficient use of the electricity grid, using available capacity and alleviating constraints.
- Demonstrate the additionality of their renewable energy use in Ireland.
- Identify where there is the potential to co-locate a renewable generation facility or advanced storage with the data centre, supported by a Corporate Power Purchase Agreements, private wire, or other arrangement.
- Demonstrate a clear pathway to decarbonise and ultimately provide Net Zero data services.

When one considers the Shannon Estuary with respect to the potential to develop an abundance of renewable energy, the proximity to existing high-voltage electrical and high-pressure gas grids (to accommodate onsite generation), coupled with the available land space within the SDLs, it is clear that data centre developments in the region would be well-aligned with the principles set out by the Irish Government. Add to that the talent pipeline that is available from local higher education institutions (University of Limerick, Technological University of the Shannon, and Munster Technological University), with 35,000 students in the region and national externally funded research centres, which support digital transformation through research in Artificial Intelligence (AI), advanced manufacturing, materials, biotechnology, health, pharmaceuticals, and sustainable development. The local engineering and construction contractors in the region also have an impressive and extensive résumé of national and international hyperscale data centre developments.

Indeed, the Shannon Estuary could be the ideal location for a significant tech cluster that is powered by renewable energy. In addition to not burdening the national grid, data centres situated along the Shannon Estuary would provide an important initial source of demand to kickstart floating offshore wind developments, helping Ireland accelerate toward its Net Zero target. Data centre developers are already taking note, with significant plans being advanced at multiple locations in the region, summarised below:

11.1 Nautilus Floating Data Center, Ted Russel Docks, Limerick

SFPC have received planning permission to create an innovative floating, water-cooled data centre at Limerick Docks in partnership with Nautilus Data Technologies. The project, a pilot project for energy efficiency, could create 24 permanent jobs as well as employing 100 people during the construction phase. Nautilus Data Technologies uses their patented Total Resource Usage Effectiveness (TRUE) cooling to provide a Zero Impact Cooling System. The data centre will operate at the highest level of energy efficiency, with no water consumption, no refrigerants, no water treatment chemicals, no wastewater, and no harm to wildlife.

11.2 Art Data Centre Campus, Ennis, Co Clare

Art Data Centre campus in Ennis is the first data centre to be approved following the Government's Policy Statement (as summarised above). It has been granted planning permission by Clare County Council. The campus will comprise six data halls of 33 MW each, an Energy Centre, and Vertical Farm. It has access to 200 MW of power from both the network grid and gas generation on site and aligns with the current CRU requirements for dispatchable Power and being located in an unconstrained area. The 200-MW Ennis Project underpins the Government Policy Statement as it has the key infrastructure, including access to grid, Main Gas Interconnector running through site which facilitates self-generation availability onsite, and access to both wind and solar farms in Clare through the grid or Private Wire. It also has the key availability of existing high-speed fibre located both on and adjacent to the site. The energy centre turbines have been designed to run on green hydrogen.[101]

11.3 Shannon Technology & Energy Park (STEP)[102], Ballylongford, Co Kerry

As part of the planning submission for the STEP project there is the provision of space for eight future data halls. The proposed development comprises a highly flexible Power Plant and a Liquefied Natural Gas Terminal. The power plant would back up intermittent renewable generation. The plant would comprise up to three highly flexible Combined-Cycle Gas Turbine generation blocks that are capable of operating on a high percentage hydrogen blend, with a total capacity of up to 600 MW, and an integrated Battery Storage Facility with a 120-MW 1-hour Ultra-Fast Response capability. Considering the self-generation availability on site with a potential for renewable gas, the access to natural gas from the import terminal, the access to onshore wind from County Kerry or from future offshore wind in the Atlantic, it would appear that this data centre campus would also be consistent with the Government's Policy.

12. Shannon Estuary Green Hydrogen Ecosystem

The abundance of potential energy available from Atlantic floating offshore wind, along with the potential to produce green hydrogen and derivatives, presents an enormous opportunity for the Shannon Estuary and the Mid-West region. This chapter will further illustrate the opportunity for the region by considering both the already established as well as the potential future industries of the region.

To date there has been significant interest from European countries who see the potential of the Shannon Estuary in producing hydrogen and derivatives from offshore renewable energy. It is also clear that having a stake in the hydrogen value chain can boost Ireland's economic competitiveness. Considering its renewable potential, the Shannon Estuary could become a focal point of green industrialisation in Ireland and further use that potential to attract additional investment through energy-intensive industry. This will require significant industry and Government collaboration.

Figure 47 provides a high-level concept of the industries that can be developed along the Estuary.

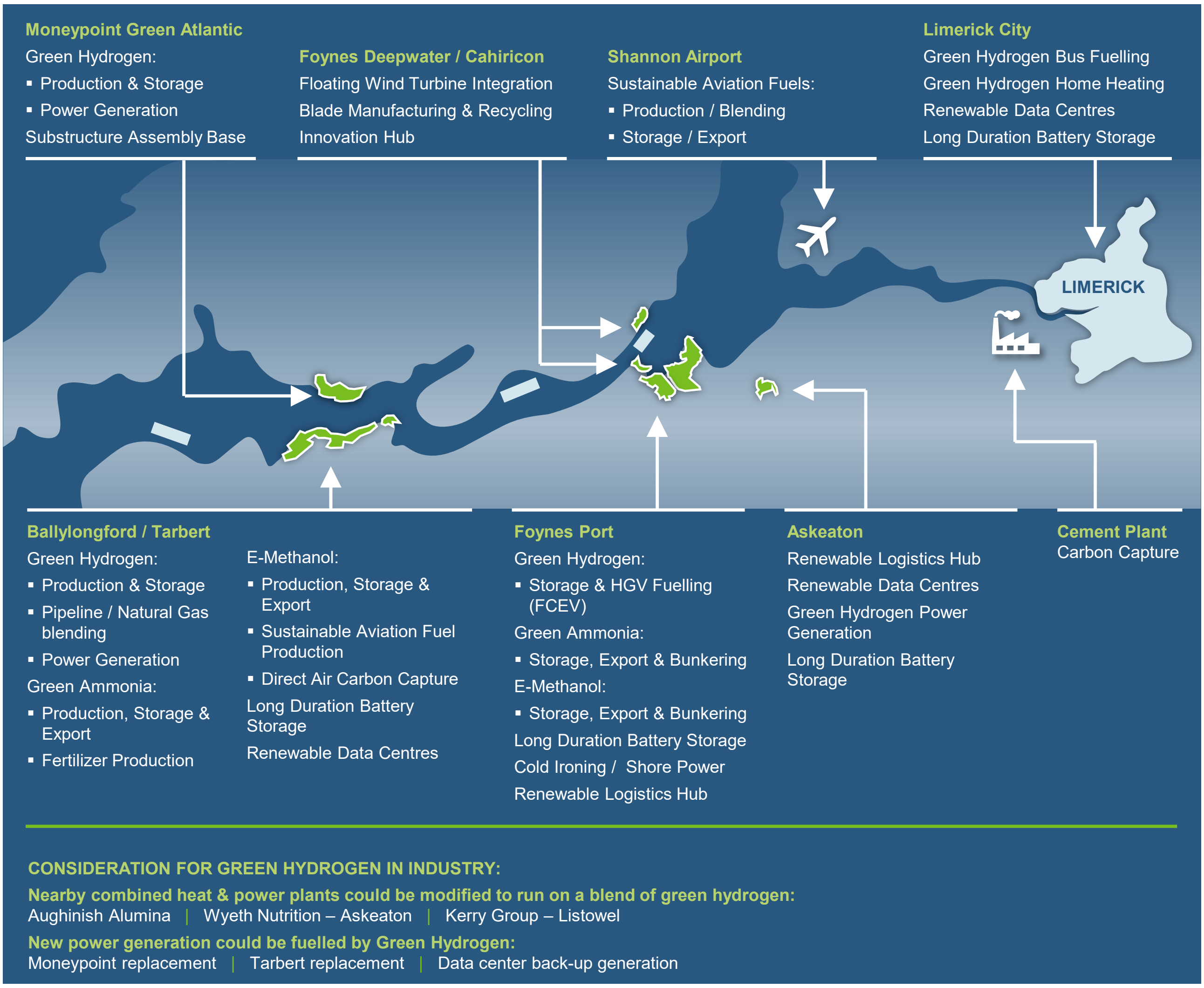


Figure 47: Shannon Estuary Green Industrial Ecosystem

The concepts mentioned above all require further investigation, including detailed feasibility studies and environmental impact assessments (EIAs), and are focused primarily on the SDL designated in the SIFP. It should be noted that some of the SDLs remain in private ownership but have been zoned for maritime-related development. The SIFP group is to be re-established shortly, and this is the ideal forum for study, collaboration, and implementation of a regional approach to this strategic national asset.

Central to the establishment of a green hydrogen ecosystem on the Shannon Estuary would be a gigawatt-scale green hydrogen facility. Among the various SDLs along the Estuary, the Ballylongford/Tarbert landbank emerges as an ideal location for such a facility considering the following:

- Available land zoned for development.
- Proximity to potential cable landfall location from offshore wind.
- Access to water for electrolysis and cooling of plant equipment.
- Deep water for new marine export facility for ammonia, methanol, or SAF.
- Connection to the EHB by 2040.[103]
- Access for blending H2 to the Gas Network through the gas line extension for the STEP project.
- Proximity to electricity grid substation infrastructure at Kilpadogue.
- Planned 600-MW STEP power plant (designed to run on 50% hydrogen).
- Existing Upper-Tier Seveso site at NORA storage facility in Tarbert.
- Existing jetty at Tarbert and planned new jetty for the STEP project, both of which could potentially be adapted to accommodate export of hydrogen, ammonia or SAFs.
- Tarbert Power Plant with grid connectivity (assuming future repowering to H_2).

The co-location of facilities could potentially reduce costs for the development of these plants. Considering the new power plant at STEP (which is already designed to run on a high blend of hydrogen), and making the assumption that the existing thermal power plant at Tarbert could eventually be replaced with a new hydrogen-capable power plant, creates an immediate demand in the area. In addition, the STEP project has planned an expansion of the gas network to Ballylongford, and this presents an opportunity to inject hydrogen into the natural gas network in this location (Figure 48).

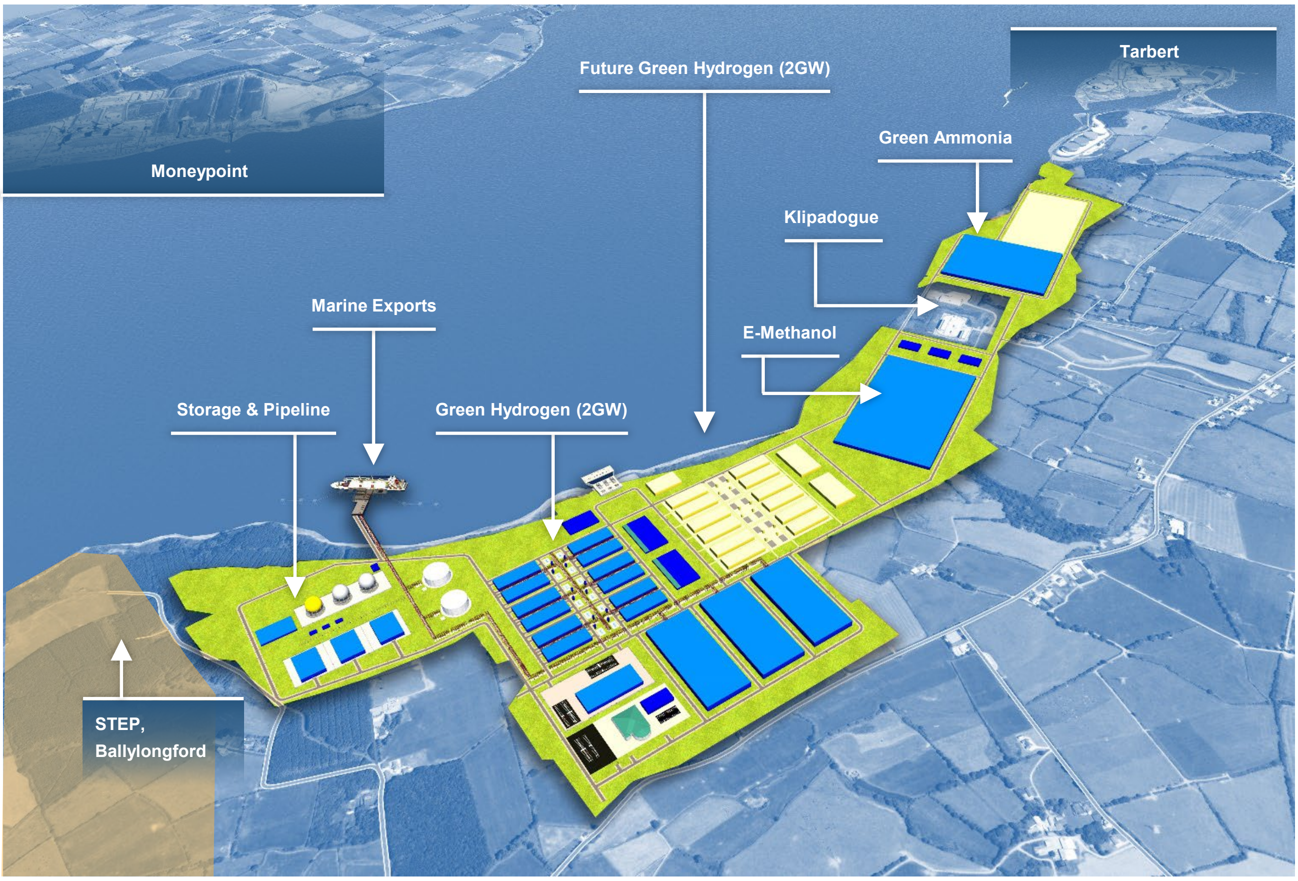


Figure 48: 2 GW Green Hydrogen, green ammonia and e-methanol production and export

Hydrogen could be piped directly to industry along the Estuary should significant demands emerge. Quantities of hydrogen could also be trucked from this location directly to industry and to hydrogen re-fuelling stations that would power heavy goods vehicles at Shannon Foynes Port or the bus fleets operating from Limerick city and the surrounding region. The benefits of green hydrogen for commercial mobility to Ireland have been clearly set out in Hydrogen Mobility Ireland's recent report.[104]

ESB's Green Atlantic project at Moneypoint already includes a planned green hydrogen production, storage and generation facility towards the end of the decade. The green hydrogen is planned to be used for power generation, heavy goods vehicles in the transport sector and to help decarbonise a wide range of industries.[105]

The production of e-methanol on the Shannon Estuary provides the potential for bunkering of future marine fuels. The future of marine fuels is still being decided however great potential exists for both e-methanol and green ammonia. The provision of large scale renewable fuel bunkering provides a further benefit to core port business. The production of e-methanol also involves an element of circular economy where CO_2 captured from local industry can be used for the production of e-fuels.

Shannon Airport imports a significant amount of aviation fuel each year. This aviation fuel could be replaced by Sustainable Aviation Fuels (SAF) produced locally. The fuel could be transported to Shannon Airport via barge from Ballylongford to the existing Shannon Airport marine terminal or through a new pipeline from the production facility to the airport. Alternatively, SAF production or blending could be considered in a new location more adjacent to the airport.

Hydrogen also provides a zero-carbon fuel option for back-up generators, which can be utilised for data centres that will primarily be powered by offshore wind. Through the use of hydrogen-powered gas turbines coupled with large-scale batteries, the data centres could also help support grid stabilisation. This presents the potential for fully decarbonised data centre operations while eliminating any demands on the electrical grid. In fact, the data centres could use fast-acting, hydrogen-powered gas turbines to supply the grid at times of peak demand and low renewable energy production.

Green hydrogen production would serve Ireland's demands first and foremost. However, considering the vast quantity of available offshore wind, Ireland must consider the export of this energy to Europe where there will be a large deficit particularly for hydrogen in industry. As discussed previously, hydrogen can be converted to ammonia as an efficient means of transporting over large distances via ships. Locating an ammonia production and export facility on the Shannon Estuary provides direct access for Irish green ammonia to enter the Trans-European Transport Network (TEN-T). Consideration should also be given to the domestic production of fertiliser using locally produced green ammonia.

The Shannon Estuary has the potential to develop a complete renewable energy ecosystem which provides significant added value beyond the development of offshore wind. The entire 2030 green hydrogen target of 2 GW could be produced and consumed within the Shannon Estuary through direct use, power generation, and the production of e-fuels and green ammonia. A development of this scale has the potential to significantly decarbonise the industry, agriculture and transport sectors in Ireland while also positioning the country to export clean energy in the form of hydrogen or ammonia to Europe.

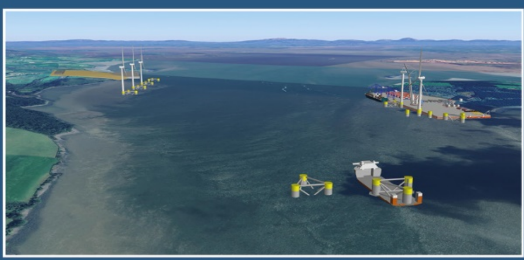
13. Driver 2 Key Takeaways

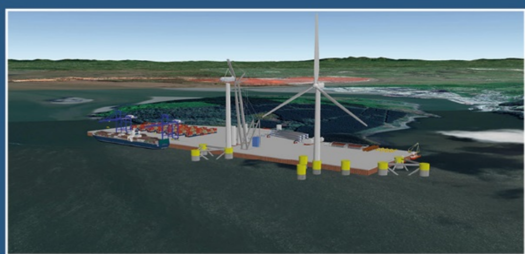
Key takeaways…

- The Shannon Estuary can take advantage of the abundant Atlantic offshore wind energy to develop an industrial ecosystem centred around green hydrogen.
- There is land available on the Tarbert – Ballylongford landbank which could facilitate the development of at least 4 GW of hydrogen electrolysers and provide a suitable location for landfall of HVDC cables transporting electricity from floating offshore wind farms in the Atlantic.
- Green hydrogen produced on the Estuary can be used to fuel local power plants and the large local industry providing an accelerated path to decarbonisation.
- Green hydrogen produced on the Estuary can be used to fuel heavy goods vehicles (HGVs) at the Port of Foynes or transported to other locations such as Limerick City to fuel HGVs, buses and coaches.
- Green ammonia can also be produced on the Estuary and can be used for the future fuelling of ships, for the production of fertiliser or for seaborne exports.
- Sustainable fuels such as e-methanol can be produced on the Estuary. This can be used as bunker fuels for large ships and maritime transport benefiting the Shannon Foynes Port and other Irish ports.
- Sustainable Aviation Fuels (SAF) can be produced on the Estuary for use in Shannon Airport and other Irish airports.
- The production of e-methanol creates a circular economy on the Shannon Estuary as it requires captured CO_2 for its production. There is a potential to capture the CO_2 either directly from the air or from the large CO_2 emitters in the region.
- The circular economy on the Shannon Estuary is further supported through the development of large data centres in the area. These provide additionality for renewable energy and can reduce the demands on the Irish electricity grid.
- Green hydrogen produced along the Estuary can be blended into the gas network and can eventually be used as a source of green hydrogen for the European Hydrogen Backbone.
- The Shannon Estuary can fulfil Ireland’s target to produce 2GW of green hydrogen by 2030.
- The production of offshore wind energy, green hydrogen, green ammonia and sustainable transport fuels from the Shannon Estuary should be accelerated to achieve Ireland’s 2030 climate targets.
- The Shannon Estuary should be designated as a dedicated “go-to” area for renewables and the need for green industrial development on the Shannon Estuary recognised as an overriding public interest.

SHANNON FOYNES PORT

Driver 3: Expanded, Diversified, and More Sustainable Logistics Services





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Adjacent to the world's busiest shipping routes, with current capacity to handle over 10 million tonnes annually and with water depths of up to 32 m, the facilities on the Shannon Estuary are uniquely positioned to expand as an international cargo hub serving the domestic, European, and worldwide markets. The turnover value of current trade handled by the Port is EUR €8.5 billion per annum, with associated economic impacts of EUR €1.9 billion per annum supporting over 3,900 jobs. SFPC is an EU Core Network Port (TEN-T) and a Tier 1 Port in the National Ports Policy, effectively designating the Shannon Estuary as a commercial watercourse of international significance.

As the largest bulk port in the country, approximately 20% of national maritime cargo tonnage travels through the Shannon Estuary across six terminals. The Port of Foynes, Limerick Docks, and Shannon Airport facilities are owned and operated by SFPC. The other three dedicated facilities at Aughinish, Moneypoint, and Tarbert are managed privately but serviced by SFPC.

Driven by base business growth and national climate objectives related to decarbonising both the energy and transport sectors, Estuary logistics will see a shifting mix in its operations and growth that will necessitate port expansions and ground transport upgrades. This port expansion and improved hinterland connectivity will also add capacity and resilience to the national freight supply chain. Shannon Foynes stands today within 2.5-hour drive of 75% of Ireland's GDP (see Figure 49), a catchment that is enhanced by the delivery of the planned road schemes for the region.

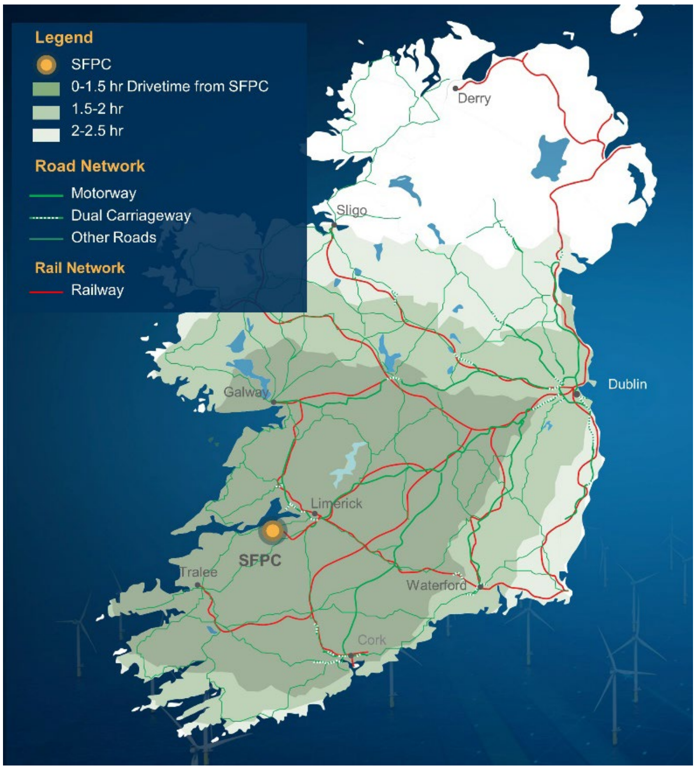

Figure 49: Travel times from Shannon Foynes

Investment in logistics infrastructure such as the Foynes Deepwater Port and expanded hinterland facilities at Foynes, new and re-purposed port facilities at Moneypoint and along the Ballylongford Tarbert landbank, and nationally strategic road and rail projects highlight the Estuary's offering of new services geared toward renewable energy and decarbonising the supply chain, enabling it to play a significant role in the Government's Climate Action Plan over the years to come.

The Port of Foynes and nearby SDLs are further advantaged in their capacity to offer cost-effective development of port-centric logistical centres located at a major port. Irish businesses have an opportunity to locate their supply chain operations within a well-connected and uncongested Tier 1 Port. Furthermore, warehouse rental rates offer a lower cost option compared, for example, to the facilities in the Greater Dublin Area (GDA). To further enhance its offering, SFPC is establishing fully integrated port and logistics facilities and services to customers looking to develop or lease business park or warehouse property.

Throughout this expansion and growth of emerging businesses, the Estuary is facing a transition away from coal- and HFO-fuelled power stations to an Estuary with the potential to deliver offshore wind units, natural gas, and renewable fuels produced using renewable energy (see Chapter 9). The proposed shutdowns of Tarbert and Moneypoint generating stations represent a near-term decrease in Estuary tonnage that will be more than offset by offshore wind and container businesses.

