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BASELINE EMISSIONS INVENTORY REPORT

Baseline Emissions Inventory Report for County Monaghan

Prepared for:

Monaghan County Council

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Abstract: This report presents the findings of a baseline emissions inventory study carried by Fehily Timoney and Company (FT) on behalf of Monaghan County Council. The report presents the baseline greenhouse gas emissions from various sectors in a year. This baseline report aims to raise awareness of climate change and the impact that different sectors in the north-east region have on Ireland's overall carbon emissions. It provides Monaghan County Council with the necessary information to make informed decisions on climate change actions to lower the county's carbon emissions. The sectors that have been included in this analysis are residential, commercial and industrial, agriculture, transport, waste and wastewater and land use, and land use change and forestry (LULUCF).

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EXECUTIVE SUMMARY

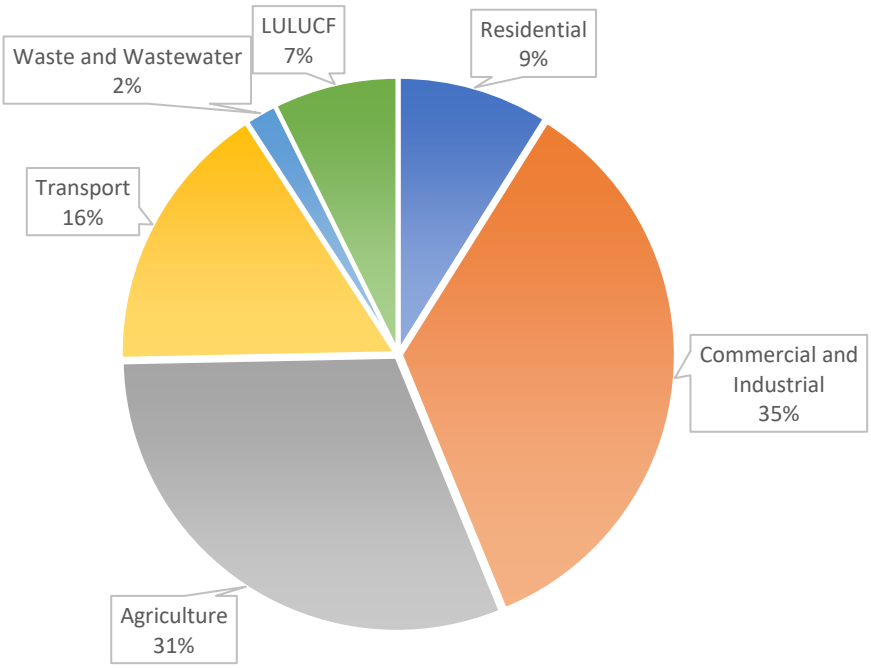
A 'Tier 2' Baseline Emission Inventory (BEI) study was prepared for County Monaghan. The report calculates the baseline greenhouse gas (GHG) emissions from various societal sectors in the county in 2018.

Baseline emissions inventories were prepared for the following sectors residential, commercial and industrial, agriculture, transport, waste and wastewater, and land use, and land use change and forestry (LULUCF).

The total emissions generated from all analysed sectors equates to 2,158,769 tCO_2-eq for the baseline year.

In 2018, the top three sectors contributing to GHG emissions were Commercial and Industrial, Agriculture and Transport, producing 35%, 31% and 16% of tCO_2-eq respectively. From this analysis, these sectors should be the main targets of energy and emission initiatives.

A percentage breakdown of sectoral GHG emissions in County Monaghan for the baseline year is provided in the figure below:



Emissions (tCO_2-eq) in County Monaghan Broken Down by Sector

1. INTRODUCTION

1.1 Background and Purpose

This report presents the findings of a 'Tier 2' Baseline Emission Inventory (BEI) study carried out by Fehily Timoney and Company (FT) for the county of Monaghan on behalf of Monaghan County Council.

The methodology is based on the Tier 2 'Bottom-Up' Approach defined in Annex C to the Local Authority Climate Action Plan Guidelines. While a Tier 1 approach requires the most basic and straightforward BEI calculation, the Tier 2 approach requires a greater degree of literature review, data collation, manipulation and data generation and subsequently more detailed outputs than the Tier 1 method. The Tier 2 method provides a greater degree of emissions breakdown and sub-categorisation of emission sources and human activities within each sector.

The report evaluates and determines the baseline greenhouse gas (GHG) emissions from various societal sectors in the county in 2018 and allows Monaghan County Council to measure the emission reductions required to achieve emission reduction targets. This baseline report aims to raise awareness of climate change and the impact that different sectors in Monaghan have on Ireland's overall carbon emissions. It provides Monaghan County Council with the necessary information to make informed decisions on climate change actions to lower the county's carbon emissions.

1.2 Overview

The sectors that have been included in the county-wide analysis is residential, commercial and industrial, agriculture, transport, waste and wastewater, and land use, land use change and forestry (LULUCF).

The methodology is based on the Tier 2 'Bottom Up' Approach defined in Annex C to the Local Authority Climate Action Guidelines.

The national emission reduction target of 51% by the end of 2030 is based on the GHG emissions reported for the end of 2018, in the national GHG emissions inventory. Accordingly, the data is collated and analysed to inform this BEI is relative to the baseline year of 2018, or the nearest year possible to 2018.

GHG emissions are reported as Carbon dioxide (CO_2) or Carbon dioxide equivalent (CO_2-eq) in this report. The Global Warming Potential (GWP) of other GHGs (e.g., Methane, CH_4) has been factored to allow for reporting in CO_2-eq. Where the term 'emissions' in and of itself is used in this report, this refers solely to GHG emissions, and not non-GHG emissions (such as Sulphur oxides, SO_x, or Nitrogen oxides, NO_x).

1.3 Baseline Year Recalculation Policy

Making meaningful comparisons of emissions data over time is an integral part of any GHG accounting assessment that aims to be credible, transparent and useful. A prerequisite for such meaningful comparisons is a consistent data set over time, or in other words, comparisons of 'like' with 'like' over time. A baseline year (2018 in this case) is a reference point in the past with which current emissions can be compared. To maintain the consistency between data sets, baseline year emissions need to be recalculated when new data or methodological approaches become available. As such, baseline year emissions, as calculated in this report, shall be retroactively recalculated when updating the BEI to reflect any future changes in either data set availability or emission accounting methodologies that would otherwise compromise the consistency of emission measurement over time and the integrity of the BEI.

1.4 Structure of the Report

This report is structured as follows from this point forward:

- **Section 2 - Context**: This section provides background detail on the climate change challenge; policy and statute underpinning climate action in Ireland; Ireland's GHG emission targets and the background to and purpose of BEIs in a local context.
- **Section 3 - Baseline Emission Inventory**: This section reports on GHG emissions associated with each societal sector in the county. Detail on methodologies for calculating sectoral emissions, results and analysis, and data assumptions and limitations is provided in this section. GHG emissions associated with the local authority's own operations have been accounted for separately.
- **Section 4 - Overview and Main Conclusions**: This section quantifies the total amount of GHG emissions in the county (broken down by sector in percentage terms) and identifies the amount of GHG emission reductions required overall for the county. It also reports on the local authority's GHG emissions and emission reductions required for the local authority as an organization.

1.5 The Sectors Examined

A list of the sectors examined and a description of the scope of each sector is provided in Table 1-1.

Table 1-1: The Sectors Examined

Sector	Scope of the Sector
Residential	This sector covers all GHG emissions associated with dwellings. It covers GHG emissions from electricity use and combustion sources. It covers both private owned dwelling and social house units.
Commercial and Industrial	This sector covers Manufacturing Combustion as well as space heating, water heating, cooking and laundry involved in Commercial Services. Generally, it covers GHG emissions from electricity use and combustion sources. It also covers GHG emissions from Industrial Processes. The Commercial Services sub-category covers the provision of services for the purpose of generating profit or revenue generally. These can include: 1) selling goods and services, 2) advertising and marketing, and 3) banking and finance. This sector also covers GHG emissions from the Institutional sector (i.e., emissions associated with local and central government, schools, hospitals etc.), which is defined as a sub-sector of the commercial sector in the EPA National Emission inventory 2021.
Agriculture	This sector covers agricultural related GHG emissions from enteric fermentation, manure management, agricultural soils, liming, and use of fertilisers and urea application. Livestock farming results in the generation of GHG emissions from enteric fermentation and manure management. The management and use of soils in agriculture (e.g., through the application of fertilizer or lime) also results in the generation of GHG emissions (e.g., through N_2O volatization from fertilizer, urine, dung; CO_2 volatization from liming or urea application).
Transport	The primary source of this sector's emissions come from the burning of diesel and petrol in combustion engines. This sector covers GHG emissions from private vehicle use as well as public transport.

Sector	Scope of the Sector
Waste and Wastewater	This sector is responsible for the emissions from the handling of waste, incineration of waste (without energy utilization), composting, and wastewater handling.
Land Use, Land Use Change and Forestry (LULUCF)	This sector is responsible for emissions as well as removals, related to land use, land use change and forestry. Forest land (and harvested wood production), grassland, cropland, wetlands, and settlement areas all result in GHG emissions and removals. The CO_2 mass balance for each type of land use is dependent on the above-ground biomass, below-ground biomass, dead organic matter (litter and dead wood) and soils associated with each land use type. Land use change results in a change in CO_2 emission / removal mass balances associated with a geographic area based on these factors.

Further detail on particularly complex sectors and sub-sectors is provided in Appendix 1.

2. CONTEXT

2.1 Climate Change Challenges

Climate change refers to the long-term changes in the earth's weather patterns or average temperatures. In Ireland this is demonstrated by rising sea levels, extreme weather events and changes in the eco-system. Extensive research and a significant body of evidence has shown a correlation between the increasing global average temperature and the increasing quantity of GHG released into the atmosphere, particularly from anthropogenic sources.

Changes in weather patterns and climate can have significant adverse impacts on the environment and human beings. The Intergovernmental Panel on Climate Change (IPCC) published the Climate Change 2022: *Impacts, Adaptation and Vulnerability in 2022*. Included in this report is an outline of observed impacts of climate change on the environment and human beings. These include impacts from inland flooding, damages to infrastructure, impacts from infectious disease, displacement, animal and livestock health and productivity, mental health and water scarcity derived from climate change.

The seriousness of the potential impacts and risks associated with climate change is reflected in the vast quantity of legislation that has been introduced to mitigate those impacts and risks, beginning with the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) treaty in 1992. Subsequent significant, international treaties, agreements have been made and international gathering taken place since, including, the Kyoto Protocol, the Paris Agreement, 2030 Climate and Energy Policy Framework and the twenty-seven UNFCC, Convention of the Parties (COP) conferences that have taken places since its formation.

The Paris Agreement was the first-ever universal, legally binding global climate change agreement, adopted at the Paris climate conference (COP21) in December 2015.

There are many significant additional benefits to reducing GHG emission levels and increasing the share of renewable energies. These include a decrease in dependency on fossil fuels, which in turn results in a higher security of energy supply, better health, lower energy costs, an increase in the county's competitiveness, and a more sustainable economy.

2.2 Greenhouse Gas Emission Targets

The Climate Action and Low Carbon Development Act (as amended) provides a statutory underpinning to climate action in Ireland. It specifies the requirement to develop a national Climate Action Plan (CAP) (and update it every year), a National Adaptation Framework (NAF), a National Long Term Climate Action Strategy and Sectoral Adaptation Plans (SAPs). It also specifies a series of carbon budgets and the associated sectoral emission ceilings.

It sets out actions that must be taken to ensure delivery of commitments and a target to reduce GHG by 51% by 2030 and to achieve net zero GHG emissions by 2050. The successful delivery of climate action and the achievement of these targets will require significant, unanimous effort across all sectors of society.

There are currently three carbon budgets, indicating the limit of GHG emissions over three consecutive five-year periods beginning with the period 2021-2025. The 51% target applies to GHGs that come from all sectors of society including industrial, agricultural, energy, land use and other anthropogenic (i.e., human-based) activities in the State. The 51% target for 2030 is the primary constraint on carbon budgets for the periods 2021-2025 and 2026-2030. Ireland's total GHG emissions in 2018 were 68.3 Mt CO_2eq. Therefore, the first two carbon budgets must lead to our total emissions being reduced to 33.5 Mt CO_2eq by 2030.

In the latest National Climate Action Plan developed (CAP23), which was published in late December 2022, Sectoral Emission Ceilings (SECs) have been defined. Sectoral Emissions Ceilings (SECs) refer to the total amount of permitted greenhouse gas emissions that each sector of the economy can produce during a specific time period. Specific GHG emission reduction targets have been prescribed for each sector of society to reflect the SECs. More detail on Sectoral Emission Ceilings for Ireland can be found via the following Government of Ireland web link - gov.ie - Sectoral Emissions Ceilings (www.gov.ie). It should be noted that the finalisation of the Sectoral Emissions Ceiling for the Land-Use, Land-Use Change and Forestry (LULUCF) sector has been deferred for up to 18 months to allow for the completion of the Land-Use Strategy.

The Environmental Protection Agency (EPA) has confirmed that Ireland has exceeded its 2020 target for GHG emissions by 6.73 Mt CO_2-eq. Projections indicate that Ireland can meet its climate action targets over the 2023 – 2030 period but only with the full implementation of CAP23. CAP23 is an update of the Climate Action Plan 2021 and is the first Action Plan delivered under the amended Act of 2021. It reflects the Government-approved carbon budgets and sectoral emissions ceilings, which seeks to provide a pathway and framework to achieving a 51% reduction in greenhouse gas emissions by the end of this decade. CAP23 was published on December the 21st 2022.

2.3 Baseline Emissions Inventories - *Setting Local Targets*

A key element of the Climate Action and Low Carbon Development Act (as amended) relevant to local authorities is the requirement for local authorities to prepare individual Local Authority Climate Action Plans (LACAPs) for their functional area. The purpose of LACAPs will be to deliver effective climate action and mitigation at local authority and community levels. Local Authority Development Plans must also be aligned with their LACAP.

The primary goal of the national CAP is to ensure a just transition to a climate neutral Ireland using *'an integrated, structured and evidence-based approach.'* The CAP also states, *'our capacity to anticipate and plan for a just transition requires the development of a robust evidence base to support policy development and effective ongoing monitoring'*. Furthermore *'data will play a critical role in assisting local authorities in forecasting where changes will occur (or are already underway), and who will be most impacted'*.

In line with this overarching policy, the primary objective of this report is the generation of a BEI for the local authority functional area of County Monaghan. This BEI will be a contemporary snapshot in time of GHG emissions in County Monaghan and will act as a reference point on which specific county wide and/or sectoral targets can be established to manage and reduce GHG emissions.

Specifically, the BEI will serve to inform the development of the LACAP for the county. LACAPs should have an inward and outward focus. Climate action in the plan should be defined by local authorities for their own organization which they have full control over (i.e., the inward focus), and for communities in their functional area, which they exert a strong influence over in partnership with relevant stakeholders (i.e., the outward focus). As such, a BEI will be prepared for all societal sectors broadly (which would facilitate outward climate action), whilst a separate BEI will be prepared for the local authority organization itself (which would facilitate inward climate action).

The BEIs will allow the monitoring and tracking of progress towards meeting targets and the efficacy of any climate action mitigation measures adopted and implemented by a local authority.

Assessing sectoral contributions will define where reductions in GHG emissions are most needed to achieve GHG emissions targets. By assessing sectoral contributions to climate change and the risks they pose with respect to climate change, local authorities can rank sectors and sub-sectors with respect to their counties contribution to climate change and make informed, practical decisions on how they can contribute to and influence mitigating these risks within each sector in partnership with relevant stakeholders.

Assessing local authority organizational GHG emissions will facilitate a local authority in understanding aspects of its organization that contribute the most in terms of GHG emissions and the optimum areas to target to successfully reduce their organizational GHG emissions in line climate action planning requirements.

LACAPs will be established for a duration of five years. It is expected that, at a minimum, and to maintain an up-to-date and accurate evidence base to inform decision making, local authority BEIs would be revised at least every five years in line with each revision of the local authority CAPs. However, it is also advised that BEIs should be updated when new, significant evidence, data etc. is available.

3. BASELINE EMISSIONS INVENTORY

3.1 Residential

3.1.1 Methodology

The following methodology was used to determine emissions from the Residential sector.

