Employment in Ireland by NACE code and selected TIM scenarios up to 2030

Scoping study part A.

November 2021

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Contents

1. Introduction

The Climate Action and Low Carbon Development (Amendment) Bill 2021 sets the Climate Change Advisory Council the task of proposing carbon budgets to the Minister. The first two five-year budget periods ending on 31 December 2030 should provide for a reduction of 51% in the total amount of greenhouse gas (GHG) emissions reported, relative to the year ending on 31 December 2018. The Bill also specified that the allocation of carbon budgets should be decided according to a list of criteria including the economy[1] and climate justice.

This paper presents the current available employment data in Ireland, by sector and location, and outputs from the energy sector model TIMES-Ireland or 'TIM' to discern the the investment flows necessary in individual sectors between 2018 and 2030 to reduce Irish greenhouse gas emissions on a scale included in the Bill. TIM is an energy system model that determines potential pathways to meet future carbon mitigation targets.[2] It is a linear optimization model which selects the optimal technology mix to meet future energy-system demand at minimum cost. Policy constraints, such as restrictions on emissions, can also be imposed.

Comparing changes in investment flows with current sectoral and regional employment numbers from the CSO provides preliminary insights to where employment effects might occur. This should facilitate a preliminary consideration of the societal implications associated with different pathways to reduce emissions by 2030. The scope of the paper does not include the impacts on the agriculture, food and drink sectors, as TIM does not include investment output for these sectors.

2. Employment in Ireland by NACE code

NACE codes are the statistical classification of economic activities in the European Union. They ensure consistent data collection for comparative purposes at a European and global level. The most recent version is NACE Revision 2, established by Regulation (EC) No 1893/2006.[3] Sectors of the economy in NACE Revision 2 are broken down into 21 broad sections from A to U. Within each section, NACE codes are classified further by 'division' (two-digit codes from 1-99), followed by 'group' (three-digit codes from 01.1-99.0) and, at the most granular level of detail, 'class' (four-digit codes from 01.11 to 99.00). The full list of the NACE sections and divisions is included in the Appendix. Irish data by NACE code is available from the Irish Central Statistics Office (CSO)[4] and Eurostat[5] and covers topics such as investment, production inputs and outputs, energy use, value added, wages, productivity and employment.

The CSO's quarterly Labour Force Survey (LFS) and Eurostat provide data by NACE section (A-U) on unemployment and participation rates by sex, age, and by NUTS III[6] region in Ireland. The LFS also provides national sectoral employment data, split by the 88 divisions specified by the NACE codes.[7]

[1] 3(3)(a)(ii)IV: 'in so far as practicable, the need to maximise employment, the attractiveness of the State for investment and the long term competitiveness of the economy'

[2] The TIM has been developed by the Energy Policy and Modelling Group, MaREI in UCC. More information on the model can be found here: https://tim-review1.netlify.app/about

[3] NACE Rev. 2 : https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF

[4] Central Statistics Office Labour Force Detailed Employment Series: https://www.cso.ie/en/statistics/labourmarket

[5] Eurostat Database: https://ec.europa.eu/eurostat/data/database

[6] The NUTS III code is an 8-region division of Ireland for statistical purposes, established by Eurostat

[7] https://www.cso.ie/en/methods/labourmarket/labourforcesurvey/aboutthelabourforcesurvey/

Beyond the divisions, the data available depends on relevance in the local economy and ensuring data protection for individual enterprises. The CSO's annual Business Demography Survey (BDS) provides some detailed group level data (01.1-99.0) by county. Available data by county, relevant to TIM outputs, will be discussed further in Chapter 10.

According to the Labour Force Survey 2019 Q4, the highest number of people employed in Ireland by NACE division were in retail ((NACE 47), 9%), education ((85), 8%), human health activities ((86), 7%), food and beverage services ((56), 5%), public administration and defense ((84), 5%), and social work ((88), 4%). Outside of these services, agriculture (4.3%), computer programming and consultancy (3.5%), specialised construction (3.3%), and financial services (2.9%) were major employers. Other notable areas of employment, which each account for between ~2% of total employment, include wholesale trade, legal activities, accommodation, transport, housing construction, manufacturing, pharmaceuticals, services to building and landscaping, residential care, and motor trades.[8]

Over the past two decades, there has been a shift away from industrial employment (317 thousand people employed in 2000 to 245 thousand in 2018) and toward employment in retail, public sectors and professional activities. The share of occupations has similarly moved away from skilled trades and elementary roles (only 32% in 2018) and toward managers and professionals (41% of total employment in 2018).

The total job vacancy rate, or the share of vacancies relative to the total number of occupied positions and vacancies, is low by international standards at around ~1%. Opportunities in 2018 were highest in financial services (2.2%) and professional activities (2.7%) and lowest in construction (0.3%).[9] It should be noted that the unemployment rate in April 2020 pre-Covid was relatively low at 4.7% (compared with 5.8% in April 2021), however the COVID-19 Adjusted Measure of Unemployment could indicate a rate as high as 22.4% if all claimants of the Pandemic Unemployment Payment (PUP) were classified as unemployed.[10] A low vacancy rate combined with low unemployment numbers would indicate that some sectors have little capacity for additional employment. The impact of the Covid pandemic on employment capacity in sectors affected by climate targets needs analysis.

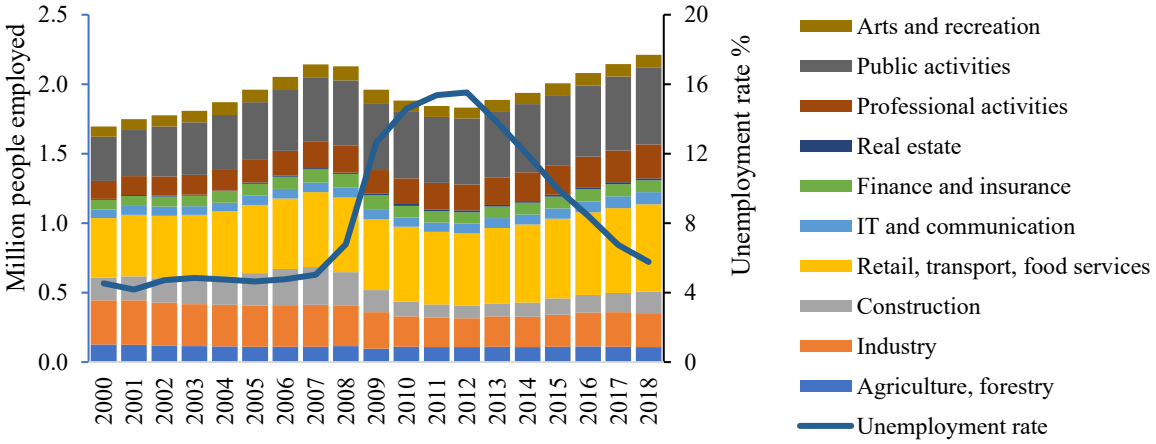
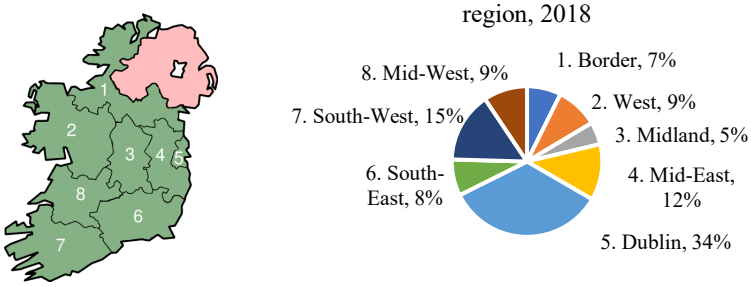


Figure 1. Employment by economic sector in Ireland
Source: Eurostat 2021

[8] CSO Labour Force Survey Detailed Employment Series 2021: https://data.cso.ie/
[9] CSO Earnings, Hours and Employment Costs- Job Vacancies by Economic Sector NACE Rev 2, Private or Public Sector, Quarter and Statistic – Table EHQ 16
[10] CSO Monthly unemployment 2021: https://www.cso.ie/en/releasesandpublications/er/mue/monthlyunemploymentapril2021/

3. Regional employment overview

Regional employment in Ireland is concentrated in Dublin, where 28% of the population live (according to the 2016 Census) and 34% of the persons employed are located. Outside of the capital, 15% of persons employed in Ireland are in the South West (counties Cork and Kerry) and 12% are in the Mid-East counties outside Dublin (Kildare, Meath, Wicklow and Louth). The remaining 38% of the working population are distributed throughout the South East, West, Midlands and Border counties. A larger share of people reside in these counties at 43%, where the difference can be attributed to commuting patterns and the age profiles of residents.



