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Investigating the Economic Impact from offshore wind in Northern Ireland

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Disclaimer

The analysis in this report has been conducted by the Fraser of Allander Institute (FAI) at the University of Strathclyde. The FAI is a leading academic research centre focused on the Scottish economy.

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Executive Summary

In line with overall UK targets, Northern Ireland is committed to becoming a net zero carbon economy by 2050. To achieve this goal the economy must undergo a transformative change, in particular in the electricity sector with the introduction of new technologies.

The Climate Change (Northern Ireland) Act 2022 committed the Department for the Economy to ensure that at least 80% of electricity consumption is from renewable sources by 2030.

The purpose of this report is to model the potential economic impacts arising from the investment in offshore wind in Northern Ireland.

We employ a Computable General Equilibrium modelling framework calibrated to the published 2018[1] Northern Ireland Input-Output (IO) data. Currently there are no operational offshore wind farms in Northern Ireland but there is the goal of at least 1GW from 2030 (and before if feasibly possible). We estimate a further 1GW is needed to reach a net zero electricity system by 2040.

This report contains six scenarios related to potential economic impact arising from development of both floating and fixed offshore wind in Northern Ireland with each scenario containing two capacity pathways – one for 1GW of offshore wind from 2030 and another for 2GW of installed capacity by 2040 to reach net zero targets.

1. **Gross economic impact**
2. **Gross economic impact with local supply constraints**
3. **Net economic impact**
4. **Gross economic impact with Belfast harbour upgrade**
5. **Gross economic impact with electricity price changes**
6. **Net impacts, with supply side constraints, investment in Belfast harbour and change in electricity price (combination scenario)**

The scale of economic impacts varies greatly by scenario with **Table 1** outlining the key results for each of the six, these are explained in detail within section four.

1 Since the analysis in this report an updated 2019 table has been made available.

Table 1: Summary impacts of the five scenarios, across two capacity pathways and farm type[1]

	GVA (£)			
	1GW Floating	1GW Fixed	2GW Floating	2GW Fixed
Scenario 1 - Gross impacts	960	570	1,830	1,090
Scenario 2 - Gross impacts with local supply constraints	580	390	1,090	720
Scenario 3 - Net impacts	610	30	1,060	320
Scenario 4 - Gross impacts with Belfast harbour upgrade	990	590	1,860	1,110
Scenario 5 - Gross impacts with electricity price changes	3,930	3,430	8,550	7,800
Scenario 6 – Combination	2,820	2,200	6,120	5,580

	Employment (person-years)			
	1GW Floating	1GW Fixed	2GW Floating	2GW Fixed
Scenario 1 - Gross impacts	8,360	4,570	15,860	8,740
Scenario 2 - Gross impacts with local supply constraints	4,660	2,860	8,740	5,250
Scenario 3 - Net impacts	6,330	1,480	11,500	4,360
Scenario 4 - Gross impacts with Belfast harbour upgrade	7,850	4,040	15,350	8,220
Scenario 5 - Gross impacts with electricity price changes	22,490	18,180	47,750	42,730
Scenario 6 - Combination	13,390	8,960	29,010	24,120

Source: *FAI calculations*

1 GVA rounded to nearest £10m and employment nearest 10 person-years. All monetary values (GVA etc, costings etc) are in 2024 prices.

Introduction

The Climate Change (Northern Ireland) Act 2022 committed Northern Ireland to ensure at least 80% of electricity consumption is from renewable sources by 2030 (which superseded the 70% target set out in the 2021 Energy Strategy), on the way to Northern Ireland being Net Zero by at least 2050. By the end of 2022, 51% of electricity consumption in Northern Ireland had been produced by renewables. This was driven mainly by onshore wind with this technology responsible for 81% of total renewable electricity generation (Department for Energy Security and Net Zero, 2023). While the rise of onshore wind technology is a success story there are limitations in its future growth potential linked to both social and technological issues. Due to this limited potential, there has been recognition that the electricity generation system in Northern Ireland must be diversified with other renewable technologies if both the 2030 and 2050 targets are to be met.

Northern Ireland, being part of the British Isles, has one of the best offshore wind resources in the world with many potential areas for future development having wind speeds in excess of 10.5 m/s (4C offshore, 2023). Due to this large resource and the need to diversify the electricity system the Department for the Economy in Northern Ireland consulted on the draft Offshore Renewable Energy Action Plan (OREAP) as the first step to enabling offshore renewables energy developments in Northern Ireland (DfE, 2023b). Several key actions were outlined in the draft OREAP report with one of the most important outcomes being the target of at least 1GW of offshore wind in Northern Ireland.

The draft OREAP includes an indicative timeline for offshore wind development in Northern Ireland, outlining the key processes which will contribute towards delivery of offshore wind and marine renewables in Northern Ireland from 2030.

Outlined in the draft OREAP consultation are five key themes (DfE, 2023b):

1. **Sustainability and Co-existence –** Offshore wind developments in Northern Ireland should aim to achieve the highest standards of environmental, social and economic sustainability in line with Department of Agriculture, Environment and Rural Affairs' draft Marine Plan and, where possible, innovative approaches to co-location and co-existence within the marine environment will be practiced.

2. **Enabling frameworks –** A coordinated and coherent process for the development of offshore renewable energy projects should be in place which covers marine licensing, development consent, planning permission along with generation and transmission licensing.

3. **Electricity Network -** Government departments, regulators and relevant bodies will establish a joint approach to deliver the Energy Strategy for Northern Ireland's long-term ambitions which includes offshore renewable energy.

4. **Economic growth –** Certainty and assurance on a route to market for offshore wind. Northern Ireland should work to achieve the greatest possible economic return from investment in offshore wind.

5. **Legislation and Regulation -** Legislation and regulation will be reviewed to determine if it is fit for purpose to deliver on the Energy Strategy's offshore wind and low carbon ambitions.

This report is focused on point four, the potential of offshore wind to bring economic benefits as well

as environmental ones to Northern Ireland. The idea of the green transition growing the economy is also a key objective outlined in the NI Energy Strategy, where the aim is for the Low Carbon and Renewable Energy Economy (LCREE) to have a turnover of around £2 billion annually from 2030, which amounts to around a doubling of the turnover in Northern Ireland in 2021 (ONS, 2023).

Due to the large investment needed, offshore wind is expected to play a part in the growth of the LCREE in Northern Ireland, however the potential size it could grow to is an unknown which we explore in this report. The first and foremost issue with offshore wind is the high level of expertise needed for many of the component and development stages, for instance the turbines themselves and the offshore vessels needed for installation of the multiple offshore components. Northern Ireland is a relatively small nation unlikely to have all the expertise, or capacity, needed to develop these components, thus the local content (i.e., goods and services bought in the domestic economy) may be small, limiting the economic growth potential. This issue was investigated in recently published work (FAI, 2023). Another issue with offshore wind is that much of the economic development and linked jobs are short-term which makes it difficult to help with the £2 billion LCREE annual targets for 2030. For example, while a full offshore wind project lasts around 30 years from pre-development to decommissioning the majority of the investment is front loaded in the first 5 years of the project, where components are being manufactured and installed. After construction the investment in offshore wind is linked to the operation and maintenance of the wind farms, and these are longer term jobs.

In this report we investigate the economic impact arising from the development of offshore wind in Northern Ireland to meet the net zero targets. In Section one the Computable General Equilibrium (CGE) modelling framework used to estimate the economic impacts, is detailed, with information on the different scenarios and how these were calculated in Section two. Section three outlines and discusses the key results of the scenarios with conclusions in the final section.

1. Modelling Framework

Here we employ a multi-sectoral computable general equilibrium "macro" model of the economy, which provides a detailed description of the economy that captures the key interlinkages between the private sector, households, government, international trade and the labour market. These models allow for extensive simulations of scenarios on the impact of a wide range of policy interventions. They are frequently used by governments to assess the merits of alternative policy choices[2].

In this paper we use the standard Northern Ireland version of the modelling framework A Model of Scotland (AMOS), calibrated on a 30- sector Social Accounting Matrix for Northern Ireland based on the 2018 published Northern Ireland IO Table[3].

The primary focus of our modelling for this report is the increase in demand for goods and services for industries linked to offhsore wind investment. In addition to the 30 sectors within the model there are three internal institutions - households, firms and governments - and two external, the rest of the UK (RUK) and the rest of the world (ROW). Northern Ireland is a small, open, regional economy so that external RUK and ROW prices are not impacted by changes in the Northern Ireland economy.

This framework has been used extensively in a wide range of applications and this specific version of the CGE model was built for the Department for the Economy for policy analysis. The model allows for a degree of flexibility in the choice of assumptions on how the economy is set up and reacts to changes. The version used in this paper assumes that industries and households within the model have no future expectations of prices and are only reactive to changes in demand/supply or prices.

Fundamentally, the model assumes that producers minimise cost using a nested multilevel production function. The combination of intermediate inputs with RUK and ROW inputs is based on the Armington function (Armington, 1969). Output is produced from a combination of composite intermediates and value added, where labour and capital combine in a constant elasticity of substitution (CES) function to produce value added, allowing for substitution between these factors in response to relative price changes.