- Central Statistics Office's (CSO) household census data for the county was reviewed to determine the number and type of dwellings within the county.
- The National BER Research Tool provides data on dwelling type, dwelling floor area and estimated emission per floor area for dwellings. This allows for an estimation of emissions from space heating, hot water, lighting and ventilation from each dwelling type in the county. The database also provides information on year of construction for each building.
- CSO data on mean metered electricity consumption for each dwelling type in the nation in 2018 is used to estimate electricity from electrical appliance use in dwellings. SEAI Conversion factors for 2018 are used to determine CO_2-eq emissions associated with this use.
- This data allows for a determination of the following:
  - Average CO_2-eq emissions per year per dwelling type for the county.
  - Total CO_2-eq emissions per year per dwelling type for the county.
  - Total CO_2-eq emissions from the Residential sector for the county
  - An estimated percentage breakdown of emissions from each dwelling type based on year of construction.
- An estimate for main source of heating fuel per dwelling type for the county can then be made using data from the CSO. This data can be used to determine the number of dwellings in the county that rely on the following fuel types as their main source of space heating: Mains Gas, LPG, Heating Oil, Electricity, Solid Fuel. This aids the characterization of Residential sector emissions, providing an additional layer of insight.

3.1.2 Results

In total, there were 21,282 dwellings recorded in the county. A breakdown of the number and type of dwellings in the county is provided in Table 3-1 and in Figure 3-1.

Table 3-1: Number and Type of Dwelling for the County

Dwelling Type	Number of Dwelling Type in the County
Detached	13,858
Semi-detached	4,213
Terraced	2,285
Apartments	926

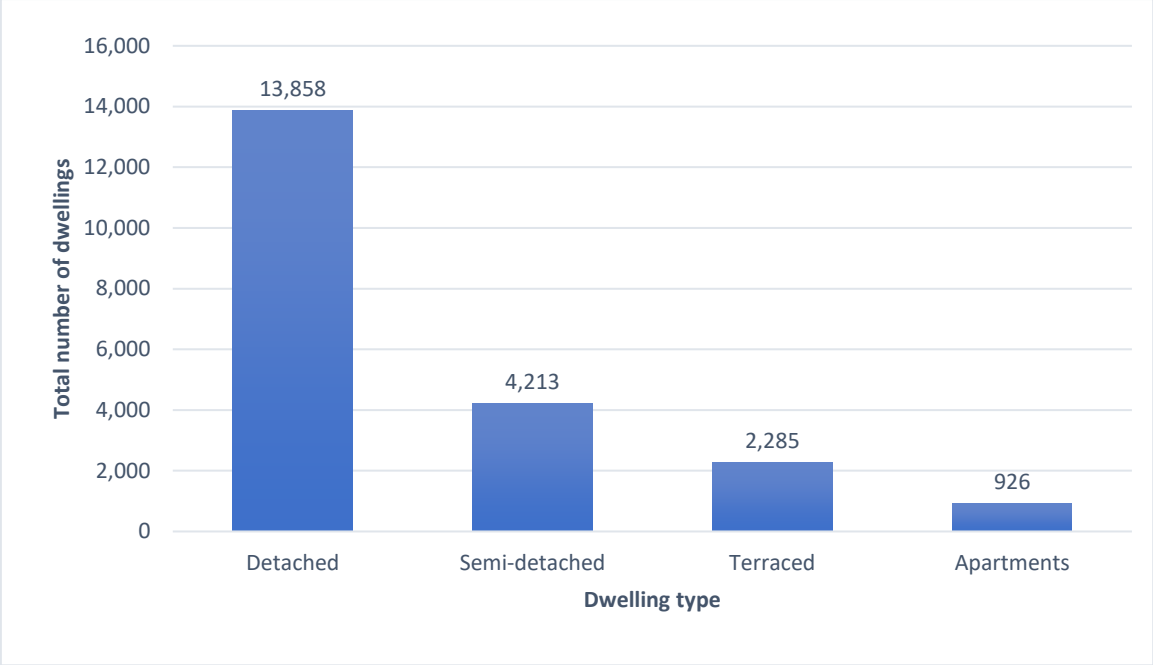


Figure 3-1: Total Number of Dwelling Type in the County

The predominant type of dwelling is detached housing, which is reflective of the rural nature of the county and the level of one-off housing. This is followed by semi-detached housing and terraced housing. There are relatively low levels of apartments in the county.

Information on CO_2 emissions from dwellings in the county for the baseline year is presented in Table 3-2 and Figure 3-2, Figure 3-3, and Figure 3-4.

Table 3-2: CO_2 Emissions from Dwellings in the County

Dwelling Type	Average CO2-eq Emissions from this Dwelling Type ($kgCO_2$)	Number of Dwelling Type in the County	Total CO2-eq Emissions from Dwelling Type in the County (tCO2)	CO2-eq Emissions per Dwelling Type unit in the County (tCO2)
Detached	10,993.74	13,858	152,351	10.99
Semi-detached	5,534.07	4,213	23,315	5.53
Terraced	5,375.82	2,285	12,284	5.38
Apartments	4,763.33	926	4,411	4.76
Total Residential Sector Emissions (tCO_2)			192,361	

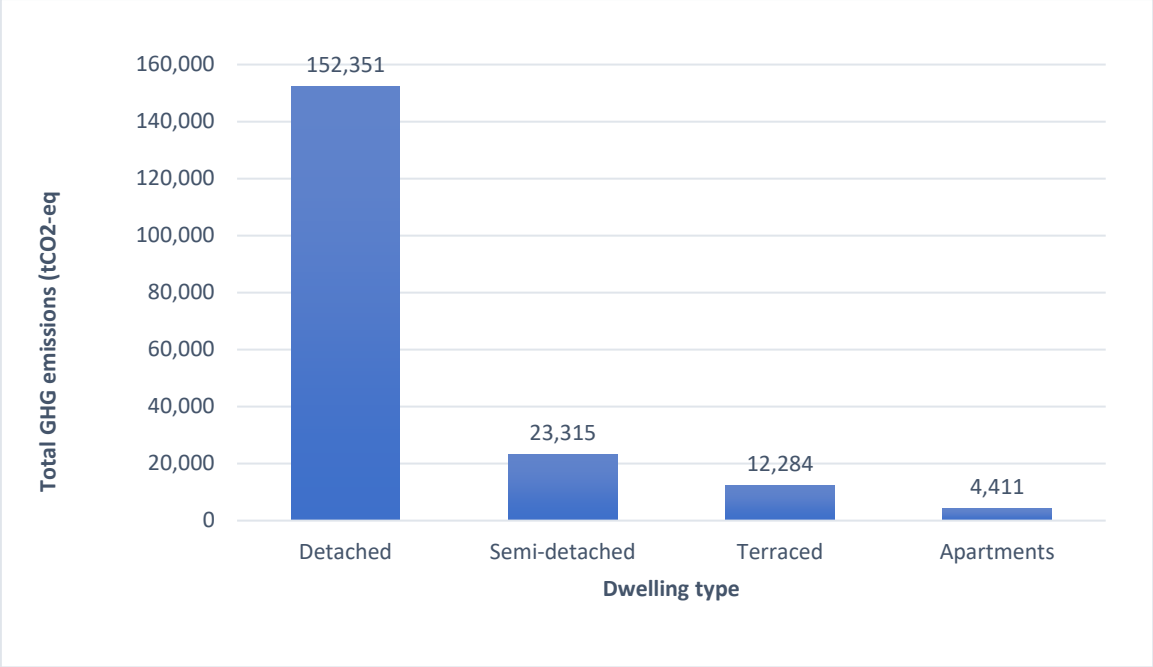


Figure 3-2: Total GHG Emissions from Dwelling Types in the County

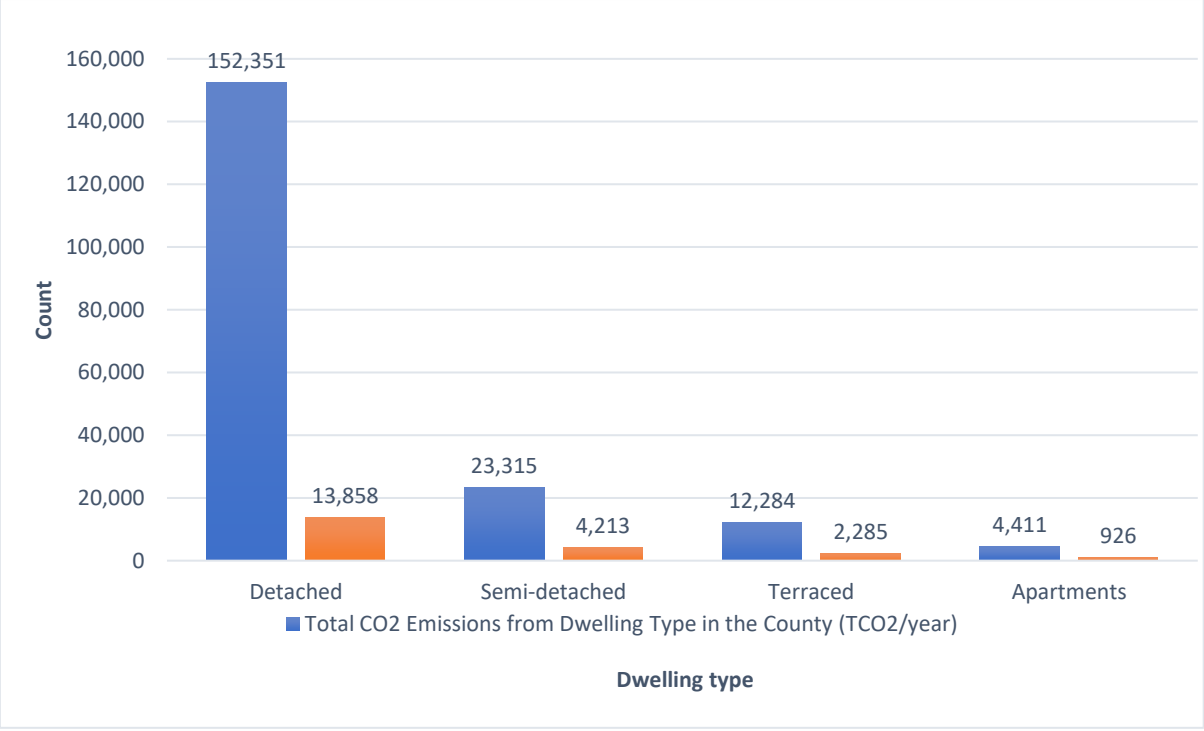


Figure 3-3: Number of Dwelling Type in the County versus Total GHG Emissions from Dwelling Type in the County

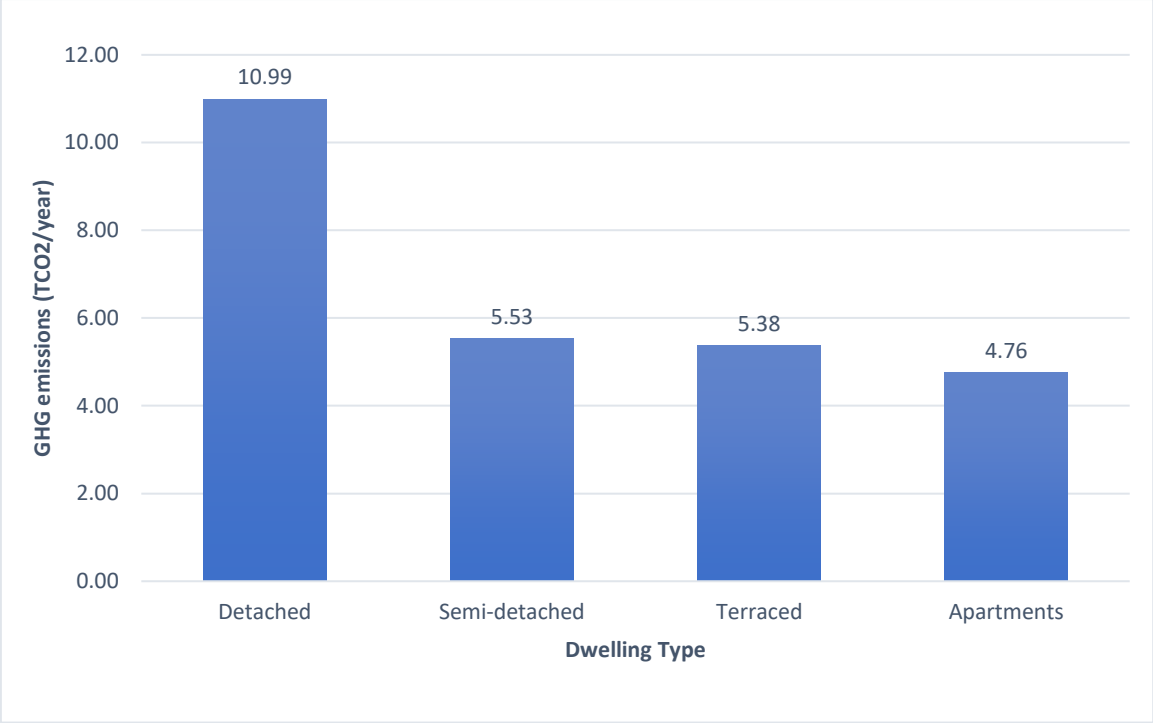


Figure 3-4: Total GHG Emissions for a Single Unit by Dwelling Type in the County

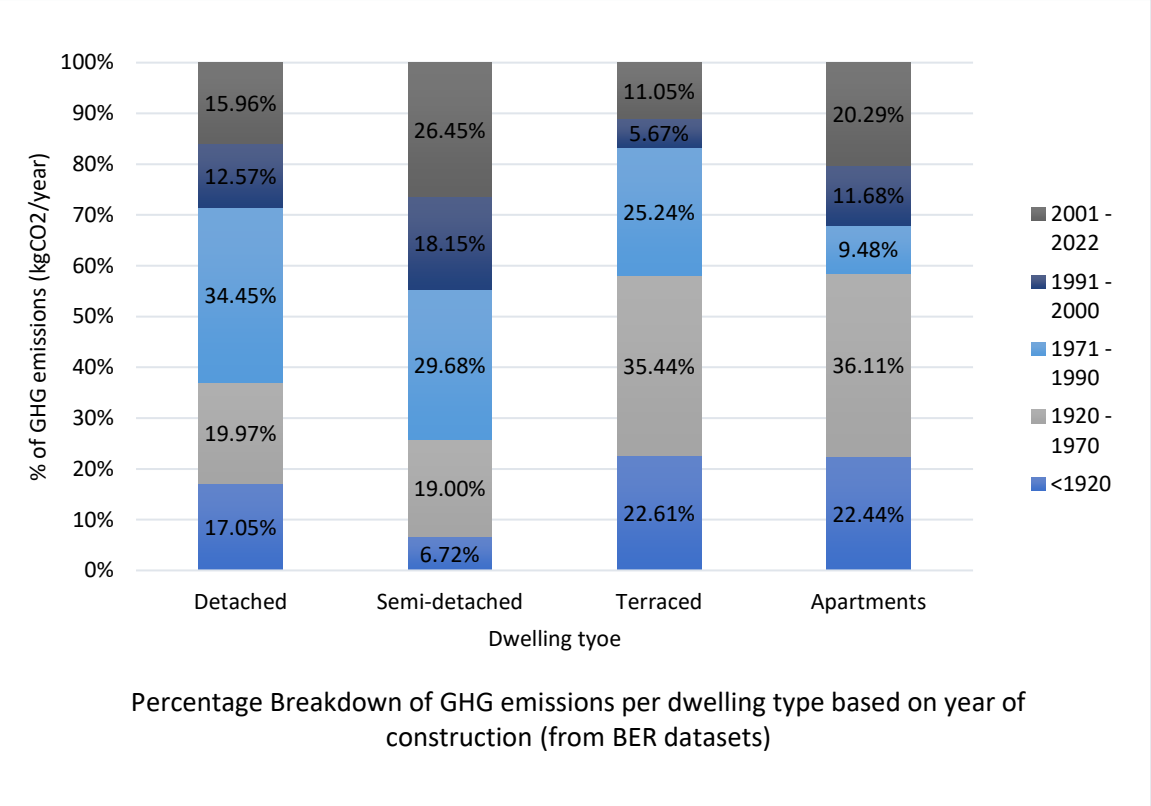
Detached dwellings contribute the most emissions by far. This reflects the relatively high numbers of detached dwellings in the county, and the higher level of space heating requirements and heat loss associated with these dwellings, which are generally larger than other dwelling types and which have four sides in which heat may be lost from the dwelling. Semi-detached dwellings contribute the second most emissions, followed by terraced housing then apartments.

Detached housing contributes the most in terms of emissions per single unit. Semi-detached housing ranks second highest, ahead of terraced housing, then apartments.

A percentage breakdown of CO_2 emissions per dwelling type based on year of construction (from BER datasets) is provided in Table 3-3 and illustrated in Figure 3-5.