NACE division	Classification of Economic Activities	Share of Persons Employed 2018
A	Agriculture, forestry and fishing	5%
B-E	Manufacturing, Electricity, Water Supply	11%
F	Construction	7%
G-I	Wholesale/retail, transport, accommodation, food	28%
J	Information and communication	4%
K	Financial and insurance activities	4%
L	Real estate activities	1%
M-N	Professional, scientific, tech; admin and services	11%
O-Q	Public admin, education, health and social	25%
R-U	Arts, entertainment, other services and households	4%

Figures 2-5: Employment in Ireland by NUTS III region and NACE division, 2018
Source: Eurostat 2021

The sectors that employ the most people, according to NACE sections, vary somewhat between regions. In 2018, by broad sectoral level, the largest share of employment was in the wholesale/retail, transport, accommodation and food sectors (27-33% depending on the region) and public sector employment such as education, health and defense (23-28%). Combined, these accounted for almost 58-59% of

employment in the Midlands and Mid-East, compared to 51% in Dublin. The manufacturing, construction and agricultural sectors employed 23% of the Irish workforce on a national basis in 2018, but up to 30% of the workforce in Border, West and Midlands.

Regional unemployment in 2018 was highest in the South-East (7.7%), followed by the Midlands (6.6%) and the West (5.8%). Conversely, Dublin, the Mid-East, South-West, and Border counties have lower unemployment rates than the national average at around 4%.

4. CO_2 mitigation scenarios, 2018-2030

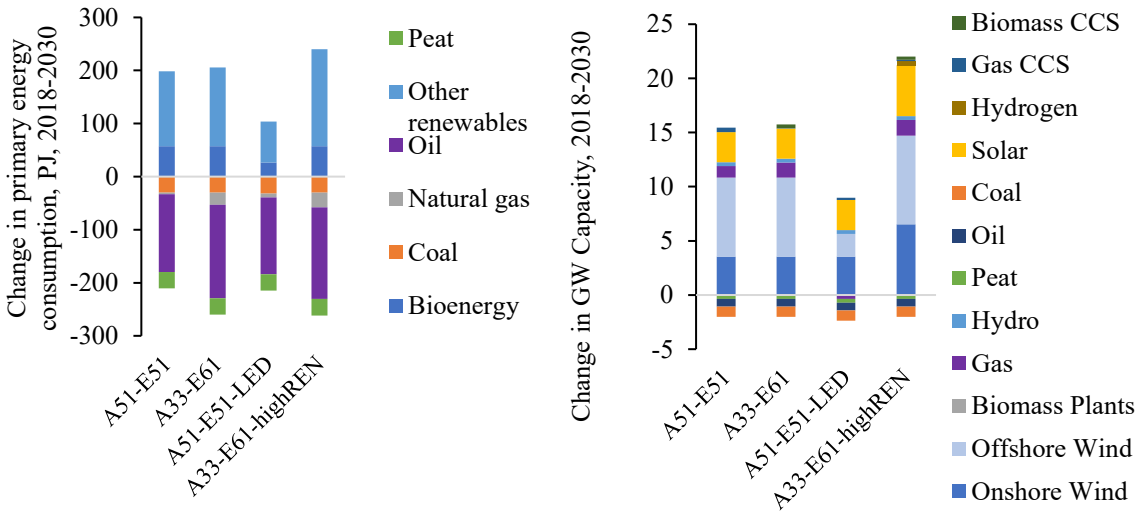
Scenarios which outline various potential trajectories to meet the overall 51% GHG reduction target by 2030, as specified by the Climate Action and Low Carbon Development (Amendment) Bill 2021, have been developed using TIM, an energy systems model created by the MaREI Energy Policy and Modelling Group (EPMG) at University College Cork.

TIM is the successor to the Irish TIMES Model. It determines the least cost technology mix required to meet a given energy demand and future carbon mitigation target. The results provide evidence based net-zero emissions energy system pathways for Ireland which inform the achievement of national decarbonisation targets for 2030 and the potential for net zero emissions by 2050. It should be noted that, at the time of writing this report, the TIM results presented below were preliminary and still under development.

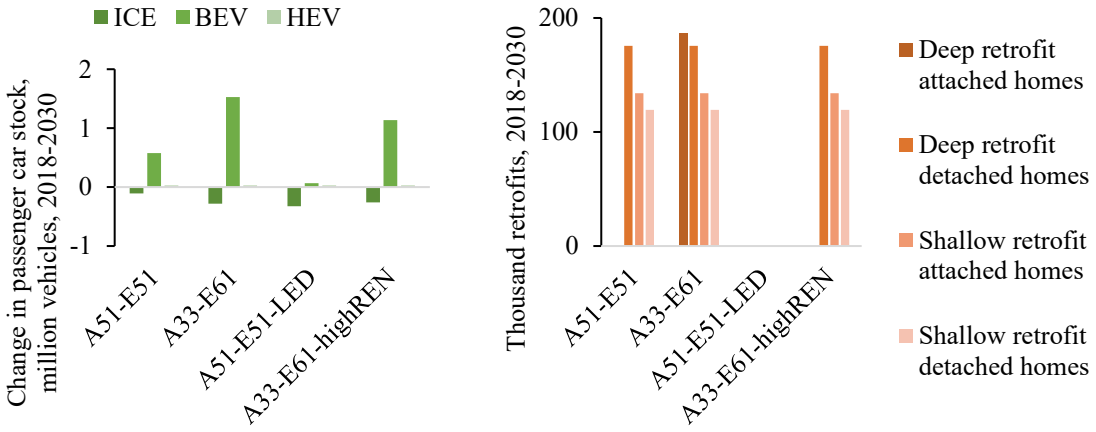
Scenarios

The four scenarios selected for analysis vary in terms of the assumptions regarding the level of abatement in the agricultural sector and therefore the decarbonisation required from the energy sector. In 2018, agricultural emissions accounted for 34% of Irish GHGs in 2018, largely from methane and nitrous oxide.

1. A51-E51: Agriculture reduces GHG emissions at the same rate as other sectors (7% per annum), requiring energy and process emissions to reduce to 19.6 Mt CO2 in 2030, from around 40 Mt in 2018. As a result, agriculture and the energy sector reduce their emissions equally, by 51%.
2. A33-E61: The second scenario assumes more effort on the energy side and less on agriculture by 2030, such that agriculture achieves 33% emissions reductions, and energy achieves 61% emissions reductions.
3. A51-E51-LED: The Low Energy Demand (LED) scenario represents the energy sector meeting GHG emissions targets through structural changes in energy service demands and de-materialising the economy. Broadly, this encompasses densification of settlement patterns, very significant investment in public transport and walking and cycling transport, and de-materialisation of the economy, which enables large-scale modal shifts in transport, lower heat demand in buildings and lower demands for materials such as cement.
4. A33-E61-highREN: The final scenario is the same as the second, with more emphasis on carbon savings from the energy sectors, but also with higher installed capacity of renewables, most notably, onshore wind.



Figures 6, 7: Change in primary energy supply (PJ) and installed capacity (GW) between 2018 and 2030 under four 51% GHG reduction scenarios
Source: TIM-Ireland (formerly TIMES-Ireland), Energy Policy and Modelling Group, 2021



Figures 8, 9: Four TIM scenarios, change in passenger vehicles and retrofits, 2018-2030. ICE = internal compression engine; BEV = battery electric vehicle; HEV = hybrid electric vehicle.
Source: TIM-Ireland (formerly TIMES-Ireland), Energy Policy and Modelling Group, 2021

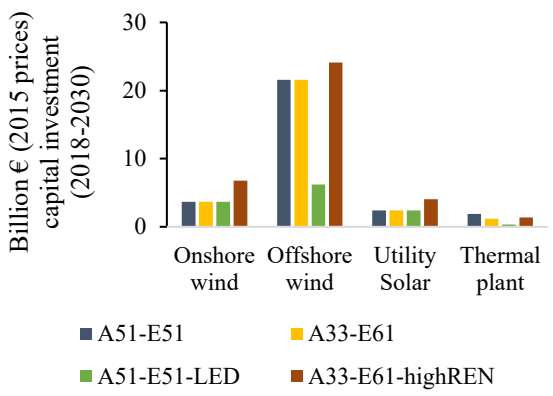
5. Capital investment in the power sector

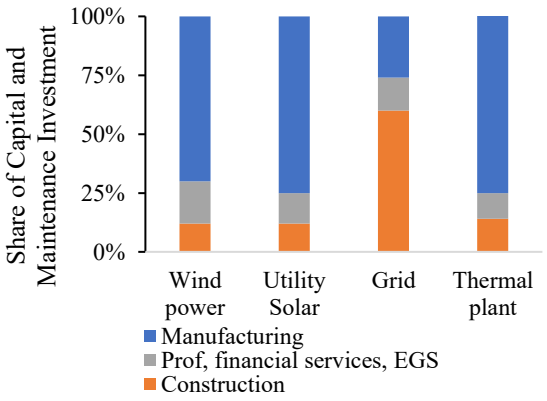
The capital investment required is displayed below for each of the scenarios. The A51-E51 and A33-E61 scenarios have the same new power generation capacity by 2030, with an additional carbon capture and storage plant in A51-E51. Based on the technology costs per kW from TIM, reaching these targets implies ~€25 billion investment in wind capacity, ~€3 billion in utility scale solar and ~€2 billion in conventional plant between 2018 and 2030. The LED scenario requires considerably less capital expenditure on offshore wind capacity as policies are targeted towards lower dependency on energy, while the high-REN scenario assumes double the investment in onshore wind and utility solar.

