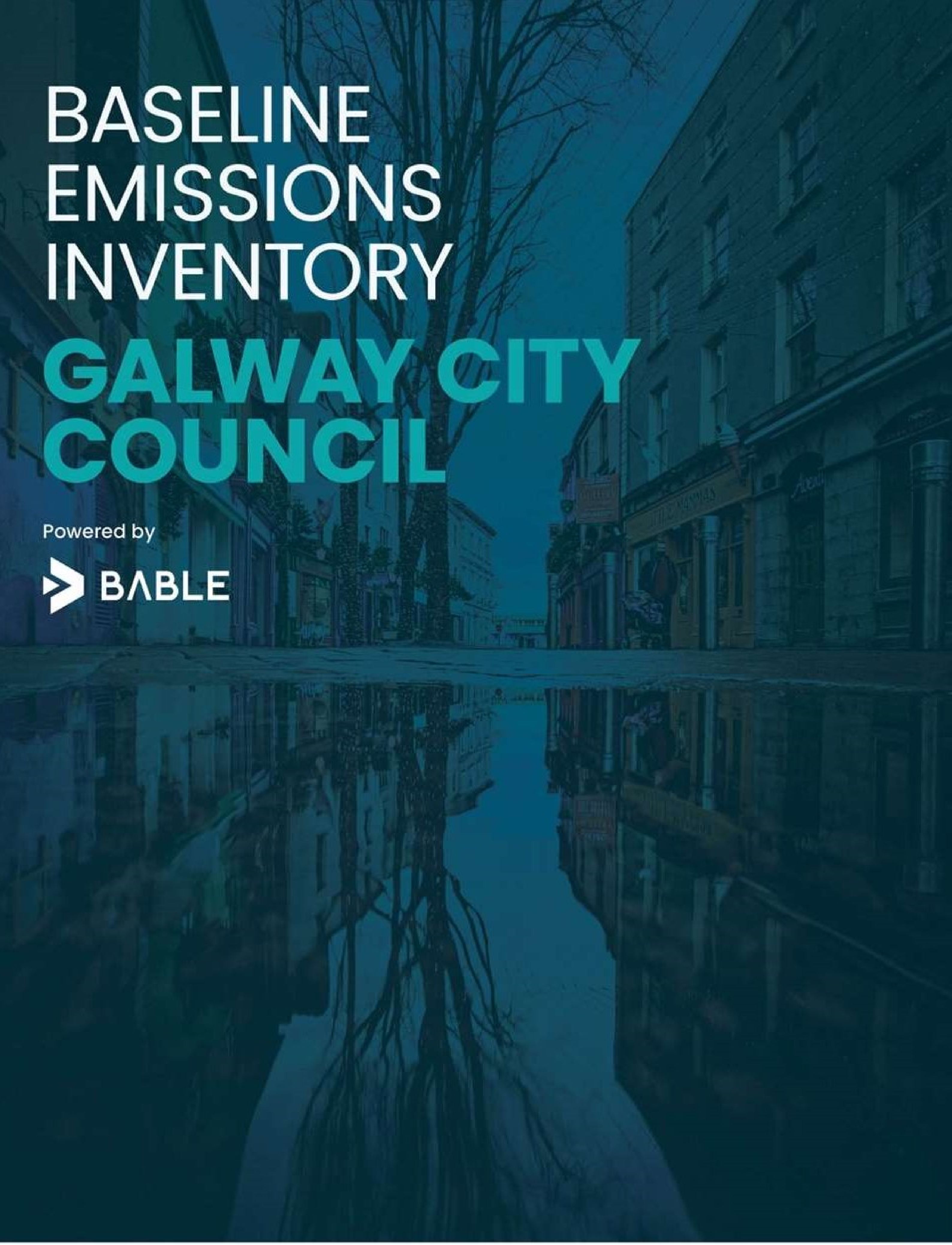


BASELINE EMISSIONS INVENTORY

GALWAY CITY COUNCIL

Powered by

BABLE

Comhairle Cathrach na Gaillimhe
Galway City Council

CARO

Contents

Glossary of Terms

AR6	Sixth Assessment Report
BEI	Baseline Emissions Inventory
BER	Building Energy Rating
CAP23	Climate Action Plan 2023
CRF	Common Reporting Format
CO_2	Carbon Dioxide
CoR	Certificates of Registration
CSO	Central Statistics Office
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
GVA	Gross Value Added
GWP	Global Warming Potential
$ktCO_2e$	Kilotonne Carbon Dioxide Equivalent
LA	Local Authority
LPG	Liquefied petroleum gas
LULUCF	Land Use, Land Use Change and Forestry
M&R	Monitoring and Reporting
NAEI	National Atmospheric Emissions Inventory
NFR	Nomenclature for Reporting
NIR	National Inventory Report
NTA	National Transport Authority
SEAI	Sustainable Energy Authority Ireland
SECAP	Sustainable Energy and Climate Action Plan
UNFCCC	United Nations Framework Convention on Climate Change
WFP	Waste Facility Permits

1. Executive Summary

Local Authorities (LA) are taking a leadership role in acting on climate and as part of the National Climate Action Plan are developing comprehensive Local Authority Climate Action Plans to address greenhouse gas (GHG) emissions in their administrative areas. These plans will be based on evidence, with the impacts measured over time. Enabling this is Baseline Emissions Inventories (BEI), a key instrument to enable LAs to design their climate plans and measure the impact of its associated actions related to emission reductions across the LA's own operations as well as varying sectors of society. This report presents the results of a BEI for Mayo County Council, breaking down the county's emissions by sector and providing Mayo-specific context towards the sectors. In addition, the emissions that the Local Authority is directly responsible for are presented.