There are four components of final demand in the model: household consumption, investment, government expenditure and exports. Household consumption is a linear function of real disposable income. Real government expenditure is constant in the model, while exports are determined again through an Armington function and so are dependent on relative prices. Investment is the change in physical capital (such as machinery, infrastructure and cash) needed to sustain economic output, detailed below.

The supply side of the economy determines the use of capital and labour in the model. Capital, in the first period, is fixed but in subsequent periods each sector's capital stock is updated through investment, which responds partially to the gap between the desired and actual (adjusted for depreciation) levels of capital stock – in line with the neoclassical investment formulation (Jorgenson, 1963). Capital is immobile between sectors.

We assumed that there is no migration in the model. The labour market is characterised by the presence of imperfect competition in which workers' bargaining power is inversely related to the rate of unemployment.

2 See FAI (2022) for a review of the AMOS framework of energy and environmental applications.

3 Since the first draft report the 2019 NI IOT was published.

There is very substantial international evidence in favour of the wage curve as well as evidence that it is an appropriate aggregate characterisation of the labour market in Northern Ireland.

A core advantage of CGE modelling over other appraisal methods such as Input-Output is that both the demand and supply-side of the economy are explicitly modelled.

In particular this is the case for large scale investments like 2GW of offshore wind. In CGE models the increase in demand affects prices which industries through-out the economy react to with changes in demand, thus there are potentially "crowding-out" effects whereby some industries actually lose out due to the increases in prices. Also, the labour force is present in CGE models which again may have an impact on prices through changes in wages.

All scenarios are run in a multi-year setting. Overall, the scenarios run for 60 years with year one being 2023[4]. The model is initially assumed to be in steady-state equilibrium, implying that, with no changes in the economy, the model simply replicates initial values over all subsequent time periods.

4 This allows for the full CAPEX and operational stages to be captured as well as any legacy effects linked to the build-up of capital stock and employment.

2. Simulation Strategy

In our modelling we carry out a range of scenarios to measure the economy-wide impacts of offshore wind development in Northern Ireland. Initially we carry out each of these simulations individually to determine the impacts in isolation then have a combined impacts in scenario six.

For each scenario the economic impacts are compared with that of counterfactual known as the business-as-usual case (BAU), i.e no investment in offshore wind. This counterfactual is the 2018 Northern Ireland economy which grows at a standard rate (based on previous growth) each year and the results are interpreted as an increase/decrease in economic indicator compared to the BAU case, for example a 1% increase is 1% increase in GVA compared to the BAU case at a particular period in time. Additionally, some results throughout the report are also compared with Scenario one, this comparative analysis is common practice in economic appraisals allowing for the examination of different simulations/scenarios and their impacts relative to each other.

Scenario one – gross economic impacts of offshore wind investment

The first, and probably most obvious simulation, is an appraisal of the impacts arising from the investment in building and running offshore wind farms in Northern Ireland. Initially we determine the overall capacity needed in Northern Ireland to meet net zero carbon and associated timelines. In 2023 the draft Offshore Renewable Energy Action Plan (DfE, 2023b) set out a goal of delivering 1GW of offshore wind capacity from 2030. According to a 2022 report by BVGA[5], it looks like Northern Ireland could see an extra 0.5 GW of offshore wind capacity added by 2032, potentially bringing the total up to around 1.5 GW. There is, however, a lack of information regarding the total expected capacity of offshore wind in Northern Ireland by the 2050 net zero deadline. Using data (Department for Energy Security and Net Zero, 2023) on current electricity consumption and generation we estimate that a total of 2GW of offshore in Northern Ireland, in combination with new and existing generation would allow for the electricity network to be fully net zero by 2040. These are the two capacity pathways used throughout all scenarios:

A. 1GW from 2030
B. 2GW from 2040 [1GW from 2030; 1.5GW from 2032]

With capacity estimated, a value of potential investment to the Northern Ireland economy related to the cost of offshore wind is needed. Currently, there are no offshore wind farms in Northern Ireland and information on the cost of wind farms currently in development is sensitive thus we use publicly available information on the cost of a generic UK based offshore wind farms.

There are two possible options for offshore wind in Northern Ireland – floating and fixed foundation. Operationally the two types of offshore wind are similar with the key difference being in the type of foundations used. While expectation is that both fixed and floating leasing will be explored there is currently no information of a breakdown between the capacity estimates for floating compared with fixed foundation. Thus, in this report, we analyse both separately for the full capacity in both capacity pathways.

With there being no public information currently available for costs of either floating fixed foundation offshore wind farms in Northern Ireland we estimate potential costs for both using UK estimates.

5 BVG Associates website – Green revolution report

The Offshore Wind Catapult recently published a detailed breakdown of expected costs for a floating offshore wind farm to be built in the UK (Offshore Wind Catapult, 2023). Overall, it is estimated that the Capital Expenditure (CAPEX) for an offshore wind farm build in the UK will be £4.2 million per MW (around 20% higher than a fixed farm) with an operations cost of around £85,000 per MW per year. In addition to the floating offshore wind, ORE Catapult (Offshore Wind Catapult, 2023b), had previously published a breakdown of the costs of a generic fixed foundation offshore wind farm in the UK. These estimates are substituted directly into our cost and breakdown model[6].

Comparing the breakdown of floating and fixed foundation offshore wind farms, much of the component costs are similar with the most notable difference being in the foundation costs itself. The similar costing for many components is to be expected as they are the same for the two types of wind farms, thus the foundation is the primary driver of cost differences between both farm types. Fixed foundations are expected to cost in the region of £311,600 per MW which increases to £950,000 per MW for floating wind farms. The significant difference in cost of floating foundations compared with fixed is a result of both the complexity and novelty of the designs. Floating wind foundations have only recently become commercially viable with several different options available.

Over time as more floating farms are installed and designs are refined, as has happened with fixed offshore foundations, the cost is expected to decrease significantly. We take this into account in the modelling by using the NREL (Shields et al, 2022) published learning rate for floating offshore wind and expected floating offshore wind capacity. An energy technology's learning rate is the cost reduction achieved when the capacity doubles, for floating offshore wind this is estimated at 11.5% (Shields et al, 2022).

We take this learning rate and assumed global capacity of floating offshore wind capacity to calculate the reduction in cost of floating offshore wind foundations between 2030 and 2040. We only reduce the cost of the floating foundations as there is a near certainty that these will reduce overtime as the market increases and there are returns to scale etc. For other components this is not necessary the case. As outlined previously, other than foundations, there is a large overlap between the components found in floating and fixed offshore wind farms with these costs reducing dramatically over the past 13 years as fixed offshore wind capacity has increased significantly. These component costs are unlikely to reduce much further and there is some argument that they might increases as spiralling costs have hampered some recent offshore wind developments in Great Britain[7]. Accounting for the learning rate in foundations we reduce the costs of the floating wind foundations in both capacity pathways over time.

For floating offshore wind, we note above that because the technology is novel there is expected to be significant decrease in foundation costs as worldwide capacity increases. This is not the case for fixed foundation as this is a more mature technology the foundation costs (as with other components) are not expected to decrease as much over time, especially considering recent cost concerns for offshore. Because of this, in the modelling, there is no reduction in costs for fixed offshore wind foundations.

In addition to the total cost for both floating and fixed offshore wind, estimations are made on the timing of development of each of the components for each wind farm type. Like costs, the timing of investment of offshore wind is highly dependent of a few key variables including location, size, and type of foundations. Unlike costs though there is no one document with agreement on timescales, but through investigating the literature and supply chain reports, we estimate that both floating and fixed offshore wind in Northern Ireland will take a total of 5 years from pre-development to full operation. Each wind farm is unique but for our modelling we assume that both floating and fixed offshore wind farm follow the same timeline of development with year o being when the wind farm

6 Comparison of fixed to floating offshore wind can be found in Appendix C.

7 The Guardian website - Biggest clean energy disaster in years

becomes fully operational. Years minus 4 to minus 3 are when the predevelopment costs such as surveying and environmental services occurs. We assume that the costs are split across both years (minus 3 & 4) evenly. An assumption is made for the fabrication of foundations with the costs spread evenly over years minus 2 and minus 1. Operation costs are spread over the 25 year-period from installation (year 0). **Table 2** gives the assumed timeline of development with key spending areas outlined.

Table 2: Timeline of offshore wind development.

Year minus 4	Year minus 3	Year minus 2	Year minus 1	Year 0
Environmental assessments	Environmental assessments	Manufacturing of turbine	Manufacturing of turbine	Installation of turbine
Resource assessments	Resource assessments	Manufacturing of foundations	Manufacturing of foundations	Installation of foundations
	Manufacturing of array cables	Manufacturing of array cables	Construction of onshore substation	
	Manufacturing of export cables	Manufacturing of export cables	Installation of array cables	
			Installation of export cables	

Source: *FAI analysis of supply chain impacts*

While the above costs for both floating and fixed offshore wind are significant there is usually a high level of expertise needed at each stage of development. As such, not all investment will go to businesses based in Northern Ireland and thus have no economic impact on the region. Because of this we need to estimate the level of 'local content' (i.e., that are spent in Northern Ireland) for each of the development stages. As with the timeline, we assume similar local content assumptions for both floating and fixed offshore wind developments. This was made as most of the components are the same and Northern Ireland already has a large offshore manufacturing industry capable of producing both floating and fixed offshore wind foundations.