Broadly speaking, up to 75% of investment in new power generation capacity is spent on the materials required to build a new plant or wind farm and will flow to manufacturing industries in the power sector.

The top turbine manufacturers are based in countries such as Denmark, the United States and China, in a relatively established, saturated market. Around 15% of investment is spent on construction, the on-site activity during the build process for between 1-4 years, and the rest goes toward financial and professional services such as consultancy and engineering, and roles in the Electricity, Gas and Steam sector.[11] The latter can range in length from less than a year in the planning phase, to longer term expenditure on research, environmental management, and electricity production.[12]

Investment in the transmission grid is the exception, where the bulk of investment is spent on the installation of cables and towers, civil engineering and safety, and only around one quarter of investment goes toward the manufactured materials, which in most cases are imported. Including at least one additional interconnector, to France or Great Britain, and upgrades to the existing grid to facilitate decarbonisation of the energy sector, implies an additional €4 billion investment by 2025.[13]





Figures 10, 11: Capital investment in power generation and the sectors where expenditure flows
Source: TIM-Ireland 2021 *Source: SEAI 2015*

6. Operations and maintenance (O&M) in the power sector

An area that will see ongoing expenditure if Irish climate targets are met is the maintenance of offshore wind turbines (particularly in scenarios A51-E51, A33-E61 and A33-E61 high-REN). Current estimates for the fixed maintenance costs of offshore wind are over double that of onshore wind (€77/kW/yr versus €30/kW/yr)[14], although maintenance costs could reduce over the next ten years in a similar fashion to onshore wind as the technology matures. Assuming O&M costs remain constant, by 2030 the O&M required to support >7 GW of offshore wind farms in Ireland will total €566 million per year. Wind farms are remotely operated and controlled and require gathering of data in real-time (wind speeds, temperature, etc.). The activities surrounding the management and upkeep of offshore wind

[11] SEAI 2015. Ireland's Sustainable Energy Supply Chain Opportunity: https://www.seai.ie/publications/Ireland___s-Sustainable-Energy-Supply-Chain-Opportunity.pdf
[12] An Enterprising Wind - An economic analysis of the job creation potential of the wind sector in Ireland: https://www.esri.ie/publications/an-enterprising-wind-an-economic-analysis-of-the-job-creation-potential-of-the-wind-sector-in-ireland
[13] EirGrid, Grid 25: http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-GRID25.pdf
[14] TIM technology costs

include management of contracts, operations and onshore facilities, and offshore servicing and logistics.[15]

Utility scale solar and onshore wind will also require long term operations and maintenance professionals in the electricity, gas and steam sectors. However, utility scale solar tends to have lower long term fixed costs compared to onshore wind power and allocates a lower share of expenditure to onsite maintenance and relatively more towards the leasing of land and the repair of electrical equipment.[16]

A reduction in expenditure on existing fossil fuel plants is expected due to the closure of oil, peat and coal plants in order to meet emissions targets. This could cease spending of approximately €33 million a year on conventional plant fixed O&M costs effecting onsite electricity, gas and steam professionals, machinery repairs, and administration and insurance activities.

Potential employment impacts

Employment impacts depend not only on investment in future installed capacity, but how much investment is captured domestically. IWEA (2017) cites EWEA analysis which estimates 15.1 direct jobs per MW are created in the construction of onshore wind farms, 12.3 of which are likely to be created abroad in manufacturing and 1.2 of which are filled by foreign teams which install the turbines. A shortage of skilled professionals in the maintenance of new renewable power sources may result in the temporary immigration of labour from abroad if professionals are not available locally. Many of the jobs in renewable energy maintenance are high skilled, so it would be necessary to support the development of job seekers to enter the industry. With upskilling as the industry continues to grow, Ireland's workforce could be generally well positioned to capture investment in specialised construction and services. According to a recent study on the economic impact of renewable energy in Scotland, 1,400 people were directly employed (full time equivalent) in 2019 in the construction and upkeep of 981 MW of offshore wind.

Sources: IWEA 2017. Jobs and Investment in Irish Wind Energy
Fraser of Allander Institute 2020. The Economic Impact of Scotland's Renewable Energy Sector

7. Changes in primary fuel demand and supply

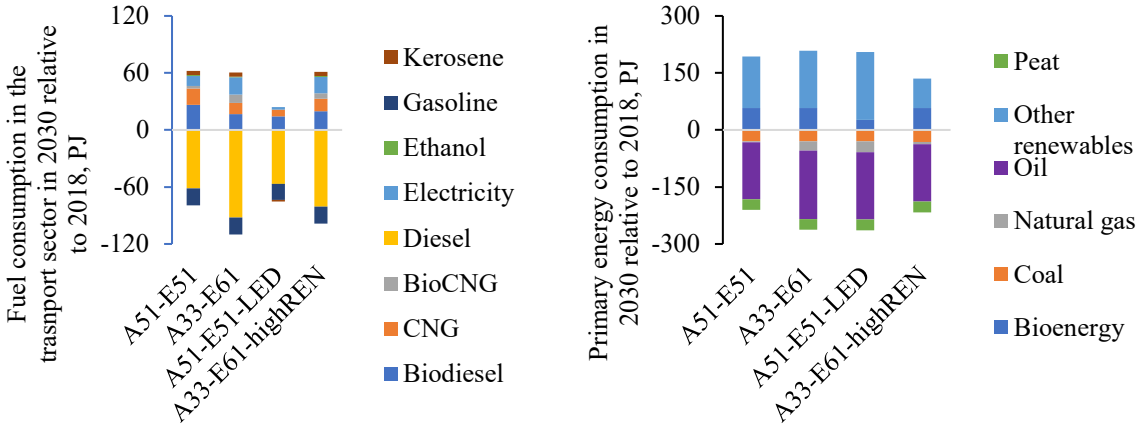
TIM scenarios assume that Ireland will gradually rely less on imported primary fuels, such as oil and gas, as it switches over to domestically produced renewable electricity, and electrifies a growing share of the heat and transport sectors. Relative to 2018, by 2030 oil consumption is expected to fall by 56% in the A33-E61 and A51-E51 LED scenarios or 47% in the A51-E51 and A33-E61 high-REN scenarios. This is primarily due to the vehicles in the transport sector starting to move away from diesel and gasoline, but is also attributed to the shift away from kerosene as a source of residential heat and retrofit activity reducing the overall demand for home heating. Oil-fired heating accounted for 45% of total residential heat in 2018, but this is expected to drop to between 5% and 12% by 2030, as the number of electrically driven heat pumps and sources of ambient heating in households increase. In terms of passenger transport, while the number of private vehicles with an internal combustion engine on the

[15] IRENA 2018. Offshore wind investment, policies and job creation: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Sep/IRENA_offshore_wind_note_G7_2018.pdf?la=en&hash=B186614D923AB1F0A07D7285612C4B037057A0C0.
[16] SEAI 2017. Solar Chain Opportunity: https://www.seai.ie/publications/Solar-Chain-Opportunity-report.pdf

road may only reduce from around 2.1 million to between 1.75 and 1.97 million by 2030, depending on the scenario, fuels such as CNG, bioCNG and domestically produced biodiesel become more prevalent.

There is some displacement of the use of fossil fuels including: coal, as Moneypoint power station shuts down; peat, with a phasing out of peat as a source of residential heat and power; and natural gas. Expenditure on the transport and storage of these fuels will be affected. This will be replaced to a certain degree by domestically produced biofuels, however, the transition will lead to unemployment and require upskilling of the workforce in the short term. For instance, as Moneypoint is closed, the transport and storage of coal and the operations and maintenance at the plant will be no longer be required. However, if maintained as a site for power generation, this will gradually be replaced with professionals involved in the upkeep of renewable power such as offshore wind and potentially the storage and distribution of hydrogen.

The production and distribution of domestically produced bioenergy implies domestic spending on the use of up to 71 PJ of locally produced biofuels and 31 PJ of domestic natural gas per year by 2030 (relative to total primary energy demand in Ireland of approximately 618 PJ in 2018, declining to slightly below or above 600 PJ by 2030 depending on the scenario). The production of bioenergy requires professionals across the agriculture and forestry sectors, and well as in research and development and natural sciences. There will need to be an expansion of waste management and treatment services, as domestically produced biodiesel and biogas become more prevalent.