The calculations for this inventory were made primarily using a dataset for 2019 from the Environmental Protection Agency (EPA) called MapEIre, which is the result of the National Mapping of GHG and non-GHG Emissions Sources project. The project spatially mapped GHG emissions on a square kilometre scale for the entire Irish Exclusive Economic Zone, assigning the emissions to where they were produced. This dataset was the basis for measuring emissions in County Mayo for the sectors Industrial Processes; Waste; Agriculture; Land Use, Land Use Change and Forestry (LULUCF), as well as the direct combustion emissions for the Residential, Commercial Services, and Manufacturing sectors. The latter three sectors (referring to the sectors mentioned earlier) also include electricity consumption emissions, which, in MapEIre, are categorized separately from other emissions due to the spatial methodology used, where all emissions from electricity are assigned to the power plant of generation, and not allocated to specific sectors.

Therefore, it is necessary for a separate analysis to distribute electricity emissions to the Residential, Commercial Services and Manufacturing categories. The Central Statistics Office (CSO) has metered electricity consumption available at the county level, split between residential and non-residential usage. This consumption data was then converted to carbon dioxide equivalent (CO_2e), the standard measure for measuring the global warming potential of GHGs and assigned to the sectors. Commercial and Manufacturing electricity were split based on an indicator of economic output.

Transport emissions were calculated using the National Transport Authority's (NTA) model and emissions from the local authority's own activities from the Sustainable Energy Authority Ireland's (SEAI) Monitoring and Reporting (M&R) programme. An inventory of Fluorinated gases, or F-gases, for the county, was also extracted from the MapEIre dataset.

The GHG emissions for Galway City in 2019 totalled 356 ktCO_2e, about 0.6% of the national total. Galway City Council's own emissions account for 4 ktCO_2e, about 1% of the city's emissions.