Overall, investments in the port's infrastructure and the national supply chain will further unlock latent capacity at Shannon Foynes. In line with Government priorities from the National Development Plan,[106] strengthening the required economic connections to this Tier 1 Port will enable Ireland to better leverage this important and needed node in the national logistics network. Specifically, this includes the delivery of the following key infrastructure developments:

- Limerick-Foynes road scheme,
- Limerick-Foynes rail line for freight with potential for a passenger service,
- Development of the Port of Foynes, and
- Development of Foynes Deepwater Port.

The chapters below will describe the current port operations, including how central Shannon Foynes is to the domestic logistics and supply chain. The logistical elements for emerging business segments in container services, distribution centres, and traffic and tonnage associated with offshore wind are described. The infrastructure delivered to unlock this capacity is then contextualised against the market drivers and demand forecasts.

14. Port Operations

Situated on the west coast of Ireland, the SFPC is Ireland's largest portal area and premier deepwater resource, routinely catering for ships up to 200,000 deadweight tonnes (dwt). The Shannon Estuary boasts many natural deepwater sites and presently accommodates six main port facilities (see Figure 50). The Port of Foynes and the Port of Limerick (Limerick Docks) are the two main generalised cargo-handling facilities owned and operated by SFPC, along with the Shannon Airport fuel jetty. The other three facilities on the Shannon Estuary include Aughinish, Moneypoint, and Tarbert. Oversight of all commercial shipping on the Shannon Estuary is the responsibility of SFPC.

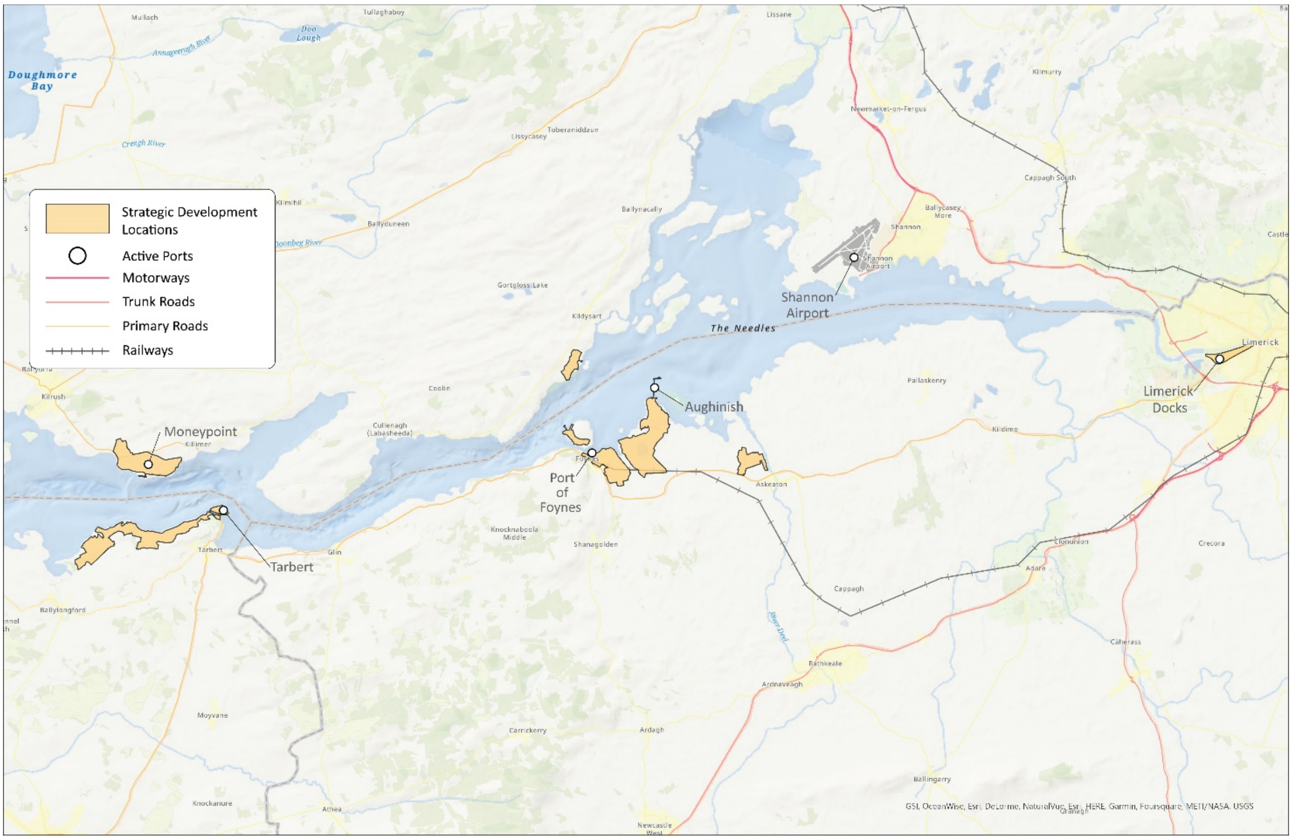

Figure 50: Estuary Map, Active Ports

14.1 Estuary Activity

SFPC handled nearly 11 million tonnes of cargo on the Estuary in 2021. SFPC cargo throughput on the Estuary consists of cargoes to privately and directly managed port traffic, where privately managed ports are those owned and operated by a third party and directly managed ports are owned, operated, and maintained by SFPC. Cargoes to privately managed terminals, the power generation facilities at Moneypoint and Tarbert, as well as the Aughinish Alumina facility, contributed nearly 60% of the Estuary tonnage. Historically, the privately managed throughput terminals have formed a steady and robust baseline for the Estuary. As highlighted throughout this report, changes at Moneypoint and Tarbert will alter the dynamic of the privately managed port throughput – with a shift toward renewables-led industries.

Table 9: Port Accommodations

Port Facility	Length of Quay/Jetty (m)	Max Vessel Length (m)	Max Vessel Draught (m)	Max Draught at Berth (m)	Max Draught for Channel (m)
Moneypoint	380	300	20+		16.3 + tide
Tarbert	317	250	14	14.0	16.3 + tide
Foynes	657	200+	10.5	10.5	7.8 + tide
Aughinish	405	235	12.5	12.5	13 + tide
Shannon	130	115	7	7.0	4 + tide
Limerick	914	152	tide	tide	1.2 + tide -0.5
Foynes Island	1,000	300+	20+	20	16.3 + tide

The directly managed ports at the Port of Foynes and Limerick have a more diverse cargo makeup than the privately managed terminals. Dominant here is cargo for the agriculture industry and construction, both of which are made up of a mix of materials and cargo types (Figure 51). At the Port of Foynes, liquid and solid fuels make up over 20% of the directly managed cargos. The directly managed ports will undergo a transition to introduce container services as well as offshore wind support facilities. The transition will coincide with significant expansions in the port's base business segments.

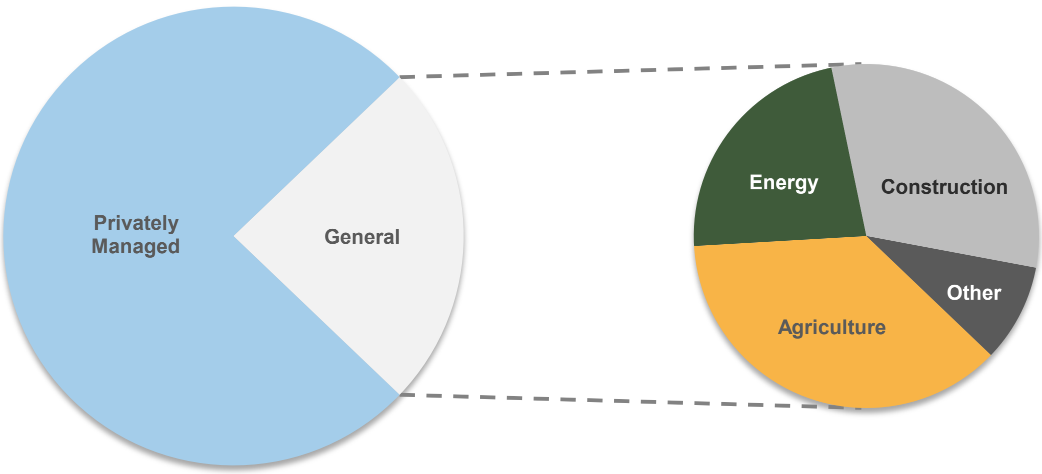

Figure 51: 2021 annual throughput (tonnes) by business segment

14.2 Port of Foynes

The Port of Foynes, including Foynes Island, is the main deepwater facility on the Estuary catering for vessels up to 200+m in length, a draught of up to 10.5 m, and vessels from 3,000 to 60,000 dwt. The port has four berths for ship-to-shore operations (with an additional berth being delivered as part of the east-west jetty connection) and a dedicated dolphin jetty for bulk liquids. The main handling equipment comprises four mobile harbour cranes to support hoppers and other equipment for bulk solid and break bulk cargo handling. Storage is made up of directly managed and leased property with open-air laydown, covered storage (warehousing), and a privately managed chemicals and fuels tank farm. The Port of Foynes is accessed via the N69 and features a dormant rail link that is due to be reinstated in the near future.

14.3 Limerick Docks

Limerick Docks enjoys a city-centre location. The operational port area comprises approximately 11 hectares with a total quay length of almost 1 km and handles a range of dry bulk, break bulk, and project cargoes.

14.4 Aughinish

Aughinish Alumina is the largest alumina refinery in Europe, producing 1.9 million tonnes of alumina per year. The facility imports bauxite to process into alumina and alumina hydrate, which is then exported through its Panamax-capable jetty, the annualised capacity of the plant is equivalent to 6.5 million tonnes of cargo via the Port of Foynes. The 285-m outer berth handles vessels up to 40,000 dwt with 12.4-m depth alongside, while the inner berth caters for vessels up to 40,000 dwt and up to 180-m length with 11-m depth alongside.

14.5 Moneypoint

Moneypoint hosts one of Ireland's largest electricity generating stations. The primary fuel for generating electricity is coal and the facility can handle and store large quantities of coal on site. The coal import terminal has a 380-m-long berth, which services vessels up to 200,000 dwt, with depth alongside of 25 m. The coal-handling equipment is of a significant scale and is supported by a 600,000-tonne storage area. The facility also has two HFO storage tanks with a capacity of 50,000 tonnes, which can be used for back-up fuel if required.

14.6 Tarbert

Tarbert Island hosts the 620-MW Tarbert Power Station and the NORA 250,000-m^3 national strategic storage facility. With a total length of 320 m and depth alongside of 14.6 m, the T-shaped fuel jetty facilitates liquid fuel imports for both the power station and the NORA facility. Tarbert is a key facility satisfying NORA's strategic storage requirements in Ireland, capable of storing a range of oil products – petrol, diesel, gas oil, kerosene, and jet fuel.

14.7 Shannon Airport

The Shannon Jetty, located next to the Shannon Airport, is the only jetty in Ireland that facilitates delivery by sea of aviation fuel directly to an airport. The dedicated fuel jetty caters for vessels up to 6,500 dwt and length of 130 m, with depth alongside of 8 m.

15. Logistics Assessments

15.1 Transport and Connectivity

Shannon Foynes is strategically located with access to the national road network by secondary road, the N69. National Ports Policy requires adequate hinterland connection to the Tier 1 ports. In this regard, the National Development Plan commits to completing the recently approved Limerick to Foynes Road (including the Adare Bypass), thereby further enhancing the Port's connectivity to the greater Irish market – unlocking this Tier 1 Port as a key node in the national logistics market. The planning application for this road scheme was approved by An Bord Pleanála in August 2022.

The ground transport for the Port of Foynes is currently conducted via roads, with over 200,000 HGV movements per year in 2021. As the port traffic grows, the HGV movements will continue to increase, coupled with traffic growth from increased economic activity across the Estuary (industrial developments, commuters, population growth). The recently commenced procurement by Irish Rail for the re-establishment of the Foynes to Limerick rail link will help support Ireland's climate goals through further decarbonisation of the transport sector. This section describes the transportation links to/from the Port.

15.1.1 Road

The Port of Foynes, as well as the other SDLs on the southern shore of the Estuary, offer businesses and carriers direct access to the national road network via the secondary road, the N69. Along the northern shore, Moneypoint and Cahiracon SDLs have not required significant ground transport access, compared to the cargo operations on the southern shores. Access to the northern SDLs via the R473, and supported by the N68, should be re-evaluated for traffic movements as the operations at Moneypoint evolve to focus on offshore-wind-related businesses and as Cahiracon is developed to support integration activities at the Foynes Deepwater Port.

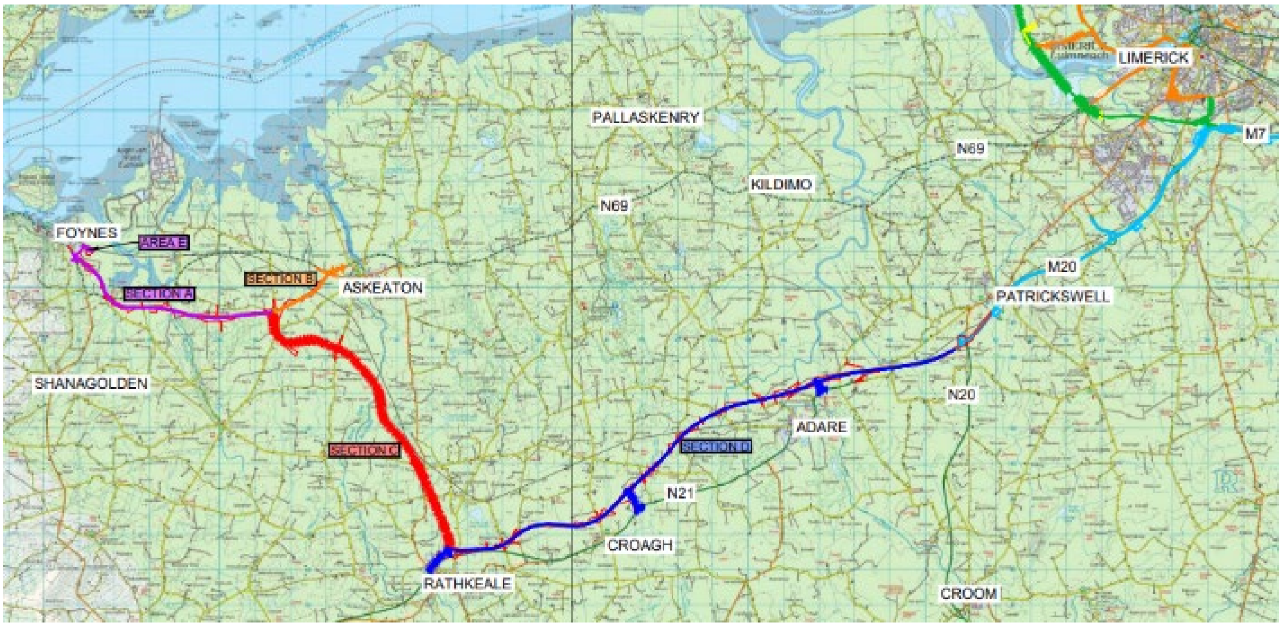

Figure 52: Planned Foynes-Limerick Road Scheme

The recently approved Foynes-Limerick Road Scheme (including the Adare Bypass) (see Figure 52) represents an enhancement to the existing infrastructure that will improve access and transit times to/from the Port of Foynes. This road scheme is considered essential and is urgently required in order to provide the hinterland connectivity and capacity to support the growth projections contained in this strategic review of Vision 2041. In addition, the climate action opportunities and supply chain benefits identified in this review will be further supported by the Limerick to Foynes Road Scheme's urgent completion.

The Foynes-to-Rathkeale Road Scheme (see Figure 52, Sections A, B) will provide additional regional capacity with the delivery of a Type 2 dual carriageway and includes a Type 1 single carriageway branch to Askeaton (Section C). A further benefit to Shannon Foynes is the planned Foynes Service Area located between the N69 and Foynes-Limerick rail corridor and bordered by the Port of Foynes access road. The service area will feature a rest area for HGV drivers, which not only improves safety for traffic within the supply chain but further enhances the ground transport value to carriers at the port. In future, this service area could also support green hydrogen re-fuelling of HGVs, which would help decarbonise the transport sector.

The recently approved Foynes-Limerick Road plans also include the Adare Bypass, a subcomponent of the larger Rathkeale-to-Attyflin Motorway Scheme (Section D). This portion of the works extends the M20 and provides a national motorway through to Rathkeale.

The ability for ground transport carriers to leverage a motorway and dual carriageway to access the Port of Foynes further cements this Tier 1 Port in the national logistics network and provides the required connectivity from quay to road.

15.1.2 Rail

The re-opening of freight rail services to the Port of Foynes is imminent given the recently published procurement for the reinstatement of the Foynes-Limerick rail line (Figure 53). This rail corridor, last operational in 2002, has the potential to move significant cargoes by rail to the Port of Foynes. The re-establishment of the Foynes rail link and investments at the national level, as outlined in Irish Rail's Freight Transport 2040, such as rail links to Limerick Junction, Waterford, and the Western Corridor, delivers freight transport options that can relieve congestion on national roads and support the decarbonisation goals for Ireland.

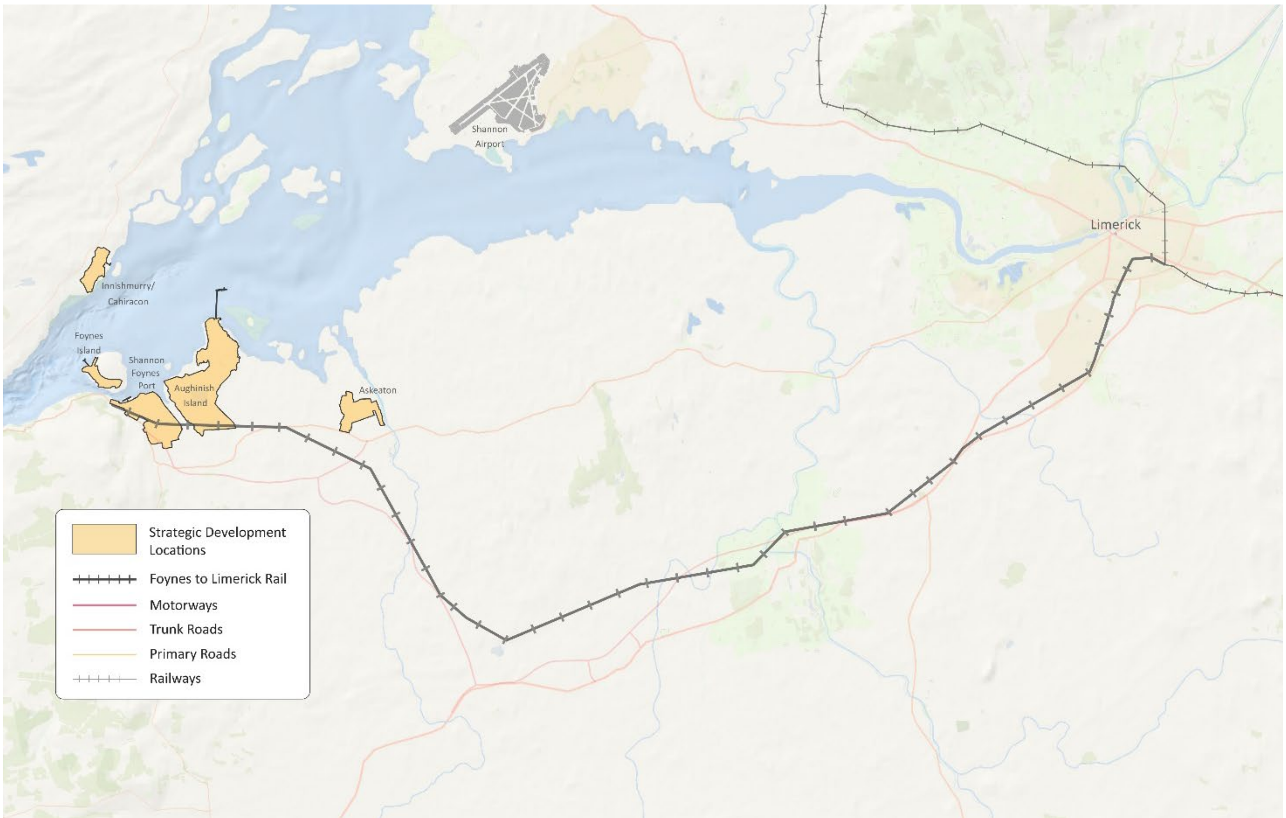

Figure 53: Foynes-Limerick Rail Corridor

New rail sidings at the Port for freight will make cargo movements to and from rail cars competitive for medium and longer haul routes. This includes bulk solid cargo, break bulk, and containers. There is potential at the port to re-introduce the branch lines running parallel to the quay and develop a rail freight centre located within the port estate. The potential freight centre will facilitate efficient transfers between marine cargo, road cargo, and rail cargo with loading bays and space for operations. With this freight connection, the Port of Foynes will enhance national and international connectivity and will be the only Tier 1 Port in the country featuring direct rail access to a Panamax-capable port.

Rail freight services will also benefit businesses in the region looking to sustainably transport bulk solid, natural resources with regularity. Further benefits (for both the Port of Foynes and the national supply chain) can be realised with investments in freight segments and re-establishing portions of the national network, such as the Western Corridor to make cargo journeys from Ballina and Sligo, and the connection to Waterford, to provide an option for businesses in these regions.

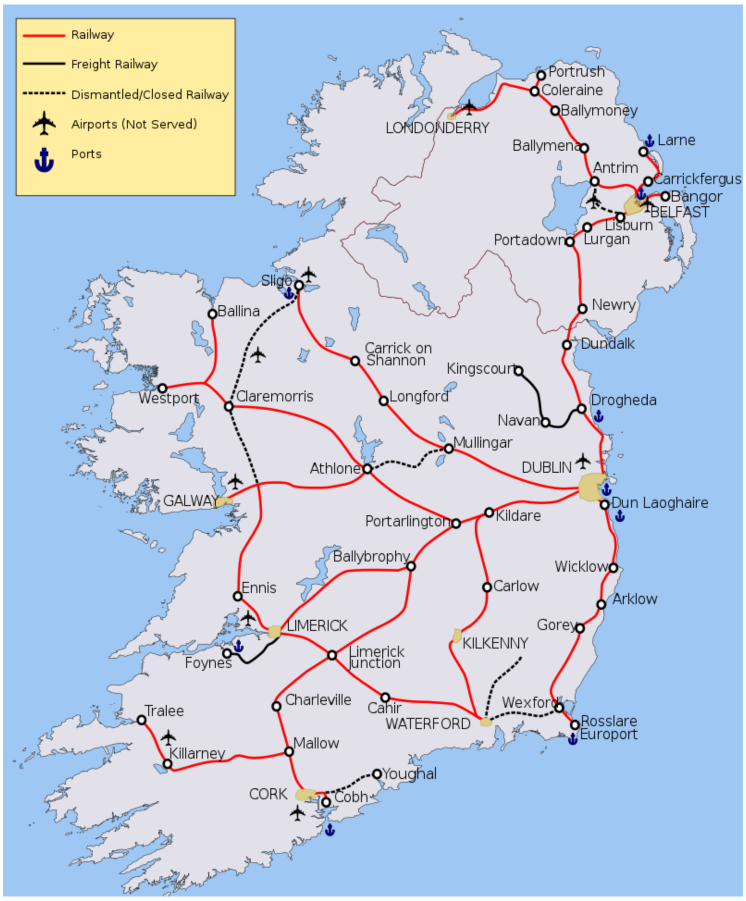

Figure 54: Ireland's rail network

15.1.3 Air

The Shannon Airport presents an additional transportation and access differentiator for SFPC. The airport will facilitate access for travellers doing business with companies along the Estuary, and further enhances the value of this Tier 1 Port that already features national roads and planned rail access. This will be particularly of benefit to the offshore wind and green hydrogen industries, which will require many technical specialists from overseas to visit the region as these industries develop.