Figures 12, 13: Fuel consumption in the transport sector and primary energy consumption in all sectors, 2030 relative to 2018; Source: TIM-Ireland 2021

8. Retrofits and new heating technologies

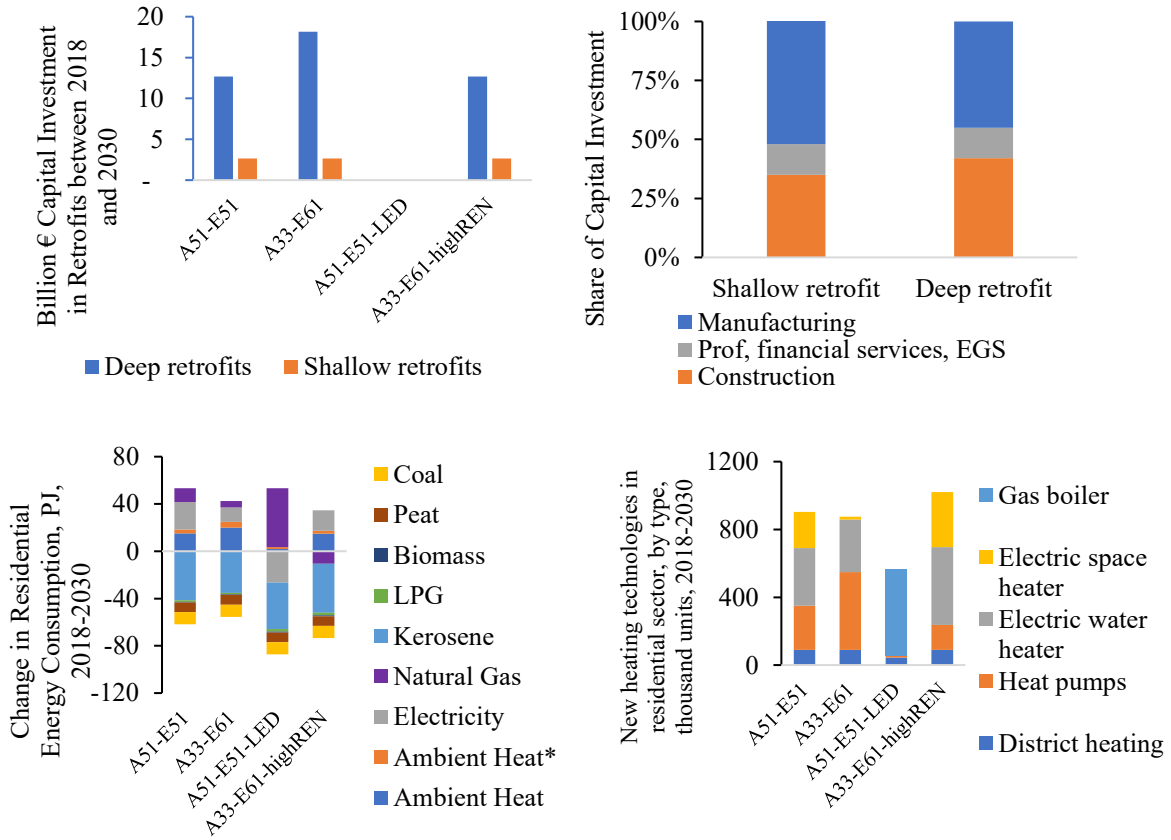
The A51-E51, A33-E61, and A33-E61-highREN scenarios all assume 250k shallow retrofits and 175k deep retrofits take place between 2018 and 2030. In comparison to scenario A51-E51, a higher rate of emission savings in the energy sector in A33-E61 is partially due to additional deep retrofit activity in the attached residential building stock (175k extra deep retrofits), and almost double the amount of heat pumps installed (458k compared to 259k). As a result, energy demand in the residential sector falls by approximately 10.5% compared to 2018 in the A33-E61 scenario versus 7% in the A51-E51 scenario.

Investment in retrofit activity has a large stimulating impact on the construction sector. Between 2018 and 2030, to reach the A51-E51 target, approximately €13 billion will need to be invested in deep retrofits (cavity, internal, external wall, roof and loft insulation, windows and doors, and new renewable heating systems) and €2.6 billion will need to be spent on shallow retrofits (roof and loft insulation,

windows and doors).[17] The more ambitious A33-E61 target would require an additional €5.5 billion spent on deep retrofits, €21.1 billion in total. Figures 14-17 show the different retrofit approaches in the four scenarios and the implications for fuel and technologies mixes.

The skills required for deep retrofits include the manufacturing and installation of insulation material and new heating technologies, such as heat pumps and efficient electric boilers (approximately 45-50% of total costs), specialised labour from the construction sector (~40% of costs), and professional advisory and financial services (10-15%). The need to import specific lighting, pipes, wire materials and, to some degree, heating technologies is likely.

In addition to ~15k deep retrofits and ~21k shallow retrofits a year needed between 2018 and 2030 to meet the less ambitious of the targets (A51-E51), there is expected to be approximately 470k new residential dwellings built between 2018 and 2030, equating to nearly 40k a year. This is in contrast to approximately 21 thousand new units built in 2019, up from around 18 thousand in 2018, and 14 thousand the year before that.[18] Considering the labour force that will be required for mass retrofit programmes, as well as new housing, there is a significant risk of a shortage of supply of skilled labour to meet the requirements in the construction sector.



Figures 14-17: Capital investment in retrofits, the sectors where expenditure flows, change in residential energy consumption and new heating technologies, 2030 relative to 2018 in 4 TIM scenarios
Sources: TABULA 2014 (Fig.14); TIMES-Ireland, Energy Policy and Modelling Group 2021 (Fig.14,16,17); SEAI 2015 (Fig.15)

[17] Calculated from the number of retrofits in each scenario multiplied by retrofit costs for shallow/deep, attached/detached dwellings taken from TABULA: https://episcope.eu/fileadmin/tabula/public/docs/brochure/IE_TABULA_TypologyBrochure_EnergyAction.pdf

[18] CSO 2021, New Dwelling Completions: https://www.cso.ie/en/releasesandpublications/er/ndc/newdwellingcompletionsq12021/

9. Transport

The predominant change in fuel use in the transport sector between 2018 and 2030 is the reduction in the use of diesel, and to a lesser degree, petrol, with a higher share of biodiesel, and some use of compressed natural gas. Up to 92 PJ worth of diesel is displaced in A33-E61 scenario leading to the potential for significant savings on imported transport fuel. In addition to changes in fuel consumption, there is a considerable move away from private car use, most dramatically in the lower energy demand (LED) scenario, to be replaced with more public transport and a modal shift from driving to walking and cycling.

Depending on the scenario, there is projected to be between approximately 600 thousand and 1.5 million new electric passenger vehicles on the road by 2030. With the shift toward electric vehicles, consumers will be required to pay far higher upfront costs on the vehicle itself, which cost upwards from around €30k in 2018, but will pay lower taxes, maintenance and fuel costs. Analysis by MIT on future mobility costs suggest that EVs cost in the order of $10,000 more to manufacture than their combustion engine equivalent.[19] Taking into consideration potential changes in battery and global raw material costs over the next decade, MIT predicts that mid-sized EVs will remain at least $5,000 more expensive than ICEs in 2030 and beyond.

In terms of the additional purchasing cost of electrifying passenger transport, TIM scenarios indicate that the vast majority of uptake of electric vehicles is going to occur in the latter half of the decade as costs decline. Assuming an additional €7,500 per vehicle, this would equate to between €4.5 and €11.6 billion additional upfront costs on purchasing new private vehicles between now and 2030. Most of this investment will be transferred along the supply chain to car manufacturers located outside of the country. Despite higher upfront costs, MIT asserts that total cost of ownership, incorporating maintenance and fuel costs, is expected to reach parity with conventional vehicles by around 2025, although the exact year is sensitive to future electricity costs, fuel costs, the rate of increase in the carbon tax, vehicle maintenance costs, and battery life.

On top of the capital expenditure on vehicles, investment in charging infrastructure will be necessary. The majority of charging is projected to take place in the home or workplace, with more expensive, faster units available for public charging. The EU's Alternative Fuels Infrastructure Directive (AFID) (EU/2014/94) has set deployment targets for publicly accessible chargers up to 2030 with an indicative ratio of 1 charger per 10 electric cars. The capital cost of fast chargers (80-120 kW for 25 to 40-minute charging) ranges between €40k and €80k per charger.[20]

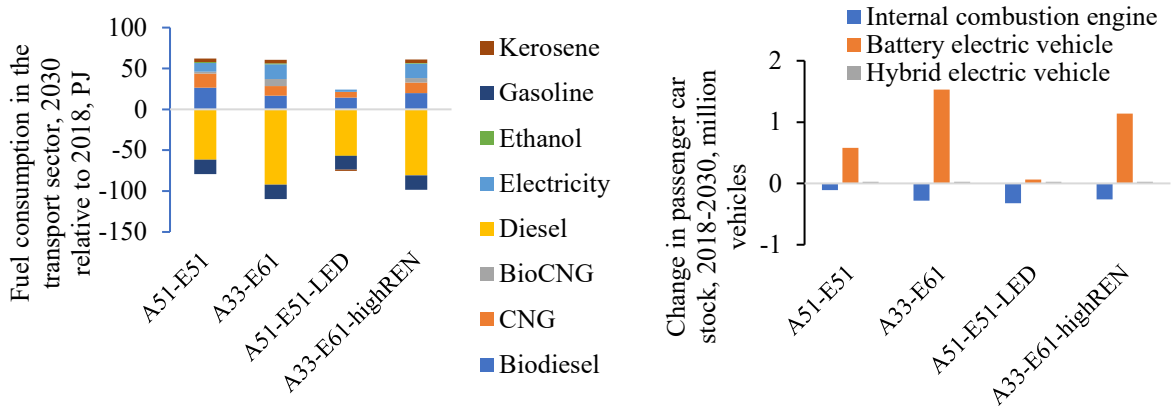
In the near term, a higher share of electric vehicles and renewable transport fuel is expected to predominantly stimulate sectors in Ireland related to the production and storage of biofuels, upgrades to the electricity network, and the associated civil engineering for new charging stations. The potential reduction in prices in the second hand market and affordability for low income households, who are generally priced out of the market for new cars, is a wider socio-economic issue that needs analysis. Recent research in the UK has started to look at the total cost of ownership savings if low income households were able to lease or buy second hand EVs.[21] In addition to affordability, there are implications for the exchequer in terms of the loss of revenue from motor oil taxes, the cost of grants,