In previous work (FAI, 2023) there were four sectors of the Northern Ireland economy which were identified as potential key players in the development of fixed offshore wind capacity: metal manufacturing for foundations; onshore electrical systems; onshore construction; and ports and harbours for Operation and Maintenance (O&M). In this report, the assumed local content for these sectors are the high local content values found in FAI (2023) for both floating and fixed offshore wind.

We also assume that most of the development stages, such as surveys and sensors are carried out by Northern Ireland based companies. Offshore wind turbines and the farms offshore cabling systems is highly specialised with our assumption being near zero for these components (there are some stages like offshore substation foundation which have some potential to be developed in Northern Ireland). As with turbines and cabling the ships needed to install large offshore components are specialised thus there is no scope to use Northern Ireland based companies, however, local companies are expected to be used in the logistical operations of installation. Overall, we estimate the total local content of offshore wind in Northern Ireland to be around 34% for floating offshore wind and 27% for fixed foundation, driven mostly by the offshore foundations being fabricated in Northern Ireland[8].

The first scenario is a simple gross impact[9] of the development and operation of offshore wind in Northern Ireland. Using the data on costs and local content we simulation the introduction of investment related to offshore wind in Northern Ireland within the CGE. In the first capacity pathway of this scenario, we isolate impacts from the planned 1GW of offshore wind capacity from 2030, then in the second capacity pathway we model the impacts arising from the full 2GW to 2040 for both floating and fixed foundations. The results are reported in Section three.

Scenario two – gross economic impacts with local supply constraints

In scenario one we assumed that Northern Ireland has the capacity to meet local content expectations for all offshore wind capacity. For most of the components this is a reasonable expectation however there may be difficulty in fabricating either floating or fixed offshore foundations. For more than a century Northern Ireland has been world renowned for the building of offshore structures, including ships, with Harland & Wolff (H&W) being a key business in the region. H&W is a global player already operational in the space of offshore wind foundation fabrication and is expected to be responsible for the vast majority of, if not all, foundation fabrication for Northern Ireland based offshore wind farms. However, during our research and discussions with stakeholders we found that H&W have just recently (2023) been awarded the contract for the fabrication of three new Royal Navy warships[10], which may impact their capacity to build offshore wind foundations.

The warship programme is expected to last until 2032 with the company spending £77million to upgrade its facilities to increase capacity[11] While H&W has still committed to offshore wind foundation fabrication during this period[11], it's unlikely the optimistic target [in scenario one] of 100% floating foundations to be developed in Northern Ireland will be met. In this second scenario we carry out some sensitivity analysis around the local content in the fabrication up until 2032. In this scenario we assume, for the two isolated (1GW and 2GW) capacity pathways, that during the time up to the final warship being built no floating or fixed offshore wind foundations will be manufactured in Northern Ireland. With these assumptions the total local content for floating offshore wind reduces to 9% (compared with 34% in scenario one) whereas the fixed offshore wind local content reduces to 17%, down from 27% in scenario one.

8 The total local content is the proportion of total offshore spend going to Northern Ireland based companies. Floating has a higher local content value as the value of floating offshore wind foundations are greater than that of floating, thus make up a larger proportion of offshore wind expenditure. As these foundations are assumed to be built in Northern Ireland the larger proportion of spend is kept in the country.

9 These are the impacts only arising from new investment, in this scenario we do not account for the substitution of generation away from other technologies such as coal or gas – this is the focus on scenario three.

10 Reuters website – Harland & Wolff wins contract

11 Harland and Wolff website – Demolition work- begins at shipyard

Scenario three – Net economic impacts of offshore wind investment

In the first two scenarios the focus is on the gross impact of offshore investment, however there will be a competing economic negative impact due to the reduction in output of conventional power plants. Northern Ireland still relies on fossil fuel generation (gas, oil) for nearly 50% of electricity Department for Energy Security and Net Zero (2023) generation and the development of offshore wind should replace some of the need for these power plants, which we account for in this scenario[12]. The first estimate needed is the amount of energy (in GWh) each 1GW off offshore wind will replace of fossil fuels. This is calculated from Equation 1 below.

(Equation 1) $$G_{\text{owind}} = C_{\text{owind}} \times \text{hrs} \times \text{Cf}$$

The offshore wind generation G_{owind} (in GWh) is a product of the Capacity (C_{owind}), number of hours in years (hrs) and the capacity factor[13] (Cf) set to 42%, based on the current average[14].

Equation 1 gives the GWh produced by 1 GW of offshore wind. Ideally in our replacement scenario we would assume that 1GWh of wind would replace 1GWh of fossil fuel. However, this is not the case and instead we assume that you need approximately 1.3GWh of offshore wind to replace 1GWh of fossil fuel generation[15]. This accounts for the variation in wind generation and the fact that fossil fuel will still be needed at times of low wind speed in light of the lack of suitable storage.

In our modelling the reduction in fossil fuel generation equates to a reduction in the running costs and variable costs. Using generation cost information (Department for Energy Security and Net Zero, 2020) we calculate the reduction in fuels, fixed O&M and variable O&M for each MWh of fossil fuel generation used. Further investigation into the structure of the Northern Ireland energy system reveals that there are no coal or gas reserves thus the fossil fuel power plants fuel is imported, meaning a reduction in output will have no impact to the Northern Ireland economy linked to fuel use. There is however, a reduction in O&M with the assumption this is a reduction in demand for the construction sector.

The focus of this scenario is only on offshore wind replacing fossil fuel generation in the generation mix. This is not to stay that there will be no fossil fuel generation plants in generation, there is expected to be at least some plants operational as back-up to supplement renewable generation when the resource is not available. During this period these plants will likely receive some capacity payments, but these are not modelled as our focus is on offshore wind generation replacing fossil fuel.

12 Net impacts in the appraisal of renewable energy technologies are an issue that is under investigated in both the academic and industrial literature.

13 Capacity factor is the average power generated over the period of a year from offshore wind divided by the maximum possible year output (i.e the power if the wind farm was running at full rated capacity for each hour of the year).

14 S&P Global website – Offshore wind load factor.

15 This estimate is not the focus of this report, but the approach is used account for difference in principles of operation between wind and traditional fossil fuel generation. The 1.3 estimate was calculated by analysing UK electricity capacity and generation data by technology. However, for a more accurate estimate a full econometric analysis would be needed, which is out the scope of this project.

Scenario four – gross impacts with Belfast harbour upgrades

The discussion with developers also indicated that to meet the increase in capacity of offshore wind, Belfast harbour requires a significant upgrade if it is to become an offshore wind O&M base and if foundations fabricated in Northern Ireland are to be transported offshore. An output from these discussions is the estimate for the costs of upgrades to Belfast harbour will be in the region of £160 million, which we account for in the fourth scenario of the modelling. For this fourth scenario, the assumption is made that, as Belfast port is integral to the economy of Northern Ireland, the upgrade is funded by the Northern Ireland Executive. Note here that this is only an assumption made for the purpose of this CGE analysis. In a full appraisal of port upgrades consideration would be needed around ownership and structures and alternative funding opportunities like those mentioned in footnote 17. Also, we only use Belfast harbour as a case study there are however other ports in Northern Ireland which could be used as a base of operations for offshore wind.

We assume that due to the type of upgrades needed that the full £160 million investment will be made in the construction sector in Northern Ireland. £160 million is a non-trivial amount of the current Northern Ireland Executive's budget and as such we cannot just assume that the investment is made into the construction sector without impacting upon the rest of the government's budget. Instead, we assume that the £160 million investment must be made under a balanced budget constraint. As most of the taxable income in Northern Ireland is under the control the UK government, the budget must be balanced through reallocation of government spending. For scenario four we assume an equitable reduction in government spending across all sectors based on the information found within the published 2018 Northern Ireland Input-Output Table (IOT). **Table 3** gives the percentage of government expenditure across the 30 sectors in Northern Ireland, along with the reduction in expenditure linked to the balanced budget of investment in ports.

Table 3: Government expenditure in Northern Ireland and reduction related to the investment in ports[16]

	Percentage of Government Expenditure	Reduction in Government Expenditure (£million)
Agriculture	0.03%	0.04
Water supply; sewerage and waste management	3.79%	6.06
Construction	1.74%	2.78
Wholesale and retail	0.17%	0.27
Communication	0.27%	0.439
Activities of head offices and management consultancy	0.02%	0.03
Other professional services	0.02%	0.02
Public services	91.52%	146.43
Other services	2.46%	3.93
Total		160

Source: *Total from offshore wind developers. Percentages NISRA (2024)*

16 We have only included sectors where the percentage of government expenditure is greater than zero with two decimal points.

As is to be expected, the largest proportion of government spending at 91.52% is public services, which includes public services, defence, health, and social care. With such a large majority of spending in public services more than £146 million of the £160 million investment needed in ports comes from these services. Other industries which see significant reduction are water sewage and supply at £6.1 million and other services a further £3.9 million[17].

Scenario five – gross economic impacts with electricity prices changes

The previous four scenarios have focused on the economic impacts related to the investment in offshore wind (i.e., demand-side) which are the most commonly thought of. In addition to these demand-side impacts there is the potential of a supply-side impact related to the electricity prices.

Increasing the capacity of offshore wind in Northern Ireland should have a reduce the price of electricity as the wind is replacing fossil fuel generation technologies reducing the link to volatile fuel prices. With electricity being a key input to nearly every business in Northern Ireland, a reduction in price will have economy-wide impacts with goods and services prices reducing, which increases consumption, driving economic activity.