Emissions Category	Galway City Emissions (ktCO_2e)	National Emissions[1] (ktCO_2e)
Residential	142 (40%)	9,552 (15%)
Commercial Services	48 (13%)	4,618 (7%)
Manufacturing	67 (19%)	6,737 (10%)
Industrial Processes	4 (1%)	2,267 (3%)
Transport	94 (26%)	12,196 (19%)
Waste	2 (1%)	991 (2%)
Agriculture	3 (1%)	22,134 (34%)
LULUCF	-4 (-1%)	6,657 (10%)
Total	**356 (100%)**	**65,152 (100%)**

2. Introduction

Climate Action at the Local Authority level is a crucial component of Ireland's policy agenda, as evidenced by documents such as the National Climate Action Plan 2023 (CAP23) and the Climate Action Charter 2019. Efforts to act against climate change and its negative impacts require urgent action and Local Authorities (LA) are taking a leadership role within their jurisdictions. As part of CAP23, local authorities are to develop Local Authority Climate Action Plans, which will consist of targeted actions informed by evidence. It is, therefore, necessary to have a comprehensive understanding of current emissions and to identify which emission sources the Action Plan should target and how.

The European Union aims to be climate-neutral by 2050 as part of its commitment to combating climate change. The 2020 Climate and Energy package and the 2030 Climate and Energy Framework[2], intend to set the EU on the path to achieving the transformation towards a low-carbon economy as detailed in the 2050 low-carbon roadmap and set the key climate and energy targets for Europe.

As part of Ireland's climate action planning framework, Galway City Council is taking the necessary steps towards contributing to the state's climate goals and taking action to adapt and mitigate the effects of climate change by working as an implementing body with local communities, businesses and the national government. To inform these actions, Galway City Council has developed a Baseline Emissions Inventory (BEI) report. The BEI report measures the amount of greenhouse gases emitted in the baseline year and provides a sectoral breakdown of the results. The BEI report is based on local data from GHG emitting activities, such as energy production and consumption statistics as well as other information that reflects local GHG emission conditions.

The purpose of this BEI report is to calculate the emissions in the Local Authority area and analyse the sources. This will provide an evidence base for the LA to further calibrate mitigation objectives and targets. A thorough understanding of local energy use and greenhouse gas emission circumstances will serve as the foundation for developing the Local Authority's climate action plan. The BEI report is based on local and national data from 2019, on energy production and consumption and other GHG emissions in Galway City and contains insights into Galway City Council's own emissions. The GHG emission figures are based primarily on MapEIre, metered electricity data provided by the CSO and NTA data for Transport. The national emission reduction target of 51% by the end of 2030 is based on the greenhouse gas emissions reported for the end of 2018, in the national greenhouse gas emissions inventory. Accordingly, the collation of data to inform the local authority BEI should be relative to the baseline year of 2018, or as close to 2018 as possible. The closest year to 2018 for the primary dataset for this BEI, MapEIre, is 2019, thus all calculations were made for 2019.

---

[1] National data drawn from https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/EPA-Ireland's-Provisional-GHG-Emissions-1990-2021_July-2022v3.pdf; but with category "Energy Industries" distributed to Residential, Commercial and Manufacturing categories using same methodology as for the Local Authority Inventory

[2] https://climate.ec.europa.eu/eu-action/climate-strategies-targets_en

3. Methodology

3.1 National Emissions Inventory

The EPA has overall responsibility for the national greenhouse gas inventory in Ireland's national system and compiles Ireland's national greenhouse gas emission inventory on an annual basis. Ireland's legal reporting obligations require that we submit data for the period 1990-2021 in January, March and April 2023 to the European Commission and the United Nations Framework Convention on Climate Change (UNFCCC).

In response to climate governance and legislative advancements in 2021, the EPA published the provisional inventory data in July 2022 for the period 1990-2021. The provisional estimates of Ireland's greenhouse gas figures for the years 1990-2021 are based on interim energy balances provided by the SEAI in June 2022 and the latest available data from other data providers such as the Central Statistics Office and the Department of Agriculture, Food and the Marine (DAFM). These are compiled using methodologies in accordance with UNFCCC reporting guidelines. Verified emissions data from installations within the EU's Emissions Trading Scheme (ETS) are included. As the baseline year for this report is 2019, the 2019 national values are shown below. However, the most recent year is 2021 and this provisional data can be found here. Additionally, it should be noted that the EPA recalculate inventories from previous years as inventory capacity is increased and better data become available.