[19] MIT 2019, Insights into Future Mobility: Executive Summary: https://energy.mit.edu/wp-content/uploads/2019/11/Insights-into-Future-Mobility-Executive-Summary.pdf

[20] PwC 2021, Electric Vehicles Charging Infrastructure: https://www.pwc.com/us/en/industries/industrial-products/library/electric-vehicles-charging-infrastructure.html

[21] Element Energy 2021, Electric Cars: Calculating the Total Cost of Ownership for Consumers: https://www.beuc.eu/publications/beuc-x-2021-039_electric_cars_calculating_the_total_cost_of_ownership_for_consumers.pdf

tax reliefs, and the different incentives that may be required to assist the uptake of new and/or used electric vehicles.



Figures 18-19: Fuel consumption in the transport sector and change in passenger car stock, 2030 relative to 2018 in 4 TIM scenarios
Source: TIM-Ireland 2021

10. Existing employment in sectors directly impacted by CO_2 mitigation scenarios

	NACE Section	**NACE Division (two-digit code), CSO's LFS 2019 Q4** ***NACE Group or Class (three or four-digit code) if available, CSO's BDS 2017***	**000 employed persons aged 15 and over, (%)**
A	Agriculture, forestry	Crop and animal production (01)	101.1 (4.3%)
		Forestry and logging (02)	n/a
C	Manufacturing	Manufacture of fabricated metal products (25)	15.6 (1%)
		Manufacture of electrical equipment (27)	n/a
		Manufacturing of machinery, equipment n.e.c. (28)	9.8 (0.4%)
		Repair and installation of machinery and equipment (33)	7.1 (0.3%)
D	Electricity, gas, steam	Electricity, gas, steam and air conditioning supply (35)	12.8 (0.5%)
E	Water, sewerage, waste	Waste collection, treatment and disposal activities; materials recovery (38)	7 (0.3%)
F	Construction	Civil engineering (42)	16.4 (0.7%)
		Specialised construction activities (43)	78.1 (3.3%)
G	Wholesale and retail trade	Wholesale and retail trade and repair of motor vehicles and motorcycles (45)	37.4 (1.6%)
		Retail trade (47)	215.6 (9.1%)
		Of which: Retail sale of automotive fuels (47.3)	*15.5*
H	Transport and storage	Land transport and transport via pipelines (49)	53.2 (2.3%)
		Warehousing, transport support activities (52)	29.6 (1.3%)
K	Financial and insurance activities	Financial service activities, except insurance and pension funding (64)	68 (2.9%)
M	Professional services	Legal and accounting activities (69)	54.9 (2.3%)
		Architectural and engineering activities; technical testing and analysis (71)	34 (1.4%)
		Of which: Engineering activities and related technical consultancy (71.12)	*19.7*
		Scientific research and development (72)	6.9 (0.3%)
		Of which: Other research and experimental development on natural sciences and engineering (72.19)	*3.1*
N	Admin and support services	Office administrative, office support and other business support activities (82)	18.1 (0.8%)

Existing employment in sectors directly impacted by CO_2 mitigation scenarios is sourced from the CSO's Labour Force Survey (LFS) 2019 Q4 and the Business Demography Survey (BDS) 2017. Detailed BDS data covers sectors B to N only and is based on administrative data received from the Revenue, whereas the LFS covers all sectors at a two-digit level and is based on household survey data collected every quarter. In 2017, the Business Demography Survey collected detailed county level data on active enterprises and employment numbers in Ireland.[22] According to that survey, 1.5 million people were employed in enterprises in 2017, compared to 2.2 million employed in the total labour force in the LFS the same year[23]. The BDS also includes high level sectoral employment extending across B to S NACE codes by county (all employment excluding agriculture, forestry, fishing and household activity), which totaled 1.92 million in 2017. The county level distribution of the working population in sectors B to S is displayed in the figure below. An usually high share of employment in Co. Westmeath is due to the fact that one of the main offices for the Department of Education is based in Athlone, where over 63 thousand people employed in the education sector are registered.

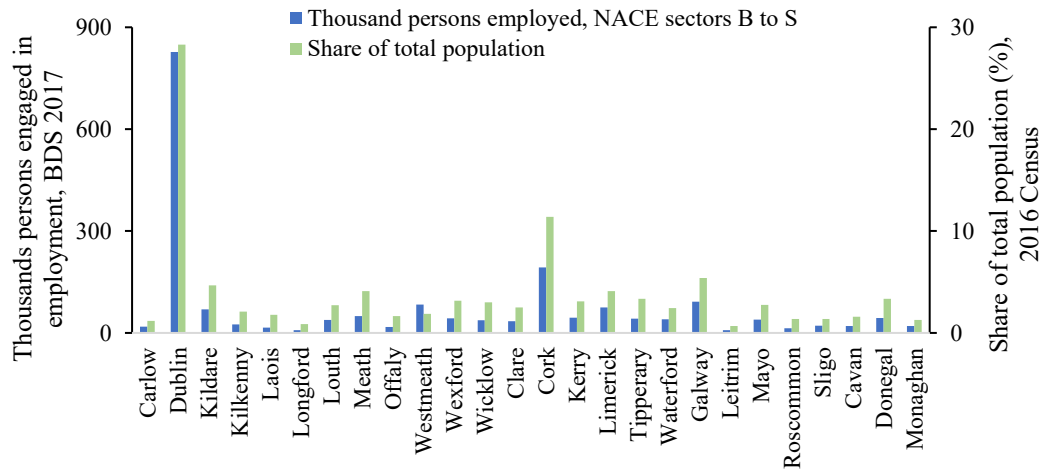


Figure 20: Thousand persons engaged in employment, total in NACE sectors B-S, Business Demography Survey 2017, contrasted with the share of the total Irish population (%), 2016 Census
Source: Business Demography Survey, CSO 2021; CSO Census 2016

Industry (B-E)

Industry (NACE sectors B-E or 5-39), which includes Manufacturing, and Electricity, gas, steam and air conditioning supply, employs ~245 thousand people in the country. It employs between 14-15% of the working population in the Midlands and Mid-West (~45 thousand people), compared to 7% in Dublin. Between 12-13% of the working population are employed in these sectors in the remaining regions.

The Electricity, gas, steam and air conditioning supply sector (NACE D, 35) employed 12.5 thousand people nationally according to the LFS 2019. Regional data for this sector are only available in the LFS for Industry as a whole. The BDS 2017 has persons employed in the Electricity, gas, steam sector by country, but almost all of the 8.37 thousand are registered in Dublin. This may be due to the fact that the location of the headquarters of most electricity generation companies are in Dublin.

County level data from the BDS for the Manufacture of machinery and equipment n.e.c. (28), includes the manufacturing of mechanical components, turbines, pumps, tools, general-purpose machinery, etc. Employment is relatively distributed across the country, with the highest shares in Cork, Dublin, Kerry

[22] CSO Business Demography Survey: https://data.cso.ie/table/BRA21
[23] https://www.cso.ie/en/releasesandpublications/er/lfs/labourforcesurveylfsquarter42017/

and Carlow. It accounts for approximately 6% of total employment in sectors excluding agriculture in Carlow and 3% in Kerry and Monaghan.

Figure 21: Manufacture of machinery and equipment n.e.c. (28), thousand persons employed, 2017
Source: Business Demography Survey, CSO 2021

Repair and installation of machinery and equipment (33) employed 7.1 thousand people in 2019 according to the Labour Force Survey. This sector includes the repair and specialised installation of machinery. On a county level, the majority of people working in this sector were located in Dublin, Clare and Cork. While only accounting for <0.5% of employment in Dublin and Cork, it accounted for 4% of employment outside of agriculture in Clare.