Table 3-3: Percentage Breakdown of GHG emissions per dwelling type based on year of construction (from BER datasets)

Dwelling Type	Built before 1920	Built between 1920 and 1970	Built between 1971 and 1990	Built between 1991 and 2000	Built between 2001 and 2022
Detached	8.95%	20.60%	25.21%	19.11%	26.13%
Semi-detached	11.10%	26.41%	7.43%	14.31%	40.75%
Terraced	12.34%	19.24%	14.69%	8.56%	45.16%
Apartments	11.11%	32.80%	19.79%	13.35%	22.94%



Percentage Breakdown of GHG emissions per dwelling type based on year of construction (from BER datasets)

Figure 3-5: Percentage Breakdown of GHG emissions per dwelling type based on year of construction (from BER datasets)

The following is observed from the above:

- Emissions from detached dwellings built between 1971 and 1990 are relatively high.
- The majority of emissions from semi-detached housing is from housing built after 1971, which reflects the greater prevalence of this type of housing constructed from that point onwards.
- Emissions from terraced housing built before 1990 are relatively high, which reflects the likelihood that this older housing stock is less energy efficient compared to other types of housing.
- A significant amount of emissions from apartments originates from apartments built before 1970. This could reflect the quantity of 'bedsit' type apartments contained in older housing stock which is less energy efficient. However, the overall number of apartments in the county is relatively low.

For further insight, a percentage breakdown of main space heating fuels for dwellings in the county is provided in Figure 3-6, Figure 3-7, Figure 3-8, Figure 3-9 and Figure 3-10.

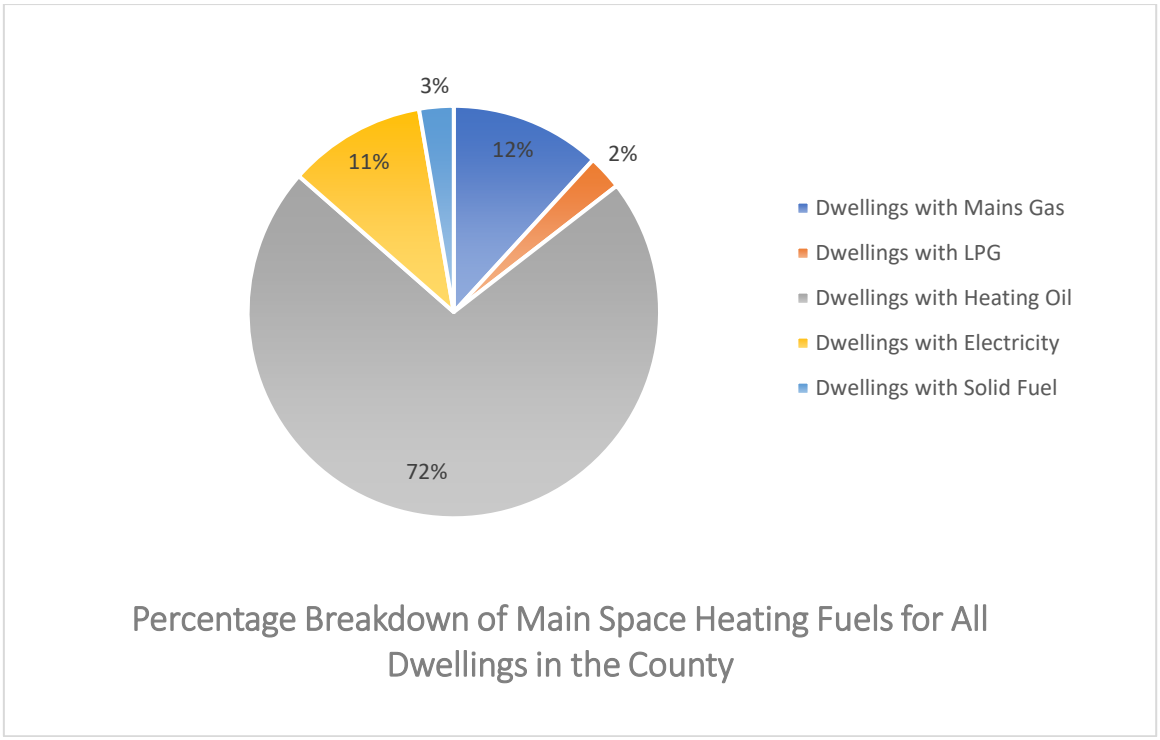


Figure 3-6: Percentage Breakdown of Main Space Heating Fuels for All Dwellings in the County

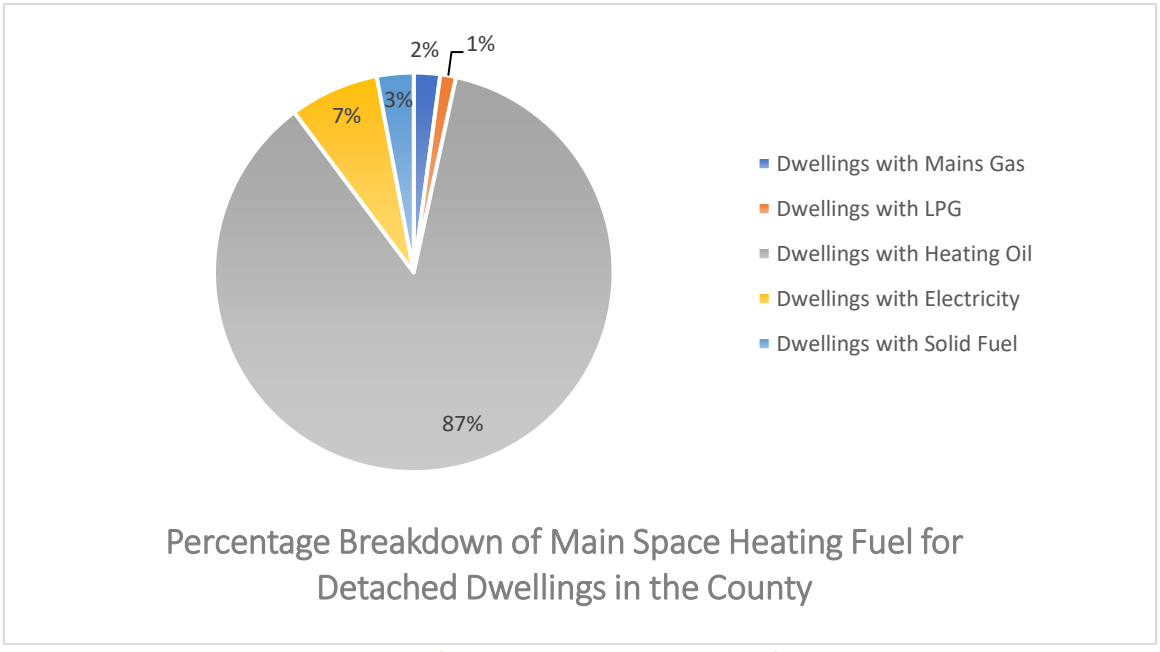


Figure 3-7: Percentage Breakdown of Main Space Heating Fuels for Detached Dwellings in the County

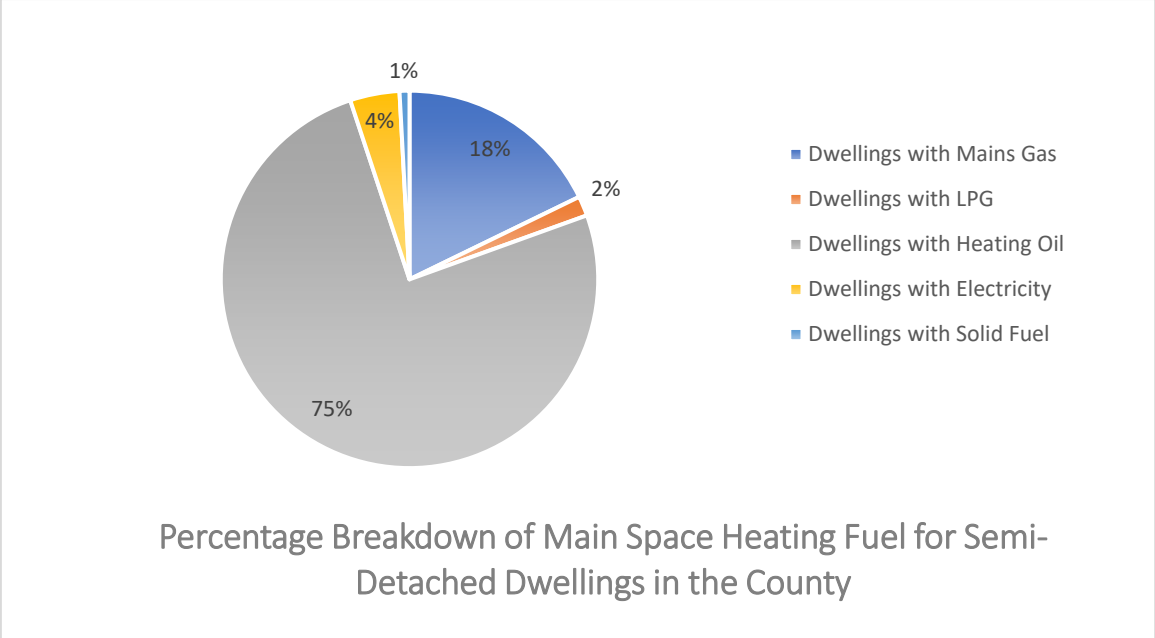


Figure 3-8: Percentage Breakdown of Main Space Heating Fuels for Semi-detached Dwellings in the County

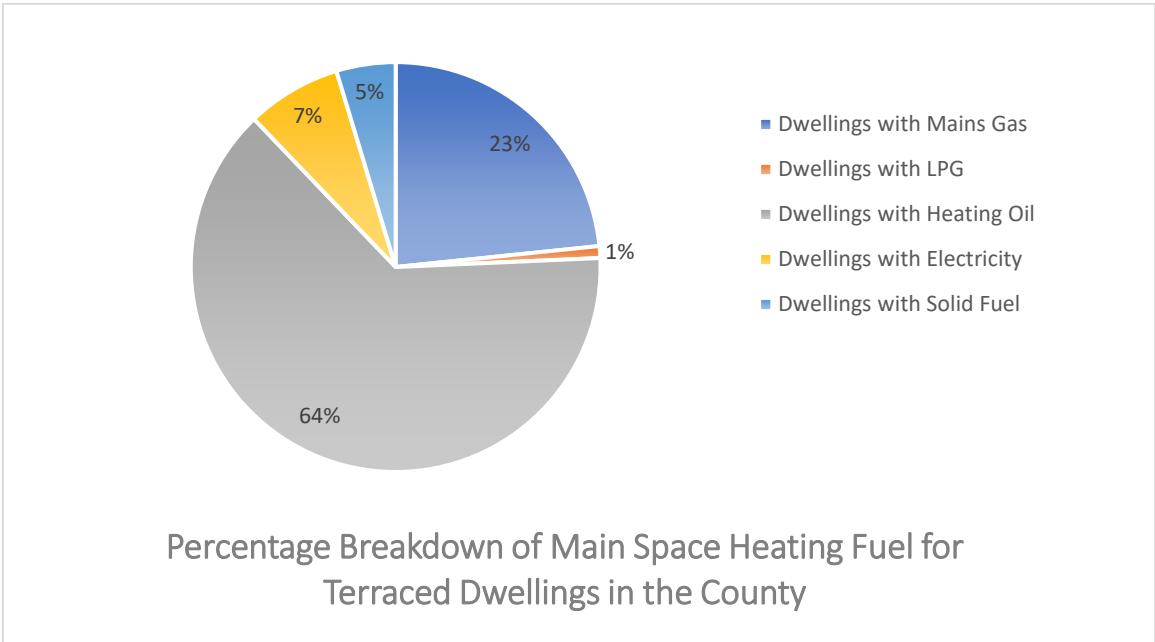


Figure 3-9: Percentage Breakdown of Main Space Heating Fuels for Terraced Dwellings in the County

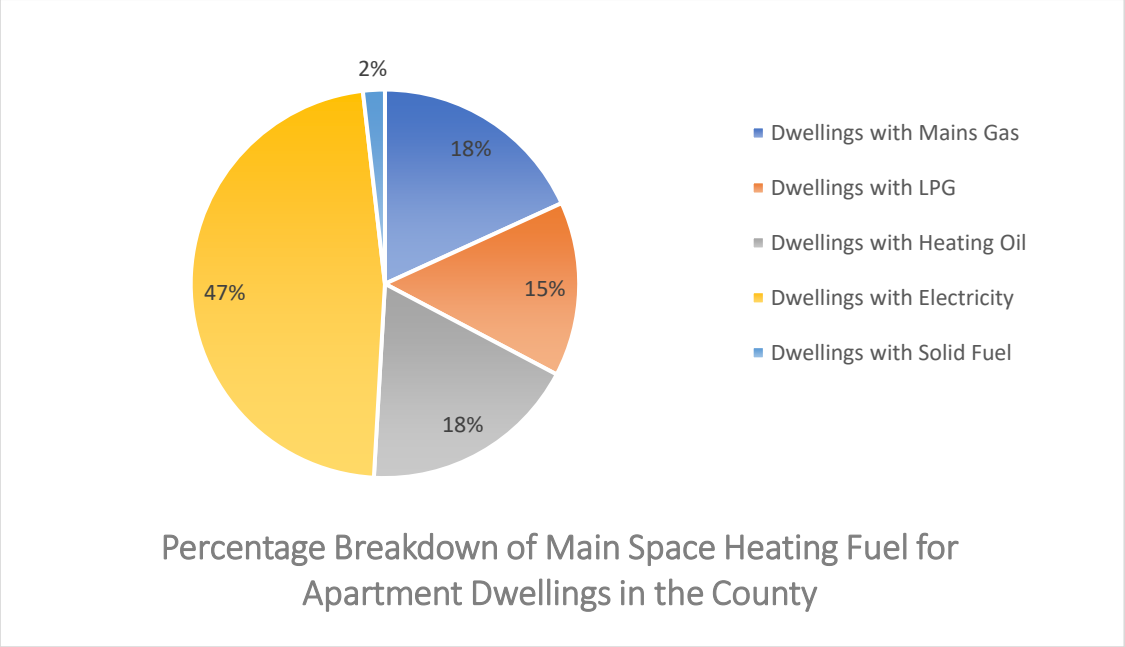


Figure 3-10: Percentage Breakdown of Main Space Heating Fuels for Apartments in the County

The following is observed from the above:

- Heating oil is the primary source of main space heating fuel in the county and is particularly prominent in detached and semi-detached dwellings. The combustion of heating oil generates a higher level of emissions per unit of energy compared to the combustion of many other heating fuels such as gas or LPG. The predominant use of heating oil in detached dwellings is likely to account in part for the relatively higher emissions from this dwelling type.
- A significant proportion of gas is used as a main heating fuel at semi-detached and terraced dwellings and apartments. This reflects parts of the county having access to the mains gas network. It also reflects the prevalence of these types of dwelling being built as part of planned development served by the gas network.
- Electricity is the primary source of main space heating fuel in the county for apartments. This is followed by heating oil, mains gas and LPG. There is a relatively high level of heating oil use as a main heating fuel in apartments. This may be reflective of the level of 'bedsit' type dwellings in houses being classed as apartments.
- Very low levels of solid fuels are used for main space heating in the county.

3.1.3 Assumptions and Limitations

The following assumptions and limitations exist in relation to the Residential sector data:

- 'Apartments' include the sum of apartments in purpose-built block, flats in converted house and bed sits.
- BER dwelling types are broken down differently to CSO data. For this macro-level emission inventory development exercise, the following was assumed:
  - A 'Detached' house under the census is the same as a 'Detached' house in the BER database.
  - A 'Semi-detached' house under the census is the same as a 'Semi-detached' house in the BER database.
  - A 'Terraced' house under the census is the same as an 'End-of-terrace' house and 'Mid-terrace' house in the BER database.

- An 'Apartment' under the census is the same as an 'Apartment,' a 'Ground-floor apartment,' a 'Mid-floor apartment,' and a 'Top-floor Apartment' in the BER database.
- The dwelling types 'House' and 'Maisonette' in the BER database are to be disregarded, as they are not directly comparable to any dwelling type under the census.

- The use of BER data is limited in that it only provides data for dwellings that have had BERs carried out on them, which only represents a proportion of the general housing stock. BER data does however provide a good representation of the housing stock generally given the level of BERs carried out on housing in the county.
- The CSO database for heating fuel type only considers dwellings in the county that have had BER Ratings completed from them. BER data does however provide a good representation of the housing stock generally given the level of BERs carried out on housing in the county.
- There is a marginal degree of overlap or double counting between the BER data and metered electricity consumption data used to inform sectoral emission data. This is because the National BER Research Tool dataset covers emissions from electric space heating and fixed lighting. There are low levels of electric space heating as a main heating fuel in the county, however, and fixed lighting generally accounts for a low proportion of household electricity usage overall. The metered consumption data is therefore reasonable representative of other electrical appliance use. The emission figures presented are therefore a slightly conservative estimate.