There is no specific information available of the expected prices differences in Northern Ireland, but we can look to the academic literature for an estimation of the impact of increasing offshore wind capacity. Using a range of time-series models and historic electricity prices Hosius et al (2023) estimate the impact of offshore wind energy on Northern European wholesale prices with the UK, Western Denmark and Germany being used as case studies. The authors calculate the marginal price impact of increasing capacity in each of the regions by 1GW, finding significant impacts.

or both the UK and Germany the impact of increasing offshore wind capacity by 1GW is that electricity prices reduce by 0.66% and 1.03%, respectively, compared to a business as usual case (BAU) where there is no offshore wind installed. For Western Denmark, the effect on price is much greater at a decrease of 6.91%. This occurs due to the populations of the regions; Western Denmark is much smaller than both Germany and the UK which have populations of similar sizes.

Western Denmark has a population similar to Northern Ireland[18], thus for scenario five we use the estimate of 6.91% for the effect of electricity price. Hosius et al (2023) also note that the pricing impact is not linear, and they include an estimate for the marginal reduction in the effect for each additional 1GW of offshore wind capacity, which for Western Denmark is 28.87%.

Using these values, we estimate that for the first 1GW of offshore wind capacity the reduction in electricity price will be 6.91%[19] followed by an additional 4.92% reduction for the second GW, bringing the total reduction from the base price to 11.83% with 2GW of capacity.

In this scenario the assumption is made that only Northern Ireland will see a decrease in electricity price, however other nations are following a net zero path so they may also see a decrease in electricity, this is dealt with in Annex A.

17 Note here that we have only modelled one option for how the port upgrades may be funded. there are many options such as: private investment, private/public partnership, shared island scheme or UK central Government funding. In these cases the economic impact will be larger as there is less redistribution of the Northern Ireland budget.

18 Northern Ireland has a population of around 1.9 million while Western Denmark (Jutland) has a population of around 2.2 million.

19 Note that this is not modelling a 6.91% decrease in electricity price of where it is at the moment, rather a 6.91% smaller electricity price relative to a business as usual (BAU) case where there is no offshore wind capacity.

Scenario six – gross economic impacts with electricity prices changes

To this point we have created individual scenarios to model the impacts relating to the investment in offshore wind in Northern Ireland. However, it Is likely that these impacts will occur in parallel which we model in scenario six. There are many possible combinations of impacts and for this scenario we try and model the most realistic possibility, this being the net impacts of offshore wind with the supply-side constraints combined with the impacts of changes in electricity price and investment in Belfast Harbour. Again, this is carried out for both capacity pathways (1GW and 2GW) and for both floating and fixed foundation offshore wind farms.

3. Simulation Results

In our modelling we carry out a range of scenarios to measure the economy-wide impacts of offshore wind development in Northern Ireland. Initially we carry out each of these scenarios individually to determine the impacts in isolation.

Scenario 1a Gross impacts - 1GW from 2030

Floating foundations

Overall, we estimate that, if the foundations are developed in Northern Ireland, then 1GW of floating offshore wind could increase Gross Value Added (GVA) in Northern Ireland by £960 million and increase employment by 8,360 person years[20] over the 60-year period. **Table 4** outlines some of the key results in different years.

Table 4: Key results at different time periods, % change from baseline (2018)[21] for 1GW of floating offshore wind[22]

	2029	2030	2031	2032	2033	2034	2036	2037
GVA	0.34%	0.10%	0.08%	0.07%	0.06%	0.05%	0.05%	0.04%
Household Consumption	0.67%	0.07%	0.07%	0.06%	0.06%	0.05%	0.05%	0.05%
Investment	0.88%	-0.20%	-0.13%	-0.08%	-0.05%	-0.03%	-0.01%	0.00%
Real Government Consumption	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Gross Wage	1.12%	0.16%	0.13%	0.10%	0.09%	0.08%	0.07%	0.06%
Real Gross Wage	0.64%	0.15%	0.12%	0.10%	0.08%	0.07%	0.07%	0.06%
Labour supply	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Capital Stock	0.13%	0.22%	0.16%	0.13%	0.10%	0.08%	0.07%	0.06%
Domestic Consumption	0.54%	0.12%	0.09%	0.07%	0.05%	0.04%	0.03%	0.03%
Indirect tax	0.80%	0.08%	0.07%	0.06%	0.06%	0.05%	0.05%	0.05%
Total household Tax	1.35%	0.22%	0.17%	0.14%	0.12%	0.10%	0.09%	0.09%
Consumer price index (cpi)	0.47%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.01%
Net Exports	-0.91%	0.15%	0.09%	0.05%	0.02%	0.00%	-0.01%	-0.02%
Employment	0.23%	0.06%	0.04%	0.04%	0.03%	0.03%	0.02%	0.02%

Source: *FAI calculations*

20 Person-years is a unit equal to the equivalent of one full time employee for the period of a year

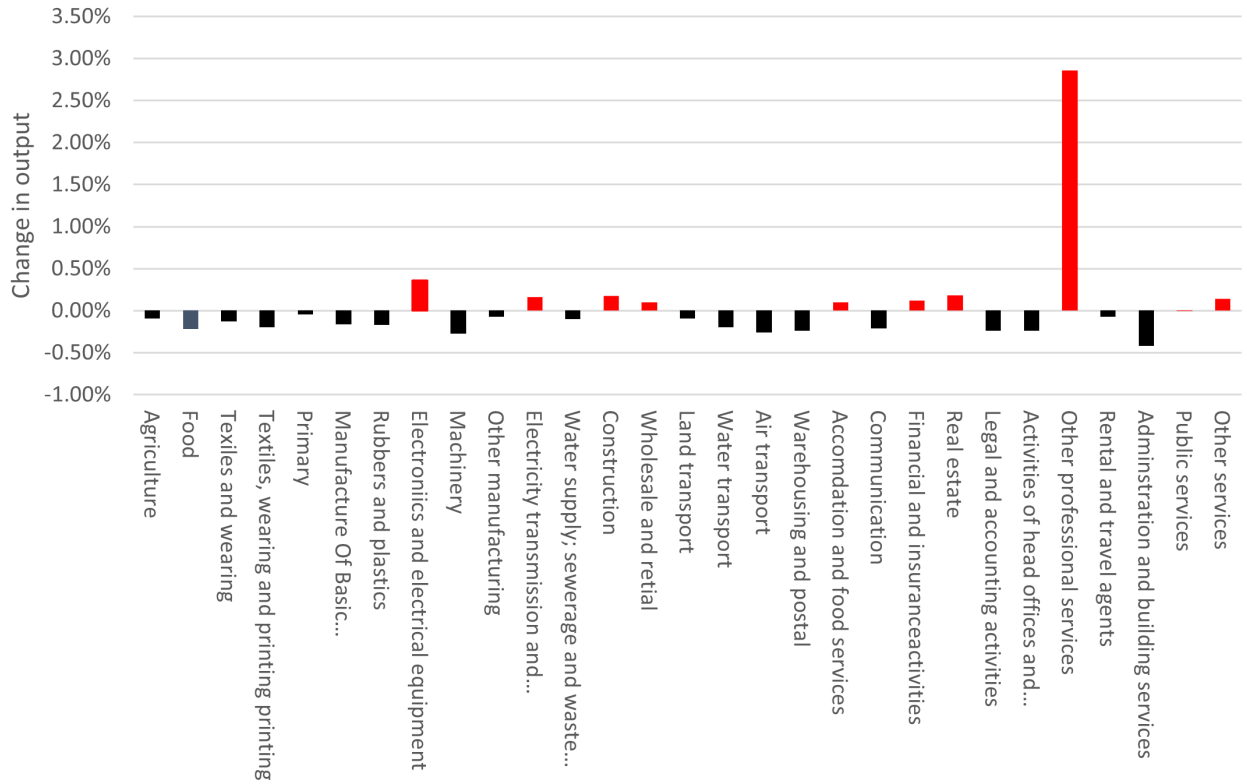
21 See Appendix B for definitions of variables.

22 Here we show the year before operation (2029) followed by the first year of operation (2030) and subsequent 6 years. While most of the impacts arise in 2026-2030 the dynamics (increase in GVA, employment, cpi etc) are the same as in 2029 with only the scale changing.

Investment in floating offshore wind, as you would expect, leads to an increase in employment which for 2029 (the period just before the completion of the first 1GW of capacity) we estimate to be around 1,790 person years. From column two of **Table 4** (2029), with an increase in overall employment there is a higher level of disposable income throughout Northern Ireland leading to an increase in household consumption of 0.67%. This increase in household consumption in conjunction with the investment in offshore wind increases prices resulting in a Consumer Price Index (CPI) increase of 0.47%. Also at this time, with increased bargaining power workers increase their real wage by 0.64%. Production costs increase due to increases in wages and CPI - driving the small reduction we see in net exports due to their less competitive positioN in the global market.

Throughout **Table 4**, we find a similar pattern whereby there is economic activity increases alongside increase with prices. While on aggregate the increase in floating offshore wind drives economic activity in Northern Ireland, this is not the case for every industry in the economy as we find some crowding-out effects linked to the afore mentioned prices increases. **Chart 1** outlines the sectoral change in output (value of all goods and services produced in £m) for 2029.