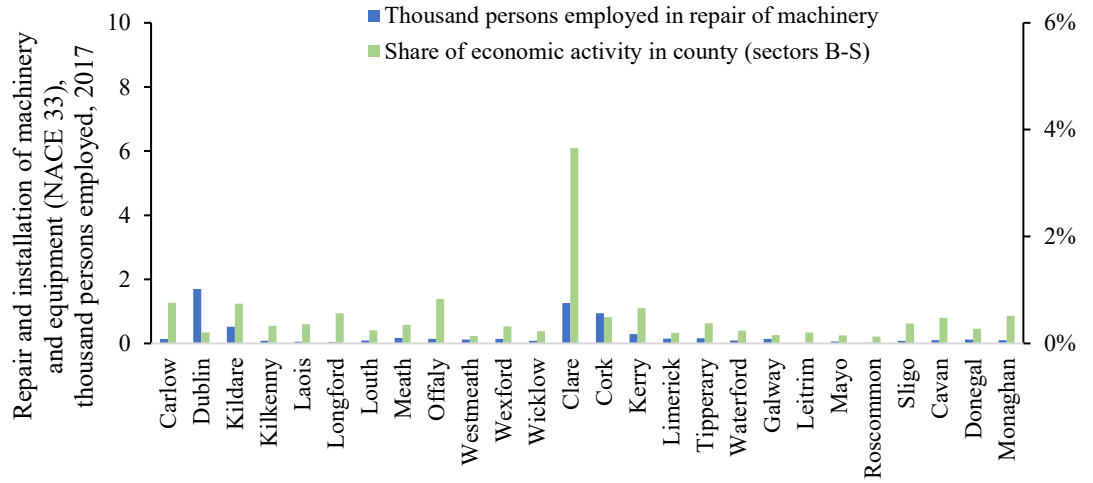


Figure 22: Repair and installation of machinery and equipment (33), thousand persons employed, 2017
Source: Business Demography Survey, CSO 2021

Gross Value Added (GVA) at basic prices (or the total output in the economy minus the intermediate consumption to produce output) was €303 billion in 2018. Industry contributed €101 billion, construction €8.5 billion, and agriculture €3 billion. Compared to other EU member states, Ireland had the highest manufacturing GVA as a percentage of total GVA (35%) in 2018. Services (84-97) in Ireland had the highest relative value added compared to output, while Agriculture and Construction had the lowest.[24]

[24] CSO Output and Value Added by Activity 2018: https://www.cso.ie/en/releasesandpublications/ep/p-naova/outputandvalueaddedbyactivity2018/output/

Construction (F)

Construction (NACE F) encompasses three NACE two-digit divisions: the construction of buildings (41); civil engineering (42); and specialized construction activities (43). In 2019, 53 thousand people were employed in the construction of buildings, 16 thousand in civil engineering, and 78 thousand worked in specialised construction such as demolition, electrical, plumbing and heating installation (LFS). On a county level, in 2017, over 14% of all those employed outside of agriculture in Longford, Meath and Cavan were in construction. However, the highest number of people employed in construction were in the counties with the major cities of Dublin and Cork (see Figure 23). Approximately 58% of people employed in the construction sector are skilled tradespeople. According to the BDS, between 2012 and 2017, the construction sector had particularly strong growth in the number of persons employed, at 18%. Compared to the rest of Europe, Ireland had the largest share of enterprises in construction, at 21% in 2016 (compared to 15% EU average).[25] The contribution of the construction sector (F) to Gross Value Added has varied over time, from 6% in 1995, to 10% in 2005, 1.5% in 2010, to 2.8% in 2018.

Figure 23: Construction (F), thousand persons employed, 2017
Source: Business Demography Survey, CSO 2021

Engineering and related technical consultancy (71.12)

Employment in engineering and technical consultancy includes the design of machines, processes and systems and consulting activities for machinery and industrial plants, among other things. It employed 17.3 thousand people in 2017. The bulk of expertise is located in Dublin and Cork. The highest share of people employed in this sector on a county level is in Cork at 2%.

[25] https://www.cso.ie/en/releasesandpublications/er/bd/businessdemography2017/

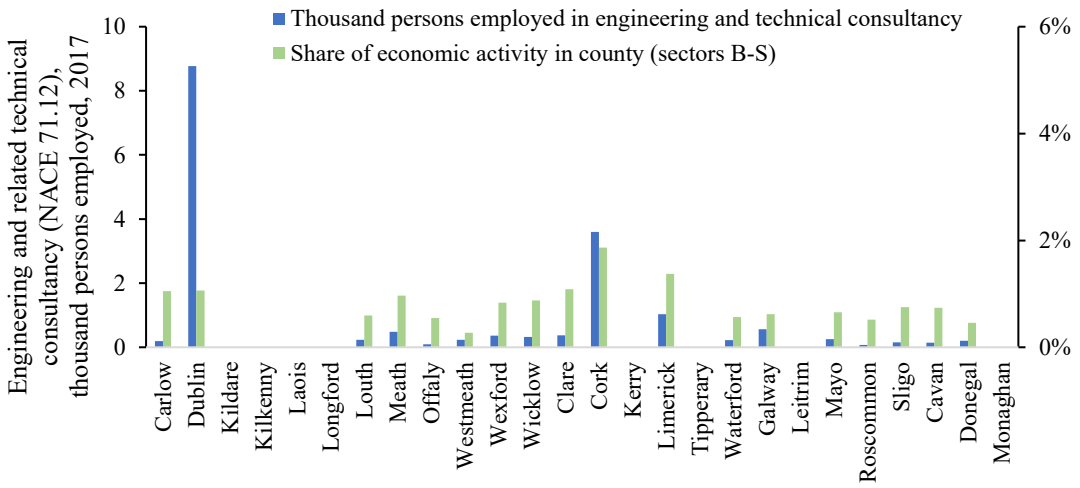


Figure 24: Engineering and related technical consultancy (71.12), thousand persons employed, 2017
Source: Business Demography Survey, CSO 2021

Sectors related to transport

Changes in the fuel used in the private vehicles will have a direct impact on a range of sectors including Water supply, sewerage and waste management (E); Retail sale of automotive fuel (47.3); and Warehousing and support activities for transportation (52). Water supply and waste, the trade and repair of motor vehicles, and the retail trade of automotive fuel are sectors which are naturally located near centres of population in Dublin, Cork and Galway. Around 37 thousand people around the country, or 2% of the working population in sectors B-S, are employed in motor trading activity and repairs. In counties Longford, Cavan and Monaghan, motor trades and repairs accounts for a higher share of economic activity outside of agriculture, at over 4%. Around 1% of employment in each county is in the retail sale of automotive fuel, with a slightly higher share in Donegal and Longford at 2%. Warehousing and support activities for transportation are more concentrated in coastal regions. It occupies the highest share of employment outside of agriculture in Leitrim at over 3% or ~250 people.

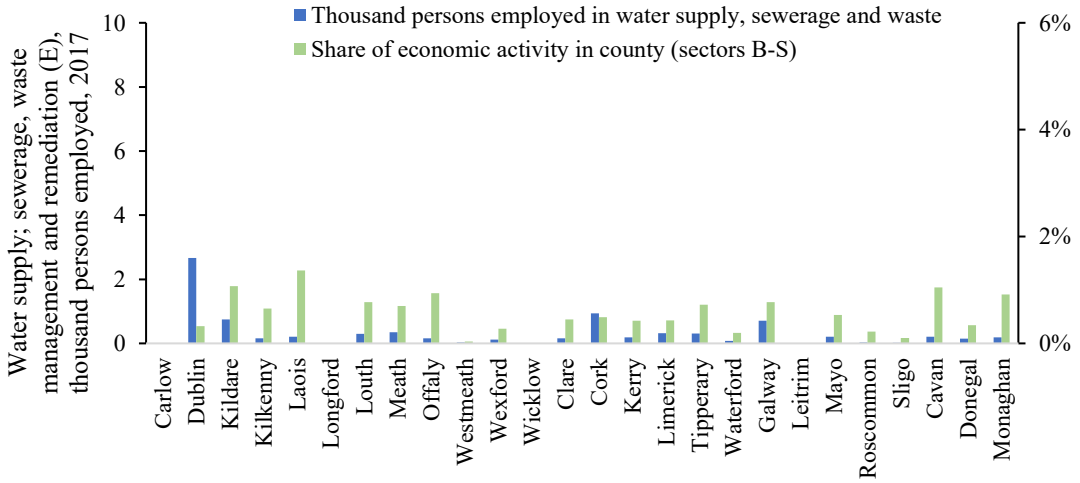


Figure 25: Water supply, sewerage, waste management and remediation (E), thousand persons employed, 2017
Source: Business Demography Survey, CSO 2021

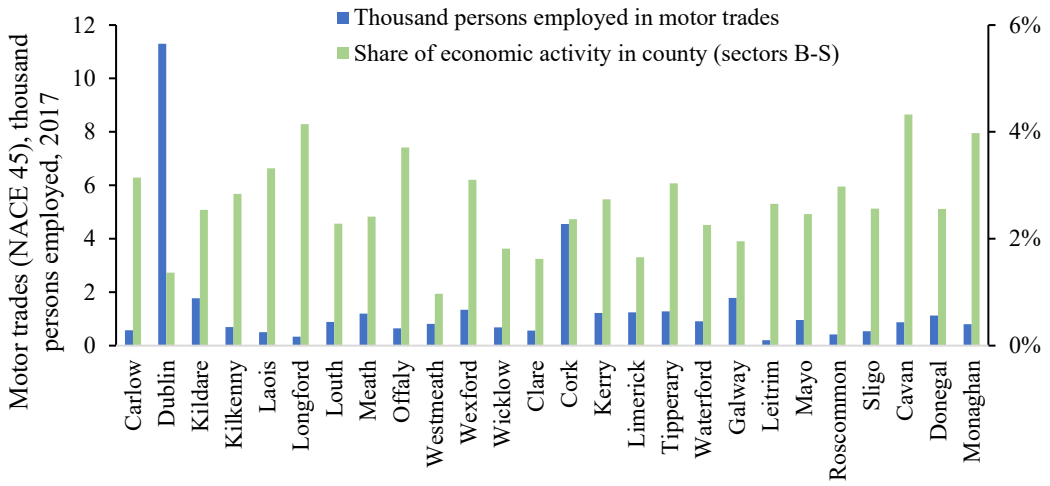


Figure 26: Wholesale and retail trade and repair of motor vehicles and motorcycles (45), thousand persons employed, 2017
Source: Business Demography Survey, CSO 2021