3.1.4 Data Sources

- Central Statistics Office, Household Census, 2016.
- SEAI, National BER Research Tool, 2022.
- Central Statistics Office, Metered Electricity Consumption, 2018.
- Central Statistics Office, Main Space Heating Fuel Per County, 2018.

3.2 Commercial and Industrial

3.2.1 Methodology

The following methodology was used to determine emissions from the Commercial and Industrial sector.

- Raw data on commercial and industrial property was downloaded from the Valuation Office's REST Web Services API website for the county. This provides information on commercial and industrial property category and area (m^2) in the county.
- The total area (m^2) associated with each commercial and industrial property category was calculated.
- Charted Institute of Building Services Engineer's (CIBSE) TM46 guidance document emission benchmarks (in $kgCO_2/m^2$) for building types were used to estimate CO_2 emissions associated with commercial and industrial property categories in the county.
- The total emissions for each of the commercial and industrial properties categories were calculated in tCO_2/year.

3.2.2 Results

In total, there were 5,670 commercial and industrials properties in the county, divided into 10 categories, as per Table 3-4.

The category with the highest area coverage is 'Industrial Uses,' followed by 'Fuel/Depot,' 10,116,383 m^2 and 3,389,647 m^2, respectively. The category with the highest number of individual properties is Industrial Uses,' 2,380 , which represents 42.0% of the total properties in the county, followed by 'Retail (Shops)' 2,196 , which represents 33.8% of the total, as per Table 3-4 and Figure 3-11.

Table 3-4: Total Area and Number of Properties per Category in the County

Category	Area (m^2)	Properties per Category
Industrial Uses	10,116,383	2,380
Fuel/Depot	3,389,647	87
Retail (Shops)	110,560	2,196
Office	46,866	683
Leisure	26,761	58
Minerals	58,694	47
Health	13,508	10
Retail (Warehouse)	45,027	96
Miscellaneous	7,917	107
Utility	381	6
Total	13,815,742	5,670

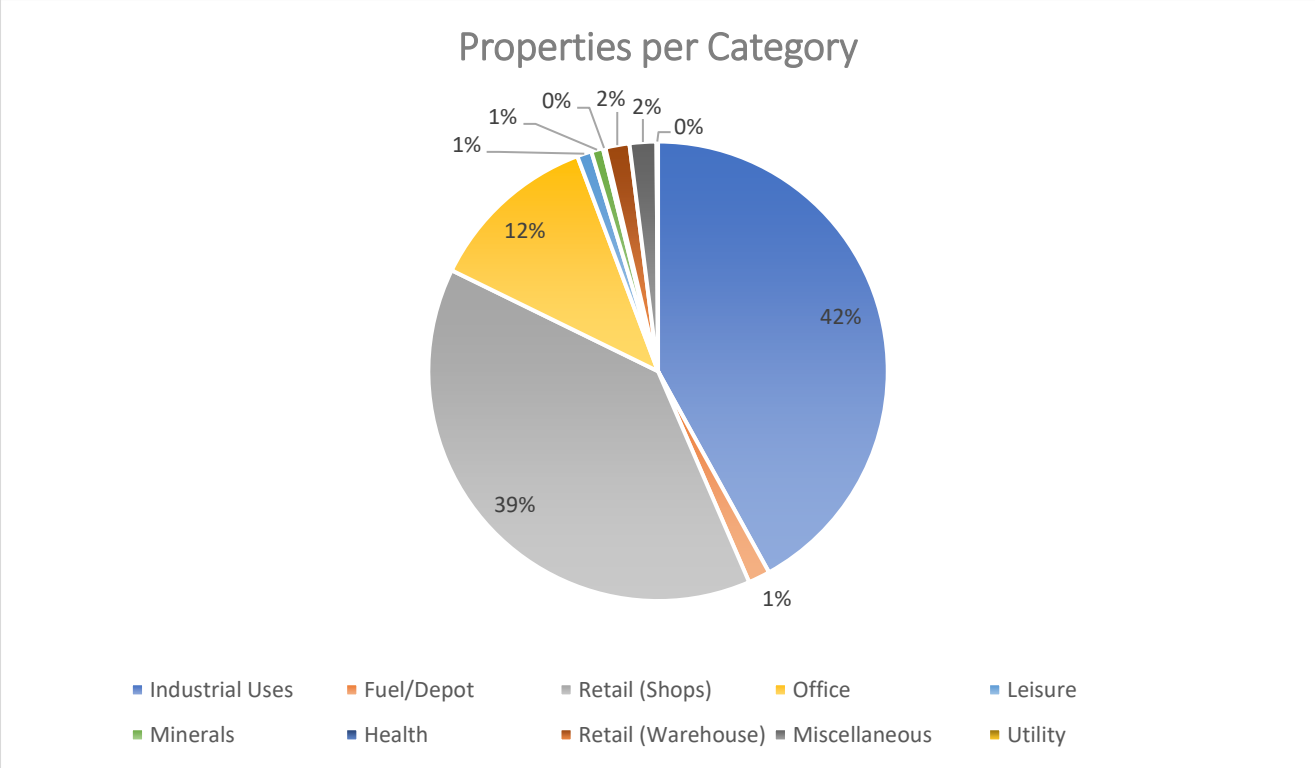


Figure 3-11: Percentage of Properties per Category

Information on CO_2 emissions for each category in the baseline year is presented in Table 3-5 and Figure 3-12, Figure 3-13 and Figure 3-14.

Table 3-5: Total Emissions by Category (tCO_2)

Category	Total Emissions (tCO_2)
Industrial Uses	544,928
Fuel/Depot	180,668
Retail (Shops)	14,875
Office	3,561
Leisure	3,186
Minerals	3,128
Health	1,561
Retail (Warehouse)	861
Miscellaneous	629
Utility	44
Total	753,442

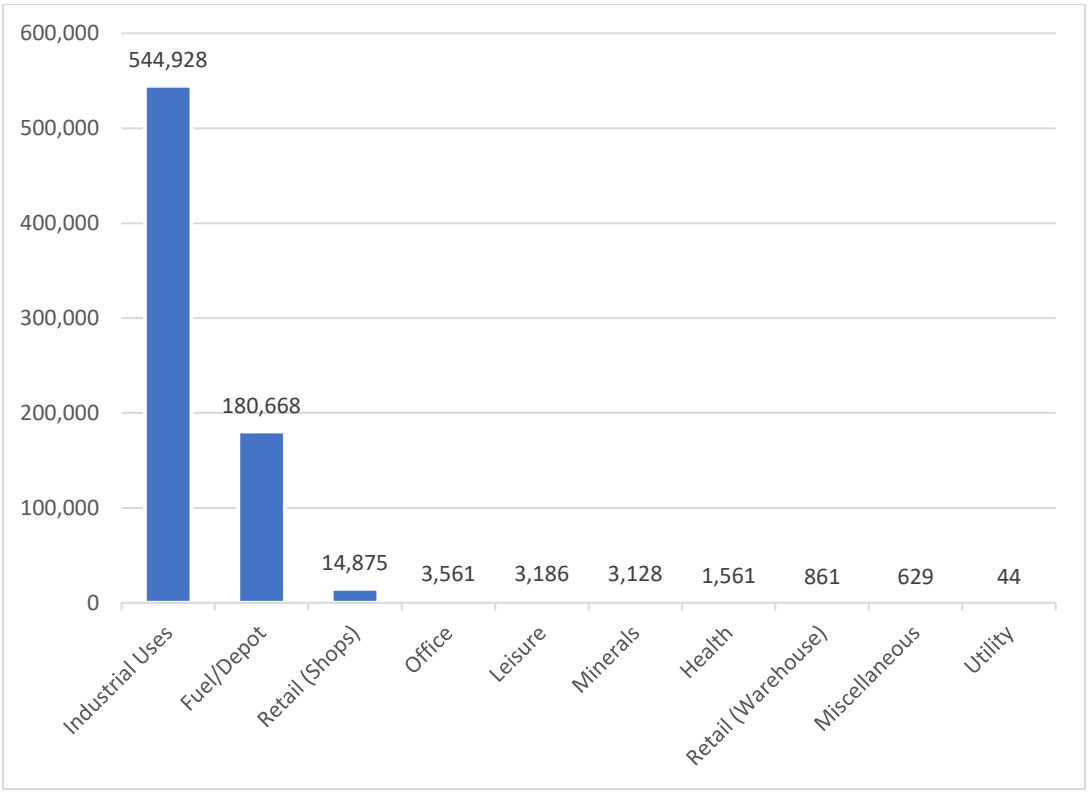


Figure 3-12: Total Emissions by Category (tCO_2-eq)

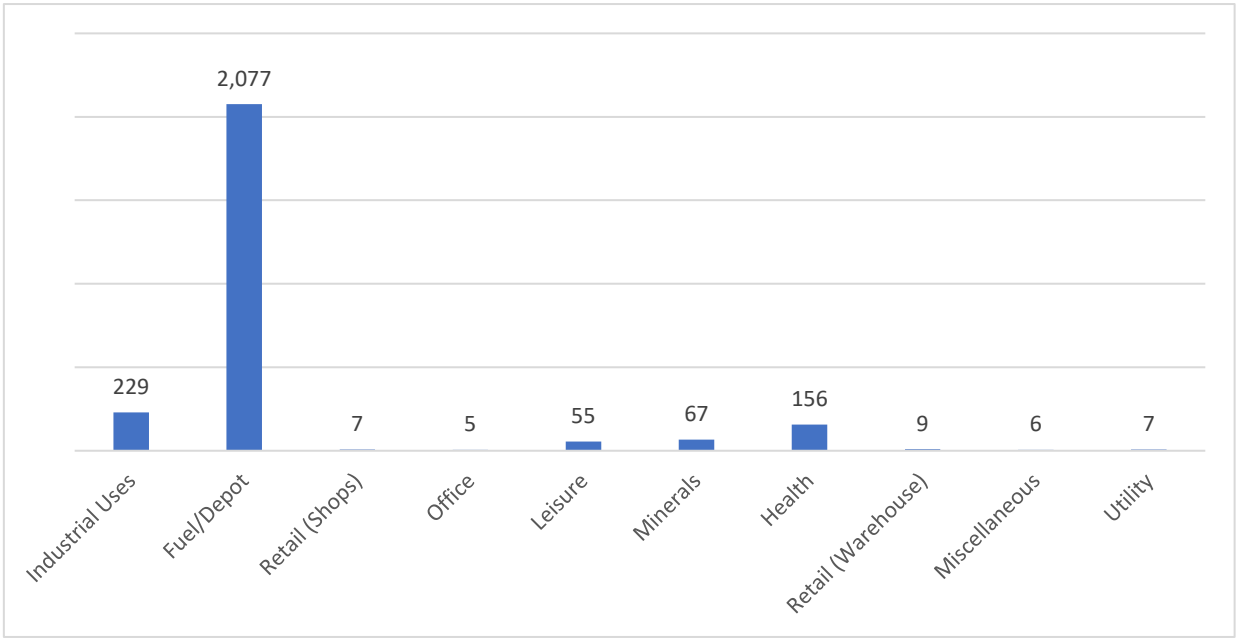


Figure 3-13: Average Emission per Property by Category (tCO_2-eq)

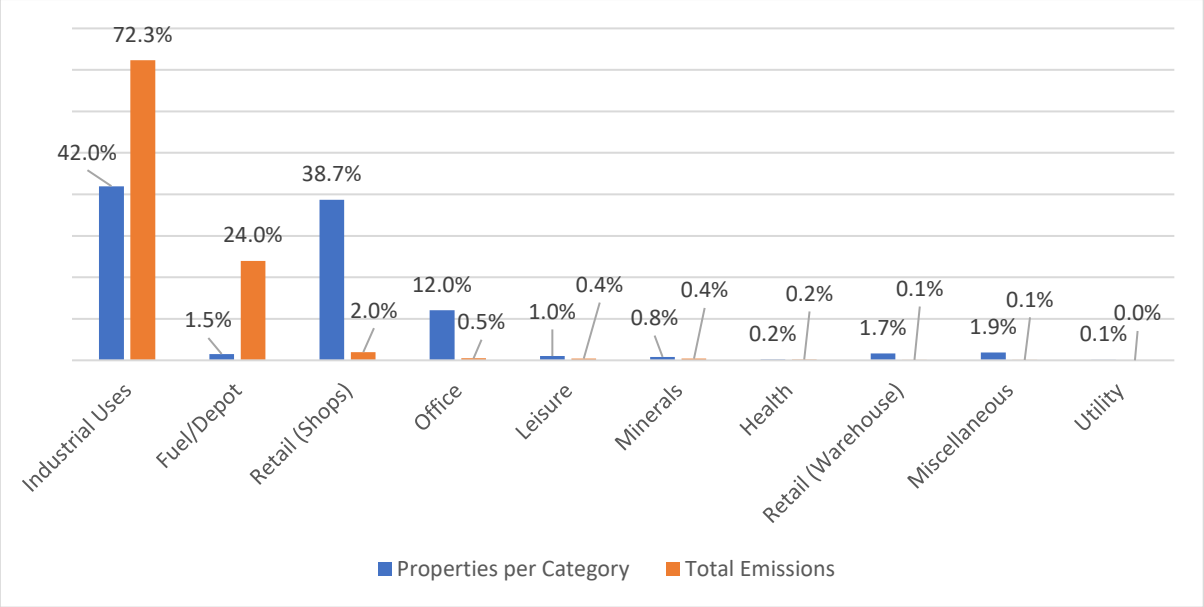


Figure 3-14: Total Emissions and Number of Properties by Category

'Industrial Uses' is the category that generates most CO_2 with 544,928 tCO_2, followed by the 'Fuel/Depot' category which generates 180,668 tCO_2. Combined, both these categories represent almost all the Commercial and Industrial emissions in the county, 753,442 tCO_2.

Within the 'Industrial Uses' category, the 'Use' that generates the highest level of CO_2 emissions is 'Factory' and 'Factory (Milk),' 375,816 tCO_2 (50%) and 107,136 tCO_2 (14%), respectively. Within the 'Oil/Fuel Depot' and 'Motor Fuel Sales' generates the highest level of CO_2 emissions, 91,122 tCO_2 (12%) and 89,546 tCO_2 (12%), respectively.

However, when the average emissions are calculated for the number of properties in each category the results show that 'Fuel/Depot' properties represent only 1.5% of the total properties in the county and emit 10 times more CO_2 than the 'Industrial Uses' properties, which represent 42.0% of the total number of properties (2,077 tCO_2/year and 229 tCO_2/year, respectively.

'Retail (Shops)' is the category with the highest percentage of properties (38.7%); however, its emission represents only 2.0% of the total in the county for the commercial and industrial sector.

The level of commercial and industrial emissions is relatively high in comparison to other counties, including more urban counties such as Dublin City or Fingal, which one would believe would have a higher level of Commercial and Industrial related emissions. From an analysis of the 'Uses' contained in each of the above categories, it is observed that this is mainly due to the level of food and drink manufacturing, general manufacturing, concrete manufacturing, quarrying, fuel / oil depots and warehousing in the county.

3.2.3 Assumptions and Limitations

The following assumptions and limitations exist in relation to the Commercial and Industrial sector data:

- The property categories defined in the REST Web Services API differ from the categories defined in the CIBSE TM46 guidance document to an extent. Several assumptions were made to allow for alignment between property/building types therefore (e.g., a 'bakery' was assumed to be a 'small foot outlet,' a 'factory' was assumed to be a 'workshop' etc.).

- The methodology employs emission benchmarks from CIBSE's TM46 guidance document. This document was produced in 2008. The benchmarks do not therefore consider improvements in the energy efficiency of buildings or renewable energy supply provisions since this time to date. This is likely to result in a noteworthy overestimation of emissions from this sector.

3.2.4 Data Sources

- REST Web Services API. Irish Valuation Office. <https://www.valoff.ie/en/open-data/api/>. Accessed on the 10th November 2022.
- Field, J. (2008) Energy Benchmarks: TM46: 2008. London: CIBSE.

3.3 Agriculture

3.3.1 Methodology

County level agricultural data was obtained from the CSO Census of Agriculture. This data was broken down into different agricultural activities and agricultural related land use relevant to the county.

Once all data was obtained, a breakdown of agricultural sector related emissions was developed. These emissions were broken into four categories, as follows:

- Livestock
- Cereals
- Other Crop, Fruit and Horticulture.
- Managed Soils (sum of direct and indirect N_2O emissions, limestone emissions and urea application emissions).

Livestock emissions at county level was determined with reference to national emissions statistics, the national herd, and the herd in the county. This is the most representative and accurate method for determining emissions for livestock.

Emissions from cereals was determined with reference to Teagasc emission benchmarks on emissions from tillage farming by area.

Other crop, fruit and horticultural emissions were broken down by type and area and estimated by using emission benchmarks developed by the UK's Crop Health and Protection and Agricultural and Horticulture Development Board, yield per tonne values provided by Teagasc and Census of Agriculture data on arable farming.