15.1.4 Marine

Global trends in marine shipping show consolidation within the industry and increasing vessel sizes[107] (Figure 55). The evolution in vessel sizes has strained port operators around the globe, highlighting the opportunity for the Foynes Deepwater Port to provide the infrastructure needed to meet maritime logistics demands for today and tomorrow.

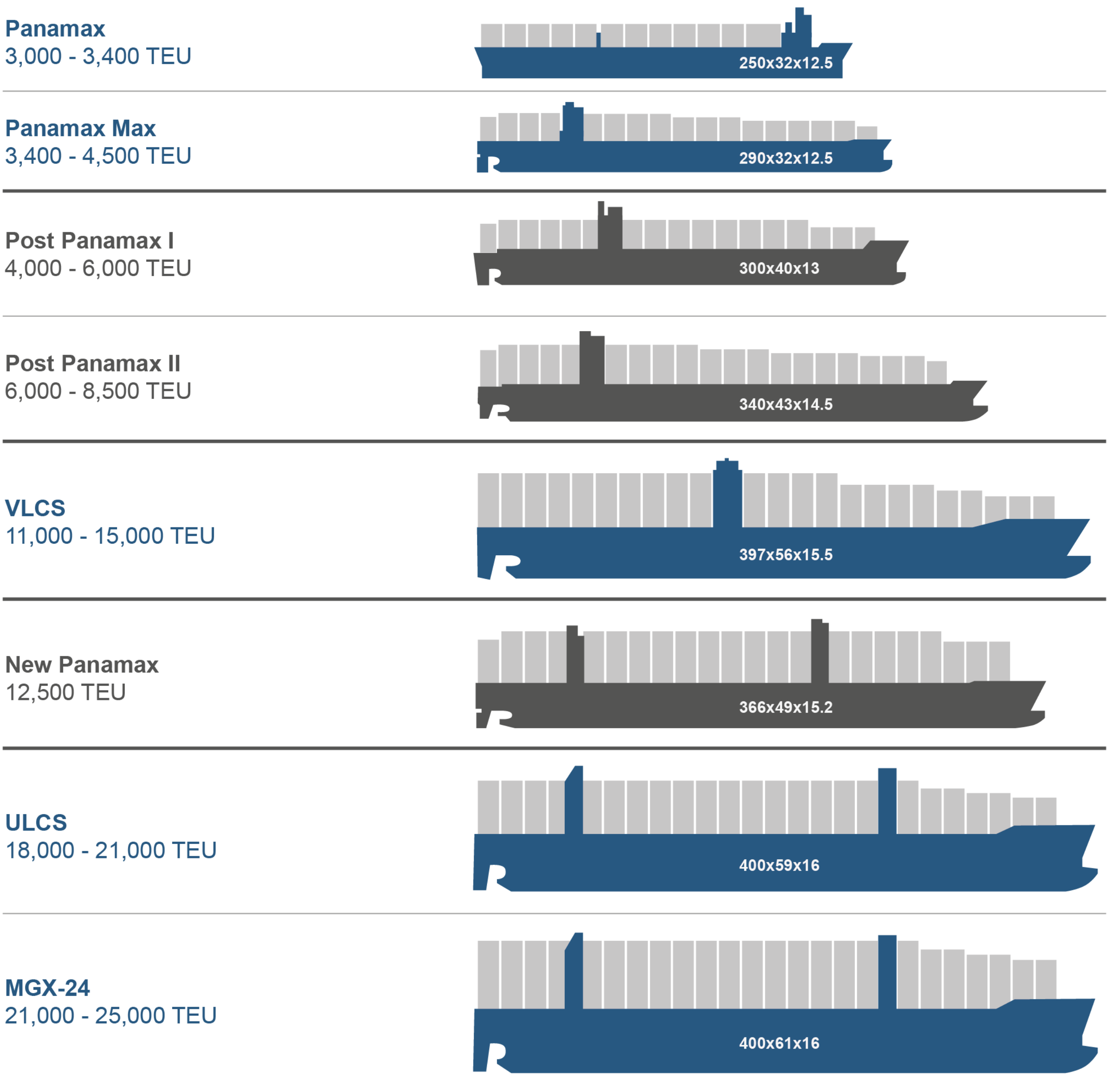

Figure 55: Container Ship Classes

15.2 Container Services

The Irish container business is experiencing a resurgence to throughputs last seen in 2008 (see Figure 56), and strong forecasts over the next 20 years show the national container business doubling to over 2 million twenty-foot equivalent unit (TEUs) per year. This growth will require port capacity for throughput and hinterland capacity for processing, maintenance, and storage. Shannon Foynes is well-placed to support this market growth and relieve congestion in the Irish supply chain.

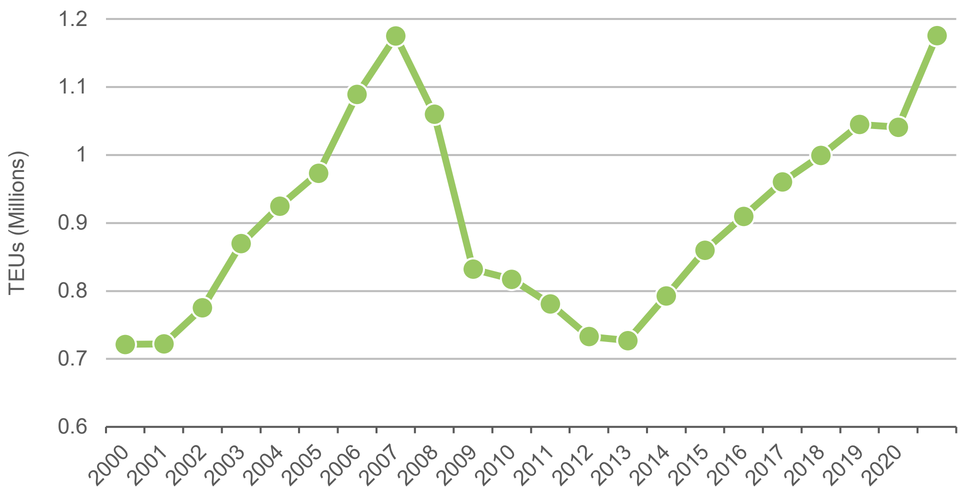

Figure 56: Ireland's annual container throughput (million TEUs per year) [108]

In the immediate term, SFPC is in the process of re-establishing a container business with the development of the East Jetty at the Port of Foynes. SFPC will then have the capacity of upward of 42,000 TEUs per annum, representing 4% of the current Irish container market. This first phase will facilitate an important node in the Irish container market. Later, the establishment of the deepwater port at Foynes Island will make Shannon-Foynes the only Panamax-ready terminal with rail access in Ireland.

Forecasting is growth is expected through identified sectorial expansion with the Americas and targeted business development activities resulting in two vessel berths per week. The container terminal at the Foynes Deepwater Port will be required to address the increased demand. Figure 57 highlights the demand opportunity facing SFPC, with the capacity at the terminal addressing the projected container volumes.

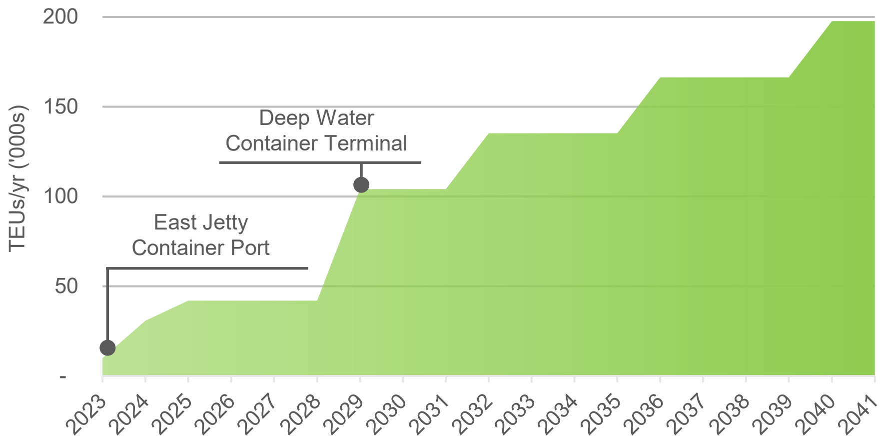

Figure 57: SFPC Container Business Projections

Ultimately, SFPC has the capability of addressing up to 12% of the projected Irish container market in 2041. Opportunities to provide transhipment services may emerge over time, complemented by sustainable re-fuelling or e-fuels services offered on the Estuary. Trends in the maritime carrier port call strategies and evolving geo-politics may also bring transhipment opportunities to Shannon Foynes.

The projections for the Estuary's container business highlight an opportunity to provide capacity (and relief) for the Irish supply chain – particularly when considering the expansions at Dublin Port and Cork. The sections below describe the operational approach to the container business initially at the Port of Foynes and then at the required deepwater terminal.

15.2.1 Port of Foynes

The Port of Foynes is developing the East Jetty to enable container services, with a capacity of 42,000 TEUs per annum. The operations will take place at Berth #5 and Berth #6 with additional laydown capacity in the Durnish Lands Phase 1 developments (Figure 58, Blue Hatching). The Durnish Lands Phase 1 development also features the ability to develop a dedicated rail siding for container rail operations.

At the East Jetty, the port will develop a regular sailings schedule via targeted routes. Reach-stackers will facilitate stacking in the yard and chassis loading.

Figure 58: Foynes Hinterland Development (Durnish Lands)

Looking ahead to 2031 and beyond, the development of the Durnish Lands Phase 3 (Figure 58, Purple Zone) will enable the Port to support (i) greater throughputs and port-centric activities, (ii) accommodate hinterland operations for the Foynes Deepwater Port, and (iii) distribution centres using the Foynes port container services. The Durnish Lands offer modal integration for sea, rail, and road as they adjoin the Foynes to Limerick rail corridor within the port area.

15.2.2 Foynes Deepwater Port

Foynes Deepwater Port plays a critical role in supporting the container services for the Estuary. The port will host one of two container terminals in Ireland capable of berthing a neo-Panamax vessel and – upon reinstatement of the Limerick-to-Foynes rail line – will be the only Panamax-ready terminal with a rail connection. Located at Foynes Island, the port will feature offshore wind integration activities, and will also dedicate 400 m of quay and associated hardstanding for container services. The 400 m will feature two berths, allowing for Neo-Panamax, Feeder Max vessels and other smaller container vessels to berth at the port, relieving operational constraints from the Foynes inner port (Figure 59).

Future expansions will be driven by the development and expansion of the offshore wind integration business. Maritime traffic coordination requirements will continue to increase through the expansion of floating offshore wind integration operations. The port may see a reconfiguration to accommodate the expansion of offshore wind, maintaining both the quay length and dedicated yard space.

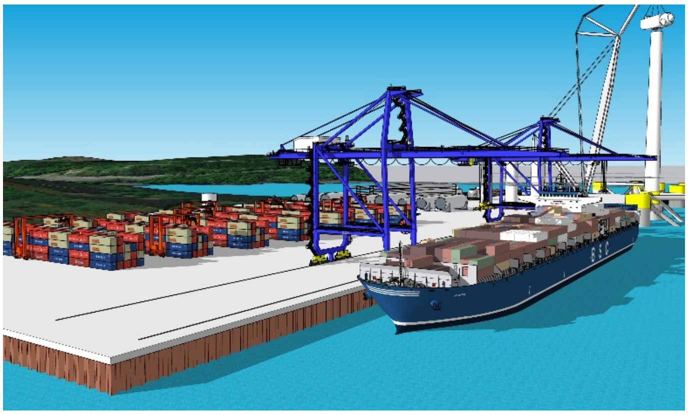

Figure 59: Container Terminal at Foynes Deepwater Port, Artistic Rendering

15.3 Distribution Centres and Industrial Parks

Shannon Foynes offers businesses a unique opportunity to locate their supply chain operations and storage within a Tier 1 Port. The land available for development is conveniently located for distribution centres, logistics facilities, and warehouses.

Shannon Foynes offers an uncongested option for Irish logistics and supply chain. Current congestion challenges in the Greater Dublin Area (GDA) highlights the need for both the capacity and optionality provided by Shannon Foynes. In addition to the congestion challenges, there are significant real estate pricing advantages in and around the Shannon Estuary for lettable industrial spaces. Considering that the GDA ranks third in world-wide costs of delivering warehouses[109] and fourth world-wide in average rental prices for logistics facilities, Shannon Foynes can provide a more economical growth option for Ireland's supply chains and businesses while diversifying the country's supply chain capacity.

15.3.1 Port of Foynes

Distribution centres and industrial parks located at the Port of Foynes represent an appealing opportunity for companies doing business at the Port. The benefit of close proximity to the quay and access to rail sidings within the port boundaries provides a unique and attractive offering. Within the 2041 horizon, the Port of Foynes is set to develop more than 40 ha of land that is well-suited for the development of warehousing with loading docks, enabling tenants to conduct container-related operations (i.e., destuffing and consolidation).

15.3.2 Askeaton

The Askeaton SDL covers almost 100 ha and is strategically located along cargo transport corridors as well as having connectivity to Ireland's natural gas network. This location is also already home to a world-class factory and R&D facility owned by Wyeth Nutrition, which supplies infant and maternal nutrition products to markets around the globe.[110] The Askeaton SDL size may provide 400,000 m^2 of lettable warehousing and industrial facilities. The proposed Foynes-to-Limerick road will improve connectivity between Askeaton and the Port of Foynes as well as to the national motorway network. In addition to expansion plans at the Port of Foynes, Askeaton offers an opportunity for businesses looking to improve their supply chain efficiency.

15.4 Logistics for Offshore Wind Delivery

Offshore wind activities represent a new business for SFPC, one that will bring a diverse and more sustainable throughput to the Estuary. Multiple SDLs will be involved in the offshore wind delivery chain, with turbine integration at Foynes Deepwater Port, substructure assembly at Moneypoint, O&M support from the Port of Foynes, and potential port and manufacturing facilities at Cahiracon. As further described in Chapter 5.3, delivering offshore wind from the Shannon Estuary will entail a whole range of logistics activities, including large marine movements through the Estuary, heavy quayside lifts and launches, wet storage of completed or partially completed turbines, and significant volumes of onshore movements of both material and people.

The offshore wind-related throughputs have many factors for consideration. This includes how units are counted (tonnage similar to cargo, or single units similar to TEUs) and the timing and location of various offshore wind activities on the Estuary. To quantify the potential contribution of offshore wind-related throughput to the total Estuary projections, the quantity of completed FOWT is estimated for 2031 based on achieving a production rate of 1–2 units per month in the base and mid scenario, building up to 27 units/yr, required to achieve a 400-MW offshore wind production rate as noted in the 10-GW base scenario for offshore wind. The 2041 projections are aligned to the production rates required to achieve the 10-GW/20-GW/30-GW wind power scenarios (base/mid/high).

Next, a total mass factor of ~20,000 tonnes is applied. The tonnage basis is derived from National Renewable Energy Laboratory (NREL) white paper[111] estimates along with forecasted masses for the various subcomponents for each FOWT. Finally, a nominal feeder cable length is assumed. Current privately owned SDLs are planning to engage in the offshore wind supply chain (i.e., Moneypoint Green Atlantic). The throughput projections for privately managed facilities have been accounted for in this emerging business, by including tonnages associated with foundation production and other wind-farm related throughput.

Figure 60: Wind Turbine Movement at Port of Foynes

O&M activities will be occurring concurrently with manufacturing and integration of the FOWTs. As described in more detail in Chapter 5.3.4, O&M activities will represent a new stream of vessel traffic in the Estuary, with their own berthing and onshore facility requirements as well as associated ground movements for people and material. As a result, SFPC will see additional throughputs related to the offshore wind business above the gross tonnages and vessel movements for integration. Due to uncertainties related to how future operators may manage the maintenance activities, throughputs for O&M activities have not been incorporated in the projections but have been accounted for in the space planning for the offshore-wind-related ports.

Overall, the offshore wind business provides an important sustainability-related throughput for SFPC and represents a strategic utilisation of Foynes Island and the deepwater capability of the Estuary. Forecasting to

2041, offshore-wind-related throughput represents ~4% of the Estuary throughput, adding diversification to the business for SFPC and contributing to the renewable objectives for the Shannon Estuary and Ireland.

16. Estuary Throughput Projections

The infrastructure described above plays a pivotal role in enabling Ireland to further leverage the capabilities and capacity offered by Shannon Foynes, to support the greater sustainability targets and economic growth potential of the country. Over the next 20 years, forecasts for Ireland's economic growth range from 2.0% to 2.5% according to the Organisation for Economic Cooperation and Development (OECD). This coarse metric forms the basis for the sector-level reviews.

Ireland's population is also projected to grow substantially through 2030 and to 2050. The Population and Labour Force Projection [112] estimates population growth to 6 million by 2050. Population growth is highly correlated with throughput or freight growth.

Annual Reviews and Outlooks from Ireland's Department of Agriculture, Food, and the Marine [113] and Food Wise 2025 [114] support mid-term outlooks for the agriculture sector, showing strong export business and sector challenges related to sustainability targets that help to shape conservative projections. Forecasts for the construction-related cargos focused on industry forecasts for the EU and the UK, as those markets are drivers for this cargo group. Oxford Economics recently published their Future of Construction, [115] which includes growth forecasts for Western Europe and the UK, making the case for nearly 4% growth per annum (compared to the Irish domestic construction sector, which may grow at a rate of 7% over the same period).

The development of the Foynes Deepwater Port will provide a differentiated product for shipping merchants in the North Atlantic, thanks to both the deep water and the hinterland connectivity to the national transportation network.

For the emerging, renewable industries coming to the Estuary, the installation rates for offshore wind needed to achieve the three scenarios drove the tonnage forecasts for the segment. Similarly for e-fuels, conservative assumptions related to proportion of tonnage that will be exported or bunkered was made to form a potential basis for an e-fuels throughput, forming no more than 5% of the total Estuary forecasted throughput in any scenario.

16.1 Lookahead to 2031, 2041

A review of the port throughput projections produced in Vision 2041 was conducted to incorporate planned container services, offshore wind, emerging renewable industries, and the planned shutting of Tarbert and Moneypoint fossil fuel-based power generation stations. As part of this review, updates to medium- and long-term growth projections were factored to consider the current state of the Shannon Estuary throughputs, the latest industry and Government reports, and GDP outlook for Ireland. The result of this update includes:

- Greater proportion of forecasted Estuary traffic to be directly managed by the SFPC (Figures 61 and 62).
- New business segments (container traffic, offshore wind, e-fuels) drive transition and traffic volume (Figure 62).
- Narrowing of the forecasted spread between the base and high scenarios (Figure 63).

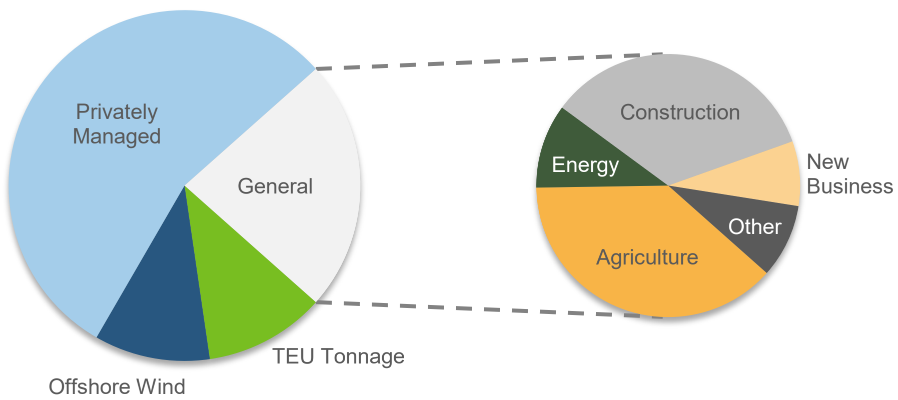

Figure 61: Cargo mix projections, 2041

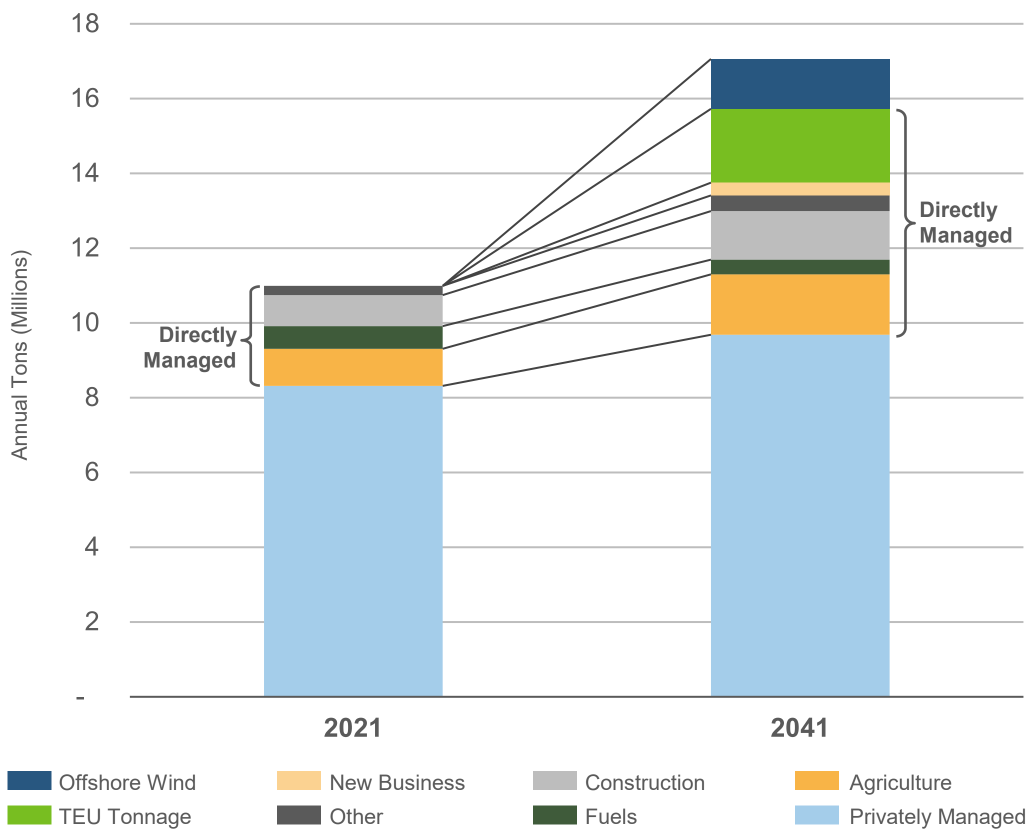

Figure 62: Projected change in throughput composition, mid-line, 2021-2041

To account for variability and uncertainty, the framework of base-mid-high line scenarios was utilized. Chapters 16.2 and 16.3 provide further insight into the growth rates and assumptions that underpin the projections. In all cases, industry benchmarks and forecasts played a central role in grounding the projections and in many cases a sensitivity was then applied to provide a conservative spread for the selected market and representative cargo throughput.

The result is a tightening of the forecasted scenarios in 2041 (relative to the original Vision 2041), with a strengthened base and mid-line. This accounts for recent historical performance and updated forecasts by market analysts and industry groups.