Chart 1: Sectoral change in output in 2029 for 1GW of floating wind[23]



Source: *FAI calculation*

By far the largest change in output is in Manufacturing of metal structures with a change of 19.73%19 (which has been omitted from **Chart 1**) in output linked to the fabrication of the offshore wind foundation structures. Increase in output is also found in: Electronics and electrical equipment; electricity; construction; wholesale and retail; accommodation and food services; financial services and other professional services with most of these linked to direct investment from floating offshore wind activities.

23 The manufacturing of metals has been omitted from the chart as the change in output of 19.73% distorts the graph.

However, for the other sectors of the economy there is a slight decrease in output due to the increase in prices throughout Northern Ireland linked to the increase in production and labour costs. Administrations and building services has the highest reduction in output at 0.42% with the public services sector seeing the least change in output compared with the business as usual case (i.e no changes in the economy). This is an important issue to note in economic appraisals.

When accounting for supply-side issues not everyone will be a winner, some of the industries not linked to the direct investment will suffer due to the change in prices – although as we have seen on aggregate there is an overall economic expansion as illustrated by the increase in GVA and employment.

In our scenarios, due to the majority the Northern Ireland Executive funding coming from central UK government in the form of the block grant, we have assumed that the NI executive yearly budget is fixed. While the government budget is fixed, the AMOS framework allows for the calculation of how much tax revenue changes in Northern Ireland. Concentrating again on 2029, the year before the first 1GW of offshore wind is assumed to come online, the taxable income linked to the increase in employment (i.e. total household tax) increased by 1.35% while other taxes linked to consumption (i.e. indirect tax) rise by 0.80%.

Fixed foundations

Carrying-out the same analysis for 1GW of fixed offshore wind capacity from 2030 we find the same dynamics as floating offshore wind as outlined in **Table 3**. The investment in offshore wind drives economic activity with increases in employment, GVA and household consumption with competing reduction in exports as prices increase.

While the dynamics are the same there are significant differences in the scale of economic impacts as for 1GW of fixed offshore wind the GVA impacts are 42% lower than the floating offshore wind case (£50 million compared with £960 million), while the employment impacts for fixed (4,570 person years) are only 55% that of floating (8,360 person-years).

The simple explanation for this key result is the cost, thus investment needed in the economy, is much greater for floating offshore wind. As noted in Section 2, Scenario One, many of the development costs of floating and fixed offshore wind farms are similar, with the major difference being in foundations with floating currently being around three times the cost of their fixed counterparts.

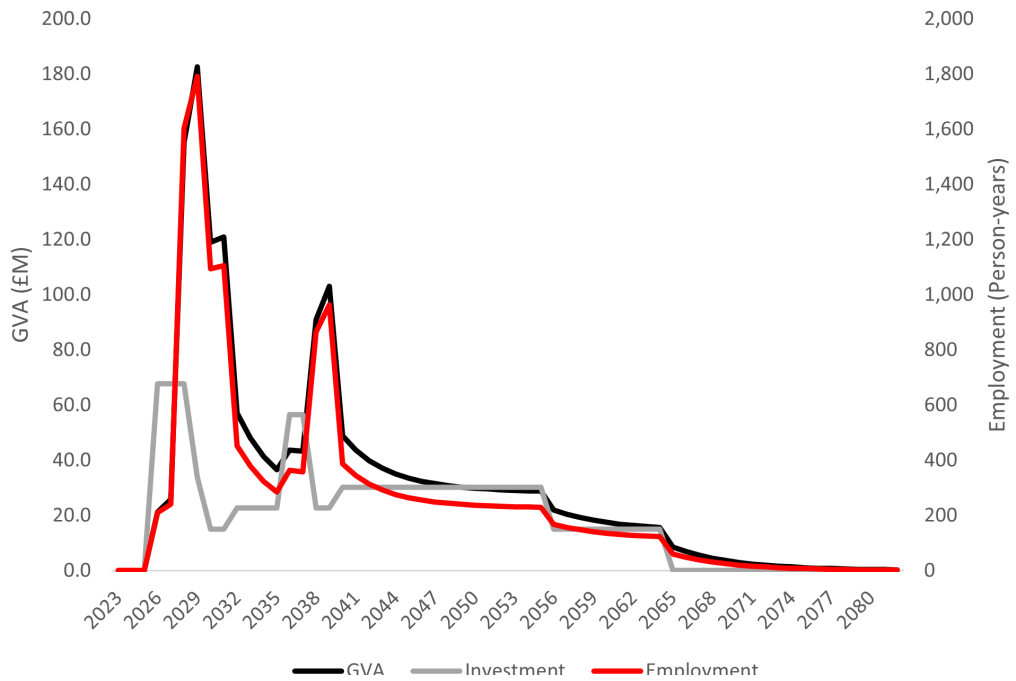
Unlike many of the components, due to the nation's expertise, most of the foundations for offshore wind are expected to be fabricated in Northern Ireland (as detailed in Section 2, Scenario One). Thus, the lower costs of fixed foundations mean less investment and as a consequence we see lower macroeconomic numbers, even accounting for the expected decrease in floating wind foundations cost overtime.

Scenario 1b - Gross impacts 2GW

Floating foundations

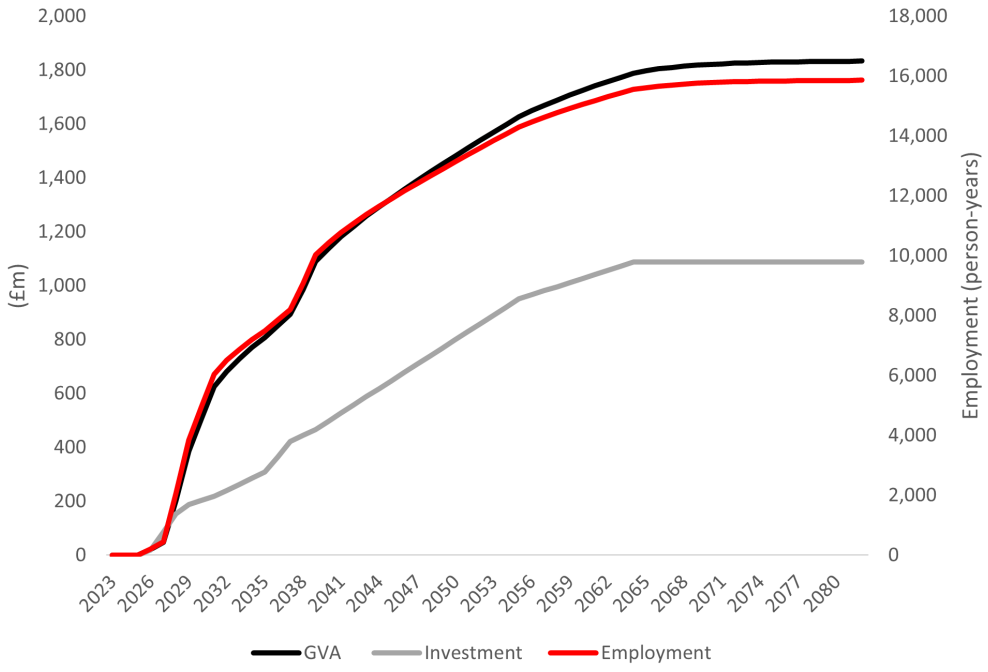
We then extend the scenario to increase the capacity of offshore wind to 2GW from 2040, with the yearly GVA and employment results found in **Chart 2** and **Chart 3** for floating offshore wind. **Chart 2** gives the impacts by year with cumulative impacts in **Chart 3** over the 60-year period.

Chart 2: Timing of yearly gross economic impacts linked to the investment of 2GW of floating offshore wind[24] (scenario one)



Source: *FAI calculations*

Chart 3: Timing of cumulative gross economic impacts linked to the investment of 2GW of floating offshore wind (Scenario one)



Source: *FAI calculations*

24 Total GVA and employment can be calculated as the area under the graph.

From **Chart 2** both GVA and employment follow similar patterns to investment, with some slight differences overall. Between 2023 and 2026 there is no increase in either GVA or employment as there is no investment in offshore wind over this time. However, in 2026 the pre-development costs for the first 1GW of wind capacity occurs and we see a small increase in both GVA and employment, with a more dramatic increase in 2029, with peaks occurring at £182.5 million and 1,792 person years of employment linked to the manufacturing of foundations. After these peaks there is a small drop of in both variables as the demand for goods and services is lower. Unlike more simple appraisal models, such as IO, the economic activity is not solely driven by demand, but also supply, hence there is a difference in the drop off rates between GVA and employment.

Between 2032 and 2035 there is a steep decline in economic activity as the only investment linked to offshore wind is the O&M cost for 1.5GW of capacity, which amounts to around £22.7 million annually spent in Northern Ireland. As CAPEX investment ramps up in 2036 for the last 500 MW of capacity we see again an increase in both variables with both having second peaks in 2039. After 2040 all offshore wind capacity is up and running with yearly local Northern Ireland O&M around £30.3 million. Again, unlike IO models, the supply-side of the economy has an effect that there is not a total drop-off in employment and GVA, rather there is gradual decrease with the first 1GW of capacity being decommissioned in 2055[25] and another 500 MW in 2057.