Managed soils emissions are estimated with reference to national emission statistics for these direct and indirect NO_2 emissions, limestone emissions and urea application emissions, the area of managed soils nationally and the area of managed soils in the county.

3.3.2 Results

A breakdown of agricultural land use (crops and livestock numbers in the county is presented in Table 3-6 and Table 3-7.

Table 3-6: Breakdown of Agricultural Land Use in the County

Breakdown of Agricultural Land Use in the County	
Land Use Type	**Hectares**
Cereals (including wheat, barley and oats)	295
Other crops, fruit, and horticulture:	578
*Oilseed Rape	0
*Beans and Peas	0
*Maize	116

Breakdown of Agricultural Land Use in the County	
Land Use Type	**Hectares**
*Potato	462
*Turnip	0
*Beet	0
*Vegetables	0
*Fruit	0

Table 3-7: Breakdown of Livestock Numbers in the County

Breakdown of Livestock Numbers in the County	
Livestock Type	**Livestock Numbers**
Dairy Cows	38,303
Other Cattle and Cows	179,887
Sheep	73,391
Pigs	28,000
Poultry	10,153,700

The main agricultural land use is potato farming followed by cereal and maize farming.

Poultry numbers constitute 97% of total livestock numbers within the county. In terms of numbers, this is followed by other cattle and cows (for beef production), sheep, dairy cows and pigs.

A breakdown of agricultural related emissions in the baseline year is presented in Table 3-8 and illustrated in Figure 3-15.

Table 3-8: Breakdown of Agricultural Emissions

Type	CO_2-eq Emissions (tCO_2-eq)
Livestock	
Cattle	393,738.98
Sheep	10,601.41
Pigs	5,845.76
Poultry	96,231.74
Cereals	
Cereals (including wheat, barley, and oats)	679
Other Crops, Fruit and Horticulture	
Total Other crops, fruit, and horticulture:	4,328.18
Oilseed Rape	0.00
Beans and Peas	0.00
Maize	950.81
Potato	3,377.37
Turnip	0.00
Beet	0.00
Fruit	0.00
Managed Soils	
Managed Soils	154,830.13
Totals	
Total Livestock	506,417.89
Total Cereals	679
Total Other Crops, Fruit and Horticulture	4,328.18
Total Managed Soils	154,830.13
Overall Total	666,254.70

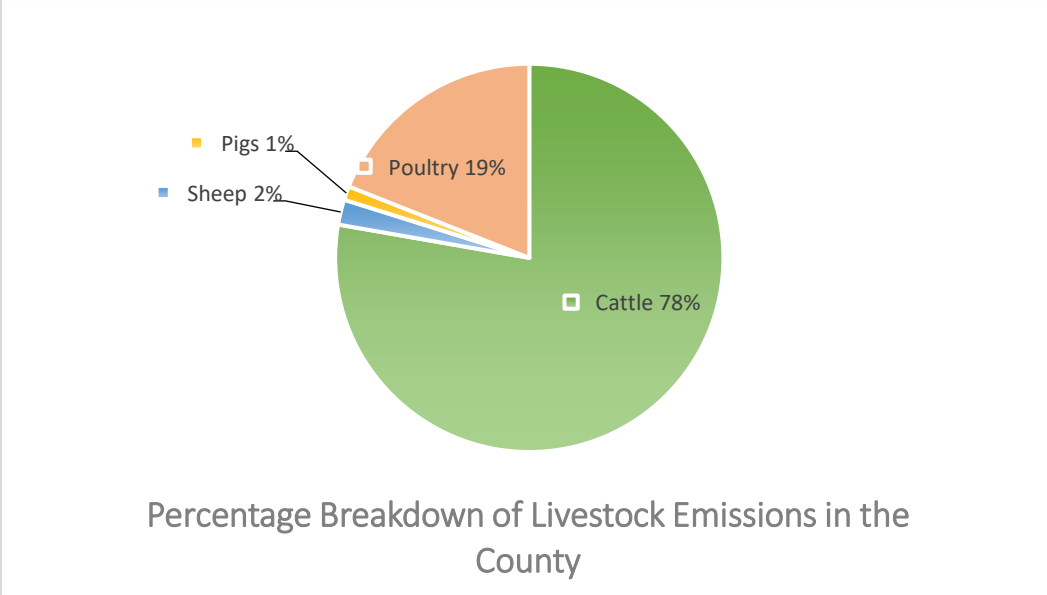


Figure 3-15: Percentage Breakdown of Livestock Emissions

Emissions from cattle (beef and dairy cows) combined contribute the most in terms of livestock related emissions by far, accounting for 78% of CO_2-eq emissions from agriculture in the county. Cattle produce much more methane emissions than poultry, and due to the higher global warming potential of methane, their impact is much larger on the environment. Emissions associated with sheep and pig farming are relatively low, yet still significant. Emissions from poultry are relatively significant given the relatively high number of poultry in the county compared to national poultry numbers. The county is well known for having a large poultry sector in national context.

Cereal farming in the county generated 679 tCO_2-eq emissions in the baseline year, which reflects the relatively low level of cereal farming in the county.

A percentage breakdown of emissions from the Other Crops, Fruit and Horticulture category in the baseline year is presented in Figure 3-16.

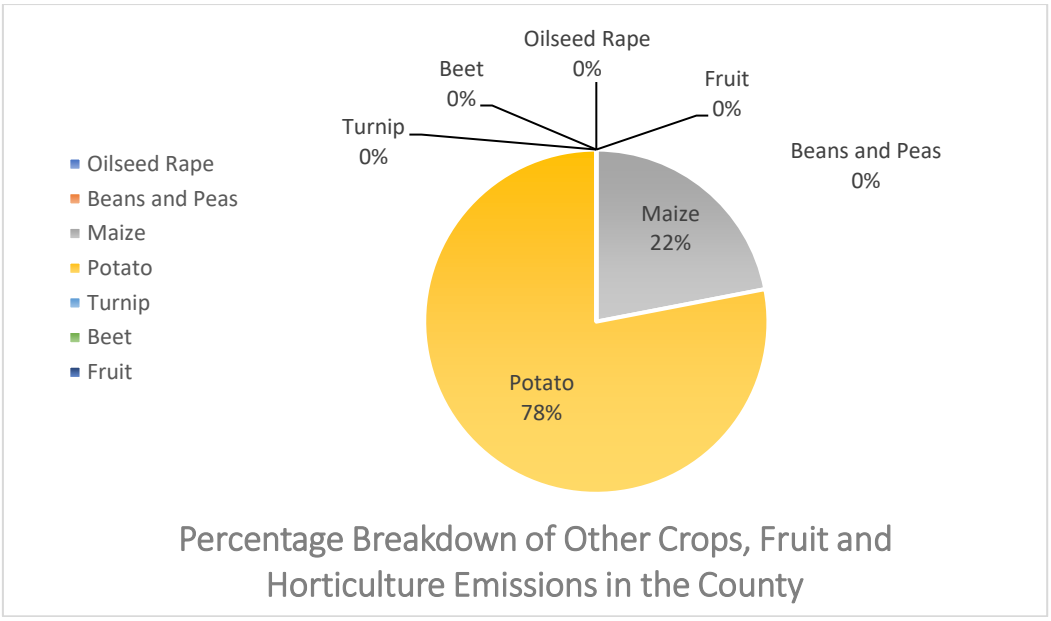


Figure 3-16: Percentage Breakdown of Emissions from the Other Crops, Fruit and Horticulture

Emissions from other crops, fruit and horticulture amount to 4,328.18 tCO_2-eq. The vast majority of emissions from this sub-category are from potato farming (78%).

Emission from Managed Soils amount to 154,830.13 tCO_2-eq.

Agricultural emissions for the county broken down by the four overarching categories, total livestock, total cereals, total other crops, fruit and horticulture and manages soils combined are presented in Figure 3-17.

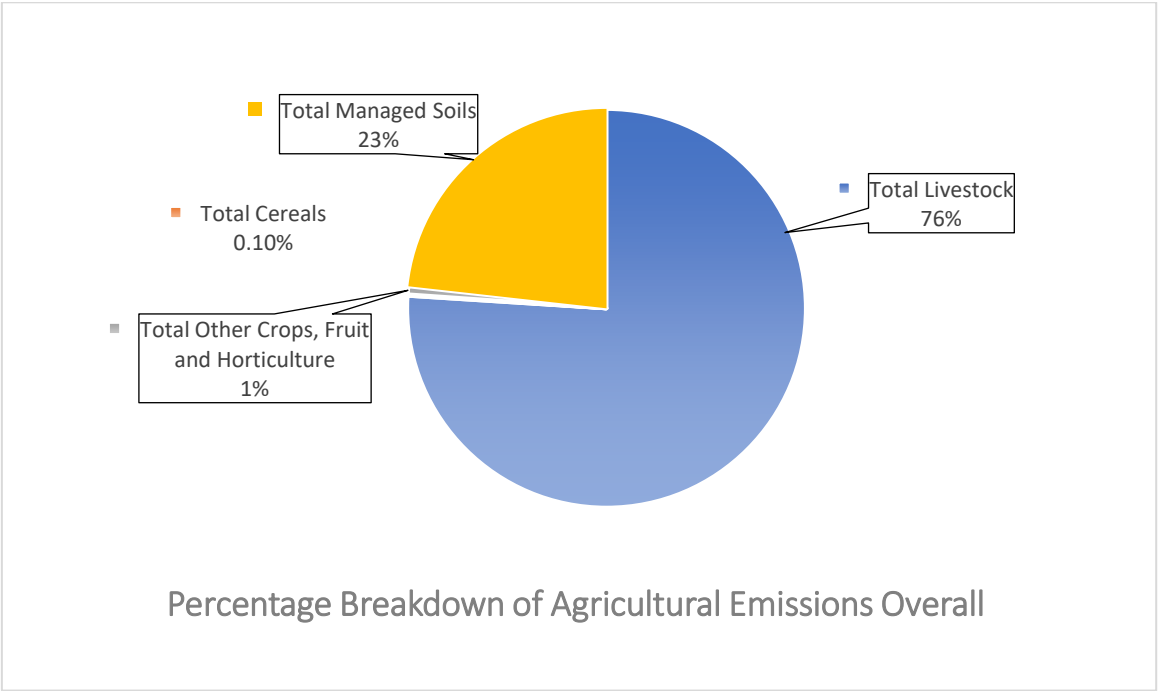


Figure 3-17: Agricultural Emission for the County Overall

As can be seen, livestock emissions, particularly cattle related emissions account for the majority of emissions for the sector overall. Emissions from poultry farming are also significant, which reflects the very high level of poultry farming in the county. Emissions from Managed Soils are significant. Emissions from cereals and other, crops, fruit and horticulture are relatively low by comparison to the other categories.

3.3.3 Assumptions and Limitations

The following assumptions and limitations exist in relation to the agricultural sector data:

- Land utilization data for 'Cereals' and 'Other Crops, Fruit and Horticulture' is suppressed in the Census of Agriculture for commercial reasons. Agricultural land utilisation data and land area for the region is determined and agricultural land utilization on a county level is prorated based on this data, to estimate the level of cover for 'Cereals' and 'Other Crops, Fruit and Horticulture' in the county.
- It is assumed that all managed agricultural soils in the county release the same level of emissions. In reality, emissions levels will vary depending on the type and level of fertilizer, lime or urea application on those soils based on their specific use (i.e., pasture, wheat, barley, potatoes).

3.3.4 Data Sources

- Central Statistics Office, Census of Agriculture, 2020.
- Environmental Protection Agency, EPA National Emission Inventory 2021.
- Central Statistics Office, Area Farmed in June, 2018.
- Central Statistics Office, Census, Population Statistics, 2016.
- Teagasc, National Farm Survey Sustainability Report, 2018.

3.4 Transport

3.4.1 Methodology

The following methodology was applied to determine transport related emissions in the county:

- The CSO's Transport Omnibus from 2018 was reviewed to ascertain mileage associated with vehicle types in the county in 2018. This was broken down into 'diesel,' 'petrol' and 'other fuel' related mileage.
- UK Department of Environment, Rural Affairs and Food (DEFRA) vehicle emission benchmarks were used to estimated emissions associated with each vehicle type.
- Public transport related emissions data for the nation was sourced from the CIÉ Group. The only public transport bodies in operation in rural counties are Bus Eireann and Iarnrod Eireann. The CIÉ Group do not have emissions data broken down by region or by county. Railway related emissions were therefore estimated using railway station numbers nationally and, in the county, assuming that the number of railway stations in a county corresponds to the level of railway services provided in that county. Bus related emissions were estimated using population statistics, assuming that the level of bus service in a county corresponds with population density.

3.4.2 Results

3.4.2.1 Private and Commercial Vehicles

Detail on kilometres travelled in the county broken down by vehicle and fuel type is presented in Table 3-9 and illustrated in Figure 3-18.

Table 3-9: Kilometres Travelled in the County broken down by Vehicle and Fuel Type

Type of Vehicle	Kilometres Travelled			
	Diesel	Petrol	Other Fuels	Total
Private cars	381,000,000	108,000,000	3,000,000	492,000,000
Motorcycles	0	1,000,000	0	1,000,000
Goods Vehicles	199,000,000	0	0	199,000,000
Tractors and machinery	34,000,000	0	0	34,000,000
Small PSVs	3,000,000	0	0	3,000,000
Large PSVs	10,000,000	0	0	10,000,000
Exempt vehicles	4,000,000	1,000,000	0	5,000,000
Other vehicles	5,000,000	1,000,000	0	6,000,000

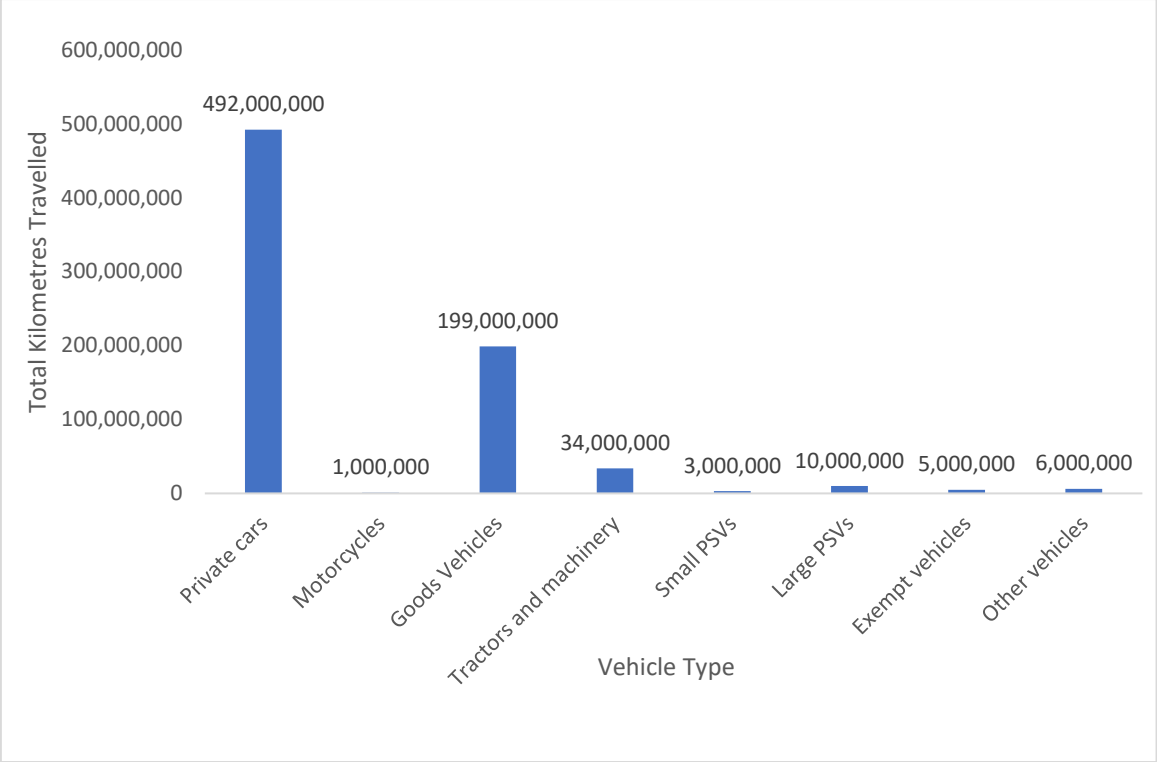


Figure 3-18: Kilometres Travelled in the County broken down by Vehicle and Fuel Type

Private cars account for most of the mileage travelled in the county, followed by goods vehicles and tractors and machinery. This reflects the rural nature of the county, the lack of public transportation and the size of the haulage industry in the county.

A breakdown of vehicle transport emissions for the county by vehicle type is illustrated in Figure 3-19.