In 2019, total emissions in Ireland were 64,220 ktCO_2 equivalent.[3] It is important to note that this figure differs from the national total mentioned at the bottom of the table on page 4 of this report, with an approximate difference of 100 kt. The disparity is attributed to various factors, such as emissions in the EPA energy industries category that are not solely related to electricity. Another factor to consider is the potential use of different Global Warming Potentials (GWPs) between the AR4 and AR6 assessment reports, which contributes to the discrepancy. These emissions are then broken down into the following categories: Energy Industries, Residential, Manufacturing Combustion, Commercial Services, Transport, Industrial Processes, F-Gases, Agriculture, Waste, and Land Use/Land Use Change/Forestry (LULUCF). Note that the 'Energy Industries' category is not represented as its own

[3]https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/Ireland_NIR-2021_cover.pdf

category in the final Local Authority inventory and thus the individual categories are not directly comparable.

Category	Description
Energy Industries	Includes emissions from fuel combustion in power plants as well as from the extraction, production and distribution of fossil fuels
Residential	Includes emissions from space and water heating in households.
Manufacturing Combustion	Includes emissions from the combustion of fuels used in manufacturing processes, such as food processing.
Commercial Services	Includes emissions from space and water heating in commercial buildings.
Transport	Includes emissions from domestic road, rail, air and maritime transport.
Industrial Processes	Includes emissions from various industrial processes such as in cement production
F-Gases	Includes emissions of fluorinated gases, potent GHGs used in refrigeration, air conditioning and other industrial processes.
Agriculture	Includes emissions from livestock, fertilizer use and agricultural soils.
Waste	Includes emissions from the disposal and treatment of waste.
LULUCF	Includes both emissions and removals of GHGs associated with land use, land-use change, and forestry activities, such as the loss, gain and management of forests, peatlands and grasslands.

Table 1 National Inventory Categories and Totals

Agriculture is the largest contributor to the overall emissions in 2019 at 33% of the total national emissions in Ireland. Transport and Energy Industries are the second and third largest contributors at 18% and 14% respectively. Residential and LULUCF emissions account for 10% each. These five sectors accounted for 85% of national total emissions in 2019. The remainder is made up of the Manufacturing Combustion at 7%, Industrial Processes sector at 3%, Waste at 2%, F-Gases at 1% and Commercial Services at 1%. To accurately depict the National Irish Baseline Emissions data, it is crucial to emphasize that the energy industry is a standalone category and does not correspond with the figures mentioned in the executive summary table. All emissions coming from electricity are assigned under the Energy Industries.