The final year of planned operation of the last 500 MW is in 2065, but from **Chart 2** we find that there is some economic activity after this time. This is the legacy effect linked to investment offshore wind, over time capital stock (i.e the amount of physical capital, such as cash and equipment, used in the production of goods and services) and employment has accumulated throughout the economy linked to direct, indirect and induced investment from offshore wind farms in Northern Ireland. This does not instantly disappear, rather the capital stock depreciates over time and the employment gradually reduces once the demand stops. During the time of capital and operational expenditures the real average wage throughout the economy is greater than the base year (2018) but once the investment stops these wages fall, which slows the need for reducing employment. Overall, the gross impact over 60 years, of investment for 2GW of floating offshore wind in Northern Ireland is an increase in GVA of £1.83 billion and 15,860 person-years of employment.

Fixed foundations

Over the 60-year period if all 2GW was fixed foundations these economic impacts would reduction to £1.1 billion and 8,740 person years of employment.

Scenario two – Gross impacts with local supply side constraints

Floating foundations

The mechanisms and dynamics for the second scenario are near identical to that of the first scenario as the increase in investment of offshore wind drives economic activity through the consumptions of goods and services as well as increase in employment. The major difference is in the scale of the impacts as well as timing of peak economic activity. The manufacturing of foundations, due to Northern Ireland expertise, is by far the largest opportunity for investment linked to offshore wind farm developments.

25 Depending on a number of factors there may be the option to repower some offshore wind farms, but this is not considered in this analysis.

However, if we take account of the potential capacity issues, we find that the economic benefits of floating offshore wind to Northern Ireland would be much reduced with the GVA impact falling to £580 million and employment of 4,660 person-years of employment (compared with £960 million and 8,740 person years in Scenario 1) for the 1GW from 2030 and £1.1 billion million and 8,740 with 2GW of floating offshore wind by 2040 (£1.83 billion and 15,860 person- years in Scenario 1).

Fixed foundations

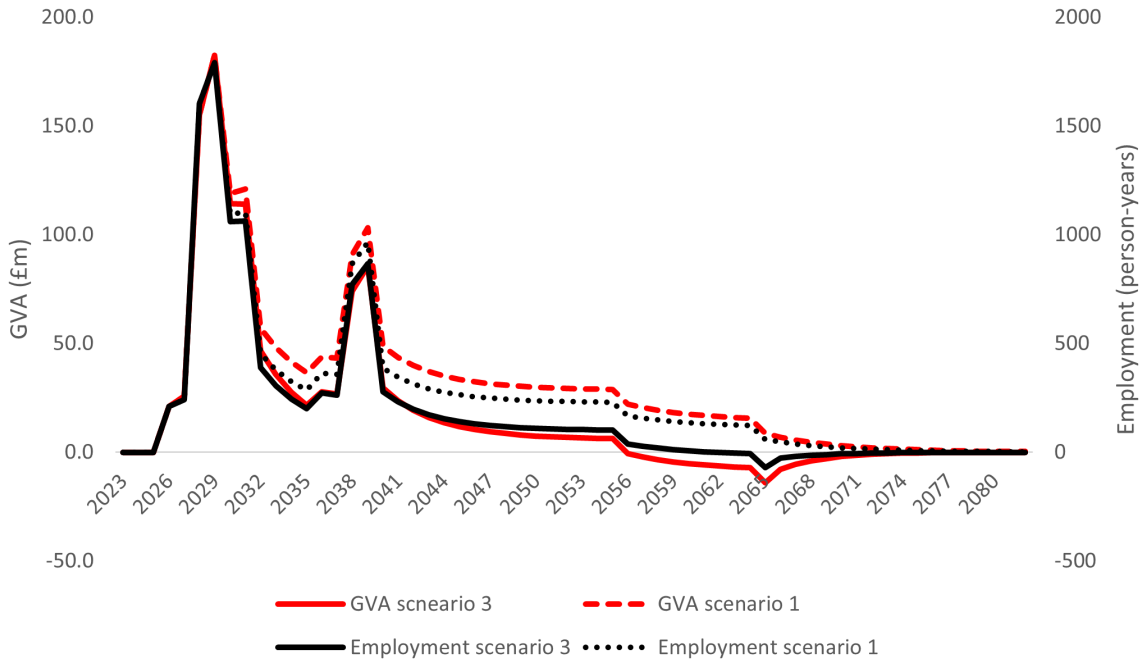
For fixed foundation capacity pathway 1GW from 2030 would increase Northern Ireland GVA by £390 million and employment 2,860 person-years of employment, while for capacity pathway 2GW by 2040 these number are with £720 million and 5,250 person-years – a 34% and 40% decrease (from scenario one) in GVA and employment respectively.

Scenario three – Net impacts

Floating foundations

In our scenario three for floating offshore wind, we find that even when accounting for the replacement of coal and gas by offshore wind there is still an increase in economic activity, but it is much reduced when compared to the gross impacts. Overall, for the floating offshore wind 1GW from 2030 capacity pathway, the expected GVA increase drops by 37% to £610 million, while employment falls to 6,330 person-years – a reduction from Scenario one of 24%. The proportionally smaller reduction in employment than GVA is linked to the fact that offshore wind O&M is on average more labour intensive than traditional coal and gas plants. For the 2GW from 2040 capacity pathway, the reduction is 42% for GVA and 27% in employment to £1.1 billion and 11,500 person-years of employment, respectively. **Chart 4** illustrates the GVA and Employment dynamics of both scenarios (one and three).

Chart 4: Timing of yearly net economic impacts linked to the investment of 2GW capacity pathway of floating offshore wind (scenario one and three)



Source: *FAI calculations*

With there being no change in the CAPEX cost, the impacts until 2030 are identical as there is no replacement of fossil fuel capacity. But after 2030 when the replacement of fossil fuel is accounted for, the economic impacts arising from the investment in floating offshore wind are dampened. At 2030, the net GVA impact of developing floating offshore wind is 4.07% lower than the gross impacts measured in scenario one, this difference rises to 18.24% by 2032. A similar difference is found until 2040 as the construction activity for the last 500MW negates some of the negative impacts of the reduction in fossil fuel generation. After 2040 when all floating offshore wind capacity is up and running and most of the fossil fuel generation is replaced, we find that there is a relatively large divergence compared with the gross impacts of scenario one. The net GVA impact in 2040 being 39.15% lower and 28.31% lower for employment than the gross impacts of scenario one. Between 2056 and 2073 the GVA impact for Scenario 3 is negative meaning that this is lower than the BAU case[26], driven by the fact that during the construction and operation of offshore wind there is a build-up of capital stock which depreciates overtime if there is less investment. Overall though this is a very small impact compared with increase in GVA seen across the previous year.

Fixed foundations

For the fixed foundation net impacts, even after accounting for the lower investment needed for fixed foundation, the impacts on the Northern Ireland economy will still be positive if fixed foundation offshore wind foundations replace current fossil fuel generation, albeit with much smaller GVA increases compared with scenario one of £30 million and £320 million for both capacity pathways (1GW from 2030 and 2GW from 2040) respectively[27].

Scenario four – Gross impacts with Belfast harbour upgrades

In this scenario, we account for an estimated[28] £160 million needed for the upgrades of Belfast harbour to enable the transfer of larger structures like floating and fixed offshore wind foundations to the farm locations. The assumption is that £160 million of investment is attributed to the construction industry, but this is funded through the reallocation of expenditure based on current government spending patterns. Overall, in this scenario with floating offshore wind it is estimated that with including the necessary upgrades to the port systems, the uplift in GVA is £990 million for the 1GW capacity pathway and £1.86 billion for the 2GW capacity pathway with the employment numbers being 7,850 and 15,350 person-years of employment, respectively. In the fixed foundation case, the increase in GVA and employment for the 1GW capacity pathway is £590 million and 4,040 person-years and £1.1 billion and £8,220 person-years of employment for the 2GW capacity pathway.

Comparing the 1GW & 2GW capacity pathways results for both fixed and floating with scenario one, we find that there is a similar increase in GVA of in the region of £20-30 million at the same time as a slight decrease in employment of around 500 person-years of employment. As all simulations within this scenario are modelling the same £160 million increase in harbour upgrades funded from the government budgets, the differences in results are expected to be similar.

While overall government spending stays the same, the reduction in person-years of employment is driven by the trade-off between spending in labour intensive industries such as social care for the

26 This doesn't mean that there is a reduction in GVA compared with 2018 rather the GVA during these times is lower than where it would have been compared with the BAU case.

27 These are only economic impacts. The reduction of fossil fuel generation will have environmental benefit of reduction in GHG gas emissions which may have additional economic benefits. For this to be calculated a full social environmental appraisal would be needed which is out of the scope of this project, there are however some examples of the socioeconomic evaluation of GHG emissions in the UK green book (UK Government, 2023).

28 Estimates through discussion with offshore wind developers in Northern Ireland.

more capital and less labour-intensive construction sector.

Over the full 60-year period of the scenario this. When comparing to Scenario one, amounts to very little change in the GVA and employment figures thus there should be no economic issue in investing in the harbour systems at the same time as investing in offshore wind energy. However, there may be social and/or political issues related to the allocation of funds from the public purse to invest in what could essentially be a private enterprise in pursuing environmental goals, but this is outwith the scope of this report. As outlined in footnote 18, this is only one option for harbour upgrades, there are several options which could be explored which will have varying economic impacts.