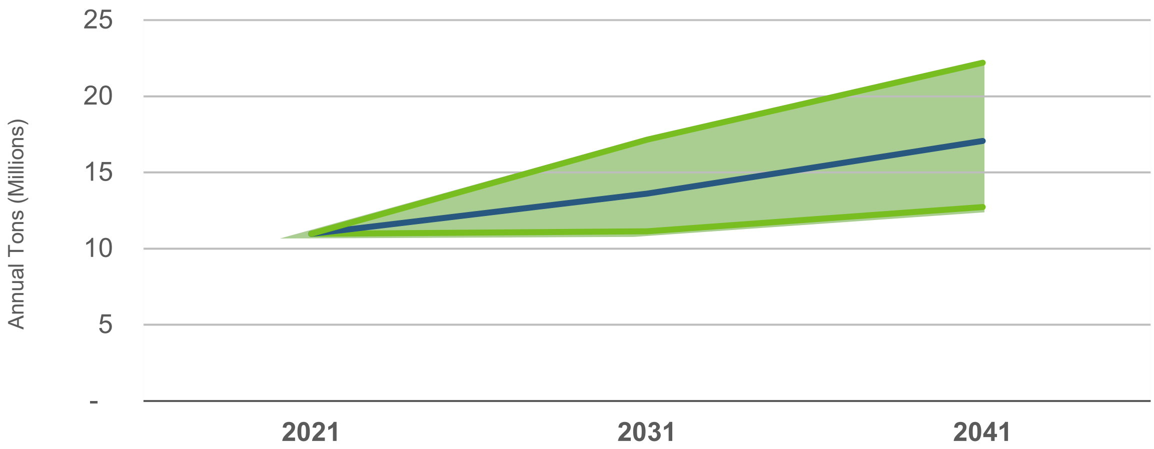

Figure 63: Estuary base-mid-high throughput projections (tonnes per year) to 2031 and 2041

Table 10 and Table 11 provide a summary view of the Estuary throughput projections aligned to the Vision 2041 projections classifications, with a breakout chart dedicated to the directly managed general cargo ports (Port of Foynes, Limerick).

In the following sections, a detailed review of the business demands driving the projections are unpacked. First, the directly managed port projections (general cargo businesses) are reviewed, followed by the privately managed ports, where the transitions of this suite of ports is reviewed.

	2021	2031	2041
Base Line	10,975,000	11,144,000	12,808,000
Mid Line	10,975,000	13,648,000	17,061,000
High Line	10,975,000	17,190,000	22,212,000

Table 10: Updated Estuary Throughput Projections – Total (tons/yr)

	2021	2031	2041
Base Line	2,657,000	3,204,000	3,311,000
Mid Line	2,657,000	3,535,000	4,072,000
High Line	2,657,000	4,020,000	5,143,000

Table 11: Updated General Cargo Projections (tons/yr)

16.2 Breakdown of Directly Managed Port Projections

Agriculture products represent a core business for SFPC, particularly at the Port of Foynes. Agriculture cargo includes products such as animal feeds, fertilizers, molasses, and wheat pellets. Projections to 2026 and the industry outlook reviews for agriculture-related products provide a basis for the 4% high-line growth to 2031. A sensitivity band of –1% and –2% is applied to determine mid- and base-line scenarios. This approach is conservative and accounts for unknowns related to fertilizer availability and transitions to take place to accomplish the industry's sustainability targets. Forecasts to 2041 have a mid-line growth rate of 2%, consistent with the Irish GDP projections [116] and the Vision 2041 long-term estimates. A sensitivity of +/- 1% is applied to establish the base and high scenarios.

Near-term, base-line forecasts for construction-related bulks are 1.5%. This is conservative given the expected rebound in the construction sector over the 2030 horizon. The heavy export nature of the construction segment requires forecasts to be based on the export markets. The 2031-forecast high scenario is based on Construction Ireland 2027 [117] and the Oxford Construction Forecasts for the UK and mainland Europe markets (Foynes exports) for a blended forecast of 5% growth. For infrastructure planning purposes, accounting for a high scenario is important for confirming spatial availability for bulk laydown.

Forecasting forward to 2041, 2% growth is assumed. This aligns with original Vision 2041 analysis and the forecasted Irish GDP growth outlook. The 2041 forecast includes +/- 1% sensitivity to establish the base and high scenarios.

Fuels throughput is composed of solid and liquid fuels (not including any e-fuels). This represents an existing business for SFPC, but one that will be dynamic over the 20-year horizon. Specifically, it is expected that hydro-carbon fuel throughput will contract over the medium and longer term. Underpinning this potential contraction is an expected reduction in solid fuels.

Forecasted high-line growth is based on maintaining the current throughputs (zero growth), with midline and base line showing contractions in the business. The 2041 projections take a more conservative view, expecting a further contraction in the fuels business (again, not considering e-fuels). This results in a base/mid/high scenario summarized in Table 12.

Fuels Growth Rates	2031	2041
Base Scenario	-2.3%	-6.0%
Mid Scenario	-1.0%	-3.0%
High Scenario	0.0%	-1.0%

Table 12: Fuel Growth Projections for Port of Foynes

The balance of the directly managed cargo throughput represents approximately 9% of the general cargo throughput, and 2% of the overall throughput for SFPC. This cargo grouping is forecasted to grow with the Irish GDP as a base scenario. Conservatively, a +0.5% and +1% sensitivity is applied to arrive at the mid-line and high-line scenarios. Given the cargo mix captured by this grouping, the Irish GDP is a conservative, comparable growth rate.

Finally, the Shannon Airport has historically realised 126,000 tons annually of throughput in the form of liquid fuels. Recent years saw a decrease in this throughput, namely due to COVID; however, the airport is expected to rebound back to their normal operations.

16.3 Breakdown of Privately Managed Port Projections

This section breaks down the projected operations for privately managed ports on the Estuary. Forecasts noted below are subject to the operator's internal planning and is based on historical data, consultations, and industry trends.

Moneypoint's current throughput is solely fuels required to operate the power plant on the SDL. Moneypoint is in the midst of an ongoing transition from solid fuels to liquid fuels, which is expected to coincide with a near-term reduction in fuel cargo throughput overall for Moneypoint. This is predominantly due to the expected shutdown of the coal-fired power plant, originally forecasted for 2025. While the definitive near-term future for Moneypoint is not known, it is expected that Moneypoint will transition to operating their boilers with HFO only, with the shutdown likely to be delayed. For these reasons, the Moneypoint throughputs (powerplant-related) are assumed to be zero from 2031. The planned offshore wind throughputs for Moneypoint are accounted for and aligned to the scenarios outlined in Chapter 4.3.

Considering Aughinish, the historic throughput has consisted of substantial bauxite imports and alumina exports, along with relatively smaller quantities of bulk liquids. The total throughput for Aughinish (6.6M tons) has remained constant and has been assumed to stay consistent through 2041. It is assumed, based on consultation with management, that Aughinish Alumina will continue operations post the Vision 2041 plan period.

The planned STEP facility proposed by Shannon LNG (New Fortress Energy) at Ballylongford is a significant opportunity for additional throughput in the Estuary. This opportunity was informed based on consultations with New Fortress Energy together with publicly available information, including planning and development materials. The STEP facility includes:

- Marine terminal for importing natural gas.
- 600-MW Combined-Cycle Gas Turbine (CCGT) power plant, capable of operating on a hydrogen blend.
- Integrated Battery Storage facility with a 120-MW 1-hour Ultra-Fast response.

In the low scenarios, to be conservative the projections account for risks associated with obtaining planning approvals and project mobilization. Looking forward to 2041, the STEP facility is a proportionally small piece of the diversifying Estuary throughput.

Green hydrogen, which will likely be transported through green ammonia, will be an emerging commodity for the Estuary with offtake demand being shaped currently. It is expected that e-fuel storage and even production will begin to feature in the 2031 horizon with growth forecasting out to 2041. Initially, the e-fuels business may be predominantly an import business as storage capacity is delivered ahead of production – building experience handling e-fuels and helping to establish an e-fuels business at the Estuary. Production rates in the 2041 horizon will be aligned to the scenarios defined in Chapter 9.2.

Looking forward to 2041, SFPC will see a more diverse mix of throughput across the Estuary, de-risking SFPC's reliance on privately managed terminals.

17. Driver 3 Key Takeaways

Key takeaways…

- Logistics are the cornerstone of SFPC today and will continue to be sustainable long into the future with the addition of more diverse markets.
- Strategic infrastructure investments in ground transport links and port expansions will allow this Tier 1 Port to develop further as a key node in the Irish logistics network and support Ireland's overall economic growth.
- The Foynes-to-Limerick Road Scheme and reinstatement of the Foynes-to-Limerick rail line are essential hinterland connections that will enhance and improve resilience in the national supply chain by improving access to the deepwater port of SFPC.
- Located at an uncongested location on the national supply chain, the development of the Foynes Deepwater Port makes the Port of Foynes the only Tier 1 neo-Panamax-ready port with rail access.
- The establishment of container services and the emergence of new renewable business sectors, such as offshore wind and e-fuels, are expected to drive growth above and beyond the base cargo businesses.
- Distribution centres and light industrial park capacity at the Port of Foynes and Askeaton SDLs offers businesses a unique opportunity to cost-effectively locate portions of their supply chain within (or within close proximity to) a Tier 1 Port.

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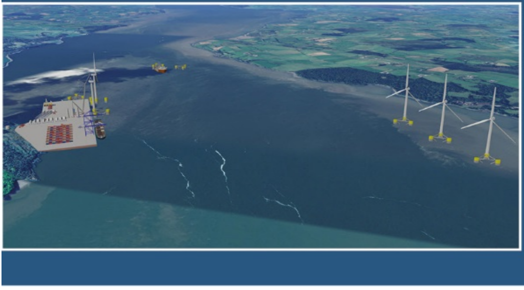
SHANNON FOYNES PORT

Review of the Strategic Development Locations



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The SDLs are locations and areas that are considered key drivers in providing the necessary focus and direction to harnessing the economic and development potential within the Estuary, as outlined in the SIFP. The recommendations for infrastructure needs and operational considerations for the highlighted SDLs to maximise their potential are summarised below. In many cases, a phased approach to development and expansion is warranted to match the SDL capacity to the demands. In all, the SDLs have been reviewed both individually and from a collective perspective to best leverage the Shannon Estuary's potential.

18. Port of Foynes

The Port of Foynes is the cornerstone of SFPC's cargo operations on the Estuary and is expected to undergo significant changes as it accommodates the projected growth and change in throughput. The port's estate is over 90 ha and when accounting for Foynes Island, is the only Tier 1 Port in the country with access to deep water in excess of 20 m. Further advantages for the Port of Foynes include planned access to ground transportation links in roads and rail at an uncongested point in the national supply chain. Specifically, the Port is located along the N69, a road link with planned upgrades and additions to improve transit times and quality. The recently approved Foynes-Limerick Road Scheme is a key component of the planned ground transport upgrades, delivering enhanced connections to the Irish motorway system. The Port of Foynes has also direct rail access, highlighting the opportunity in the reinstatement of the dormant Foynes-Limerick rail line.

The port estate is expected to grow to over 125 ha by 2041 based on the scope of operations (noted below) and the growth projections highlighted in Chapter 16. Drivers of this expansion include hinterland operations for the container business, storage and laydown for bulk solids in the agriculture and construction sector, and other port centric activities. The Port of Foynes may also accommodate emerging e-fuels production and storage as well as other renewables-related industries within the current SDL boundaries. The storage of e-methanol and ammonia both require significant real estate as shipments can be in the order of 80,000 cm. There is space available within the port for significant tank storage which would facilitate export of product and also bunkering of fuels for ship refuelling.

18.1 Scope of Operations

In the following sections, the projections and operations will be knitted together to describe the land usage requirements over the next several decades. The objective is to provide context and a holistic view of the Port of Foynes moving forward. Forecasted storage requirements for the Port of Foynes (Table 13) were reviewed and compared to the current projects in planning approval. The result is a recommended land allocation to match-fit the operations, along with requirements for additional development land in accordance with the projected storage requirements.

Table 13: Forecast Storage Requirements at Port of Foynes

	2020		2041	
	Mid	High	Mid	High
Covered Storage (ha)	20	25	50	75
Open Storage (ha)	10	15	20	40
Liquid Storage (ha)	20	20	30	50
Quayside Set Down (ha)	3	3	25	50
Port-Centric Projects (ha)	10	15	30	40
Total (ha)	63	78	155	255

18.1.1 Bulk Liquid

The current bulk liquid business at the Port of Foynes is serviced by three dedicated loading manifolds through which bulk liquid fuels is pumped to the Atlantic Fuels Supply Company (AFSC) storage facility at the port. An improved molasses piping network from the quay is being delivered as part of the East-West Jetty connection capital works.

Over the next 20 years, the port should be prepared for potential increases in the bulk liquid business. An emerging e-fuels business may require new storage capacity and piping network. Locations in proximity to the AFSC storage tanks could be prioritized to consolidate bulk liquid operations, where possible.

18.1.2 Bulk Solid

Bulk solid cargo composition will change over the coming decades and will be driven by growth in identified sector and reductions in the volume of solid fuel cargo (Figure 64). Growth may also be driven by consolidation within individual sectors, which SFPC is well placed to benefit from due to its strong comparative advantages.

Figure 64: Bulk Solid Operations at Port of Foynes

To address the growth in bulk agriculture cargo tonnage, a grain silo farm should be evaluated to optimize grain operations. Silo technology would provide SFPC with best-in-class marine-to-transport operations. Accommodating a silo farm may necessitate the relocation of traditional flat stores resulting in a significant increase in land usage requirements for covered storage in the dry bulk sector.

18.1.3 Break Bulks

The current break bulks business at the Port of Foynes is comprised mainly of construction related cargo imports, such as steel bars, project cargoes, and machinery. The balance of the SFPC break bulk business takes place at Limerick Docks, where recyclable exports are the primary driver of tonnage. Projections for break bulks highlight a need for increased laydown at the Port of Foynes and contribute to the 40 ha of open storage forecasted. Beyond the construction-related cargo, break bulks may include offshore-wind-related machinery and components that require storage, inspection, or maintenance. The offshore wind sector, due to the large component sizes, requires significant land space to store and manoeuvre in and out of the port estate. This leads to a significant increase in open storage land requirements and supporting internal road layouts.

18.1.4 Container Services

See Chapter 15.2 for a detailed description of container services.

18.1.5 Warehousing & Business Parks

SFPC is currently developing the 38-ha Durnish Lands at the Port of Foynes, where the first phase will bring open and covered storage capacity. Later phases of the Durnish Lands property will be utilised for additional open storage and port-centric projects.

The Port of Foynes SDL also features strategically located development land between the N69 and the rail corridor that provides capacity for warehousing and business parks within the port property. The additional offshore-wind-related storage requirements will increase the need for covered storage at the Port of Foynes as well as the supporting road infrastructure to move large component parts to the quayside. Covered storage and loading docks will optimize hinterland operations and allow businesses to better leverage the growing container business at the Port. The logistical advantages the port will offer include:

- Co-packing facilities for agriculture cargo,
- Container de-stuffing and consolidation,
- Offshore wind component storage,
- Offshore wind O&M-related storage requirements, and
- Other supporting operations.

18.1.6 Renewable Industries

Emerging renewable industries in floating offshore wind and e-fuels bring value to the Estuary and their respective operators by locating the businesses at the Port of Foynes. For offshore wind, SFPC may allocate area within the Port for one or more future operations bases. An operations base will typically consist of a port-based marine operations facility and a central control room. The port requirements described in Chapter 5.3.4 describe the quayside facilities, and the west pier at Port of Foynes meets much of these criteria.

As the e-fuels business and supply chain develops, the Port of Foynes may allocate space for fuel storage. This could include lands adjacent to the existing AFSC tank farm or future Durnish Lands development.

18.1.7 Cruise Traffic

The Port of Foynes may see tourist traffic in addition to the cargo traffic. It is expected that any cruise vessels will be anchored in proximity to the Port of Foynes with tendering vessels used to move passengers to the Port. This is to prioritise quayside availability for cargo operations, while keeping the cruise vessel in more optimal position within the Estuary to reduce their transit times and provide proximity to any re-fuelling options.

18.2 Port of Foynes Land Development

The Port of Foynes is completing a capital works program that includes connecting the east and west jetties and establishing a container terminal at the East Jetty. Figure 65 captures the infrastructure required for SFPC to accommodate the changing cargo throughput mix and related growths projected (see Chapter 16 for more information).

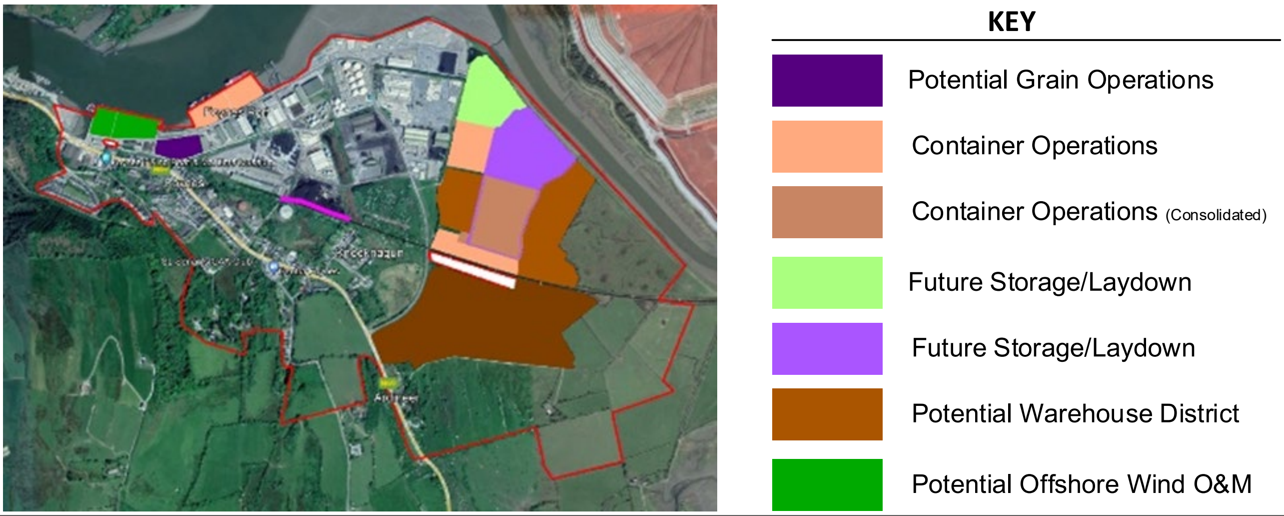


Figure 65: Port of Foynes potential land development

It is anticipated that additional land development at the Port of Foynes will be primarily centred around establishing and growing container services, storage and laydown for bulk solids, and supporting the wind farm delivery chain and other renewables-led industries. The container operations at the East Jetty can be supported by open storage at the Durnish Lands development, which can be further enhanced with a dedicated rail siding. The Port of Foynes can continue to expand further into the Durnish Lands to colocate its container services and introduce supporting operational facilities and distribution centres. This will enable the Port of Foynes to deliver comprehensive hinterland container services and address the projected growth in container throughput.

Similarly, quayside facilities oriented toward wind farm delivery and O&M activities can be further supported from available space within the Durnish Lands, which could accommodate a range of activities from general laydown and storage to more value-added support such as miscellaneous fabrication and other renewables-related industry.

A key influence on the ability for the Port of Foynes to address the projected throughputs and evolving cargo mix is adequate ground transportation. The reinstatement of the Foynes-Limerick rail line will certainly have a positive impact, but wider network considerations will also play a role in the success of freight transported over rail (and reduction of HGVs on the road). Network considerations for rail include:

- Adequate sidings within the Port of Foynes with appropriate shunting necks to facilitate efficient operations.
- Establishing container exchange programme, route, and schedule with other ports and inland ports.
- Rail yard capacity and operational capability at Portarlington, Waterford, and other key customer areas.
- Reinstatement of the Western Rail Corridor providing rail connection to Claremorris and beyond.

In addition to the Foynes-Limerick rail line reinstatement, the completion of the Limerick to Foynes Road Scheme is also required. Updated projections, even accounting for traffic relief by rail, will put more strain on the road network. The expansions and upgrades to the Shannon Estuary's ground transportation links are crucial for facilitating the expansion and shift in the logistics business to a more diverse and sustainable mix. The planned Limerick-Foynes Road scheme is critical to provide ground transport carriers the ability to leverage a motorway and dual carriageway to access the Port of Foynes (Figure 66).

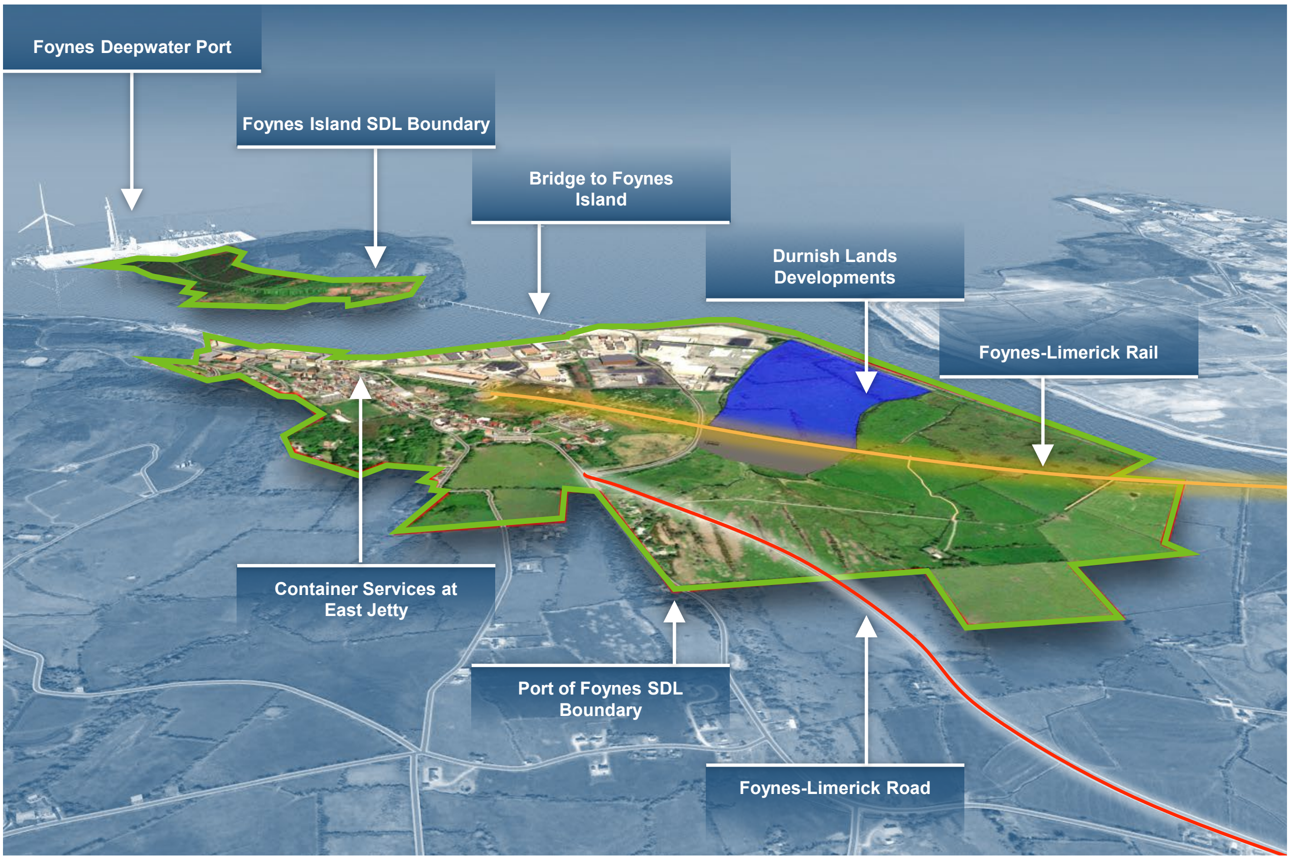


Figure 66: Port of Foynes, Rendering

19. Foynes Deepwater Port

Foynes Deepwater Port is located on Foynes Island, which is directly across the main berthing channel from the Port of Foynes. Foynes Island previously facilitated port operations with an operational oil jetty until the late 1970s. With its proximity to the Port of Foynes, and its extensive access to natural deep water (occurring between 12.5- and 20-m depths), the island provides immediate access to the main navigation channel of the Estuary with no capital or maintenance dredging required.