of

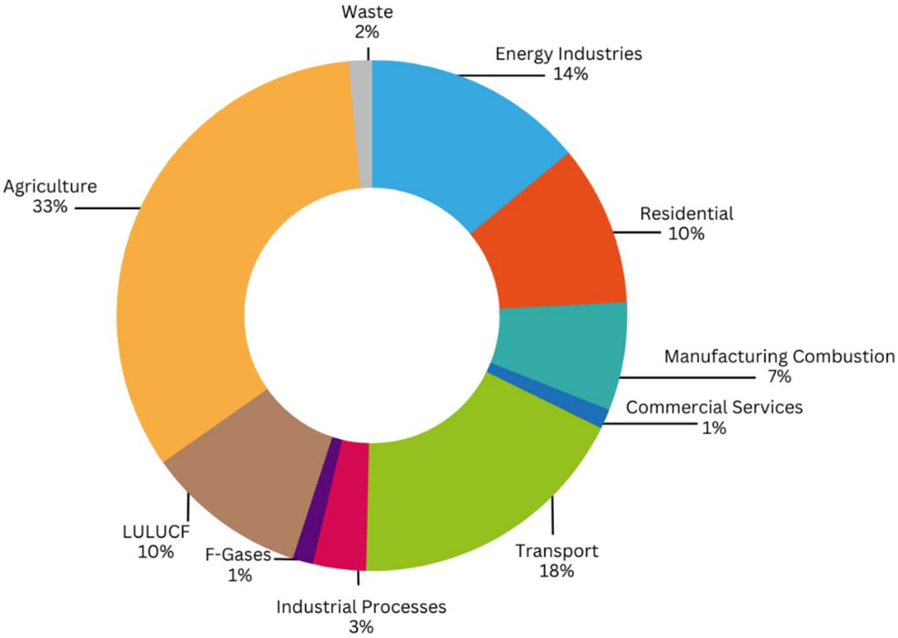


Figure 1 National Emissions Inventory (2019)

3.1.1 Reported Greenhouse Gases

Emissions data for the following gases are reported on an annual basis: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).

Ireland has higher than average emissions of methane and nitrous oxide because we have the highest relative agriculture emissions contribution from any of the EU member states.

For the inventory, these gas emission quantities are converted to CO_2 equivalent using Sixth Assessment Report (AR6) GWP values for a 100-year time horizon[4] by multiplying the mass of the emissions by the gas' corresponding GWP. GWPs compare the global warming impacts by measuring how much energy the emissions of 1 tonne of gas will absorb over a period of time. It should be noted that the 2019 EPA Inventory used IPCC Fourth Assessment Report values for Global Warming Potential, which will result in minor differences between this BEI and the EPAs 2019 data.

[4] https://report.ipcc.ch/ar6/wg1/IPCC_AR6_WGI_FullReport.pdf

Greenhouse Gas	Global Warming Potential
Carbon Dioxide (CO_2)	1
Methane (CH_4)	29.8
Nitrous Oxide (N_2O)	273
Sulphur Hexafluoride (SF_6)	25,200
Hydrofluorocarbons (HFCs)	4 - 14,600
Perfluorinated Compounds (PFCs)	6,630 - 11,100
Nitrogen Trifluoride (NF_3)	17,400

Table 2 Greenhouse Gases Global Warming Potential (AR6[5])

3.1.1.1 Carbon Dioxide

CO_2 is the main greenhouse gas emitted through anthropological activities, causing global warming. It is present in all sectors and easily outweighs the other GHGs in terms of raw mass of emissions. As the reference gas, the GWP will be 1 regardless of the time period used. A 100-year horizon was used for this report. CO_2 stays in the atmosphere for hundreds of years.

3.1.1.2 Methane

Methane has a GWP of 29.8. It absorbs much more energy than CO_2 but stays in the atmosphere for only about 10 years.

3.1.1.3 Nitrous Oxide

N_2O has a GWP of 273. Agriculture is the main sector emitting N_2O. It stays in the atmosphere for over 100 years.

3.1.1.4 F-gases

Fluorinated gases trap substantially more heat than CO_2 does per tonne. Sulphur Hexafluoride ($SF_{6)}$, has a GWP of 25,200, Hydrofluorocarbons (HFCs) have a GWP ranging from 4 to 14,600, Perfluorinated compounds (PFCs) range from 6,630 to 11,100 and Nitrogen trifluorides (NF3) has a GWP of 17,400. SF_6 is present in Industrial Processes. In the national inventory, F-gases are grouped as their own sector accounting for about 2% of national emissions.

[5] Note: The 2019 EPA Inventory used IPCC Fourth Assessment Report values for Global Warming Potential, which will result in minor differences between this BEI and the EPAs 2019 data.