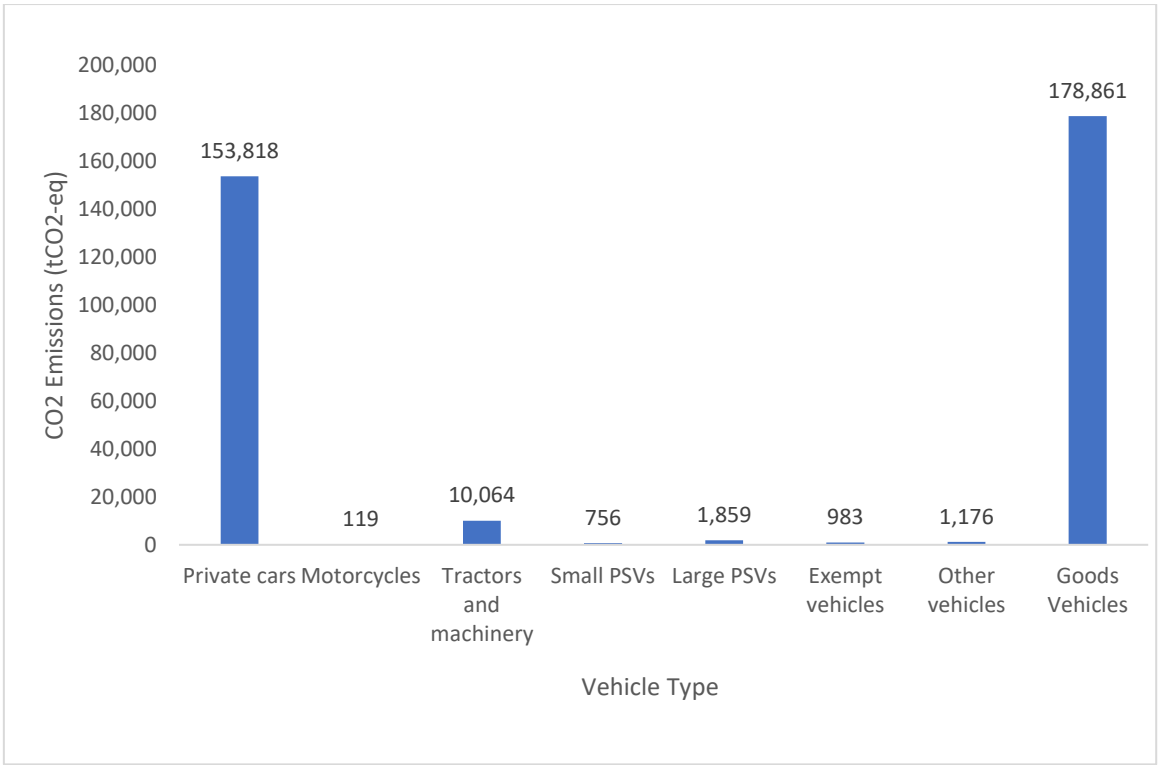


Figure 3-19: Breakdown of Vehicle Transport Emissions for the County by Vehicle Type

Good vehicles contribute most in terms of emissions, followed by private cars then tractors and machinery. This reflects the relatively high level of carbon emissions associated with weight laden goods vehicles, the relatively high numbers of private cars in the county, and the rural nature of the county.

A breakdown of vehicle related emissions by fuel type is illustrated in Figure 3-20.

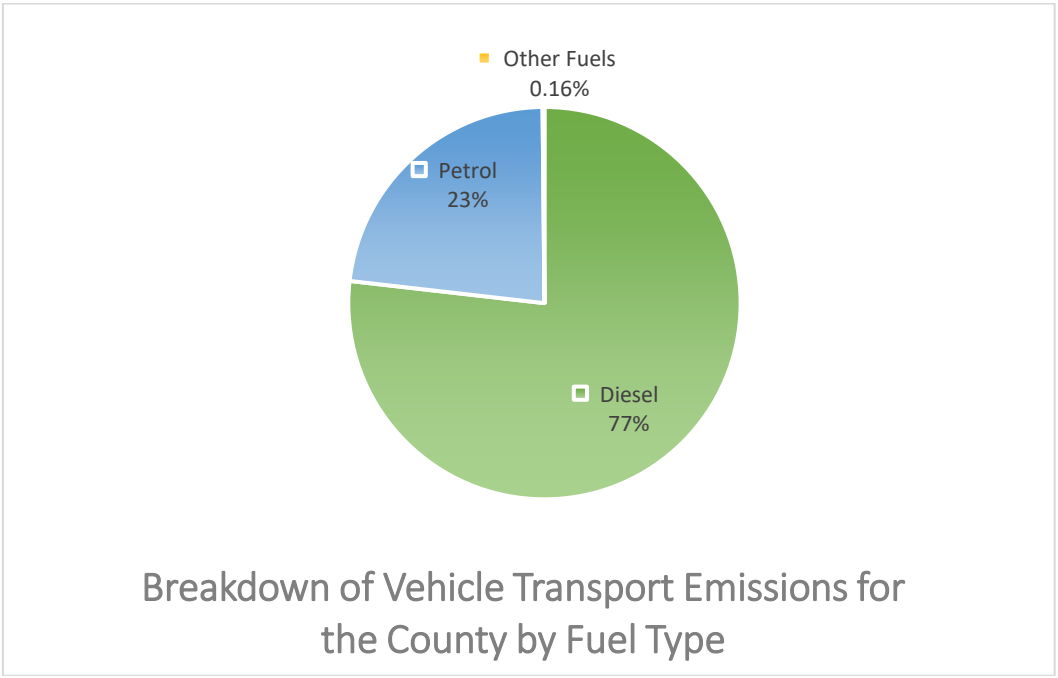


Figure 3-20: Breakdown of Vehicle Related Emissions by Fuel Type

Diesel accounts for the vast majority of fuel use in the county, followed by petrol, then other fuels (e.g., biofuel, electricity). Significantly, a relatively large number of private cars in the county use diesel.

3.4.2.2 Public Transport

There is a relatively small public transport sector in the county. This is due to the county being rural in nature and having a sparse, dispersed population compared to counties that have a great population density and more urban settlement.

Public 'intercity' and local bus services generate an estimated 967 tCO_2-eq per year. This represents a minor contribution to emissions relative to private and commercial transport in the county.

3.4.3 Assumptions and Limitations

The following assumptions and limitations exist in relation to the Transport sector data:

- There is currently a lack of county level data on public transport emissions. This data / data from which this can be estimated (e.g., rail length per county) is currently being sought from the relevant bodies. Railway related emissions are estimated using railway station number nationally and in the county. It is assumed that the number of railway stations in the county corresponds to the level of railway services provided in that county. Bus related emissions are estimated using population statistics. It is assumed that the level of bus service in the county corresponds with population density.

3.4.4 Data Sources

- Transport Omnibus 2018, Central Statistics Office, 2018.
- 2011 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors, DEFRA, August 2011.
- CIÉ Group Annual Report Year Ended 31 December 2021, CIE, 2022.
- Census of Population 2016, Central Statistics Office.

3.5 Waste and Wastewater

3.5.1 Methodology

3.5.1.1 Waste

Qualitative analysis of the waste sector in the county was carried out to determine the level of GHG emissions associated with the sector. The following waste categories defined in the EPA's National Emission Inventory 2021 were examined.

- Managed Waste Disposal,
- Composting,
- Anaerobic Digestion (AD),
- Incineration, and
- Open Burning of Waste.

Using the EPA's licencing and permitting database, all waste facilities in the county that fall under the above categories were identified.

Table 3-10 lists the regularized managed waste disposal sites identified in the County. One EPA licenced closed landfill exists in the county, namely Scotch Corner Landfill.

There are an additional three unlicenced landfills with Certificates of Authorisation, namely Scotch Corner, Killycard and Killycronaghan landfills. Although these landfills are no longer operational, they still emit Carbon dioxide and Methane due to the decomposition of organic matter that occurs within the waste bodies of the landfills.

Table 3-10: Managed Waste Disposal Facilities in the County

EPA Authorisation Reference	Name of Facility
W0020-03 (IED)	Scotch Corner Landfill
H0363-01	Scotch Corner Historic Landfill
H0364-01	Killycard Historic Landfill
H0366-01	Killycronaghan Historic Landfill

There are two landfills in the county which are unlicensed, and which do not currently hold a Certificate of Authorization, Corkeeran and Tiragarvan landfills.

Emissions associated with managed waste disposal were calculated using the EPA's Pollution Release and Transfer (PRTR) database, which contains information on emissions to air from landfills. Total Methane (CH_4) and CO_2 emissions for each landfill were determined. CH_4 emissions were converted to CO_2-eq using having regard to its GWP.

Some landfill facilities did not have data on emissions to air registered on the PRTR database. In these cases, the study resorted to reviewing a combination of emission monitoring reports, Annual Environmental Reports (AERs) and Tier 1, Tier 2 and Tier 3 Environmental Risk Assessments (ERAs) for the landfills (preferably from 2018) to determine emissions associated with these facilities. In some cases, historic AERs which would have typically contained mass emissions data were referenced.

No data on mass GHG emissions was available for the two unregularized landfill sites, Corkeeran and Tiragarvan landfills. Tier 1, 2 and 3 Environmental Risk Assessments have been completed for these sites; however, the assessments for these sites did not involve any monitoring or estimation of mass emission rates from the landfills. This represents a data gap in this study. To overcome this data gap, an emission factor for landfill gas emissions in the county was calculated having regard to mass emissions data relating to Killycard landfill. This emission factor was the mass emission quantity estimated for the baseline year at Killycard landfill divided by the size of the interred waste body in the landfill. This emission factor was then applied to estimate mass emissions from Corkeeran and Tiragravan landfills, having regard to the size of the interred waste bodies at these sites. The justification for using this estimation method is that each of these landfills broadly operated over the same time period and accepted similar types of waste (mixed municipal waste). There is however a degree of uncertainty of measurement associated with this method given the number of variables affecting landfill gas generation at a specific landfill site.

The accumulated emissions data for managed waste disposal facilities in the county were combined to determine emissions in tCO_2-eq for the baseline year.

One authorised composting facility was identified in the County, Terralift Ireland Ltd's facility based in Castleblayney. GHG emissions for the facility were estimated by prorating national composting emissions, having regard to waste management capacity at the facility versus waste management capacity at composting facilities nationally. There are no Anaerobic Digestion, or Incineration facilities in the county. Thus, there are no emission in the county from these categories of waste facility.

GHG emission from the open burning of waste were calculated on a pro-rata basis using national emissions data for this category and considering national and county population levels. There is no local data on GHG emissions from this unregularized and uncontrolled activity.

3.5.1.2 Wastewater

Using national emissions data for the wastewater sector defined in the EPA's National Emission Inventory 2021, emissions associated with this sector for the county were estimated for the county on a population pro-rata basis. This was determined to be the most accurate method of estimating domestic wastewater related emissions as there is no 'bottom up' emissions data for municipal wastewater facilities that have an operating capacity less than 100,000 Population Equivalent (PE) (which is the case for all municipal wastewater treatment facilities in the county), on-site wastewater treatment systems, or septic tanks.

3.5.2 Results

3.5.2.1 Waste

A breakdown of the total known emissions from managed waste disposal facilities in the county for the baseline year is presented in Table 3-11 and illustrated in Figure 3-21 and Figure 3-22.

Table 3-11: Emissions from Managed Waste Disposal Facilities in the County

Authorization Reference	Name of Facility	Emissions kgCH_4/year	Emissions kgCO_2/year	Total **tCO_2-eq/**year
W0020-03 (IED)	Scotch Corner Landfill	889,184	1,209,290	23,439
H0363-01	Scotch Corner Historic Landfill	232,826.00	635,000	6,456
H0364-01	Killycard Historic Landfill	65,480.47	179,000	1,816
H0366-01	Killycronaghan Historic Landfill	105,626.94	288,000	2,929
Not Applicable	Corkeeran Historic Landfill	34,592	94,563	959
Not Applicable	Tiragarvan Historic Landfill	55,118	150,673	1,529

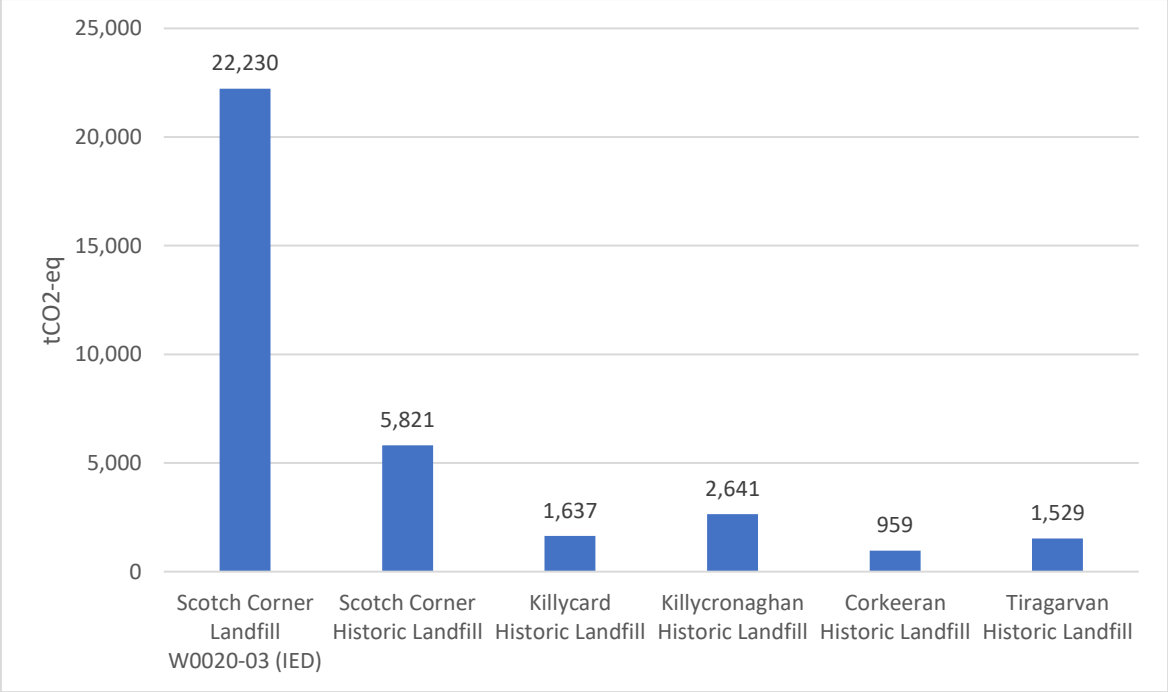


Figure 3-21: Managed Waste Disposal Emissions

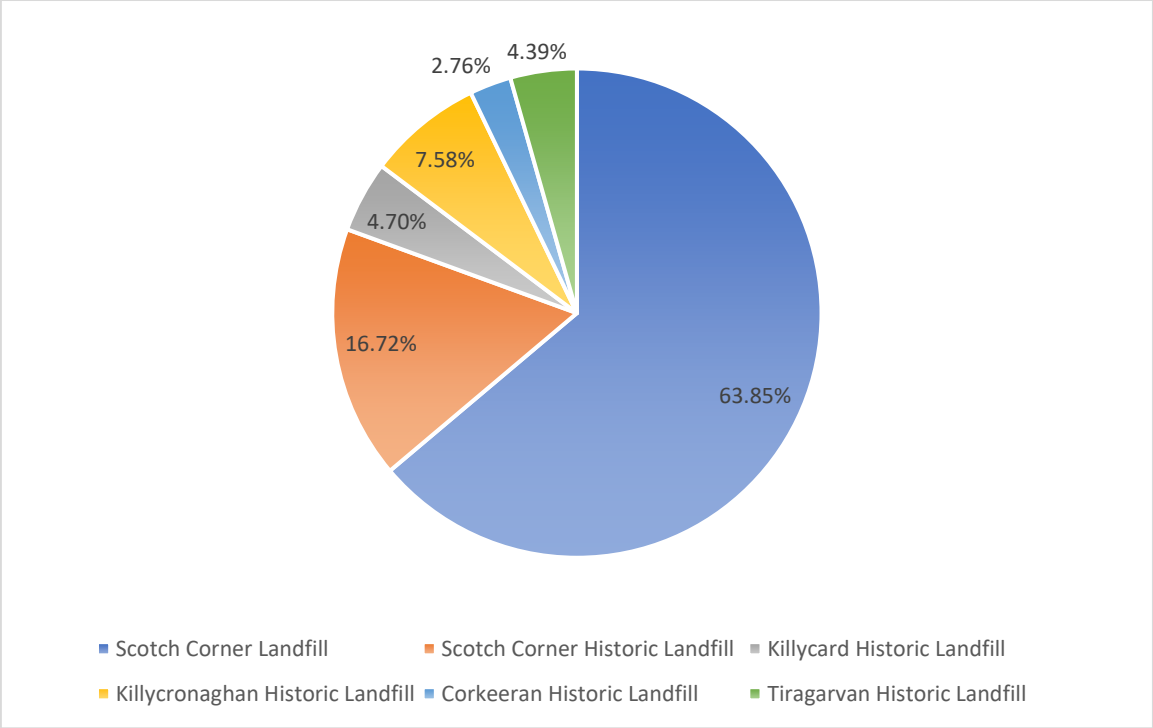


Figure 3-22: Landfill tCO_2-eq Equivalent Breakdown

As can be seen, most emissions are being generated by Scotch Corner Landfill. This is followed in order by the four historic landfills at Killycronaghan, Killycard, Tiragarvan and Corkeeran. Overall size and spatial extents of the waste landfilled at these sites is the primary factor determining CO_2 emissions.