The planned Foynes Deepwater Port is the most important expansion of port capabilities for the Estuary. The intended multi-functional nature of the port – enabling both offshore wind integration and related throughputs as well as a Neo-Panamax capable container terminal – will diversify the Estuary's cargo base and position it for a future that is attuned to Ireland's climate objectives. This facility could also accommodate Panamax bulk vessels. The container terminal will provide the required capacity to expand the container business at the inner Port of Foynes. Further complimented by its rail access, this Neo-Panamax-ready terminal offers a distinct opportunity to decarbonise the national supply chain, enabling it to play a significant role in the Government's Climate Action Plan over the years to come.

19.1 Preliminary Development Concept

The planned Foynes Deepwater Port will be capable of supporting both FOWT integration and pre-commissioning activities ("integration port") as well as container and bulk operations (container terminal) simultaneously. The initial development features at least 800 m of quay and associated hardstanding that is split evenly between the two intended operations (Figure 67). At peak capacity, the three berths within the integration port portion will be capable of supporting up to a 400-MW/year integration rate, sufficient to achieve the installation rate considered in the offshore wind low scenario. The container terminal will feature up to 3,600 slots, capable of supporting a throughput of 190,000 TEUs/year. Both capacities would require validation during detailed design, taking simultaneous operations and other operational parameters into consideration.

In Vision 2041, SFPC committed to examining and providing for suitable provision for onshore power / cold ironing in any future potential infrastructure projects. The EU Fit for 55 package launched in 2021 includes the FuelEU Maritime Regulation which requires container and passenger vessels to connect to shore power from 2030 for stays longer than two hours. The future port expansions will be designed accordingly.

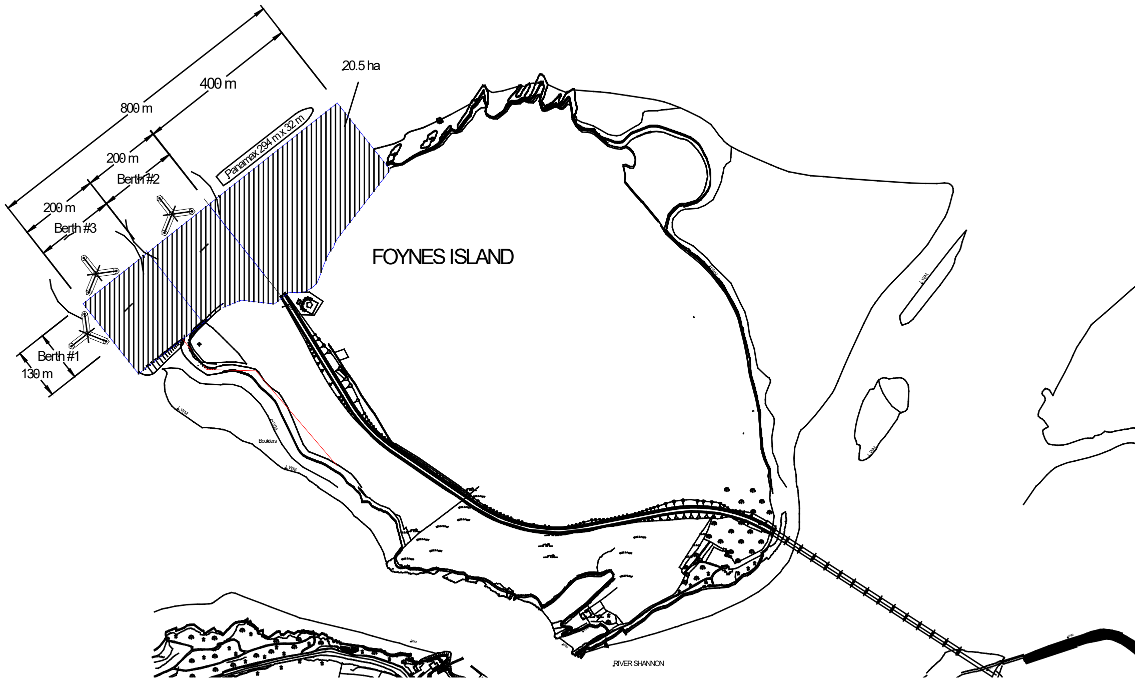


Figure 67: Preliminary Design Concept for Foynes Deepwater Port

The road connection to the port will be utilized not only by the container chassis being trucked on/off the island, but also by vehicles supporting the offshore wind operator transporting people and smaller equipment and materials.

The option of establishing a rail connection to relieve traffic on and off the island should be modelled and reviewed against costs of delivering the connection. This option will require the delivery of a rail yard both at the island and the Port of Foynes (Figure 68). Such yards typically feature several rail sidings and, with space being a premium, will require further study for feasibility.

Figure 68: Foynes Deepwater Port, Rendering

20. Cahiracon

The Cahiracon SDL is located across from the Port of Foynes and Foynes Island on the north side of the Estuary and is accessed from the R473. Given the deep water just off its southwestern edge and its large (approximately 63 ha) and relatively flat hinterland area, Cahiracon is well suited to support the delivery of offshore wind, be it for marshalling, assembly, or manufacturing operations. The establishment of a port facility and associated hinterland development at Cahiracon would provide additional supply chain options to offshore wind developers looking to deliver from the Estuary, thus boosting the local content potential for the region.

20.1 Preliminary Development Concept

A preliminary development concept was produced to illustrate Cahiracon's potential (Figure 69). Although there is a disused pier on the northern half of the site, the water depth is relatively shallow and not suitable to cater to the deep water needs of the large-scale floating offshore wind industry. Depth improves toward the south end of the site, and therefore this preliminary development concept proposes the establishment of up to a 450-m-long berth along the SDL's southern half. To reduce or eliminate the need for dredging (which will ultimately depend on the depth requirements of the facility's users), the quay is shown to protrude out from the natural shoreline with reclaimed hardstanding behind.

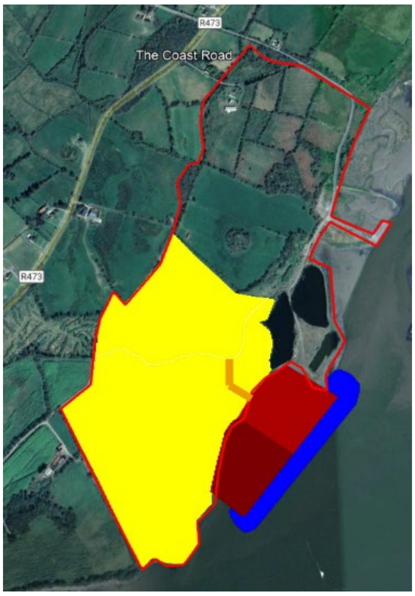


Figure 69: Preliminary development concept for Cahiracon SDL

In addition to the core wind farm delivery facilities (i.e., integration at Foynes Deepwater Port, substructure assembly at Moneypoint, and O&M from Port of Foynes), Cahiracon is identified in Chapter 5.3.5 as a suitable location for turbine blade manufacturing – a delivery chain activity that could be established locally if and as annual turbine delivery rates increase to a point where colocation becomes an attractive investment for potential developers. Projects such as the Coastal Virginia Wind Project (in Norfolk, Virginia, USA), are prime examples of locating a blade-manufacturing facility close to an integration port.

In addition to quayside access, offshore wind turbine blade manufacturing requires large, custom facilities for fabrication and ample laydown space. The 32 ha of developed land (*yellow-shaded area*) shown behind the quayside in the preliminary concept is benchmarked against manufacturing facilities producing similar-sized turbine blades.

In addition, as the technology progresses, Cahiracon could also be a suitable site for the colocation of offshore wind turbine blade-recycling facilities. Should the development of a blade-manufacturing and -recycling facility progress in this location, consideration should also be given to establishing a Research, Development, and Innovation facility supported by the regional Universities close to this location. This would facilitate innovation and provide benefits not only to the local students and Universities but to the entire Irish Offshore Wind supply chain. This concept would further support the Atlantic Green Digital Basin and maximise the regional economic and environmental benefits that can be gained from the major renewable energy potential of the region as set out in the Mid-West regional enterprise plan.[118]

A short road from the R473 will be required to provide access to the developed portions of the SDL and newly established quay. Over time, upgrades to the local road connections may be required to support HGV movements or increased personal vehicle traffic along the northern shore of the Estuary.

Cahiracon is located close to high-voltage (220-kV) electricity lines running between the substations at Moneypoint and Prospect, and within 0.5 km from the Galway-to-Limerick high-pressure natural gas pipeline, necessitating only short spurs to feed the site.

Though the preliminary development concept is based specifically around blade manufacturing, the actual provisions involved – up to 450 m of deepwater quay length, some 63 ha of relatively flat land, an access road and utility connections – could flexibly facilitate the establishment of a wide range of wind farm and other maritime-related industries. For instance, Cahiracon could also be utilised to support substructure assembly in the event where additional capacity is required beyond Moneypoint, with the total area within Cahiracon on par with the space earmarked by ESB in their Green Atlantic development. The key to unlocking the potential of Cahiracon, of course, will be in establishing a port facility with deep enough water alongside such that it can be leveraged by potential developers (Figure 70).

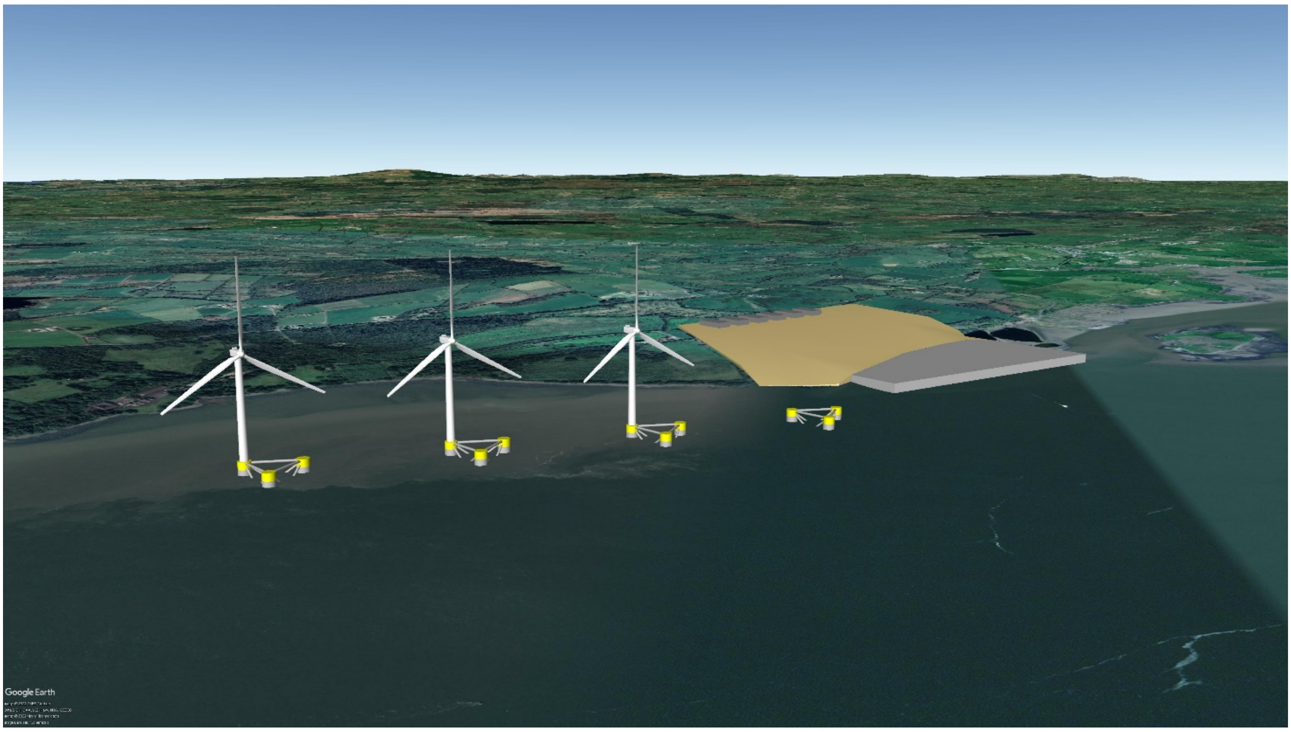


Figure 70: View of potential Cahiracon port development (background, yellow shading)

21. Askeaton

The Askeaton SDL is strategically located along the N69 east of the Port of Foynes. Covering over 92 ha of land appropriately zoned for industrial use, the Askeaton SDL has been identified as an important site from a business and employment perspective in the Limerick County Development Plan. The eastern edge of this SDL is alongside the River Deel and hosts a world-class factory and R&D facility owned by Wyeth Nutrition, which supplies infant and maternal nutrition products to markets around the globe.[119]

Already well-connected through the N69, the recently approved Foynes-to-Limerick road will further strengthen the links between Askeaton and the Port of Foynes as well as to the national motorway network. As noted in Chapter 15.1.1, the Foynes-Limerick Road Scheme includes a new Type 1 single carriageway branch that connects to the N69 directly across from the Askeaton SDL (see Figure 71).

Askeaton is also close to existing high-voltage electricity and high-pressure natural gas lines, with Wyeth Nutrition being fed by a spur from the Galway-to-Limerick high-pressure natural gas pipeline.

21.1 Development Options

Askeaton is well-suited as a business park and light industrial zone geared toward logistics and emerging green industries. On the logistics side, the connectivity of Askeaton and proximity to the Port of Foynes offer an opportunity for businesses looking to improve their supply chain efficiency by establishing warehousing or co-packing facilities on site.

Askeaton could also be considered as a potential location for a hyperscale data centre, which would further support the emerging green industry in the location. The site has key infrastructure, including access to the electricity grid and the existing high-pressure gas grid, which would facilitate self-generation of power on the site. In addition, the proximity of the site to the potential offshore wind energy and potential hydrogen production facilities provides the potential to colocate a renewable powered electricity generation facility and/or advanced long-duration battery storage, supported by a Corporate Power Purchase Agreements, private wire or other arrangements. The site is a location that could easily comply with the Irish Government's Principles for Sustainable Data Centre Development.

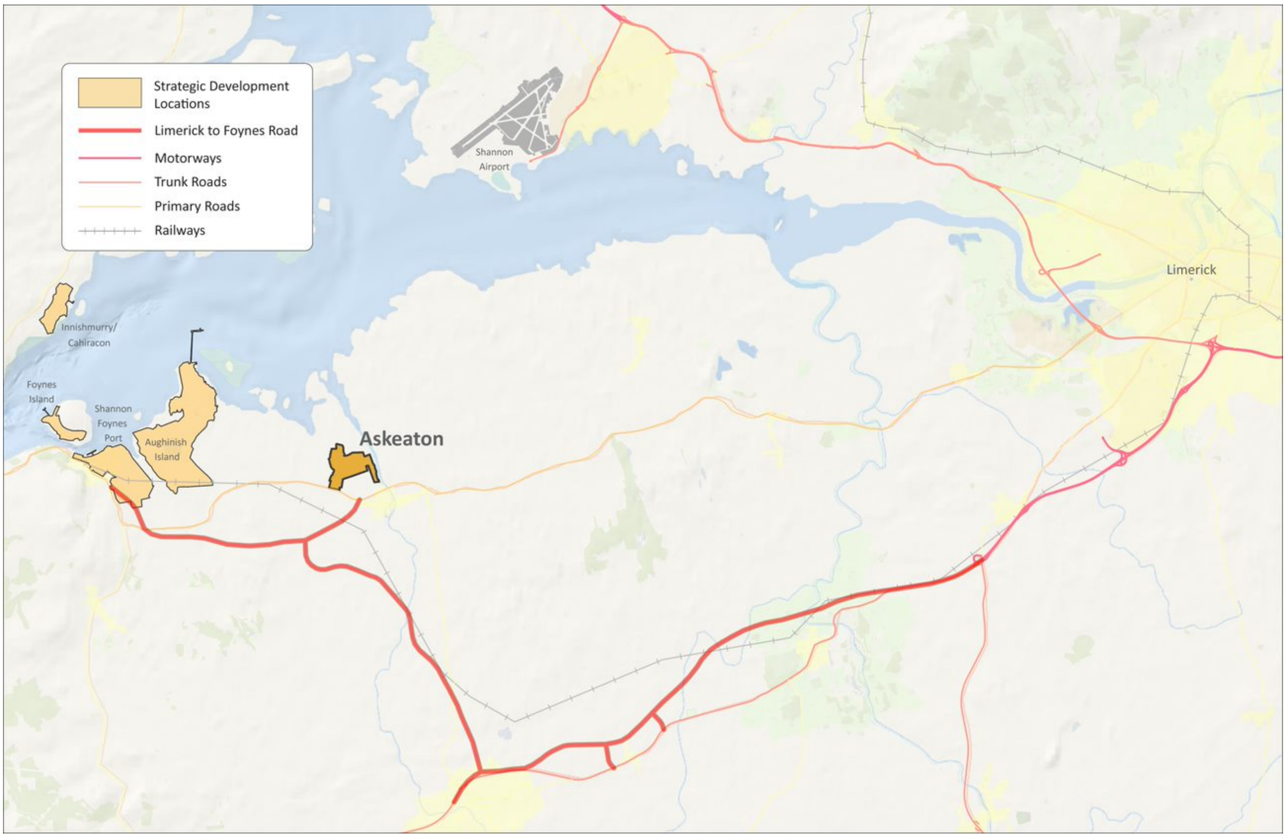


Figure 71: Askeaton SDL and Ground Connections

22. Moneypoint

The Moneypoint SDL is predominantly occupied by ESB's 915-MW coal-fired power generation facility (Figures 72 and 73 [120]). To handle and store the coal, the facility includes a deepwater jetty capable of accepting vessels up to 250,000 dwt and a 600,000-tonne storage area. The site hosts a 400-kV substation that is situated on the western end of Ireland's main 400-kV cross-country transmission lines, offering access to the national grid and making it a major hub for electricity transmission.

Figure 72: Moneypoint SDL with ESB's property shaded yellow

Figure 73: ESB's 915-MW Power Station, jetty, and coal storage yard at Moneypoint [120]

22.1 Development Plans

ESB has long signalled its intent to cease burning coal at Moneypoint, as part of the company's broader Net Zero strategy. In April 2021, ESB announced the Green Atlantic at Moneypoint project, which will transform the site into a green energy hub. The first phase of this project has already commenced via the installation of a new Sustainable System Support facility, which features the largest Synchronous Compensator of its kind in the world and will enable higher volumes of renewables on the Irish grid system.

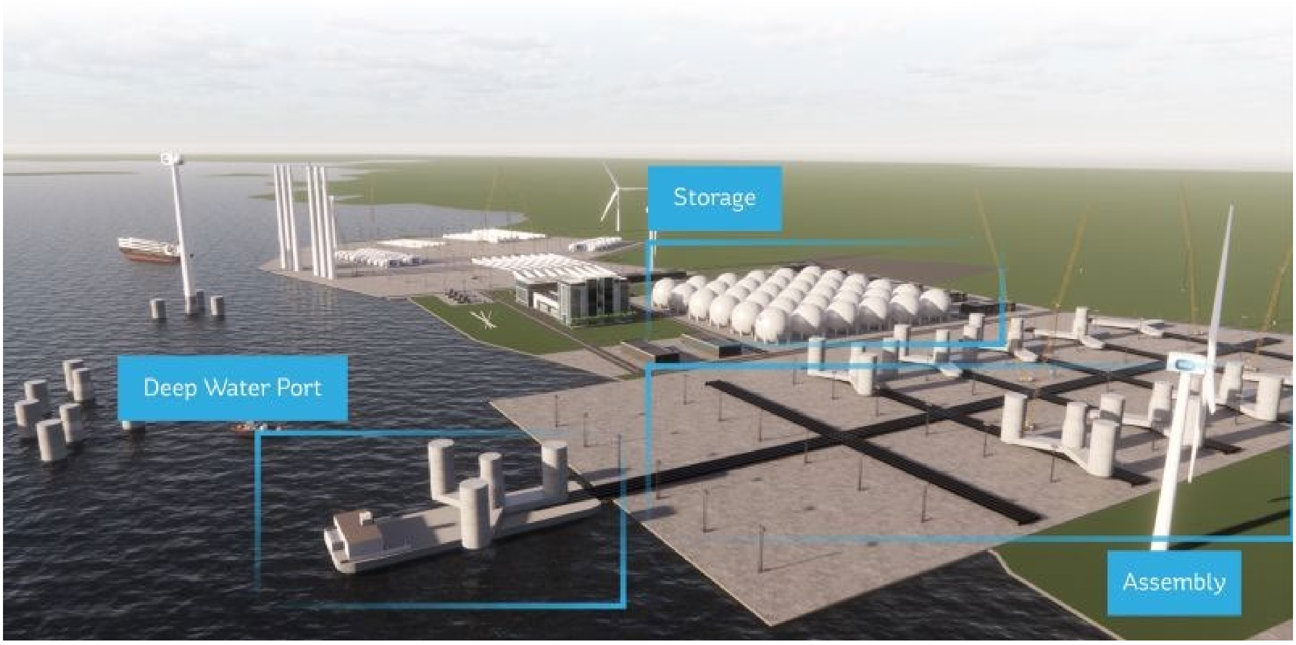


Figure 74: ESB's Green Atlantic at Moneypoint project concept [121]

Central to ESB's Green Atlantic project is a new floating offshore wind farm of 1,400-MW capacity off the coast of Counties Clare and Kerry, to be delivered in two phases (Figure 74). In addition, ESB intends for its Moneypoint site to become a centre for the construction and assembly of floating wind turbines, leveraging its deepwater access and significant land area that would be made available upon decommissioning of the coal-fired power station.

As outlined in Chapter 5.3, the substructure assembly facility at Moneypoint would serve as one of the Estuary's core delivery bases for floating offshore wind and would complement the turbine integration port currently planned for Foynes Island. Though subject to confirmation during the initial planning and design stages, ESB is targeting its substructure facility to be capable of delivering 1,000 MW annually, which aligns well with the throughput envisaged for the Foynes Island development. The targeted completion by 2028 also coincides with the Foynes Island plans, setting the Estuary up well for being able to deliver 10 GW by 2050 as per the low scenario defined in Chapter 4.3.

ESB's plans at Moneypoint also include investment in a green hydrogen production and storage facility. As noted in Chapter 12, the Moneypoint SDL is well-suited for e-fuels production, given the high-voltage substation within its boundaries as well as its deep water alongside to accommodate seaborne exports.