Figure 27: Retail sale of automotive fuel in specialised stores (47.3), thousand persons employed, 2017
Source: Business Demography Survey, CSO 2021

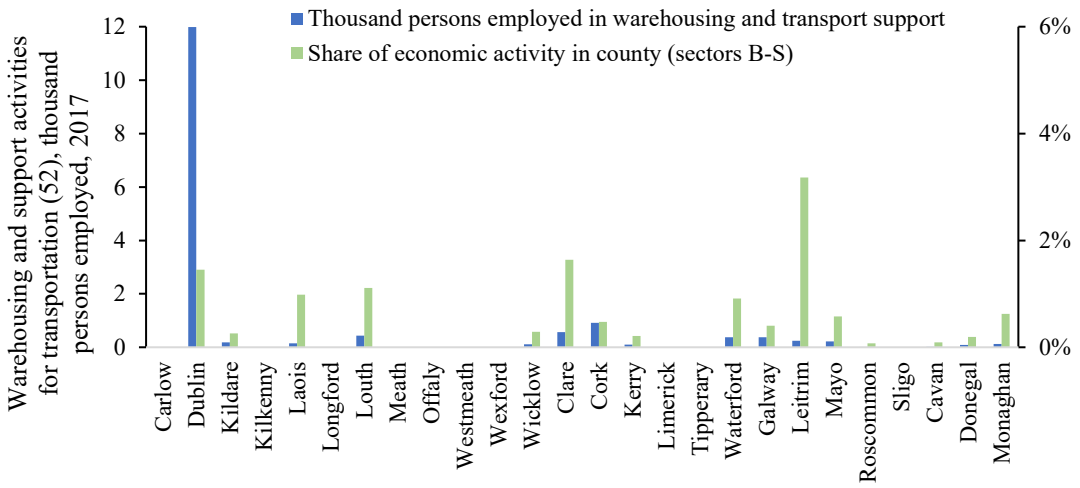


Figure 28: Warehousing and support activities for transportation (52), thousand persons employed, 2017
Source: Business Demography Survey, CSO 2021

11. Expenditure impacts in different sectors

The overview of the capital investment required to meet targets in the power, residential, and transport sectors, combined with existing employment data, offers a preliminary indication of the economic sectors most likely to be affected by policies to drive carbon emissions reductions up to 2030.

Manufacturing

In the case of power generation and transport, the majority of capital investment in decarbonisation goes toward purchasing of imported manufactured products such as turbines or vehicles and will therefore indirectly stimulate the supply chain in sectors related to manufacturing abroad. In the A51-E51 scenario, in the power sector alone, around €23 billion will need to be directed toward manufactured end products to meet installed capacity targets for 2030, as well as between an additional €4.5 and €11.6 billion in the transport sector, depending on the scenario, on top of the normal cost of purchasing private vehicles. A large share of this will be spent on imported products such as turbines, towers, vehicles and batteries.

Where there is an existing manufacturing base, certain components of power and/or heat generation facilities and electric vehicles have the potential to be produced in Ireland, such as the controls and instruments, industrial boilers, mechanical equipment, precision tools, storage tanks, and pumps. The manufacturing of machinery and equipment in Ireland at present focuses on agricultural machinery, food processing, and materials handling, employing almost 12 thousand people in 2017 (BDS), and accounting for 4% of total manufacturing employment in the country (according to the LFS 2019). The manufacture of fabricated metals, excluding machinery and equipment, is also a notable employer in Ireland, with 15.6 thousand people employed, or 7% of total manufacturing employment, on a national basis in 2019 (LFS). The American company, Magna, based in Co. Carlow and producing high-end, light weight panels and doors for the global automotive industry is one example in the transport sector.[26]

In the residential sector, in the A51-E51 scenario, approximately €7 billion will need to be spent on sourcing retrofitting materials such as insulation, cladding, double/triple glazing, heating technologies

[26] IDA Engineering in Ireland: https://www.idaireland.com/how-we-help/resources/infographics/engineering-in-ireland

and controls, lights, piping, and wiring. Ireland has a strong competency in architecture and construction and therefore has the potential to be able to source many of the manufactured products for retrofitting domestically.

Construction

There will be a large increase in demand for skills in the Irish construction sector to meet decarbonisation targets. Construction activity in Ireland traditionally has a relatively low import intensity so the majority of this investment could be captured domestically if the required skills and workforce is locally available. At least €6 billion will be directed toward the sector for the specialised labour required to retrofit residential households and install new heating technologies, and another €2 billion will be required for the construction of new wind farms, solar power plants, and thermal generation facilities. Further investment will also be needed to upgrade the electricity transmission grid and distribution network, as well as to install new EV charging and smart metering capabilities.

With a complete redesign of our homes and the way we consume energy, the construction sector will need to rapidly anticipate the skills required for reducing emissions across the building, industrial and power sectors to capture investment and prevent an overheating of the sector due to a squeeze on employment. The risk of a shortage of skilled tradespeople in the Irish construction sector is already becoming apparent in the industry, as the government ramps up construction of houses and infrastructure.[27] Formal training in a university or vocational institution, or an apprenticeship and gaining on site experience, would assist in developing the necessary expertise to meet the skilled construction and trades that will be required. In addition to traditional roles in building, plastering, glazing, floorers, electrical trades, and general labourers, newbuilds and mass retrofit programmes will require qualified construction managers, surveyors, building envelop specialists, plumbers, and heating and ventilation specialists who are trained in net zero emission construction techniques.[28]

Jobs will also be more distributed across the country. Out of the ~2 million dwellings in Ireland, approximately 870 thousand buildings have a Building Energy Rating (BER). The share of properties with ratings of A or B is highest in Dublin and surrounding counties, and Cork, at between 20% to 25%. In the rest of the country, over 80% of the building stock will require some form of retrofit to meet a B standard or higher. Over 50% of the BER rated properties on the West coast and Midlands have a D rating or lower and would require a deep retrofit to meet efficiency targets (see Figure 29).

[27] Closing the Construction Skills Gap, Irish Building Online, May 2021: https://www.irishbuildingmagazine.ie/2021/05/14/closing-the-construction-skills-gap/

[28] Building Skills for Net Zero, CITB 2021: https://www.citb.co.uk/media/vnfoegub/b06414_net_zero_report_v12.pdf

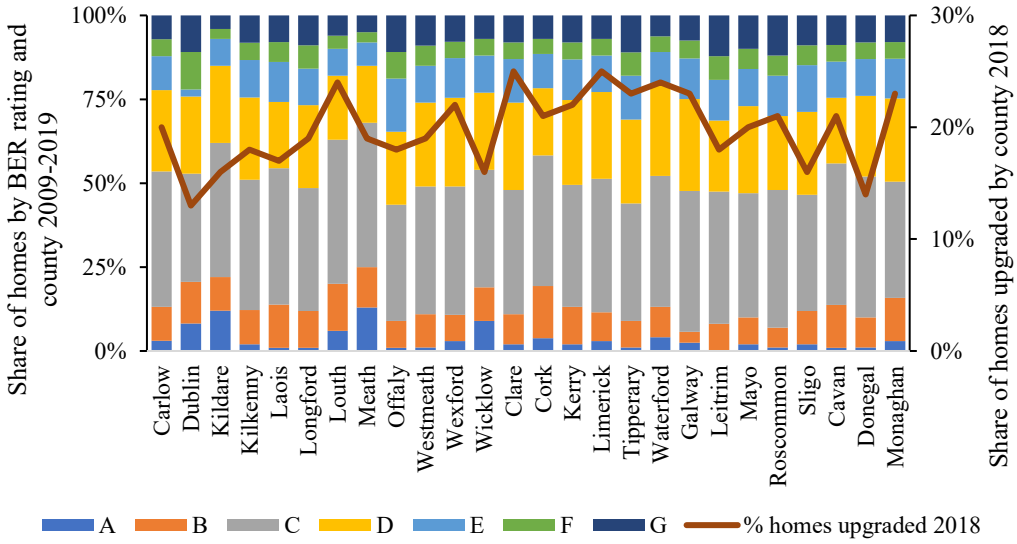


Figure 29: Household dwellings by county, BER rating and share upgraded in SEAI database
Source: CSO Domestic Building Energy Ratings 2009-2019[29] and SEAI 2018[30]

Professional roles and other supporting services

In addition to manufacturing and construction, numerous other roles and services will be required to support the transition to a decarbonised economy, spanning across research and development, project management, investment, engineering consultancy, energy utilities and agencies, financial, insurance, and legal services, transportation, and public administration. Many of these roles already exist today, while some will need to be created to meet the needs of the future energy system. Approximately 15% of total investment goes towards these services, amounting to €4.6 billion between 2018 and 2030 in the power sector, and €2 billion related to residential retrofits.