It has been estimated that Monaghan's only composting facility, operated by Terralift Ireland Ltd, generated 765.08 tCO_2-eq in the baseline.

It is estimated that the open burning of waste in the county generated 46.7 tCO_2-eq in the baseline year.

Figure 3-23 presents a breakdown of waste sector GHG emissions in the county for the baseline year.

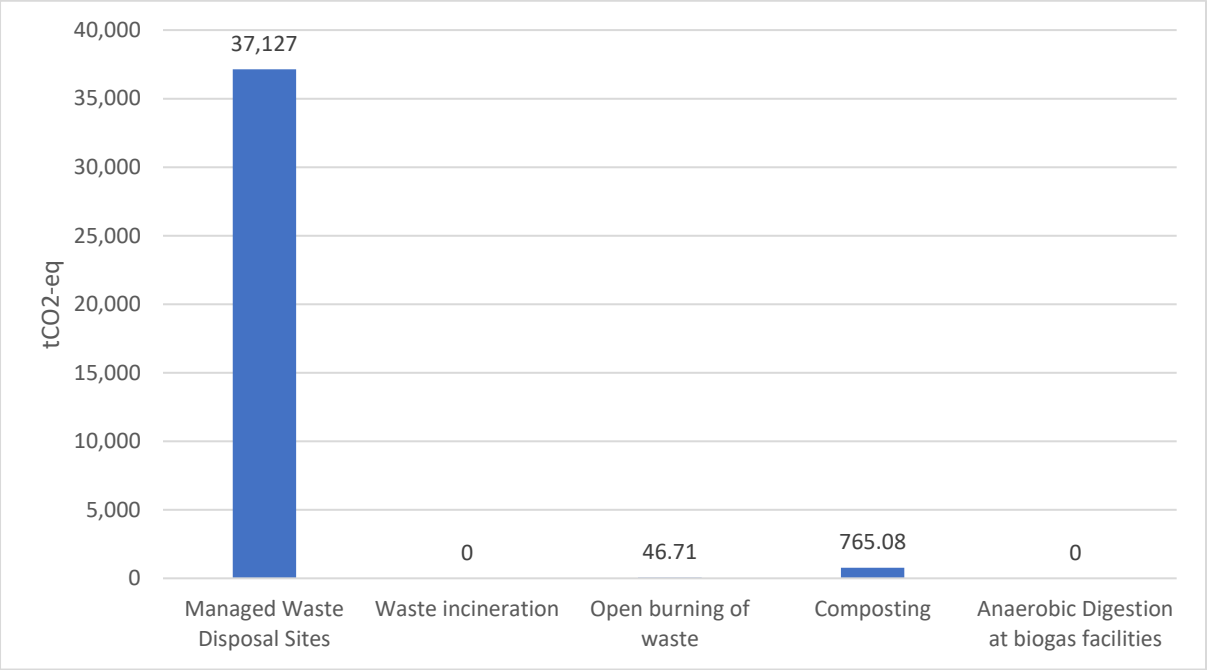


Figure 3-23: Breakdown of Waste Sector GHG Emissions in the County for the Baseline Year

3.5.2.2 Wastewater

Estimates for GHG emissions from the wastewater sector in the county for the baseline year are presented in Table 3-12.

Table 3-12: Wastewater Emissions

Sector Category	National CO_2 Emissions (tCO_2-eq)	Population Ireland 2018	Population in the County	Total CO_2 Emissions (tCO_2-eq)
Domestic Wastewater	147,900	4,761,865.00	61,273	1,903

A comparison between wastewater sector emission in the county and in the nation overall is illustrated in Figure 3-24.

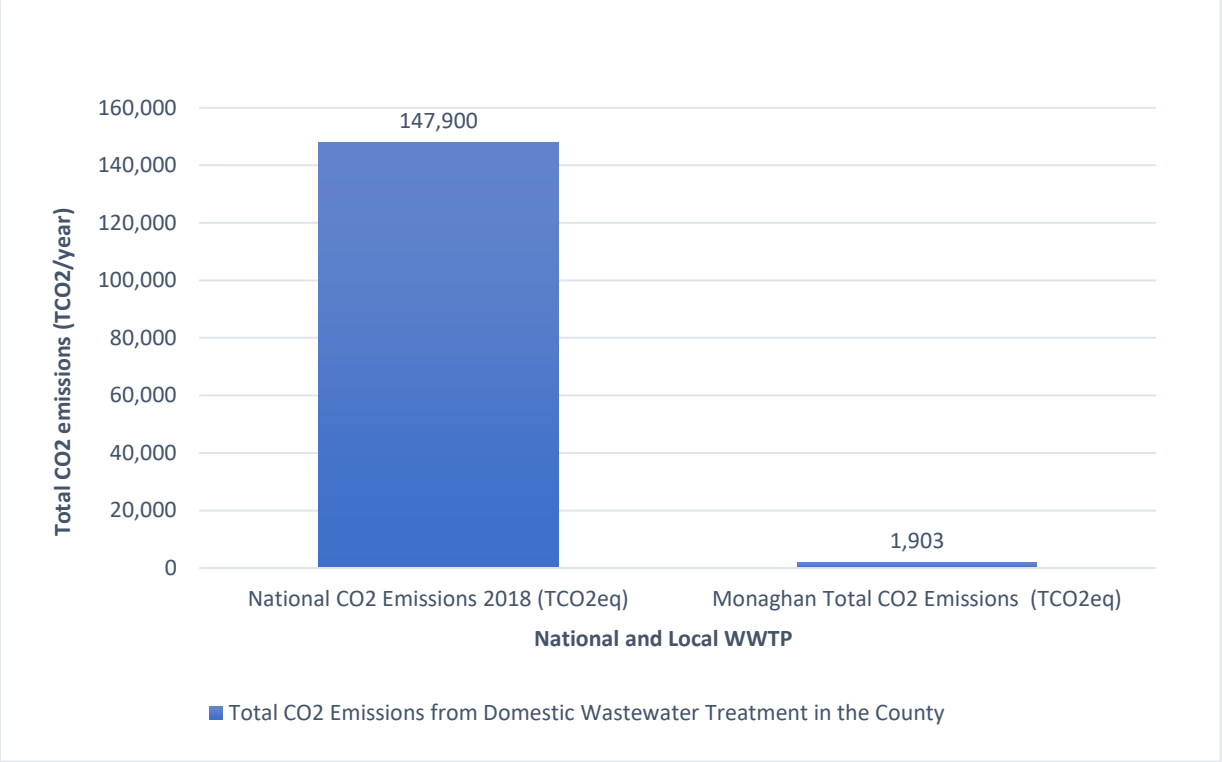


Figure 3-24: County and National Wastewater Emissions

3.5.2.3 Summary

A summary of the key findings for the waste and wastewater sectors is presented below:

- Total emissions from the waste sector in the county were estimated to be 37,939 tCO_2-eq, which is relatively high for a county that is predominantly rural in nature.
- The majority of waste sector emissions in the county are generated by Scotch Corner landfill.
- Methane made up approximately 93% of the CO_2-eq emissions from landfills overall.
- Carbon dioxide made up approximately 7% of the CO_2-eq emissions from landfills overall.
- Total emissions from the wastewater sector in the County were estimated to be 1,903 tCO_2-eq, which represents a small fraction of domestic wastewater emissions nationally.

A breakdown of the emissions from the waste and wastewater sector in the county is illustrated in Figure 3-25.

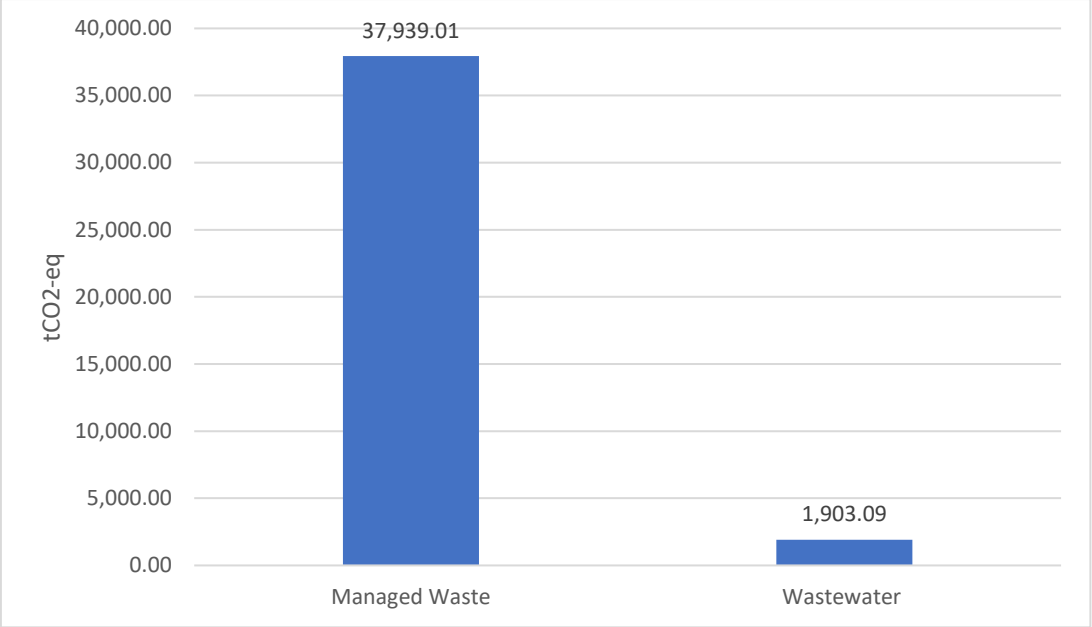


Figure 3-25: GHG Emissions from the Waste and Wastewater Sector

3.5.3 Assumptions and Limitations

The following assumptions and limitations exist in relation to the Waste and Wastewater sector data:

- Managed waste disposal related to all regularized landfills including operational landfills and closed or historic landfill that are regulated by Certificate of Authorization by the Environmental Protection Agency (EPA).
- In some cases, historic AERs which would have typically contained mass emissions data (before 2015) were referenced due to a lack of data on mass emissions to air from the landfills in the desired baseline year of 2018. This represents a limitation in the case of historic landfills due to changes in landfill gas generation within a waste body over time.
- Landfill gas mass emission rates at Killycard landfill were assumed to be representative of landfill gas emission rates at Corkeeran and Tiragarvan landfills. The justification for this is that each of these landfills broadly operated over the same time period and accepted similar types of waste (mixed municipal waste). There is however a degree of uncertainty of measurement associated with this method given the number of variables affecting landfill gas generation at a specific landfill site.
- There is no 'bottom up' emissions data for municipal wastewater facilities that have an operating capacity less than 100,000 Population Equivalent (PE) (which is the case for all municipal wastewater treatment facilities in the county), on-site wastewater treatment systems, or septic tanks.

3.5.4 Data Sources

- Central Statistics Office, Census of Population, 2016
- National Emission Inventory, EPA, 2021.
- EPA IE licence, IPC licence, waste licence and WFP search databases and licence files for landfills contained within them - accessed 15/11/2022.

3.6 Land Use, Land Use Change and Forestry (LULUCF)

3.6.1 Methodology

The following methodology was used to determine emissions from the LULUCF sector.

- The EPA's National Emissions Inventory 2021 was reviewed to determine emissions associated with land use types defined under this category - Forestland, Cropland, Grassland, Wetland.
- The CORINE Land Cover Inventory for Ireland was reviewed to ascertain the area in km^2 of each land use type in the county and in the nation overall.
- National GHG emissions for each land use type were then pro-rated for the county based on land use type cover nationally versus land use type cover in the county. An estimation of emission release and CO_2 absorption levels for the county for each land use type can then be made.

3.6.2 Results

A breakdown of land use type cover in the county is presented in Table 3-13.

Table 3-13: Breakdown of Land Use Type Cover in the County

Land Use Type Cover for the County	
Land Use Type	**km^2**
Forestland	30
Cropland	108.74
Grassland	1,110.55
Wetland	24.76

Grassland is the most dominant land use type cover spanning across 1110.55 km^2 across the county. This is followed by cropland covering 108.74 km^2, forestland at 30 km^2 and then wetland at 24.76 km^2.

Information on tCO_2-eq emissions related to land use, land use change and forestry for the various land uses in the county for the baseline year is presented in Table 3-14 and Figure 3-26.

Table 3-14: Breakdown of LULUCF Emissions by Land Use Type for the County

LULUCF Emissions Broken Down by Land Use Type	
Land Use Type	**tCO_2-eq**
Forestland	-25,939
Cropland	-1,617
Grassland	180,762
Wetland	5,061
Total	+158,266

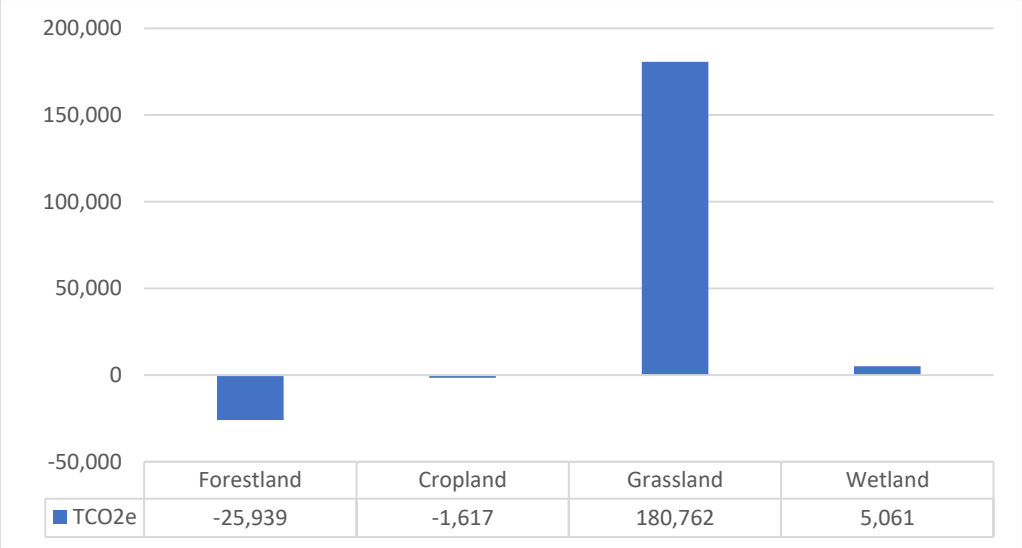


Figure 3-26: Breakdown of LULUCF Emissions by Land Use Type for the County

Grassland in the county is the land use type that contributes most in terms of emissions.

This is followed by Wetland. Wetlands refer to unmanaged wetlands and managed peatlands, which are those wetland areas drained for the purpose of commercial exploitation and harvesting of peat. Unmanaged wetlands include peatlands not commercially exploited, inland marshes, salt marshes, moors and heathland and intertidal flats. Carbon stock changes for wetland reflect both carbon losses and gains cumulatively (e.g. losses from vegetation and soil removal from peatland working/harvesting, gains associated with areas of restored peatland).

Forestland and Cropland serve to absorb CO_2 considering both CO_2 gains and losses overall. These land use types generally absorb more carbon (e.g., through vegetative photosynthesis) than they release (e.g., through deforestation or harvesting).

3.6.3 Assumptions and Limitations

It is assumed that each land use type has a universal rate of GHG generation / absorption. In reality, emission / absorption levels would differ between specific land use types (e.g., an area of conifer forest versus an area of broadleaved forest).

3.6.4 Data Sources

- CORINE Land Cover Inventory for Ireland - Accessed 14/11/2022.
- Environmental Protection Agency, EPA National Emissions Inventory, 2021

4. OVERVIEW AND MAIN CONCLUSIONS

The analysed sectors in the county generated 2,158,769 tCO_2-eq in the baseline year, overall. A breakdown of these emissions and targeted emission levels for 2030 by sector is presented in Table 4-1.