23. Tarbert-Ballylongford Landbank

The Tarbert Ballylongford landbank is zoned for industry within the Kerry County Development Plan 2015-2021 (Figure 75). In the updated draft Kerry County Development Plan 2022-2028, the area has expanded to connect the zoned landbank with the existing industrial facilities at Tarbert. [122]

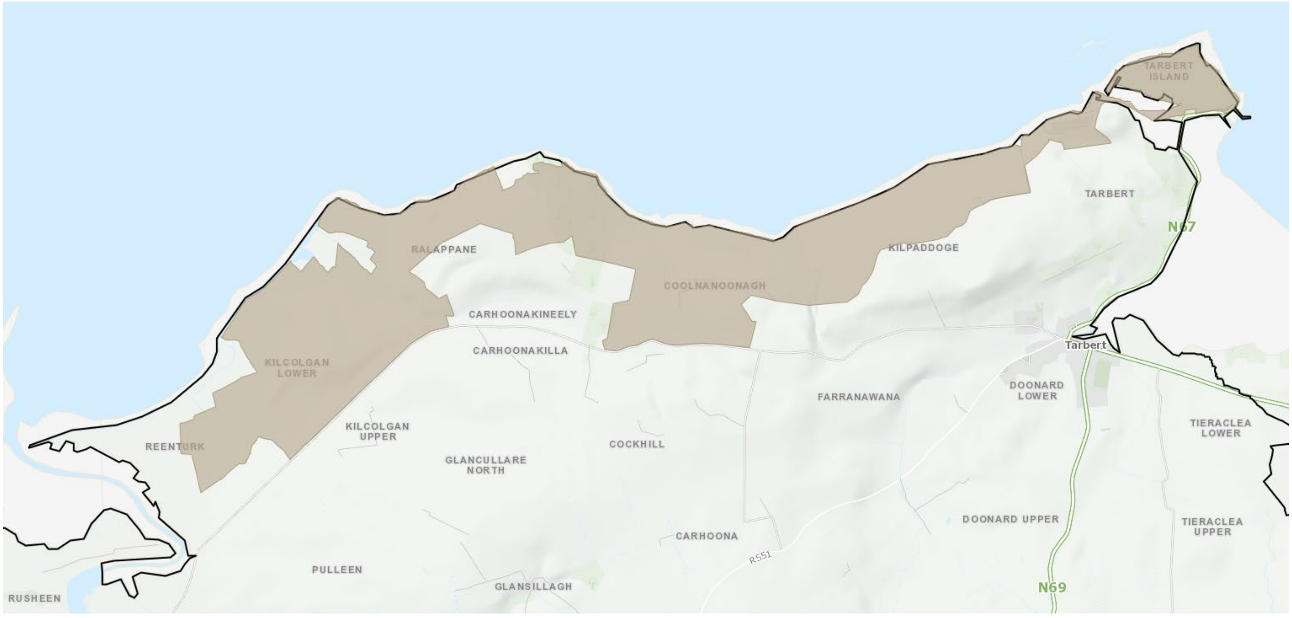


Figure 75: Tarbert-Ballylongford Landbank, Kerry County Development Plan 2022-2028 [123]

23.1 Scope of Operations

SSE currently operate a 620-MW thermal power plant at Tarbert. The station comprises two 60-MW and two 250-MW oil-fired turbines. This plant is currently operated using HFO and as such the station will be likely to close in the near future in line with EU emissions regulations. [124] The plant has significant oil storage infrastructure, cooling water supply and return infrastructure, and grid connection facilities. The power station has its own 91-m (300-ft) jetty and oil storage tanks, which have a capacity of 250,000 tonnes.

The NORA has storage facilities at Tarbert. NORA holds responsibility for the maintenance of strategic supplies of oil in line with the Irish state's stockholding obligations to the EU and International Energy Agency (IEA). There are currently four large storage tanks in Tarbert. Each tank measures 61 m in diameter and is 14.5 m high. The facility is an Upper Tier Seveso site.

The 26-MW Statkraft Kelwin-2 battery project is also located on the landbank. The construction of this battery was completed in April 2021, and its main purpose is to respond instantly to the electrical fluctuations that result from intermittent power generation. [125]

The ESBN/ EirGrid Kilpadogue 220-kV substation is also located on the landbank 3 km west of Tarbert. This is a significant piece of electrical grid infrastructure that benefits the landbank and is connected to the 400-kV substation at Moneypoint.

23.2 Development Plans

The main development plans for the landbank are those of the STEP project (Figure 76), which is being planned by Shannon LNG Limited at the Ballylongford end of the landbank. The proposed development would occupy approximately 100 acres on the eastern side of the 242.8-ha (600-acre) landbank.

The proposed development comprises a highly flexible Power Plant and an LNG Terminal. The power plant would back up intermittent renewable generation. The plant would comprise up to three highly flexible CCGT generation blocks, with a total capacity of up to 600 MW, and an integrated Battery Storage Facility with a 120-MW 1-hour Ultra-Fast Response capability. The terminal would import, store, and re-gasify LNG. LNG is natural gas that has been cooled to approximately –160°C, reducing its volume 600-fold to facilitate shipping. A Floating Storage and Regasification Unit-Ship (FSRU) will be moored at the jetty to receive and store the LNG. The FSRU would re-gasify the LNG and the terminal would pipe the gas to the adjacent power plant and to the GNI national gas grid.

Figure 76: STEP Representation of proposed development [126]

23.3 Considerations

As stated in the STEP planning documents, the site is uniquely suitable for major industrial development with a marine dimension:

- 600-acre strategic development Landbank assembled by Industrial Development Agency (IDA) Ireland
- 450 acres of land zoned for industrial development with a marine dimension
- Marine navigational access to a wide, sheltered, deepwater zone
- Estuary 2 km wide at deepwater zone
- Waves typically less than 1.5 metres at deepwater zone
- Water depth of 14 metres close to shore at deepwater zone
- Proximity to Foynes Port, a designated EU Core Network Port in the TEN-T Network
- Close to electricity and gas grids

For the same reasons as the STEP development, the location is also very well suited to the development of giga-watt scale green hydrogen production facility. Such a facility will benefit from the colocation with the STEP project and the proximity to Kilpadogue and NORA. The facility could encompass the following plants.

- Green hydrogen production & storage & blending into the gas grid
- Green ammonia production & storage & marine export
- E-Methanol production & storage & marine export
- SAF (Synthetic kerosene from e-methanol) production & storage & export

The concept above considers the initial development of 2 GW of hydrogen electrolysers that will be powered by offshore renewable energy which comes ashore via a HVDC cable near Kilpadogue. There is space to expand the electrolyser plant to provide 4 GW of green hydrogen production using current technologies. The green hydrogen can be used to fuel the power plants and industry in the local region. Considering the proximity to the national gas grid, hydrogen can also be blended into the natural gas network at this location. Green hydrogen produced here can also be trucked to Shannon Foynes Port or further to Limerick and beyond to be used in re-fuelling stations for Fuel Cell Electrical Vehicles.

Green hydrogen provides the additional potential to produce sustainable shipping or aviation fuels in the location which would utilise CO_2 captured from industry or directly from the air in the Estuary to make e-methanol. This can be used for bunkering of fuels by Shannon Foynes Port and for jet fuel at Shannon Airport.

There is also the potential for the production of green ammonia which could be used for the production of fertiliser for Ireland further helping to decarbonise the agriculture sector. Green ammonia could also be used for export to Europe to help with the overall European hydrogen deficit.

Figure 77 is a concept of what could be achieved in this location.

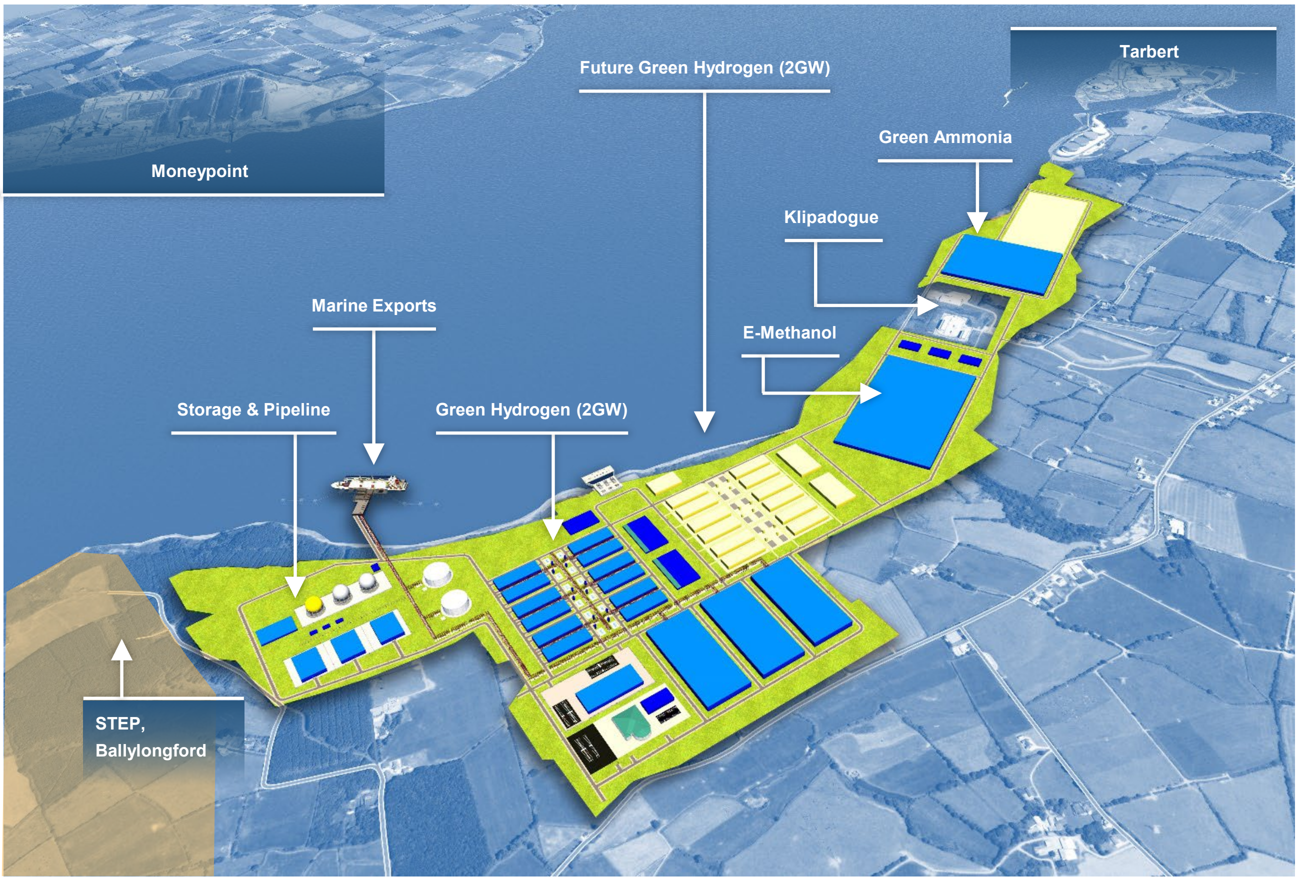


Figure 77: Conceptual green hydrogen, green ammonia, e-methanol and sustainable fuel production on the Shannon Estuary

This potential development, in an area specifically zoned for industry, could help Ireland's energy security by greatly reducing our dependence on energy imports from overseas.

24. Aughinish

Aughinish since 1983 has operated a large alumina refinery based in West Limerick employing almost 600 people. The alumina plant is one of the most energy efficient in the world and produces 30% of EU alumina requirements. The Aughinish Alumina plant is currently producing 1.9 million tonnes of alumina per year. It is the largest bauxite refinery in Europe and also one of the most efficient globally.

The plant has its own dedicated deepwater jetty which is used to import bauxite (raw product) and export alumina from the Shannon Estuary.

24.1 Scope of Operations

In recent years Aughinish has switched its energy usage from a HFO base to natural gas in order to comply with EU legislation and environmental targets. The Aughinish high efficiency cogeneration plant (CHP) is a significant user of gas nationally. Since commercial operation in 2006, the CHP plant has played a major role in Ireland reaching its energy efficiency targets and reducing emissions, accounting for an average saving of approx. 330,000 tonnes of CO_2 per annum.

Aughinish is one of the least carbon intensive alumina plants in the world producing alumina with an intensity of 0.52 tCO_2 per ton product compared to the world average of 1.3 tCO_2 per ton product.[127]

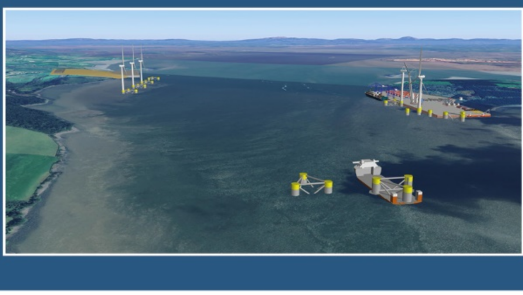
24.2 Development Plans

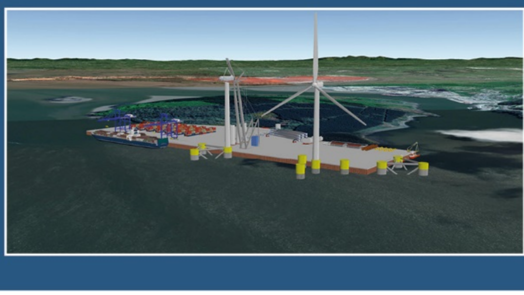
During the development of this strategic review, the team consulted with Aughinish Alumina. Decarbonisation including energy efficiency improvements has and continues to be a key strategic goal of Aughinish.

The company is currently working on increased electrification of boilers that will boost efficiency improvements and also help to further decarbonise the plant.

Future plans include additional utilisation of renewable power and expanded electrification of processes.

Environmental Considerations





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25. Overview

As a statutory port authority and a significant landowner SFPC has environmental duties laid out in statute. International EU and national policy also require port authorities to strike an appropriate balance between the long-term protection of the environment and the securing of sustainable economic growth. The evolving opportunities which have been identified for Shannon Foynes Port are heavily influenced by the need for carbon emissions reduction and preparation for climate change. In positioning the Shannon Estuary for the future, SFPC will support compliance with a number of recently enacted environmental policies and legislative requirement but must also mitigate against and manage the environmental impacts which these opportunities may generate.

In the development of the Vision 2041 SEA and natura impact AA were undertaken to identify the potential environmental consequences of the Vision strategy. Such studies were also undertaken to incorporate specific strategic environmental objectives into the Vision strategy and consequently, to influence any future site-specific projects undertaken. Through separate processes, the preparation of the 2041 Vision statement was also cognisant of the findings of the environmental and ecological assessments (SEA and AA) carried out for the purpose of the SIFP, its objectives for the Shannon Estuary and its wider environment.

As noted in Vision 2041, the development of new port-related projects which have the potential to cause significant environmental impacts would require a planning application and an accompanying environmental impact assessment and where relevant an AA. This remains the case, and will play an important part of assessing the feasibility of opportunities presented in this review.

Much of what is highlighted in this review was broadly addressed in the SEA and AA undertaken alongside the Vision 2041 Strategy. Should a full revision of Vision 2041 Strategy be undertaken, it will be developed in tandem with an update to the SEA and AA, to inform and guide the objectives set out and the decisions taken.

This environmental review highlights changes in how environmental issues must be managed as well as how the environment may be affected by the new activities proposed. The opportunities which have been identified for SFPC may result in additional or more significant environmental consequences over and above those identified and assessed when Vision 2041 was developed. In addition, there have been changes in environmental policy and regulation since that time as well as heightened urgency and awareness relating to climate change. This review will take account of:

- Introduction of new environmental legislation and policy on many key topics including planning permission and consents, environmental impact assessment, energy and carbon, water and marine environment, air quality, circular economy, biodiversity and habitat
- Environmental impacts and constraints of potential developments including wider range of impacts, increase in likelihood and or severity intensity of already identified environmental impacts
- Greater knowledge and understanding of risks related to climate change and carbon and elevation in importance, scale and urgency relating to environmental issues such as carbon emissions, climate change, curlew protection, and cumulative effects

25.1 SEA Environmental Objectives

Targets and Indicators were developed for the SEA of Vision 2041 based on the aims and objectives of Vision 2041 and the significant environmental issues in the area. The Objectives and Targets are intended to give a high level of protection for the environment in implementing the Plan. The objectives developed were as follows:

1. Prevent damage to terrestrial, aquatic and soil biodiversity, particularly EU and Nationally designated habitats, sites and species. Improve local biodiversity if possible.
2. Provide an economic boost for the region and contribute to environmentally sustainable development.
3. Prevent nuisance dust, noise and odours emanating from port activities.
4. Avoid damage to the function and quality of the soil resource in the study area.
5. Development and operation of SFPC facilities not to cause deterioration in water status of any waterbodies.
6. Minimise emissions to air as a result of development and operation of SFPC facilities.
7. Minimise contribution to climate change by emission of greenhouse gasses associated with development and operation of SFPC facilities.
8. Develop SFPC facilities and provide vehicle for development of new sustainable infrastructure for the region.
9. Avoid damage to cultural heritage features during development and operation of SFPC facilities.
10. Avoid damage to local landscape and vistas.

25.2 Update on Key Issues Identified in Vision 2041

Since Vision 2041, SFPC has put in place an Environmental Management System (EMS) which provides a framework for identifying and managing environmental commitments and compliance and to proactively support and work towards sustainability in the Port.

- SFPC signed up to ECOPORTS in 2014 and gained accreditation to the ECOPORTS PERS standard, a specific port-related environmental management standard under the auspices of the European Sea Ports Organisation, in 2014.
- SFPC in tandem developed and implemented an ISO 14001 based EMS which achieved certification in 2014.

Updates on the other commitments and key issues as identified in Vision 2041 are provided in Table 14.

Table 14: Update on key issues identified in Vision 2041

Vision 2041 Key Issues	Status
Ensure a balanced approach between the conservation of the natural environment, biodiversity and the objectives in Vision 2041 in future development projects, in conjunction with relevant statutory bodies.	Ongoing, this will be taken forward as projects develop
Develop an EMS for both Limerick Docks and the Port of Foynes and to proactively support and work towards sustainability in the Port areas in accordance with the ESPO Green Guide (2012).	Completed, this has been in place since 2014
Review and implement the necessary objectives and mitigation measures identified in both the SEA Environmental Report and the NIR in the context of future development proposals within Vision 2041.	Ongoing, has been and will be incorporated into projects
Safeguard the integrity of all designated Natura 2000 sites, including consideration of potential cumulative effects on such sites in accordance with relevant Directives and associated legislation, regulations, and guidance.	Ongoing, has been and will be incorporated into projects and plans
Examine suitability and feasibility of providing for cold ironing in any future potential infrastructure projects.	Consideration will be given in line with national/EU legislative requirements
Continue to work with relevant stakeholders and statutory bodies to ensure that continued least impact is achieved in relation to ongoing dredging and explore potential for cooperation across relevant sectors in preparing a Strategic Dredging Management Plan for the Shannon Estuary.	Maintenance Dredging Foreshore License updated licence granted 2020, with SEA and AA undertaken
Meet its obligations under the Planning & Development Act, 2000 in relation to Architectural Heritage in terms of securing the preservation of all Protected Structures within the Port.	Ongoing, has been and will be incorporated into projects and plans
Minimise and mitigate the impacts arising from Port operations upon nearby residential occupiers within the parameters of operating the business, where practical.	Ongoing, has been and will be incorporated into projects and plans
Continue to work closely with the statutory bodies and local authorities to protect water quality on the Shannon Estuary and to ensure that any future development does not conflict with the requirements and objectives of the Water Framework Directive.	Ongoing, has been and will be incorporated into projects and plans

25.3 Legislation and Policy

There are many relevant policy and regulations which have been introduced or updated in recent years which address wider environmental issues. The most notable are:

- **EU Green Deal (2019), European Climate Law and Fit for 55:** European Green Deal commits Europe to cut greenhouse gas (GHG) emissions 55% by 2030 and become a climate-neutral continent by 2050, setting out a wide range of major policy and legislative proposals including funding plans. The strategy for implementing the Green Deal is laid out in the Fit for 55 package. The Green Deal includes:
  - EU Biodiversity Strategy (2020)
  - EU Action Plan: "Towards a Zero Pollution for Air, Water and Soil (2021)
  - Sustainable and Smart Mobility Strategy (2020)
  - Circular Economy Action Plan
  - EU strategy on adaptation to climate change (2021)

- Chemicals strategy for sustainability (2020)
- EU strategy on offshore renewable energy (2021)
- EU Hydrogen strategy for a climate-neutral Europe (2020)
- Industrial Strategy
- Updates to EU ETS Directive, Energy Efficiency Directive, Renewable Energy Directive and Energy Taxation Directive, non-financial reporting directive

- **Maritime Area Planning (MAP) Act 2021 – National Marine Planning Framework:** The Act focuses on marine spatial planning and allows for the designation of a part of the maritime area for the establishment of a zone to facilitate activities which are of economic, social or environmental importance (e.g., offshore renewable energy). It provides for a new Maritime Area Consent regime to enable development consent, or planning permission, with one environmental assessment. The Act applies to foreshore licences and leases, as well as planning permissions for marine projects, including floating and fixed offshore wind. A new agency, the Maritime Area Regulatory Authority (MARA), will be established and operational from 2023 and will be responsible for:
  - Granting all Maritime Area Consents (MACs) for the maritime area,
  - Marine licencing for specified activities,
  - Compliance and enforcement of MACs, licences and offshore development consents, and
  - Administration of the existing Foreshore consent.

- **Climate Action and Low Carbon Development Act Amendment**: **Climate Action Plan 2021:** commits Ireland to being carbon neutral by 2050, with the aim to transition to a climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy

- **European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 (S.I. No. 296 of 2018):** transpose the requirements of the 2014 EIA Directive into existing planning consent procedures
  - Refinement of environmental factors: aspects to be considered include resource efficiency, climate change, disaster prevention, population and human health, biodiversity and disaster risk prevention and management
  - Enhancement of cumulative impacts assessment
  - Strengthening of screening procedures

- **Update plans for Marine Framework Directive and Water Framework Directives:**
  - Marine Strategy Framework Directive (MSFD) and National Marine Planning Framework (NMPF8) NMPF8 for Ireland was published in 2021 (DHLGH, 2021) - this plan sets out the intended approach for to use, protection and enjoyment of seas over the next 20 years. A revised version of the programme of measures under the MSFD to bring Ireland's marine ecosystems to Good Environmental Status is due in 2022
  - The 3rd Cycle plan of the Water Framework Directive covers the period 2022-2027 and is a programme of measures to protect and restore bodies of water to at least 'good status' by 2027. Progress to date has been slow, so new targeted and effective measures are necessary in the River Basin Management Plan.

26. Floating Offshore Wind Delivery Chain

Offshore wind projects will be delivered in the context of the National Marine Planning Framework, underpinned by the new development management system to be contained in the MAP Bill.

The promotion of specific offshore wind projects and associated estuary-based delivery chain activities would require a planning application and accompanying applicable impact assessments. Impacts will be differentiated by project activity and – depending on the route for development of the supply chain – may be staged.

26.1 Potential Environmental Impacts

A high-level assessment of environmental impacts across the delivery stages of floating offshore wind is shown in Table 15. Many of the impacts related to activities that will take place in the Estuary, are broadly addressed in the SEA and AA from the Vision 2041 Strategy and as such the mitigations therein are applicable. More specific mitigations would be identified through project-specific EIA and AA as the projects develop.

Table 15: Indicative environmental impacts of potential Floating Offshore Wind delivery chain developments

Activity	Potential Impacts	Coverage in SEA/AA
Develop Port Facilities For Manufacture And Assembly, Integration	Terrestrial Impacts (increased activity) ▪ Resource use: water, energy, materials (waste) ▪ Emissions & Traffic - noise, dust, vibration, light, contamination. Impacts on: water, air, land quality, land quality, habitat, flora & fauna Marine Impacts ▪ Emissions - underwater noise and vibration, sediment, light, contamination. Impacts on: water, air, quality, land quality, habitat, flora & fauna ▪ Interaction with and risk to marine fauna of entanglement, collision ▪ Vessel/Equipment Movements: shipping & navigation Visual impact – landscape and seascape	SEA and AA mitigations address increased activity, increased traffic, dredging, construction activities, port equipment, displacement, & disturbance of & interaction with of flora and fauna, loss of habitat, noise and dust, underwater noise, environmental incidents
Wet Storage of FOWT	▪ Visual Impact ▪ Interaction with and risk to marine faunas of entanglement, collision ▪ Emissions – as above	SEA and AA cover displacement, & disturbance of & interaction with of flora and fauna, loss of habitat, water quality (environmental incidents), sediment and turbidity
Wet Towing	Increased vessel movements: marine impacts, as above: ▪ Emissions ▪ Interaction with marine fauna ▪ Shipping & Navigation	SEA and AA cover increased vessel numbers, displacement, & disturbance of & interaction with of flora and fauna, collision risk water quality (environmental incidents)
Installation at Wind farm	Mooring lines, piles, submarine cables, trenching: ▪ Disturbance/destruction of seabed habitat and flora & fauna, water quality impacts. Sediment movement	Offshore impacts outside of Estuary not covered in SEA/AA
O&M Base	Increased vessel movements: marine impacts, as above: ▪ Emissions ▪ Interaction with marine fauna ▪ Shipping & Navigation	SEA and AA cover increased vessel numbers, displacement, & disturbance of & interaction with of flora and fauna, collision risk water quality (environmental incidents)

26.2 Potential Environmental Challenges

There are a number of potential environmental issues which may require early engagement to mitigate and minimise to reduce impacts on project development. These are summarised in Table 16.