Longer term gains and losses in the power and transport sectors

Over the longer term, the professionals required in the electricity, gas and steam sector will expand from mechanical onsite roles in conventional power generation plants to also include wind technicians and field operatives for routine maintenance of turbines and solar PV plants. In 2030, most gas-fired power stations will still be operational as a source of back up generation, but at a reduced capacity to ensure at least a 70% renewable electricity target is reached. The operational labour intensity of different power generation types in the UK is 1.4 full time employees per MW for coal (500 MW plant), 0.3 for gas (500 MW plant), 0.4 for solar PV (30 MW plant), and 0.6 for wind (100 MW onshore facility or 300 MW offshore).[31] Existing peat, oil and coal plants in Ireland are likely to close, affecting employees in up to eight power stations, if not repurposed for renewable generation. To smooth the transition, employees will need to be supported in upskilling. Greater complexity and digitisation of the electricity system is also likely require additional high-tech roles in the operation of the electricity grid or network. Ireland has already established itself as a hub for high value-added information technologies, making it well suited to a further convergence of IT and managing energy distribution and consumption.

[29] CSO BERs by County (Table 4): https://www.cso.ie/en/releasesandpublications/er/dber/domesticbuildingenergyratingsquarter42019/
[30] SEAI, 2018: Home Energy Upgrades by County: https://www.seai.ie/grants/home-energy-grants/home-upgrades/Home-Energy-Upgrades-by-County-Nov-2018.pdf
[31] Bryan et al. 2017. Regional electricity generation and employment in UK regions, *Reginal Studies,* 51:3;414-425

In the transport sector, charging stations for electric vehicles tend to be self-service and require less maintenance than petrol pumps, so the longer term onsite operational labour requirements are expected to be low. Lower maintenance of electric vehicles due to fewer components, less wear over time, and less need for lubricants, will result in a gradual shift away from a need for mechanical skills, to be replaced with a more concentrated niche skillset in mobility technology. This is likely to affect the approximate 2% of the working population outside of agriculture in the retail sale and repair of vehicles and 1% the sale of automotive fuels. In scenarios with a higher modal shift toward public transport, job creation in public transportation may offset future job losses in vehicle trade and maintenance activities.

Changes in primary fuel use will shift employment away from peat extraction (4.8 thousand employees nationally in 'other mining and quarrying', which includes quarrying and peat extraction), the importation, transport and storage of fossil fuels such as oil, coal and natural gas, and toward less carbon intensive fuels such as energy crops and waste products. The impacts that this will have on employment in the agricultural, forestry, natural science, and waste management sectors is outside the scope of this analysis and requires further research.

12. Conclusions

The outputs from TIM indicate that there will be significant investment in CO_2 mitigation to reach 51% reduction in total greenhouse gases by 2030. This will provide future employment opportunities but also some losses and costs. Skilled workers in specialised construction will be particularly important in the creation of new low carbon power generation capacity and the deep retrofitting of at least 175 thousand homes and 250 thousand shallow retrofits between 2018 and 2030. The share of investment in the materials required to build wind farms and new electric vehicles is likely to be spent on manufactured imports, given Ireland's limited heavy manufacturing base. Investment in the infrastructure to facilitate decarbonization will be important, such as network upgrades and battery charging points. To ensure employment is captured domestically, upskilling will be required for professionals involved in the installation and maintenance of low carbon technologies.

The majority of employment in Ireland at present is in wholesale/retail, transport, accommodation and food sectors, and public sector employment such as education, health and defense. Sectors of direct relevance to CO_2 mitigation scenarios such as manufacturing, construction and agriculture employed 23% of the Irish workforce on a national basis in 2018, but up to 30% of the workforce in Border, West and Midlands. As a result, higher demand for these skills should have a more pronounced impact on these regions. On a county level, in 2017, over 14% of all those employed outside of agriculture in Longford, Meath and Cavan were in construction. Other skills of relevance to the development of low carbon technologies such as the manufacturing and repair of machinery, and engineering consultancy, are concentrated in Dublin and Cork. Sectors related to transport fuel, such as waste collection and retail of automotive fuels are more evenly distributed with the population. Around 1% of the workforce outside of agriculture in each county are employed in the sale of automotive fuels, which will be eventually eliminated in the low carbon transition.

In addition to direct employment due to investments to meet targets, there are wider implications in terms of changes in the price of energy, housing, private vehicles, government expenditure, and taxes, all of which have knock-on impacts on affordability, spending patterns and the disposable income of consumers in different income brackets. More detailed analysis is required into the cost to the exchequer, and the wider distributive and competitive impacts of price and income changes on households and businesses. Overheating of the construction sector and the knock-on effects on wages, as well as the implications for the level of residential investment, availability of lending, and house

prices, will also require further study to understand the wider macroeconomic and employment impacts in Ireland.

13. Appendix: List of NACE codes by letter and two-digit classification

	2-digit code	Description
A	1	Crop and animal production, hunting and related service activities
A	2	Forestry and logging
A	3	Fishing and aquaculture
B	5	Mining of coal and lignite
B	6	Extraction of crude petroleum and natural gas
B	7	Mining of metal ores
B	8	Other mining and quarrying
B	9	Mining support service activities
C	10	Manufacture of food products
C	11	Manufacture of beverages
C	12	Manufacture of tobacco products
C	13	Manufacture of textiles
C	14	Manufacture of wearing apparel
C	15	Manufacture of leather and related products
C	16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C	17	Manufacture of paper and paper products
C	18	Printing and reproduction of recorded media
C	19	Manufacture of coke and refined petroleum products
C	20	Manufacture of chemicals and chemical products
C	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C	22	Manufacture of rubber and plastic products
C	23	Manufacture of other non-metallic mineral products
C	24	Manufacture of basic metals
C	25	Manufacture of fabricated metal products, except machinery and equipment
C	26	Manufacture of computer, electronic and optical products
C	27	Manufacture of electrical equipment
C	28	Manufacture of machinery and equipment n.e.c.
C	29	Manufacture of motor vehicles, trailers and semi-trailers
C	30	Manufacture of other transport equipment
C	31	Manufacture of furniture
C	32	Other manufacturing
C	33	Repair and installation of machinery and equipment
D	35	Electricity, gas, steam and air conditioning supply
E	36	Water collection, treatment and supply
E	37	Sewerage
E	38	Waste collection, treatment and disposal activities; materials recovery

E	39	Remediation activities and other waste management services
F	41	Construction of buildings
F	42	Civil engineering
F	43	Specialised construction activities
G	45	Wholesale and retail trade and repair of motor vehicles and motorcycles
G	46	Wholesale trade, except of motor vehicles and motorcycles
G	47	Retail trade, except of motor vehicles and motorcycles
H	49	Land transport and transport via pipelines
H	50	Water transport
H	51	Air transport
H	52	Warehousing and support activities for transportation
H	53	Postal and courier activities
I	55	Accommodation
I	56	Food and beverage service activities
J	58	Publishing activities
J	59	Motion picture, video and television programme production, sound recording and music publishing activities
J	60	Programming and broadcasting activities
J	61	Telecommunications
J	62	Computer programming, consultancy and related activities
J	63	Information service activities
K	64	Financial service activities, except insurance and pension funding
K	65	Insurance, reinsurance and pension funding, except compulsory social security
K	66	Activities auxiliary to financial services and insurance activities
L	68	Real estate activities
M	69	Legal and accounting activities
M	70	Activities of head offices; management consultancy activities
M	71	Architectural and engineering activities; technical testing and analysis
M	72	Scientific research and development
M	73	Advertising and market research
M	74	Other professional, scientific and technical activities
M	75	Veterinary activities
N	77	Rental and leasing activities
N	78	Employment activities
N	79	Travel agency, tour operator and other reservation service and related activities
N	80	Security and investigation activities
N	81	Services to buildings and landscape activities
N	82	Office administrative, office support and other business support activities
O	84	Public administration and defence; compulsory social security
P	85	Education
Q	86	Human health activities
Q	87	Residential care activities
Q	88	Social work activities without accommodation
R	90	Creative, arts and entertainment activities
R	91	Libraries, archives, museums and other cultural activities
R	92	Gambling and betting activities

R	93	Sports activities and amusement and recreation activities
S	94	Activities of membership organisations
S	95	Repair of computers and personal and household goods
S	96	Other personal service activities
T	97	Activities of households as employers of domestic personnel
T	98	Undifferentiated goods- and services-producing activities of private households for own use
U	99	Activities of extraterritorial organisations and bodies