Scenario five – gross impacts with electricity price changes

Floating foundations

Scenario five, where both the demand and supply-side are accounted for, gives by far, the largest positive economic impact related to the investment in offshore wind energy. We estimate over the 60-year period that, for the 2GW capacity pathway of floating offshore wind, GVA could increase to £8.6 billion and there would be an employment of 47,750 person years over this period[29]. This is 4.7 and 3 times the increase in GVA and employment respectively, when compared with the demand only case in scenario one. **Chart 5** shows the evolution of the GVA and employment impacts over the 60-year period with the development of 2GW of floating offshore wind capacity.

Chart 5: Timing of yearly gross economic impacts linked to the investment for a 2GW capacity pathway of floating offshore wind with price changes (scenario five)

Source: *FAI calculations*

The evolution is much the same as is found in **Chart 2**, which only accounts for the demand side, however the major difference being the scale of the impacts. For example, in 2034 the GVA increase is £41 million for scenario one compared with £182 million for scenario five.

29 For the 1GW capacity pathway, the increase in GVA is £3.1 billion and 22,297 person-years of employment.

This scale of increase is found across time within this scenario.

With the reduction in electricity prices, goods and services in Northern Ireland becoming cheaper to produce, which not only drives up domestic consumption but also competitiveness in the export market. In scenario 1 the "crowding-out" of industries not directly linked to offshore wind was outlined. The decrease in electricity price counteracts this crowding-out, meaning more industries increase output throughout the 60 years by being more competitive on the global market[30].

Fixed foundations

Similar to previous scenarios, the dynamics of investment of fixed foundation offshore wind is similar to that of the floating simulation. For example, the 2GW capacity pathway of fixed foundation, is estimated to lead to increases in GVA of £7.8 Billion and 42,730 person-years of employment. Again, this demonstrates how much the economic impacts are dominated by the prices changes as the difference in GVA impacts between floating and fixed foundation for the 2GW capacity pathway is only 9%, compared with the 40% for Scenario one.

Scenario six – gross impacts with electricity price changes

In this final scenario we report on potentially the most realistic situation for offshore wind in Northern Ireland. This is the net demand (investment) and supply (price) impact of offshore wind in Northern Ireland replacing fossil fuel generation in the electricity mix with upgrades to Belfast Harbour and constraints on foundation fabrication due to other policy goals (warship contract). Across the two types of wind farms and both capacity pathway (1GW and 2GW), we find significant positive economic impacts, reported in **Table 5**.

Table 5: Summary results for combination scenario six

	GVA (£m)	Employment (person-years)
Floating (1GW)	2,820	13,390
Floating (2GW)	6,120	29,010
Fixed(1GW)	2,220	8,960
Fixed(2GW)	5,580	24,120

Source: *FAI calculations*

Northern Ireland has the objective of becoming Net Zero by 2050 and these results show that this can be done in a way which dives economic activity, a key goal of recent energy policy in Northern Ireland. The analysis on how the investment in offshore wind drives economic activity has been detailed in Section 3 and **Table 4** outlines that the 2GW capacity pathway of offshore wind could increase Northern Ireland GVA by between £6.12 billion and £5.58 billion (depending on farm type) and increase employment up to 29,010 person-years.

30 Appendix A carries out some sensitivity analysis around export prices.

Conclusions

Recent environmental policy (i.e., Climate Change Act (Northern Ireland) in Northern Ireland has stipulated that at least 80% of electricity consumption should be from renewable sources by 2030 and by 2050, in terms of greenhouse gas emissions, should be in a net zero position. Currently the vast majority of renewable electricity generation comes from onshore wind but with technical and societal issues limiting the growth potential for onshore wind, the electricity system in Northern Ireland must be diversified further. Being an island with a high wind resource, offshore wind is seen as a pivotal technology if Northern Ireland is to meet its Climate Change Act related targets. In addition to the environmental goals, the recent energy strategy in Northern Ireland have increased emphasis on green economic growth, which due to the large investment needed, offshore wind can contribute to. In this paper, an investigation is made into the economic impact of investment in offshore wind in Northern Ireland, across two capacity pathways: 1) to reach 1GW from 2030 and2) 2GW from 2040, on the net zero transition by 2050 targets.

Currently there are no operational offshore wind farms in Northern Ireland but there is the goal of at least 1GW being in operation from 2030. Using this goal as a base, and information from other sources, another 500MW is predicted to be online by 2032 (BGVA, 2022) and we estimate a further 500MW from 2040 bringing the total to 2GW. With these two capacity pathway estimates, we model a series of scenarios for both floating and fixed foundation offshore wind farms, with different assumptions are made, these are:

- Scenario one: Full gross economic impact appraisal of 1 and 2GW capacity pathways of offshore wind in Northern Ireland with high level estimates on local content supply. Economic activity in this scenario only arises due the direct and indirect impacts of investment in offshore wind.

- Scenario two: Full gross economic impact appraisal of 1 and 2GW capacity pathways of offshore wind in Northern Ireland with high level estimates on local content supply but with capacity limitation issues modelled. This is similar to scenario one but through discussions with developers, it was realised there is the potential for supply chain issues related to foundations. The main contractor for offshore wind foundations in Northern Ireland, H&W, recently won the contract to build components for three royal navy warships, which may lead to capacity issues meaning the foundations need to be built outside Northern Ireland.

- Scenario three: Full net economic impact appraisal of 1 and 2GW capacity pathways of offshore wind in Northern Ireland with reduction in fossil fuel generation. In most economic appraisals the focus is on the gross impact (i.e., new) arising from investment decisions. But 'net' impacts are important for electricity/energy investments as the new technologies will replace older generation, which we model in this scenario.

- Scenario four: Full gross economic impact appraisal of 1 and 2GW capacity pathways of offshore wind in Northern Ireland with high level estimates on local content supply but upgrades to Belfast harbour accounted for. Through discussions with developers, it was also realised that the current Belfast harbour, due to sea depth, is unsuitable for transport of offshore foundations from land to see. As estimation of £160 million is needed to sufficiently upgrade the harbour to enable transport. Scenario four extends scenario one by accounting for these upgrades assuming that the £160 million is spent in the construction sector and is funded by a reallocation of government spending based on the current spending pattern.

- Scenario five: Full gross economic impact appraisal of 1 and 2GW capacity pathways of offshore wind in Northern Ireland with high level estimates on local content supply and change in electricity prices. In the appraisal of offshore wind, we use a CGE model which allows for estimation of both the demand and supply side impacts of economic changes. In the previous four scenarios the focus was on the demand side (i.e., investment) changes driving economic activity. However, by investigating the academic literature, there is evidence that increasing offshore wind capacity reduces consumer prices, which produces positive system-wide economic activity. In scenario five we model the change in electricity price along with the investment of offshore wind capacity. Annex A further gives a further simulations whereby other nation's electricity price reduces similar to Northern Ireland. While this does has some impact on GVA and employment, the impacts of electricity price reduction in Northern Ireland are still significantly large compared with impacts related to construction and operation of offshore wind.

- Scenario six: Each of the previous scenario impacts are investigated in isolation, however potentially they will occur in parallel. This final scenario is a combination of the most realistic assumption for offshore wind in Northern Ireland -net demand (investment) and supply (price) impact of offshore wind in Northern Ireland replacing fossil fuel generation in the electricity mix with upgrades to Belfast harbour and constraints on foundation fabrication.

The impacts of the investment of offshore wind in Northern Irelands is largely dependent on the type of wind farm, capacity, and scenario. **Table 6** summaries the aggregate GVA and employment impacts across all simulations over a 60-year period.

Table 6: Summary impacts of the five scenarios, across two capacity pathways and farm type[31]

	GVA (£)			
	1GW Floating	1GW Fixed	2GW Floating	2GW Fixed
Scenario 1 - Gross impacts	960	570	1,830	1,090
Scenario 2 - Gross impacts with local supply constraints	580	390	1,090	720
Scenario 3 - Net impacts	610	30	1,060	320
Scenario 4 - Gross impacts with Belfast harbour upgrade	990	590	1,860	1,110
Scenario 5 - Gross impacts with electricity price changes	3,930	3,430	8,550	7,800
Scenario 6 – Combination	2,820	2,200	6,120	5,580

	Employment (person-years)			
	1GW Floating	1GW Fixed	2GW Floating	2GW Fixed
Scenario 1 - Gross impacts	8,360	4,570	15,860	8,740
Scenario 2 - Gross impacts with local supply constraints	4,660	2,860	8,740	5,250
Scenario 3 - Net impacts	6,330	1,480	11,500	4,360
Scenario 4 - Gross impacts with Belfast harbour upgrade	7,850	4,040	15,350	8,220
Scenario 5 - Gross impacts with electricity price changes	22,490	18,180	47,750	42,730
Scenario 6 - Combination	13,390	8,960	29,010	24,120

Source: *FAI calculations*

31 GVA rounded to nearest £10m and employment nearest 10 person-years. All monetary values (GVA etc, costings etc) are in 2024 prices.

Some key takeaways from Table 6 are:

- Across all scenarios, investment in offshore wind in Northern Ireland leads to increase in economic activity as these are large scale investment projects. This is even true when accounting for the impacts of reducing fossil fuel generation (as modelled in scenario three).