Table 16: Potential Environmental Challenges related to Floating Offshore Wind

Environmental Impact	Overview	Approach
Visual Impact	**Wet Storage will have a visual impact** ▪ **Overall turbine height** (including blades) may exceed 200m ▪ **Potential wet storage locations:** further assessment would be undertaken as part of project specific development, with full visual impact (landscape and seascape) being assessed and considered at that point.	**The relevant mitigation from the SEA:** ▪ Ensure new SFPC facilities are designed to blend with the local environment and landscape context. **Some additional high-level mitigations** may include: ▪ Seek to locate wet storage in areas where development is compatible with key visual characteristics of the baseline view.

Environmental Impact	Overview	Approach
	▪ Visual impact may give rise to local objection, some local areas of high visual amenity	▪ Seek to locate wet storage where it can use topographic screening effect. ▪ Paint turbines for merging into the background.
Shipping and Navigation	**There may be significant shipping and** navigation risks associate with both storage, wet tow and O&M	**Extensive liaison with stakeholders and development of plan will be required to inform** ▪ Full risk assessment required as part of EIA ▪ Implementation of industry best practice regards to the management and mitigation of shipping and navigation activities.

26.3 Recommendations

- Perform assessment of impacts on habitat and species of Foynes Deepwater Port Development to inform EIA, AA and project development for FOWT delivery activities.
- Engage with industry and representative bodies for fishing, shipping and navigation to proactively identify challenges and begin to identify how they will be managed.
- Engage with potential affected parties for visual impact to understand challenges and begin to identify how they will be managed.

27. Estuary Transmission Infrastructure

The Shannon Estuary is well-positioned to serve as a major receiving node for offshore wind electricity generated off the west coast. The specific environmental impacts of transmission infrastructure would be assessed and incorporated during project development.

27.1 Potential Environmental Impacts

A high-level assessment of environmental impacts of the element of transmission infrastructure is shown in Table 17. Although substations and cabling are not specifically covered in the SEA and AA which informed the Vision 2041 Strategy, some of the impacts related to the activities that will take place in the Shannon Estuary are broadly addressed in the SEA and AA, and as such the mitigations therein are applicable. More specific mitigations would be identified through project-specific EIA and AA as projects develop. Impacts outside of the Estuary are noted for information.

Table 17: Indicative environmental impacts of Estuary Transmission Infrastructure

Activity	Potential Impacts	Coverage in SEA/AA
Onshore Substation Expansions/Upgrades	Construction: ▪ Landuse (excavation, piling, construction) - loss/disturbance of: habitat; flora & fauna; water regime; heritage assets; landscape (visual) ▪ Resource use: water, energy, materials (waste) ▪ Emissions & Traffic - noise, dust, vibration, light, contamination. Impacts on: water, air, land/soil quality, habitat, flora & fauna Operation ▪ Resource use: water, energy, materials (waste) ▪ Emissions & Traffic - noise, dust, vibration, light, contamination. Impacts on: water, air, land quality, land quality, habitat, flora & fauna	▪ Broadly covered in SEA/AA - multiple impacts related to new onshore of new substation, preference for previously developed sites, locally sympathetic design, to avoid habitat loss and visual impact, effective use of existing assets

Activity	Potential Impacts	Coverage in SEA/AA
Cable Landfall	▪ Land and water (landtake, excavation, dredging, piling,construction): loss/disturbance of: habitat; flora & fauna (tidal/terrestrial); water regime; heritage assets; visual ▪ Emissions - noise, dust, vibration, light, contamination. Impacts on: water, air, land/soil quality, habitat, flora & fauna ▪ Resource use: water, energy, materials (waste) Operation ▪ Resource use: water, energy, materials (waste) ▪ Emissions & Traffic - noise, dust, vibration, light, contamination. Impacts on: water, air, land quality, habitat, flora & fauna	▪ Cable not covered specifically, installation of cables will have to be assessed as part of project EIA, AA ▪ Dredging covered in SEA and AA and habitat and flora and fauna disturbance covered– multiple mitigations to be incorporated Some additional high-level mitigations may include ▪ Location of landfall ▪ Minimising working and stockpile areas
Cable Corridor – Estuary	Installation (trenching, cable lay etc) ▪ Emissions - underwater noise and vibration, sediment, contamination. Impacts on: water quality, habitat, flora & fauna, heritage assets ▪ Interaction with and risk to marine fauna of entanglement, collision ▪ Vessel/Equipment Movements: shipping & navigation Operation: ▪ EMF and heat generated by active power cables impacts on marine animals	▪ Cable not covered specifically, installation of cables will have to be assessed as part of project EIA, AA ▪ Trenching covered in SEA and AA and habitat and flora and fauna disturbance, heritage asset disturbance covered– multiple mitigations to be incorporated for location, construction and operation
Inter-array And Export Cable	Project Developer Responsible	Offshore impacts outside of Estuary - not covered in SEA/AA
Offshore Substation	Project Developer Responsible	Offshore impacts outside of Estuary - not covered in SEA/AA

27.2 Potential Environmental Challenges

Some potential key issues which will be required to be addressed through project specific EIA and AA include:

- With regard to cable routing through the Estuary, benthic, biodiversity, geophysical and geotechnical surveys will inform the best route for cable taking into account avoidance of obstructions and protection of habitat and sensitive benthic fauna and heritage assets
- Location of cable landfall to address habit protection and impact on species and heritage assets
- Cable and landfall installation methods to address habitat protection and impact on species. This need to be managed by selection of appropriate construction, trenching and reinstatement methodology
- Construction and operation environmental management and mitigations and monitoring will be required to reduce risk of accidental releases, and damage to habitat and wildlife, particularly marine based

27.3 Recommendations

Some upfront actions to mitigate risks to developing and progressing Estuary transmission projects could include:

- Identify and progress surveys to inform cable channel and landfall route, including consents required for survey

28. Green Industrial Development and Transition

The Shannon Estuary's proximity to renewable power in offshore wind provides the potential for a transformational role in Ireland's energy transition. A key element of this is using wind power used to produce green hydrogen and green hydrogen derivatives (some of which are produced using recycled or "captured" carbon) that can be used to replace their fossil fuel-based counterparts.

28.1 Potential Environmental Impacts

A high-level assessment of environmental impacts of industrial development and transition is shown in Table 18. There is limited reference to these types of impacts in the SEA and AA from the Vision 2041 Strategy, however some the mitigations therein are applicable. More specific mitigations would be identified through project-specific EIA and AA as projects develop.

Table 18: Indicative Environmental Impacts related to Green Industrial Development Proposals

Activity	Potential Impacts	Coverage in SEA/AA
Green Hydrogen	▪ Resource Use: water consumption, and energy for electrolysis (high water demand) ▪ Emissions - noise, dust, vibration, light, by products, contamination. Impacts on: water, air, land/soil quality, habitat, flora & fauna ▪ Risk of accidental releases, fire, explosion ▪ Hazardous waste/effluent	▪ Not addressed specifically, dangerous substances which can be toxic to plants and animals referenced
Desalination (to support green hydrogen electrolysis)	▪ Resource Use: water consumption, and energy intensive ▪ Marine life in water can be impacted by intake and treatment process ▪ Emissions - noise, dust, vibration, light, contamination. Impacts on: water, air, land/soil quality, habitat, flora & fauna. Risk of accidental releases ▪ Brine discharge can be hazardous to the marine environment due to high levels of salinity, total alkalinity and alteration to temperature	▪ Not addressed specifically, dangerous substances which can be toxic to plants and animals referenced
Green Ammonia	▪ Emissions - noise, dust, vibration, light, contamination. Impacts on: water, air, land/soil quality, habitat, flora & fauna. Risk of accidental releases ▪ Hazardous waste/effluent ▪ Physical hazards – flammable gas which may cause flash fires ▪ Hazardous to the aquatic environment, contamination of waterbodies and groundwater, very toxic to aquatic life if discharged or leaked into water, long lasting effects	▪ Not addressed specifically, dangerous substances which can be toxic to plants and animals referenced
E-methanol	▪ Emissions - noise, dust, vibration, light, contamination. Impacts on: water, air, land/soil quality, habitat, flora & fauna. Risk of accidental releases ▪ Hazardous waste/effluent	▪ Not addressed specifically, dangerous substances which can be toxic to plants and animals referenced

Activity	Potential Impacts	Coverage in SEA/AA
	▪ Leaked methane contribute towards the greenhouse effect ▪ Many hydrocarbons are toxic, mutagenic and carcinogenic bio-accumulative	
CCUS	▪ Resource Use: water consumption, and energy intensive ▪ Emissions - noise, dust, vibration, light, contamination. Impacts on: water, air, land/soil quality, habitat, flora & fauna. Risk of accidental releases ▪ CO_2 release: harm to soil, water, people, flora, fauna contaminate ground water ▪ CO_2 release: climate change	▪ Not addressed specifically, dangerous substances which can be toxic to plants and animals referenced
Data Centres	Construction: ▪ Land use (excavation, piling, construction) - loss/disturbance of: habitat; flora & fauna; water regime; heritage assets; landscape (visual) ▪ Resource use: water, energy, materials (waste) ▪ Emissions & Traffic - noise, dust, vibration, light, contamination. Impacts on: water, air, land/soil quality, habitat, flora & fauna Operation ▪ Resource use: high energy use, water, materials (waste) ▪ Emissions & Traffic - noise, dust, vibration, light, contamination. Impacts on: water, air, land quality, land quality, habitat, flora & fauna ▪ Waste – including electrical	▪ Broadly covered in SEA/AA - multiple impacts related to new onshore activities, preference for previously developed sites, locally sympathetic design, to avoid habitat loss and visual impact, effective use of existing assets ▪ SEA and AA mitigations address increased activity, increased traffic, construction activities, port equipment, displacement, & disturbance of & interaction with of flora and fauna, loss of habitat, noise and dust, environmental incidents

28.2 Potential Environmental Challenges

There are a number of potential environmental issues which may require early engagement to mitigate and minimise to reduce impacts on project development. These include:

- There are currently no green hydrogen or green ammonia production plants (or other e-fuels) in Ireland so the planning and consent path may be challenging with lack of precedent.
- Development of ammonia production, storage and transport related projects will be limited to certain locations. Location of ammonia production and or storage site locations would need to be carefully considered in the context of environmental, aquatic and habitat protection.
- During construction and operation, detailed environmental management and mitigations and monitoring will be required to reduce risk of accidental releases, and damage to habitat and wildlife.

28.3 Recommendations

Some upfront actions to mitigate risks to developing and progressing opportunities and projects to meet 2030 renewables and other wider targets for transition could be taken by SFPC. These include:

- In developing project plans, careful consideration informed by detailed investigations will required to inform site selection, layout and infrastructure
- Given that green hydrogen is a relatively new concept, it is recommended that progress and impact assessment and mitigation at hydrogen plants under development in Europe and the UK, should be tracked so best practices can be identified. (e.g., Holland Hydrogen I in Port of Rotterdam)
- Engagement and research regarding best available technology (BAT) for management of green ammonia and other green hydrogen derivatives ahead of challenges and objections

29. Shannon Estuary Logistics

Positioning the Estuary for a green industrial future may result in significant traffic increases which need to be carefully planned and managed with environmental impacts considered holistically..

29.1 Potential Environmental Impacts

A high-level assessment of environmental impacts of increased the logistic capacity are shown in Table 19. Many of the impacts related to activities that will take place in the Shannon Estuary are broadly addressed in the SEA and AA from the Vision 2041 Strategy and as such the mitigations therein are applicable. More specific mitigations would be identified through project-specific EIA and AA as projects develop.

Table 19: Indicative environmental impacts of Logistics proposals

Activity	Potential Impacts	Coverage in SEA/AA
Port Expansion	Expansion/ Shipping and channel construction ▪ Land and water (land take, excavation, dredging, piling, construction): loss/disturbance of: habitat; flora & fauna (tidal/terrestrial); erosion; water regime; heritage assets; visual ▪ Emissions - noise, dust, vibration, light, contamination. Impacts on: water, air, land/soil quality, habitat, flora & fauna ▪ Resource use: water, energy, materials (waste) ▪ Visual impact – landscape and seascape	▪ SEA and AA mitigations address increased activity, increased traffic, dredging, construction activities, port equipment, displacement, & disturbance of & interaction with of flora and fauna, loss of habitat, noise and dust, underwater noise, environmental incidents SEA addresses existing environmental pressures ▪ The environmental impacts of much of the Port of Foynes expansion proposals are already covered in the EIA for the Capacity Extension at Shannon Foynes which was approved in 2018 ▪ 10-year permission to facilitate 'port capacity extension' at the Port of Foynes.
Ground transport	Traffic increases: ▪ Emissions - noise, dust, vibration, light, contamination. Impacts on: water, air quality (climate change), land/soil quality, habitat, flora & fauna; human health ▪ Disruption and congestion on roads, safety	▪ SEA addresses existing environmental pressures at high level ▪ SEA and AA mitigations address increased activity, increased traffic, displacement, & disturbance of & interaction with of flora and fauna, loss of habitat, noise and dust, environmental incidents
Estuary Activity	Marine Impacts ▪ Emissions - underwater noise and vibration, sediment, light, contamination. Impacts on: water, air, quality, land quality, habitat, flora & fauna ▪ Interaction with and risk to marine fauna of entanglement, collision ▪ Vessel/Equipment Movements: shipping & navigation	▪ SEA addresses increased vessel numbers ▪ SEA and AA mitigations address increased activity, increased traffic, displacement, & disturbance of & interaction with of flora and fauna, loss of habitat, noise and dust, environmental incidents

29.2 Potential Environmental Challenges

There are a number of potential environmental issues which may require early engagement to mitigate and minimise to reduce impacts on project development. These include:

- Ground transport: In the shorter term, in advance of technological advances and fuel adaptations and rail connection, the transport sector will continue to be is a significant source of emissions to air generally, including carbon emissions and specifically NOx, NMVOC and PM2.5. It will be important to look at the issues of in a strategic and holistic way, as impacts will be cumulative as well as project based.
- General increase in port activities will lead to multiple cumulative effects and environmental pressures on water quality, water supply, noise, traffic, generation of waste, risk of accidental releases leading to contamination, increased risk to human health and habitats and species.

29.3 Recommendations

Some upfront actions to mitigate risks to developing and progressing opportunities and projects to meet 2030 renewables and other wider targets for transition could be taken by SFPC. These include:

- Work with Shannon Foynes Economic Taskforce and SIFP group to develop integrated strategies to manage cross cutting environmental issues which may include climate change, flood risk, noise, air quality etc.

30. Review of Cumulative Environmental Impacts

The key drivers for this review are the carbon emissions, climate change and energy transition goals to which Ireland has committed. If development at the Shannon Estuary is to play a significant role in supporting and enabling this transition, it is likely that there will be a significant ramp up in activity in a relatively short time to accommodate a rapid increase in capacity, involving multiple projects and a wide range and number of stakeholders. There are some significant potential challenges which could result from this are described summary in the key issues section here:

30.1 Potential Environmental Challenges

- Skills gaps and resource shortages in the related areas of environment, planning and consents.
- Multiple projects seeking approval and consent at the same time puts pressure on consenting bodies especially where emerging technologies project types are required with relatively unknown impacts.
- Multiple construction projects which will have cumulative impacts which must be considered in undertaking EIA and AA. This may lead to objections and delays or failure in planning permissions.
- When multiple construction projects get underway, cumulative impacts may give rise to complaints, and delays to projects. These may include noise, traffic, dust, air quality, waste generation, water supply.
- Skills and labour shortages leading to influx of workforce and demand on local and community resources (e.g., housing, healthcare, schools, water, electricity, waste, traffic, community amenities, etc.).

30.2 Recommendations

Some upfront actions to mitigate risks to developing and progressing opportunities and projects to ramp up activity to meet transition commitments could be taken by SFPC. These include:

- Early, proactive, and ongoing stakeholder engagement on cumulative impact identification and management including:
  - Planning Authorities (Local County Councils and An Bord Pleanála where necessary)
  - Community Engagement
  - Business and Industry Stakeholders
  - Education/Skills/Training Bodies & Agencies
- Development of collaborative, strategic management plans or standards with the Shannon Estuary Economic Taskforce and local councils including noise, air quality, code of construction practice, etc.

31. Environmental Key Takeaways

Key takeaways…

- Significant progress has been made on implementing a number of key environmental considerations identified in the 2041 Masterplan. SFPC has formalised their approach to environmental management through EMS and EcoPorts.
- Floating Offshore Wind and alternative green fuels provide opportunity for the Shannon Estuary to significantly contribute to Ireland's Climate Action Plan and the EU's Green Deal.
- If it is decided to undertake a formal update to Vision 2041 Strategy, then an SEA and an AA which consider the new development opportunities and take account of new and updated legislation and requirements, should be carried out.
- The potential impacts of climate change are better understood and need to be more fully addressed in undertaking updated SEA and AA, including flooding, extreme temperatures, storms, wind changes, rainfall.
- With multiple projects potentially seeking consent at the same time and enhanced focus on cumulative impact assessment through the EIA process there is potential for additional inter-related challenges, objections, and delays in achieving planning permission.
- It is likely that there will be a lot of construction work happening at the same time once projects get underway, which may give rise to issues such as increased traffic, noise, and emissions. This will need to be managed strategically to minimise complaints, work stoppages and delays.
- Due to the low-lying nature of much of the area, the visual impact of integration and wet storage of wind turbines will need to be addressed, and locations carefully selected to minimise impact on areas of high visual amenity. Project proposals may be subject to objections on visual impact grounds.
- Careful consideration of locations for e-fuels developments in light of biodiversity and habitat, for example ammonia is highly toxic. Proposals for ammonia production/storage are likely to draw objections on environmental grounds.
- If the Estuary experiences a rapid increase in activity, air quality impacts in the short term need to be planned for at a cumulative level.
- Other cumulative impacts of note may include noise impacts, water quality, water supply. This may result in similar issue to air quality, but may be over longer timescales, knock on impact to habitat and wildlife as well as human health must be considered at cumulative level.

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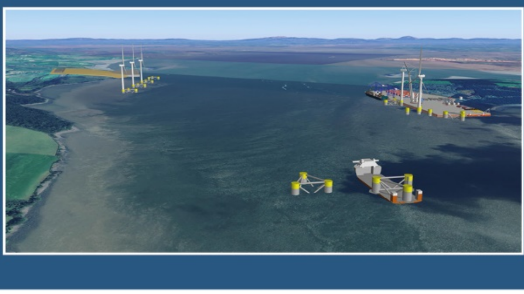
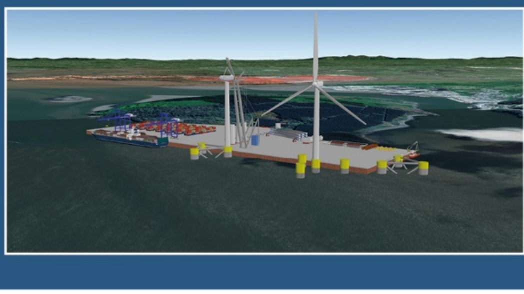
Policy Review





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Statutory and policy requirements at national level to mitigate climate change and increase renewable energy generation are informed by higher level international and European legislation. This policy context contributes directly to establishing a clear and urgent need to leverage the opportunities of the Shannon Estuary and the energy potential of the west coast of Ireland.

The growth of the offshore renewable energy sector presents an opportunity for the Shannon Estuary in respect of new infrastructure and supply chain opportunities. As illustrated in the chapters below, there is significant policy at international, national, and regional level to enable and support the Shannon Estuary as a major receiving node for offshore wind electricity generated off the west coast of Ireland.

32. International and EU Policy

32.1 International Policy

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty negotiated in 1992. Its ultimate objective was to achieve "... stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system"[128].

Every year the UNFCCC hosts the Conference of Parties (COP) to assess progress in dealing with the issue of climate change. At COP21 in Paris in 2015 the first-ever universal, legally binding global climate deal was brokered, namely The Paris Agreement. That agreement sets out a global action plan to put the global community on track to avoid dangerous climate change by limiting global warming to well below 2°C above pre-industrial levels and pursuing efforts to limit it to 1.5°C above pre-industrial levels.

32.2 EU Directives and Policies

The various directives and policies of the EU set a clear mandate for each member state to transition to sustainable, renewable energy and reduce greenhouse gas emissions.

The EU Directive on the Promotion of the Use of Energy from Renewable Sources (2009/28/EC)[129] set a target of 20% of EU energy consumption from renewable sources by 2020 and a 20% cut in greenhouse gas emissions by 2020, the so-called 20:20:20 plan. As part of this Directive, Ireland's overall national target for the share of energy from renewable sources in gross final consumption of energy in 2020 was 16% (increased from 3.1% in 2005). Whilst Ireland has made significant progress in achieving its 2020 renewable electricity targets it did not meet its electricity target of 40% of energy from renewable sources.[130, 131]

32.2.1 2030 Climate and Energy Framework

In October 2014, EU leaders adopted the 2030 Climate and Energy Framework which was subsequently updated in 2018.[132] This framework provides a long-term perspective beyond 2020 targets. The 2030 Climate and Energy Framework sets out three key targets for the year 2030:

- At least 40% cuts in greenhouse gas emissions (from 1990 levels)
- At least 32% share of renewable energy
- At least 32.5% improvement in energy efficiency (from 1990 levels).

Further to this, the European Commission in 2016 published its 2030 emissions targets break down for each Member State. While the overall EU target is a reduction of 40% on 1990 greenhouse gas emissions by 2030, every Member State negotiates an individual target. Ireland's target is to reduce its emissions by 30% relative to its 2005 emissions.[133]

32.2.2 A Roadmap for Moving to a Competitive Low Carbon Economy in 2050

Looking beyond 2020, in compliance with the EC Energy Roadmap 2050, an EU target of at least 27% has been indicated as the share of renewable energy consumed in the EU in 2030. The Roadmap has informed national policy and has influenced the Climate Action Plan (2021) which sets out actions to reduce climate change towards 2050.[134]

32.2.3 Recast Renewable Energy Directive (RED2)

An agreement was made in Europe between negotiators for the European Commission, the European Parliament and the European Council in 2018 with regard to increasing renewable energy use in Europe. The new regulatory framework includes a binding renewable energy target for the EU for 2030 of 32% with an upwards revision clause by 2023. This agreement will help the EU meet The Paris Agreement goals.[135]

32.2.4 European Green Deal (2019)

The European Green Deal is a growth strategy for the EU which aims to transform the EU into a fair and prosperous society, improving quality of life with modern, resource efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. The EU aims to do this by becoming climate-neutral by 2050. A key principle for achieving this will be to develop an energy sector based largely on renewable resources.

32.2.5 EU Strategy for Offshore Renewable Energy

In July 2020, the EU launched a roadmap for its Strategy for Offshore Renewable Energy.[136] The aim of the roadmap was to inform citizens and facilitate participation in consultation activities. This roadmap for the Strategy for Offshore Renewable Energy also highlighted the EU response to the COVID-19 pandemic with regards to offshore renewable energy.

"As Europe deals with the effects of COVID-19 it is crucial to avoid significant delays in offshore renewables investment, as this sector can also ensure the recovery leads to sustainable growth."

The aim of the strategy is to ensure that offshore renewable energy can help reach the EU's ambitious energy and climate targets. The European Commission estimates between 240 and 450GW of offshore wind power is needed by 2050 to keep temperature rise below 1.5°C. The Strategy proposes to increase Europe's offshore wind capacity from its current level of 12GW to at least 60 GW by 2030 and to 300 GW by 2050.