Table 4-1: Breakdown of Emissions Per Sector in the County

Sector	Emissions 2018 tCO_2-eq	SEC Reduction Required	Target Emissions 2030 tCO_2-eq
Residential	192,361.0	40%	115,417
Commercial and Industrial	753,442.0	45%	414,393
Agriculture	666,254.7	25%	499,691
Transport	348,603.0	50%	174,302
Waste and Wastewater	39,842.0	50%	19,921
LULUCF*	158,266.4	-	-
Total	**2,158,769.1**		**1,223,723**

* Finalisation of the Sectoral Emissions Ceiling for the Land-Use, Land-Use Change and Forestry (LULUCF) sector has been deferred for up to 18 months to allow for the completion of the Land-Use Strategy.

A percentage breakdown of emissions in the baseline year is provided in Figure 4-1.

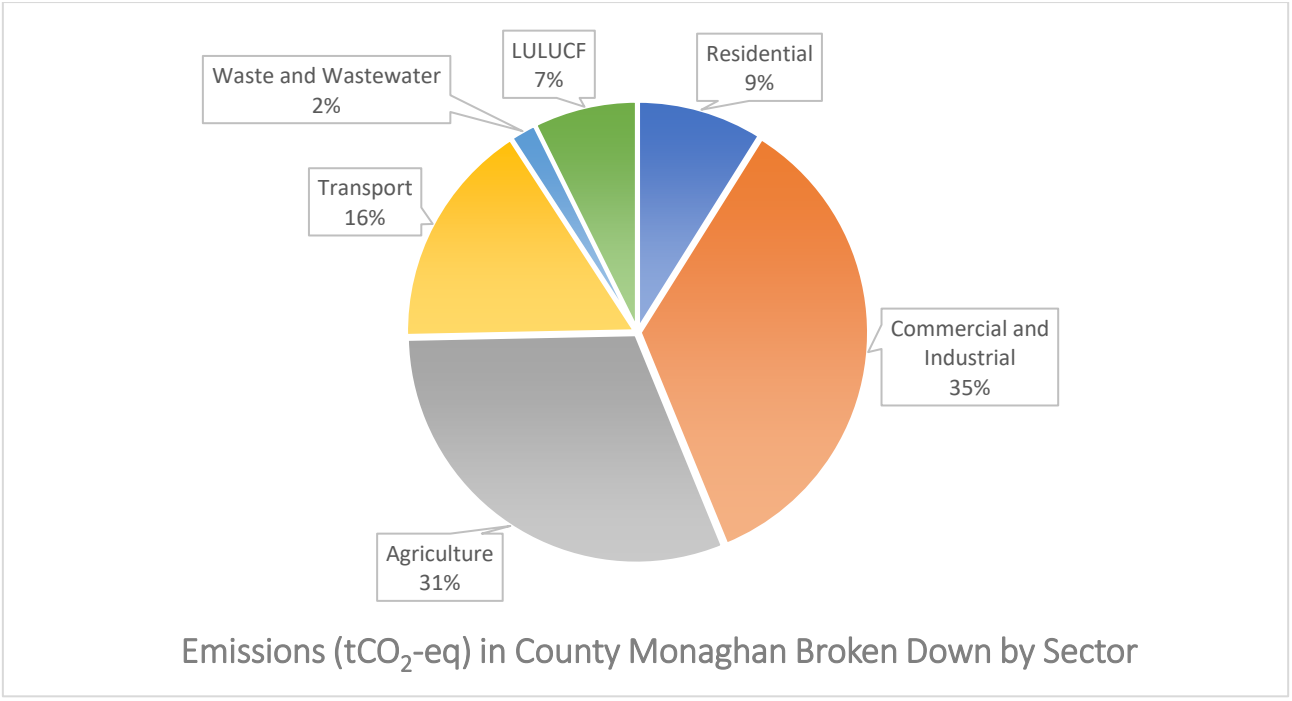


Figure 4-1: Breakdown of Emissions Per Sector in the County

The top three sectors in the county in terms of GHG emission levels were Commercial and Industrial, Agriculture and Transport, producing 35%, 31% and 16% of tCO_2-eq respectively, of the total emissions in the county. From this analysis, these sectors should be the main targets of energy and emission initiatives.

A summary of the main areas for potential action generally is presented below:

- Promoting renewable energy development, to assist with the reduction of CO_2 emissions associated with electricity usage.
- Reducing GHG emissions from the food and drink manufacturing (i.e., dairy and meat processing), general manufacturing, concrete manufacturing, quarrying and the 'fuel / oil depot' industrial category.
- Reducing greenhouse gas emissions from cattle and poultry farming.
- Promoting alternative, less carbon intensive forms of agriculture (e.g., growth of biomass crops for the bioeconomy).
- Promoting the use of vehicle fuels other than diesel (e.g., electricity for private cars, biofuel for goods vehicles).
- Promoting and develop public transportation services.
- Increasing energy efficiency in detached dwellings.
- Replacing Residential sector heating oil use.
- Increasing the level of forestation in the county.

The Climate Action and Low Carbon Development (Amendment) Act 2021 commits Ireland to reach a legally binding target of net-zero emissions no later than 2050, and a cut of 51% by 2030. An overall emission reduction of 935,046 tCO_2-eq is required for the county to meet the defined sectoral emission ceilings targets (not including the LULUCF sector).

An illustration of the target emissions for 2030 broken down by each sector is provided in Figure 4-2.

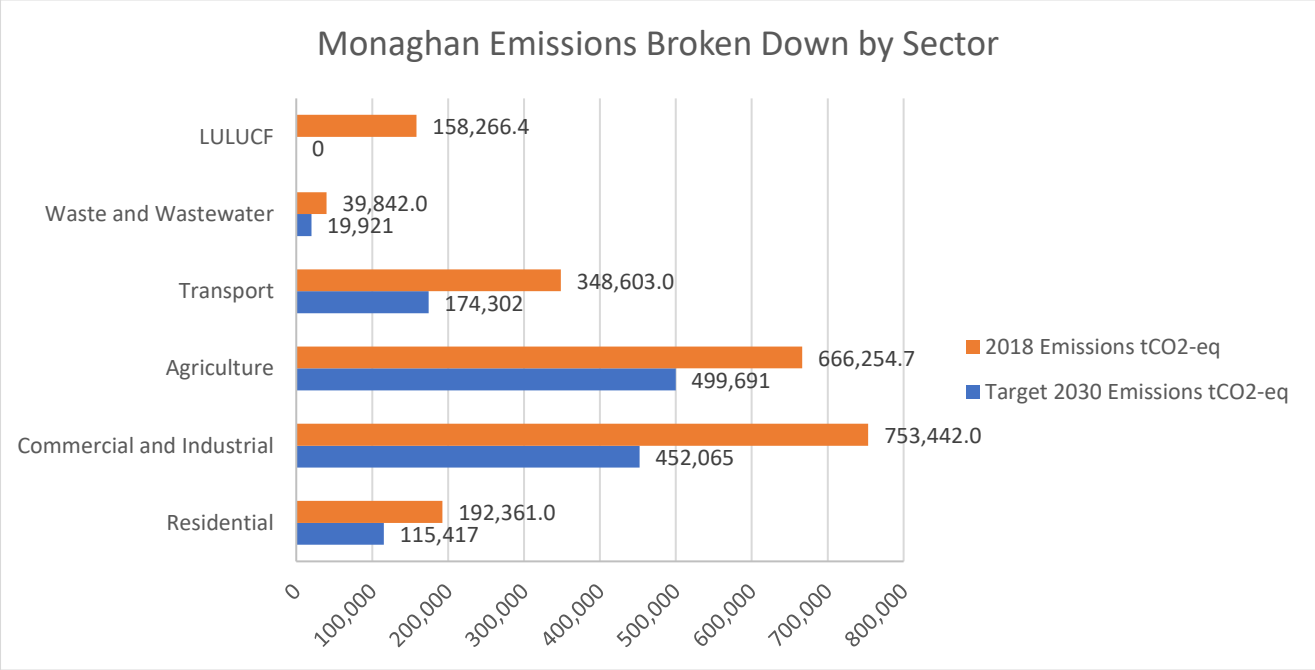


Figure 4-2: Emission Reduction Requirements Per Sector

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APPENDIX 1

Further Explanation of the Sectors

Detailed Explanation on Subsectors/Subcategories for Each Sector

The sections below provide further detail on particularly complex to understand subsectors/subcategories, including:

- Agriculture - Managed Soils
- LULUCF
- LULUCF - Grassland
- LULUCF - Wetlands (Peatland)

The EPA's National Emissions Inventory Report (NIR) provides more information on these sectors.

Agriculture - Managed Soils

The 2006 IPCC Guidelines on National Greenhouse Gas Inventories defines managed soils as all soils on land, including Forest Land, which is managed. Nitrous oxide is produced naturally in soils through the processes of nitrification and denitrification. Nitrification is the aerobic microbial oxidation of ammonium to nitrate, and denitrification is the anaerobic microbial reduction of nitrate to nitrogen gas (N2). Nitrous oxide is a gaseous intermediate in the reaction sequence of denitrification and a by-product of nitrification that leaks from microbial cells into the soil and ultimately into the atmosphere. One of the main controlling factors in this reaction is the availability of inorganic N in the soil.

Under the agriculture sector, GHG emissions from managed soils are therefore estimated based on N_2O emissions.

The emissions of N_2O that result from anthropogenic N inputs or N mineralisation occur through both a direct pathway (i.e., directly from the soils to which the N is added/released), and through two indirect pathways: (i) following volatilisation of NH_3 and NO_x from managed soils and from fossil fuel combustion and biomass burning, and the subsequent redeposition of these gases and their products NH_4^+ and NO_3^- to soils and waters; and (ii) after leaching and runoff of N, mainly as NO_3^-, from managed soils.

There are two key emission source categories in Ireland (see the EPA's National Emissions Inventory Report) for agricultural soils, namely 'Direct N_2O Emissions from Managed Soils' and 'Indirect N_2O Emissions from Managed Soils'. These are further explained in the table below:

Emission Source Category	Description
Direct N_2O Emissions from Managed Soils	This category includes emissions from **inorganic N fertilisers, organic N fertilisers, urine and dung deposited by grazing, crop residues, mineralisation / immobilization associated with loss / gain of soil organic matter and cultivation of organic soils**.
Indirect N_2O Emissions from Managed Soils	This category includes emissions from **atmospheric deposition and nitrogen leaching and run-off** from two indirect pathways: (i) following volatilisation of NH_3 and NO_x from managed soils and the subsequent redeposition of these gases and their products NH_4^+ and NO_3^- to soils and waters; and (ii) after leaching and runoff of N, mainly as NO_3^-, from managed soils.

This sub-category is distinct from the LULUCF sector in that it solely relates to GHG emissions which are as a result of land spreading and deposition related to agricultural activity (i.e., fertilizer application emissions, loss of N contained in fertilizer through volatilization or leaching and run-off).

LULUCF

The rate of build-up of carbon dioxide (CO_2) in the atmosphere can be reduced by taking advantage of the fact that atmospheric CO_2 can accumulate as carbon in vegetation and soils in terrestrial ecosystems. Under the United Nations Framework Convention on Climate Change any process, activity or mechanism which removes a greenhouse gas (GHG) from the atmosphere is referred to as a "sink". Human activities impact terrestrial sinks, through land use, land-use change and forestry (LULUCF), consequently, the exchange of CO_2 (carbon cycle) between the terrestrial biosphere and the atmosphere is altered.

LULUCF stands for Land Use, Land Use Change and Forestry. It is defined by the United Nations Climate Change Secretariat as 'a greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities.' The LULUCF sector includes the land use categories: Forest land, Cropland, Grassland, Wetlands, Settlements, Other land and Harvested Wood products.

Breaking down LULUCF into its individual terms:

- **'Land Use'** refers to the human use of the material on land which represents the economic and cultural activities practiced at a given place.
- **'Land Use Change'** is then the process by which human activities transform the natural landscape, referring to how land has been used.
- **'Forestry'** refers to the practice of creating, managing, planting, using, conserving and repairing forests and woodlands for associated resources for human and environmental benefits. Note that land cover does not equate to land use (land cover refers to only the physical material on the land).

A description of each land use category is provided in the table below:

Land Use Category	Description[1]
Forest Land	Includes all public and private plantation forests. Forest land is an area of land where tree crown cover is greater than 20% of the total area occupied. It refers to emissions and removals from forest management activities such as **timber harvesting, thinning and replanting, and ecological processes** such as tree growth and decomposition.
Grassland	Includes improved grasslands, unimproved grasslands and grasslands not currently in use. Improved grasslands include areas identified as lands managed for **livestock grazing and grass-based feed and winter fodder production** (pasture, silage and hay). Unimproved grasslands are identified as **rough grazing** for livestock, predominantly sheep or low intensity beef farming. Grasslands not in use are those lands identified as dominated by grass habitats, but not currently managed (in any one year) for livestock.

[1] *Table 6.3 Description of Land Use Categories*, Ireland's National Inventory Report 2022.

Land Use Category	Description[1]
Cropland	Refers to emissions and removals from annual and perennial cropland, as well as from forest lands and grassland converted to cropland. Cropland includes lands in annual crops, summer fallow and perennial crops.
Wetlands	Includes unmanaged wetlands and managed wetlands. Managed wetland are areas commercially exploited for **public and private extraction of peat** and areas used for **domestic harvesting of peat**. Unmanaged wetlands are natural unexploited wetlands.
Settlements	Refers to emissions and removals occurring on developed lands (such as urban environments, transport infrastructure and mining), from land conversion of forests and agricultural land to settlements and the footprint of industrial, commercial/institutional, and residential buildings.

LULUCF - Grassland

Grasslands have a significant amount of carbon content and can act as either as a carbon emitting land use or a land use that sequesters carbon. This depends on a complex array of processes in combination with land use activities occurring on a grassland. GHG emissions associated with grasslands are a function of these processes of affecting biomass and soils containing carbon.

In Ireland, grassland grazing, for example, contributes to grassland related GHG emissions, depending on interactions between soils, plant species, and climate. Rainfall significantly effects carbon releases on grasslands that are subject to grazing. On sites with higher rainfall, grazing generally increases soil carbon releases on sandy, coarse-textured soils, while clay soils respond with weak increases to strong decreases in soil carbon releases. Naturally, the Irish climate is characterized by cool and damp, cloudy and rainy weather conditions throughout the year. This significantly contributes to the release of carbon emissions from grasslands (the same can be said for wetlands).

Emissions from grassland can also be due to their intensive use for food and forage production because of their high natural soil fertility. Carbon stores within grasslands are sensitive to management and are thus vulnerable to losses in soil carbon. Land degradation—which is a long-term decline in plant productivity and the associated soil and water functions that support it—is widespread in grasslands in part due to soil carbon losses.

When grassland becomes degraded, these soils can lose carbon, converting to carbon dioxide in the process. Conversely, when grassland is restored (for example, from cropland), carbon can be sequestered. Emissions here therefore refer to the net balance of these carbon losses and gains from grassland biomass and soils.

Studies have suggested that grassland soils can potentially act as significant carbon sinks. Land management practices can enable sequestration. An article published by Teagasc (Grassland and carbon sequestration, Teagasc) provides some examples of possible management techniques to increase carbon sequestration. These include:

- Grazed pastures may sequester more carbon than grasslands used for silage or hay production, due to the recycling of organic matter and nutrients from faeces and plant residues.
- Improve fertiliser management. Combine liming treatments with nutrient fertilisation.
- Ensure good grazing infrastructure — this will lead to less grassland damage and less frequent reseeding.

LULUCF - Wetlands (Including Peatlands)

Peatlands are known to be the largest natural terrestrial carbon store. They are able to store more carbon than all other vegetation types in the world combined. In peatlands, year-round water-logged conditions slow plant decomposition to such an extent that dead plants accumulate to form peat. This stores the carbon the plants absorbed from the atmosphere within peat soils, providing a net-cooling effect and helping to mitigate the climate crisis.

Forested peatlands are productive carbon sinks considering trees are good CO_2 sequesters. Combined with the properties of unexploited peatlands, the sequestered carbon from trees remains stored in peat soils.

However, the harvesting and overexploitation and associated degradation of peatlands release large quantities of GHG emissions and are responsible for almost 5% of global anthropogenic CO_2 emissions. Such harvesting has been common place across Ireland for decades, which means that Peatlands are net emitters in an Irish context. Ireland's wet climate results in the disturbed organic soils in these lands being very well drained. This drainage results in soil carbon releases to the environment, which decompose and volatize as a GHG emission. Peatland rehabilitation and restoration can reduce emissions significantly and change peatlands from net emitters to net sequesters.

For more information on the LULUCF sector, please refer to the following links:

Land Use, Land-Use Change and Forestry (LULUCF) | UNFCCC

Climate change reporting (europa.eu)

LULUCF | Environmental Protection Agency (epa.ie)

Ireland’s forests a source or sink of carbon dioxide? | Gov.ie

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