- Floating offshore has larger economic impacts as these are much more expensive to develop than fixed foundation wind farms. Much of the economic activity in Northern Ireland is driven by the fabrication of offshore wind foundations (either floating or fixed).

- On a normalised basis for the combination scenario (6) £1,000,000 of investment in floating offshore wind increases Northern Ireland GVA by 450,000 and supports 2.71 person-years of employment whereas for fixed £1,000,000 increase GVA by £460,000 and supports 2.37 person years of employment. Appendix E gives the table for the normalised impact across all simulations.

- There are some non-environmental policies (mainly the building of three new warships) which may limit the potential economic benefit of offshore wind in Northern Ireland.

- The supply-side impacts related to the reduction (compared with the Business As Usual case) in electricity prices are much greater than that of only the investment in the construction and maintenance in offshore wind. This is consequences rarely identified in the policy or academic literature.

- Taking the most realistic situation for offshore wind in Northern Ireland (scenario six) we find that the economic growth could be between £6.12 billion and £5.58 billion (depending on farm type) and increase employment up to 29,010 person-years over a 60 year period.

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Appendix A – Fixed Exports with price changes

In scenario five we initially we take the standard approach and say that only Northern Ireland's electricity price is impacted upon with the increases in offshore wind capacity and externally prices do not change, thus in relation to the rest of the UK and ROW prices are lower. This has a positive economic consequence as goods and services developed in Northern Ireland are cheaper and are likely to be bought in greater quantities from outside the region. However, this may not be the case as the move to renewable electricity is a world-wide phenomenon so it may be the case that across the world electricity prices fall in relation to where they would have been without the green transition. To fully analysis we would need a multi-regional CGE framework as well as detail on nations plans for the type and capacity of renewable electricity generation over the next 60 years.

This is out of scope for this project. However, we can carry out some sensitivity around our results by fixing Northern Ireland's exports to the rest of the UK and rest of the world. By doing this we are essentially assuming that the move towards renewables does not make Northern Ireland more competitive on the global market as increasing renewable electricity capacity is a world-wide phenomenon, meaning the decrease in electricity prices only effects domestic consumption. **Table 7** outlines the key GVA and employment results for scenario five with fixed exports.

Table 7: Scenario 5 for with price changes and if exports are fixed

	GVA	
	1GW (2030)	2GW (2040)
Floating foundations (scenario five)	3,930	8,550
Fixed foundations (scenario five)	3,430	7,800
Floating foundations (exports fixed)	3,920	8,320
Fixed foundations (exports fixed)	3,190	7,140
	Employment	
	1GW (2030)	2GW (2040)
Floating foundations (scenario five)	22,490	47,750
Fixed foundations (scenario five)	18,180	42,730
Floating foundations (exports fixed)	22,770	46,490
Fixed foundations (exports fixed)	16,580	36,010

Source: *FAI calculation*

In **Table 7** we see the impact fixing exports has on the results for scenario five for both the fixed and floating foundation offshore wind farms and capacity pathways (1GW and 2GW). Overall, from **Table 7**, across all simulations, we can say that while the fixing of exports does have some difference, the impact of electricity price reduction from the development of offshore wind is clearly still the driver of economic activity.

Appendix B – Variable Explanation

Gross Value Added – the percentage difference, compared with BAU on the values of goods and services produced in Northern Ireland

Household Consumption – the percentage change, compared with BAU, in the aggregate consumption of goods and services from households, this includes domestic production and imports.

Investment – the percentage difference, compared with BAU in the production of physical capital, the tangible man-made goods such as machinery, which is used are the production of goods and services.

Real Government [Gov] Consumption – the percentage difference, compared with BAU in government spending in real terms (i.e. accounting for inflation).

Gross wage – the percentage difference, compared with BAU in the average gross wage value across Northern Ireland in nominal terms (i.e the current value).

Real gross wage – the percentage difference, compared with BAU in the average gross wage rate across Northern Ireland in real terms.

Labour supply – the percentage difference, compared with BAU in the population of working age (16-65) adults.

Capital stock – the percentage difference, compared with BAU of the total physical capital (human-created tangible assets or inputs that are used to support the production of goods and services).

Domestic consumption – the percentage difference, compared with BAU in the total consumption of domestically produced goods and services.

Indirect tax – the percentage difference, compared with BAU), in the value of taxes raised linked to changes in consumption (i.e vat, business taxes).

Household tax – the percentage difference, compared with BAU in tax take linked to employment (i.e income tax and national insurance).

CPI supply – the percentage difference, compared with BAU the consumer price index [CPI].

Exports – the percentage difference, compared with BAU in total exports to other regions (RUK and ROW).

Employment – the percentage difference, compared t with BAU, in the number of people in employment in full-time equivalent.

Capital Expenditure (CAPEX) – Expenditure in the development of offshore wind. Includes pre-development, construction and operation.

Appendix C – Comparison of floating and fixed offshore wind farms costs

Table 8: Comparison of floating and fixed offshore wind farms costs

Category	Floating	Fixed	Unit
CAPEX			
Development and project management	180,120	133,210	£/MW
Development and consenting services	81,650	56,140	£/MW
Environmental surveys	10,570	3,670	£/MW
Resource and metocean assessment	7,930	4,400	£/MW
Geological and hydrographical surveys	10,570	4,450	£/MW
Engineering and consultancy	10,570	4,450	£/MW
Project management	54,030	60,090	£/MW
Wind turbine	1,561,000	1,113,970	£/MW
Balance of plant	2,041,310	814,610	£/MW
Array cable	85,250	38,950	£/MW
Export cable	240,150	144,670	£/MW
Cable accessories	52,830	2,230	£/MW
Floating substructure	1,152,740	456,270	£/MW
Structure	948,610	311,600	£/MW
Mooring systems	216,140	0	£/MW
Offshore substation	180,120	139,110	£/MW
Onshore substation	98,460	33,390	£/MW
Installation and commissioning	444,290	488,150	£/MW
Inbound transport	10,450	0	£/MW
Offshore cable installation	168,110	244,830	£/MW
Mooring and anchoring pre-installation	81,650	0	£/MW
Floating substructure - turbine assembly	81,650	111,290	£/MW
Floating substructure - turbine installation	63,640	55,640	£/MW
Offshore substation installation	28,820	38,950	£/MW
Onshore export cable installation	6,840	33,390	£/MW
Offshore logistics	2,640	4,060	£/MW
OPEX			
Operations and maintenance	85,250	84,520	£/MW/year
Operations	28,820	25,990	£/MW/year
Maintenance	52,830	56,760	£/MW/year

Source: *Offshore Renewable Catapult. (2023a,b)*

Appendix D - Combination of simulations produced through CGE modelling covering the scenario; capacity pathway and farm type

Table 9: Combination of simulations produced through CGE modelling covering the scenario; capacity pathway and farm type

Scenario	Capacity Pathway			
	1GW from 2030		2GW from 2040	
1 – Gross Impacts	FIXED (1A)	FLOATING (1A)	FIXED (1B)	FLOATING (1B)
2 – Gross Impacts and local content supply constraints	FIXED (2)	FLOATING (2)	FIXED (2)	FLOATING (2)
3 – Net impacts	FIXED (3)	FLOATING (3)	FIXED (3)	FLOATING (3)
4 – Gross impacts and harbour upgrade	FIXED (4)	FLOATING (4)	FIXED (4)	FLOATING (4)
5 – Gross impacts and supply effects through electricity prices	FIXED (5)	FLOATING (5)	FIXED (5)	FLOATING (5)
5A – Gross impacts and supply effects through electricity prices and exports fixed	FIXED (Appendix A)	FLOATING (Appendix A)	FIXED (Appendix A)	FLOATING (Appendix A)
6 – Net impacts; local content supply constraints; harbour upgrade and supply effects through electricity prices	FIXED (6)	FLOATING (6)	FIXED (6)	FLOATING (6)

Source: *FAI calculations*

Appendix E - Normalised results across all simulations

Table 10: Normalised results across all simulations

Millions pounds increase in GVA with million pound of investment				
	1GW Floating	1GW Fixed	2GW Floating	2GW Fixed
Scenario 1 - Gross impacts	0.15	0.12	0.15	0.11
Scenario 2 - Gross impacts with local supply constraints	0.09	0.08	0.09	0.07
Scenario 3 - Net impacts	0.10	0.01	0.09	0.03
Scenario 4 - Gross impacts with Belfast harbour upgrade	0.16	0.12	0.15	0.11
Scenario 5 - Gross impacts with electricity price changes	0.63	0.72	0.69	0.77
Scenario 6 – Combination	0.45	0.46	0.50	0.55
Person-years per million pounds of investment				
	1GW Floating	1GW Fixed	2GW Floating	2GW Fixed
Scenario 1 - Gross impacts	1.69	1.21	1.63	1.10
Scenario 2 - Gross impacts with local supply constraints	0.94	0.76	0.90	0.66
Scenario 3 - Net impacts	1.28	0.39	1.18	0.55
Scenario 4 - Gross impacts with Belfast harbour upgrade	1.59	1.07	1.58	1.03
Scenario 5 - Gross impacts with electricity price changes	4.55	4.80	4.91	5.36
Scenario 6 - Combination	2.71	2.37	2.98	3.02

Source: FAI calculations

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