32.2.6 EC REPowerEU Plan

In 2022 the European Commission presented its response to the hardships and global energy market disruption caused by Russia's invasions of Ukraine. The EC outlined their objectives to "ending the EU's dependence on Russian fossil fuels" and "tackling the climate crisis".

The measures in the REPowerEU Plan seek to phase out Europe's dependency on Russian fossil fuels through "energy savings, diversification of energy supplies, and accelerated roll-out of renewable energy". It recognises that a significant "scaling-up and speeding-up of renewable energy" will accelerate EU energy independence and assist in the green transition.

The European Commission proposes to "increase the headline 2030 target for renewables from 40% to 45%" under the 'Fit for 55' package of European Green Deal legislation. This increased ambition recognises the need to "tackle slow and complex permitting for major renewable projects", and a targeted amendment to the Renewable Energy Directive to recognise renewable energy as of overriding public interest.[137]

33. National, Regional, and Local Policy

33.1 National Policy

National energy and climate policy is derived from the overarching European policy which aims to unify the European Union in energy and climate goals.

33.1.1 Climate Action and Low Carbon Development (Amendment) Act 2021

The Climate Action and Low Carbon Development (Amendment) Act 2021[138] provides for the approval of plans by the Irish Government in relation to climate change for the purpose of pursuing the transition to climate neutral economy by the end of the year 2050. The Act establishes a legally binding framework with clear targets and commitments set in law and will ensure the necessary structures and processes are embedded on a statutory basis to ensure national, EU and international climate goals and obligations are achieved.

The Act embeds the process of carbon budgeting into law. The Government is required to adopt a series of economy-wide five-year carbon budgets, including sectoral targets for each relevant sector, on a rolling 15-year basis, starting in 2021. This includes a provision for the first two five-year carbon budgets to equate to a total reduction of 51% emissions over the period to 2030, in line with the Programme for Government which commits to a 7% average yearly reduction in overall greenhouse gas emissions over the next decade, and to achieving net zero emissions by 2050. This Act will drive implementation of a suite of policies to help achieve this goal.

The Act also requires that all Local Authorities prepare individual Climate Action Plans to include both mitigation and adaptation measures, representing a mandate for Local Authorities to adapt to climate change.

33.1.2 Climate Action Plan (2021)

First published in June 2019, the Climate Action Plan (CAP) is fundamental in implementing the Climate Action and Low Carbon Development (Amendment) Act 2021. A new updated CAP was published in November 2021[139] which updates the targets for renewable energy by 2030 from the previous 70% to now 80% target. Similar to the 2019 CAP, the target is to be achieved by providing at least 5GW of offshore wind energy by 2030.

To achieve this target, the 2021 CAP deems it necessary to "Finalise design and rollout of dedicated offshore RESS auction" (Action 122) and to "Develop a clear Offshore Renewable Energy Grid Connection Policy" (Action 118).

33.1.3 National Energy and Climate Plan 2021-2030

Ireland's National Energy and Climate Plan (NECP)[140] was first submitted to the European Commission on the 31st December 2018. The NECP is a consolidated plan which brings together energy and climate planning into a single process for the first time. The NECP 2021 – 2030 was updated in June 2021. The 2021 publication was prepared to incorporate all planned policies and measures that were identified up to the end of 2019 and which collectively target the delivery of a 30% reduction by 2030 in greenhouse gas emissions from 2005 levels.

Under the Programme for Government: Our Shared Future[141], Ireland is committed to achieving a 7% annual average reduction in greenhouse gas emissions between 2021 and 2030. The NECP was drafted in line with the current EU effort-sharing approach, before the Government committed to this higher level of ambition, and therefore does not reflect this higher commitment. Ireland is currently developing those policies and measures and intends to integrate the revision of the NECP into the process which will be required for increasing the overall EU contribution under The Paris Agreement.

The NECP identifies three phases to developing offshore wind in Ireland:

- Phase 1, which will take place in the first half of the NECP's timeframe, includes early projects, as well as the development of a consenting regime for offshore wind;
- Phase 2 focuses on achieving the 2030 target of at least 3.5GW of offshore wind, moving towards full decarbonisation; and
- Phase 3 looks beyond 2030, at longer-term options.

33.1.4 Project Ireland 2040: National Planning Framework and Revised National Development Plan 2021-2030

Project Ireland 2040 (PI2040)[142] includes the National Planning Framework (NPF) which sets the overarching spatial strategy for the next 20 years and the National Development Plan (NDP) which sets out the 10-year investment strategy. Whilst the NPF sets out a spatial hierarchy of urban centres that are programmed for significant population and economic growth over the plan period, the NDP sets out funding to underpin key Government priorities including measures to enable a step-change in investment to ameliorate the effects of climate change. Securing the alignment of the NPF and the NDP will be achieved through delivery of National Strategic Outcomes (NSOs).

Under NSO 8 'Transition to Sustainable Energy', the NPF states that *"the development of onshore and offshore renewable energy is critically dependent on the development of enabling infrastructure including grid facilities to bring the energy ashore and connect to major sources of energy demand. We also need to ensure more geographically focused renewables investment…".*

The NDP recognises that *"Ireland's ORE ambitions will entail investment of tens of billions of euros … and development of indigenous supply chains and port infrastructure. The significant role for ports, and need for associated infrastructure development in Irish ORE development is recognised"*.

33.1.5 National Marine Planning Framework

In May 2021, the Government published Ireland's first national framework for managing marine activities, the National Marine Planning Framework (NMPF)[143]. The objective of the Framework is to provide for a more strategic, plan-led and efficient use of marine resources.

The NMPF supports the establishment of Ireland as a world leader in offshore renewable energy deployment, highlighting the importance of offshore renewable energy in Ireland's decarbonisation journey ad promoting a number of policies, including:

ORE Policy 1 *"Proposals that assist the State in meeting the Government's offshore renewable energy targets, including the target of achieving 5GW of capacity in offshore wind by 2030 and proposals that maximise the long-term shift from use of fossil fuels to renewable electricity energy, in line with decarbonisation targets, should be supported…".*

ORE Policy 11 *"Where appropriate, proposals that enable the provision of emerging renewable energy technologies and associated supply chains will be supported".*

ORE Policy 10 *"Opportunities for land-based, coastal infrastructure that is critical to and supports development of ORE should be prioritised in plans and policies, where possible".*

Further, the MPF recognises that "Ports can support the growth of other marine activities such as offshore renewable energy, including emerging technologies such as floating offshore wind, through the provision of support services and facilities including for import and export of equipment and for vessels supporting the industry".

33.1.6 Offshore Renewable Energy Development Plan

In 2014, the Government published the Offshore Renewable Energy Development Plan (OREDP)[144]. The OREDP sets out key principles, policy actions and enablers for delivery of Ireland's significant potential for offshore renewable energy.

The OREDP provides a framework for the sustainable development of Ireland's offshore renewable energy resources and identifies opportunity for the following:

- The sustainable development of Ireland's abundant offshore renewable energy resources;
- To increase indigenous production of renewable electricity;
- To contribute to reductions in our greenhouse gas emissions;
- To improve the security of our energy supply; and
- create jobs in the green economy.

Looking towards 2030 and 2050, the OREDP sets out goals which will require the expansion of renewable generation including offshore wind. The OREDP actions seeks to:

- *"Develop the Supply Chain for the Offshore Renewable Energy Industry in Ireland … export renewable electricity which could bring potentially significant employment creation opportunities. In addition to construction, and operations and maintenance jobs, the supply chain for wind generation will be galvanised as such projects are likely to form a significant part of the initial export activity."*
- *"Ensure Appropriate Infrastructure Development: The development of offshore renewable energy is critically dependent on the development of enabling infrastructure at a number of points in its value chain, including grid and port facilities."*

It should be noted that OREDP II is currently being developed by the Department of the Environment, Climate and Communications and is expected to be available for consultation during 2022.

33.1.7 National Ports Policy 2013

The National Ports Policy[145] was published by the Department of Transport, Tourism, and Sport in 2013 and represents a detailed and descriptive policy document outlining the categorisation of Ireland's ports in the context of the EU TEN-T transportation network as well as corporate governance and environmental issues.

As Ireland's second largest port in terms of total throughput/trade handled and its access to deepwater resources, SFPC was designated by the Government in the National Ports Policy as a Tier 1 Port of National Significance. This means that the port must continue to play a key role, both regionally and nationally, in meeting the external trading requirements of the Irish economy, and that the continued successful commercial development of the port represents a key policy objective in this regard.

As noted in the National Ports Policy, *"The continued commercial development of Shannon Foynes Port Company is a key strategic objective of National Ports Policy" and "It is the Government's position that those ports considered to be of national significance must be capable of the type of port capacity required to ensure continued access to both regional and global markets for our trading economy."*

This implies that government policy anticipates that the Tier 1 Ports of National Significance, including Shannon Foynes Port, will lead the response of the State commercial ports sector in addressing the future national port capacity requirements.

33.1.8 Policy Statement on the Facilitation of Offshore Renewable Energy by Commercial Ports in Ireland, 2021

Pending a review of overall National Ports Policy in 2022, the Department in conjunction with the Irish Maritime Development Office (IMDO), carried out an assessment of the options for Irish commercial State Ports to facilitate the ORE sector and assist in Ireland achieving its emission reduction targets.[146]

While the primary function of the State ports is to facilitate maritime transport, it is recognised that ports are also enablers of other activities. The significant role that ports can play in facilitating the development of the Irish offshore renewable energy sector is widely recognised.

The key recommendation arising out of the assessment is that a number of port facilities will be required for deployment activity and a multiple of ports will be needed for O&M operations. The Policy Statement recognises that ORE developments will typically require both large-scale port infrastructure for project deployment and smaller-scale port facilities to provide ongoing operation and maintenance (O&M) services. Around the Irish coast, ORE projects will develop in several phases.

The Policy Document advises that the Offshore Renewable Energy Development Plan II will inform the identification of the optimal areas for renewable technologies through a comprehensive assessment of all available data and information. This will include identification of areas off the South West and West coasts which typically have deeper waters, and a less developed onshore transmission system than on the East coast. Floating turbines, where the turbines are anchored to the seabed rather than directly fixed, will provide the opportunity to develop the deeper waters in the South West and West coasts. The potential to generate green hydrogen from offshore wind will also provide an opportunity for development in these areas that is not fully electricity grid dependant. In that context, the Policy Document recognises that ports such as Shannon Foynes Port can also play a significant part in the provision of the required large scale port infrastructure.

33.2 Regional Policy

33.2.1 The Regional Spatial and Economic Strategy for the Southern Region 2019-2031

The Regional Spatial and Economic Strategy for the Southern Region (RSES)[147] is a 12-year strategic plan which identifies regional assets, opportunities and pressures and provides appropriate policy responses in the form of Regional Policy Objectives (RPOs). At this strategic level, it provides a framework for investment to better manage spatial planning and economic development to sustainably grow the Southern Region to 2031 and beyond. The marine economy is identified as an emerging sector in the RSES (Objective RPO76) with the Shannon Estuary, its ports and future development identified as a significant economic driver and transport corridor in the region.

The RSES supports the continued and future development of SFPC. Section 6.3.4.2 of the RSES has a number of Regional Policy Objectives (RPO's) supporting the Region's strategic ports and harbour assets. RPO146 provides continued support for the capital infrastructure projects in SFPC's Infrastructure Development Programme including capacity extension works and infrastructure investment towards deepwater berthage on Foynes Island and offshore resources. The RSES also recognises that the Strategic Integrated Framework Plan for the Shannon Estuary (SIFP) provides significant opportunities to grow the Blue Economy through offshore wave and wind renewable energy in the Shannon Estuary.

The RSES acknowledges that the region is particularly rich in renewable energy resources and contains significant energy generation infrastructure of national and regional importance, including hydro-generation, thermal generation at Moneypoint, and Tarbert. The Plan recognises that there is significant potential to use renewable energy across the region to achieve climate change emission reduction targets. The RSES supports renewable industries and requirements for transmission and distribution infrastructure. It provides two RPO's in support of such efforts, including RPO 99 where *"it is an objective to support the sustainable development of renewable wind energy (onshore and offshore) at appropriate locations and related grid infrastructure in the Region in compliance with national Wind Energy Guidelines"* and RPO100 where *"it is an objective to support the integration of indigenous renewable energy production and grid injection".*

33.2.2 Strategic Integrated Framework Plan for the Shannon Estuary

Perhaps the single most important regional document to be prepared in terms of the Shannon Estuary is the inter-jurisdictional Strategic Integrated Framework Plan (SIFP)[148]. It provides a coherent spatial plan to recognise the economic potential of the Estuary and is significant in that it has 'buy in' from all relevant stakeholders and policy makers. SIFP aims to support the multifunctional nature of the Shannon Estuary and facilitate diversification of the economy through the promotion of commercial/industrial employment and maritime energy over a thirty-year horizon. It seeks to transform the estuary into an international economic hub by taking advantage of what are among the deepest and sheltered harbours in Europe and the world. It has identified an additional 1,200 hectares for port development (9 no. strategic development locations) by building on existing industry connectivity and synergy as well as the existing infrastructure to create more sustainable and attractive network for further investment.

The Strategic Development Locations (SDLs) are a unique national maritime asset as the land within the SDLs adjoins identified sheltered deepwater (>15-m depths) sites on the Shannon Estuary. It is intended that these SDLs will attract substantial maritime commerce consistent with the Governments Harnessing our Ocean Wealth assisting in achieving its economic targets.

33.3 Local Policy

This section details the relevant local policies contained in County Development Plans that have statutory significance over the Shannon Estuary including the Limerick, Kerry and Clare Development Plans.

33.3.1 Limerick Development Plan 2022-2028

The Plan is underpinned by a strategic vision intended to guide the sustainable future growth of Limerick.[149] There are a number of policies and objectives in the Development Plan supporting development in the Port of Foynes, the wider Shannon Estuary and promoting Offshore Renewable Energy as follows:

Objective ECON O55 – It is an objective of the Council to encourage, facilitate and promote the Shannon Estuary's economic growth potential and promote marine related industrial development, while ensuring that the environment and natural resources of the area are protected, managed and enhanced.

Objective ECON O57 – It is an objective of the Council to safeguard the Strategic Development Locations at Foynes Port, Foynes Island and Aughinish Island for the sustainable growth and development of marine related industry and industrial development at Askeaton

Objective ECON O58 – It is an objective of the Council to:

a) Support the expansion of the Port at Foynes and promote the economic and industrial development of the Shannon Estuary as a strategic transport, energy and logistics Hub, serving Limerick and the wider region by utilising naturally occurring deepwater characteristics and by identifying and safeguarding existing and future strategic transportation links, subject to fulfilling the requirements of the Habitats Directive and the conservation objectives of the Lower River Shannon SAC site.
b) Promote and support Shannon Foynes Port Company's Masterplan Vision 2041

Objective ECON O59 – It is an objective of the Council to:

a) Support in conjunction with other relevant agencies, wind energy initiatives, both on-shore and offshore and wave energy, when these are undertaken in an environmentally acceptable manner.
b) Promote Limerick to become the primary hub for the development of Ireland's west coast renewable energy, with potential in research, innovation, logistics, development, maintenance and administration.

33.3.2 Draft Kerry Development Plan 2022-2028

The Kerry Development Plan is at Material Alteration Stage and is due to be adopted before the end of the year.[150] It establishes a broad framework for the way in which the economy, society, environment, and the use of land should evolve in County Kerry. The Plan has 10 main goals including promoting the growth of a Sustainable and Strong Economy.

The Development Plan recognises that there are significant opportunities to grow offshore wave and wind renewable energy in the Shannon Estuary reflecting the key natural assets of wave and wind energy, together with the presence of grid connections. The Strategic Development Location (SDL) at Tarbert/Ballylongford in North Kerry is recognised for its potential as an Energy Hub and for industrial development at a regional and national level. The relevant objectives to consider include,

Objective KCDP 2–2 seeks to facilitate and support national climate change objectives contained in the Climate Action Plan 2019 and the actions contained in the KCC Climate Change Adaptation Strategy 2019-2024 and successor strategies.

Objective KCDP 9-22 seeks to support and promote the delivery of the Strategic Development Locations (SDLs) as set out in the SIFP for the Shannon Estuary subject to the implementation of mitigation measures outlined in the SEA and AA undertaken on SIFP and zoned in the Local Authority Development Plans.

Objective KCDP 12-29 which seeks to support the sustainable development of onshore infrastructure, including grid connections, to facilitate the development of offshore energy projects at appropriate locations and further to environmental assessments.

Objective KCDP 9-25 which safeguards the role and function of the Power Plant Hub at Tarbert, including the NORA Strategic Oil Reserves Plant, as a key driver of economic growth in the Region, encouraging its sustainable growth and diversification, in accordance with Regional and National Energy Objectives.

Objective KCDP 12-12 which maximises the development of all renewable energies at appropriate locations in a manner consistent with the proper planning and sustainable development of the County.

33.3.3 Clare Development Plan 2017-2023

One of the Key Goals of the Clare Development Plan [151] is Goal X, which seeks to develop *"A County Clare that builds on the strategic location and natural resources of the Shannon Estuary by facilitating and maximising its potential for various forms of development while managing the estuarine and natural environment in full compliance with all relevant EC Directives"*. The Plan states that it is through the delivery of these goals that this common vision for County Clare will be realised.

Chapter 11 in the Development Plan is devoted to the potential of the Shannon Estuary as it strives to support and expand the existing economic base, including port and harbour facilities and related activities. It also seeks to implement the SIFP (Objective CDP11.2) and in particular seeks to capitalise on the natural deepwater potential and existing port and maritime infrastructure, by facilitating and proactively encouraging development within the Strategic Development Locations (SDL's) – Objectives CDP 11.3 and 11.4.

Objective CDP11.7 seeks to facilitate and promote the economic growth of shipping trade and investment within the Shannon Estuary and Objective CDP11.8 seeks to ensure that the objective of the Council is to ensure that the Shannon Estuary fulfils it optimum role in contributing to the diversity and security of energy supply. The Development Plan aims to harness the potential of the estuary for the sustainable development of renewable energy sources to assist in meeting renewable energy targets.

The Development Plan recognises that the growth of the offshore renewable energy sector presents an opportunity for the Shannon Estuary in respect of new infrastructure and supply chain opportunities. The Shannon Estuary is well placed to capture a significant share of that market.

33.3.4 Regional Enterprise Plan to 2024 Mid-West[152]

The Mid-West Regional Enterprise Plan to 2024 recognises that renewable energy presents the Mid-West with a number of wonderful opportunities for future economic prosperity and further states that growing international interest suggests that the waters off the Clare/Kerry coastline can be the most reliable locations in Europe for large-scale generation of wind energy.

Action 2.1 presents the Atlantic Green Digital Basin whose strategy is to decarbonise industry by developing the Shannon Estuary as a renewable energy hub.

33.3.5 Regional Enterprise Plan to 2024 South-West[153]

The South-West Regional Enterprise Plan to 2024 also contemplates the emergence of offshore floating wind as a cost-effective and highly efficient renewable energy source that sees the Shannon Estuary as the ideal location from which to deliver on a world leading energy resource of up to 70GW in the coming decades.

Action 5.5 calls for the collaboration between the South-West and Mid-West regions to support the economic development potential of the Shannon Estuary and the surrounding region.

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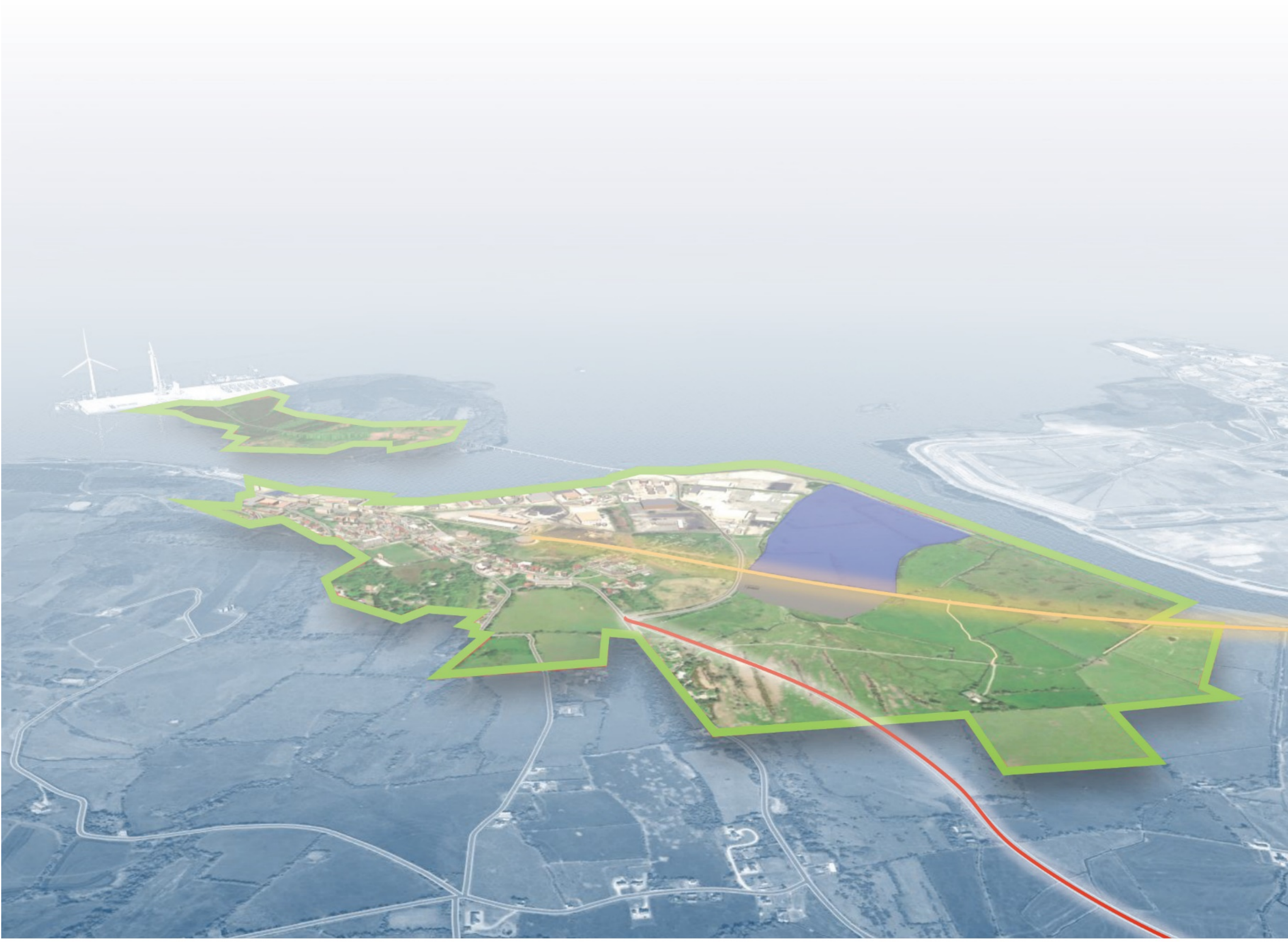

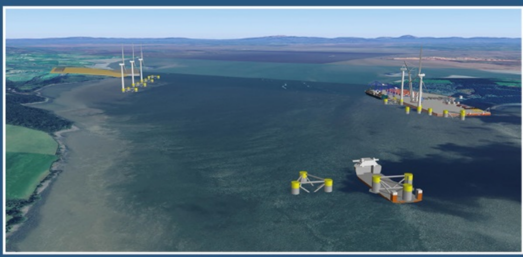

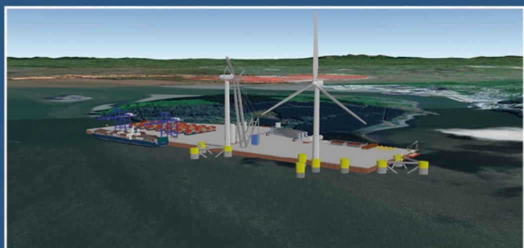

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Contact:

Paul Deane | Bechtel Infrastructure Ireland Limited | pdeane@bechtel.com