3.2 National Grid Fuel Breakdown

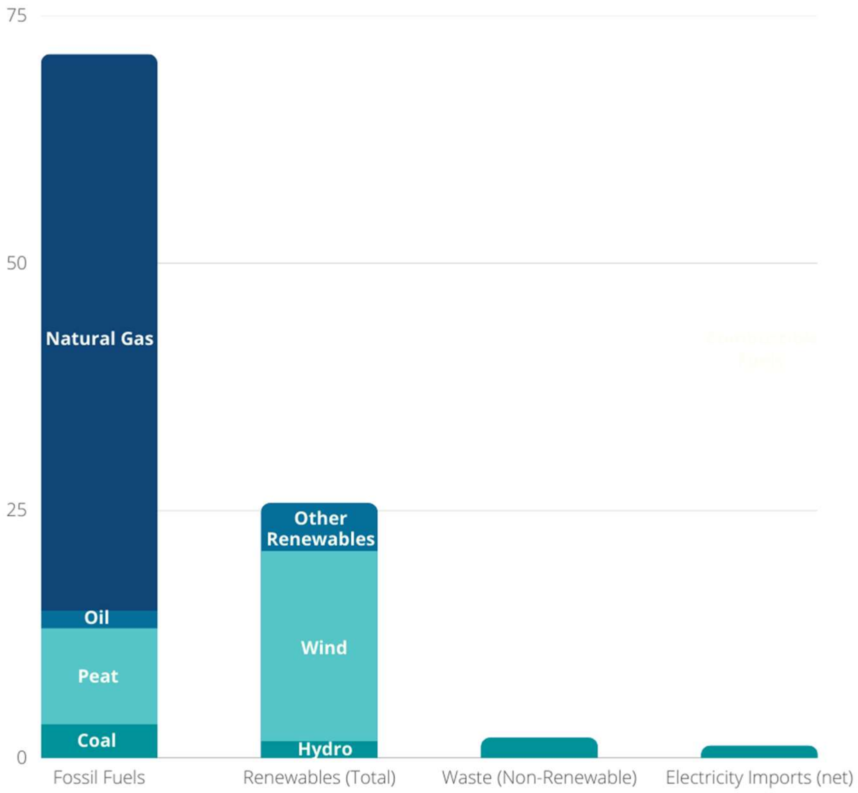


Figure 2 National Grid Fuel Breakdown (%)

The bulk of Ireland's electricity comes from natural gas, which accounted for 56% of the energy input in 2019. Wind energy is second, accounting for 19% of the input. All renewable sources combined made up 26% of the energy inputs to electricity generation. The generation efficiency of Ireland's grid was 54%, meaning 46% of the energy inputs are lost before reaching the final customer. Overall, the CO_2 intensity of Ireland's grid is trending down, from 636 gCO_2/kWh in 2005 to 324 gCO_2/kWh in 2019[6].

3.3 The MapEIre Project

Beginning in 2016, the EPA, in cooperation with Aarhus University in Denmark, carried out the National Mapping of GHG and non-GHG Emissions Sources (MapEIre) project.[7] The purpose of this project was to assign a spatial distribution to the national emissions inventory. As such, all greenhouse gas emissions from the Irish emissions inventory are distributed according to a square kilometre grid covering the entire Irish Exclusive Economic Zone, categorised by type of gas and by the subsectors corresponding to the common reporting format (CRF) and Nomenclature for Reporting from the UNFCCC. This dataset can then be used to calculate emissions inventories for a smaller area as well, in this case, a Local Authority area. It should be noted that the methodology used by the MapEIre project varied among the subsectors and some may have been mapped more robustly than others.

[6] https://www.seai.ie/publications/Energy-in-Ireland-2020.pdf
[7] https://projects.au.dk/mapeire/

This methodology accounts for emissions in the square kilometre where they are created, and not necessarily where the outputs of the emissions are consumed. For example, transportation emissions reflect the locations of rail lines, road networks and airports. Power plants will heavily influence the spatial emissions of where they are located but would be difficult to see on the map as they would only be reflected in a single grid cell. Below is a sample result from MapEIre's CO_2 inventory. The image on the left depicts CO_2 emissions on a 1km x 1km for all of Ireland, while the image on the right shows what this grid looks like on a local scale.

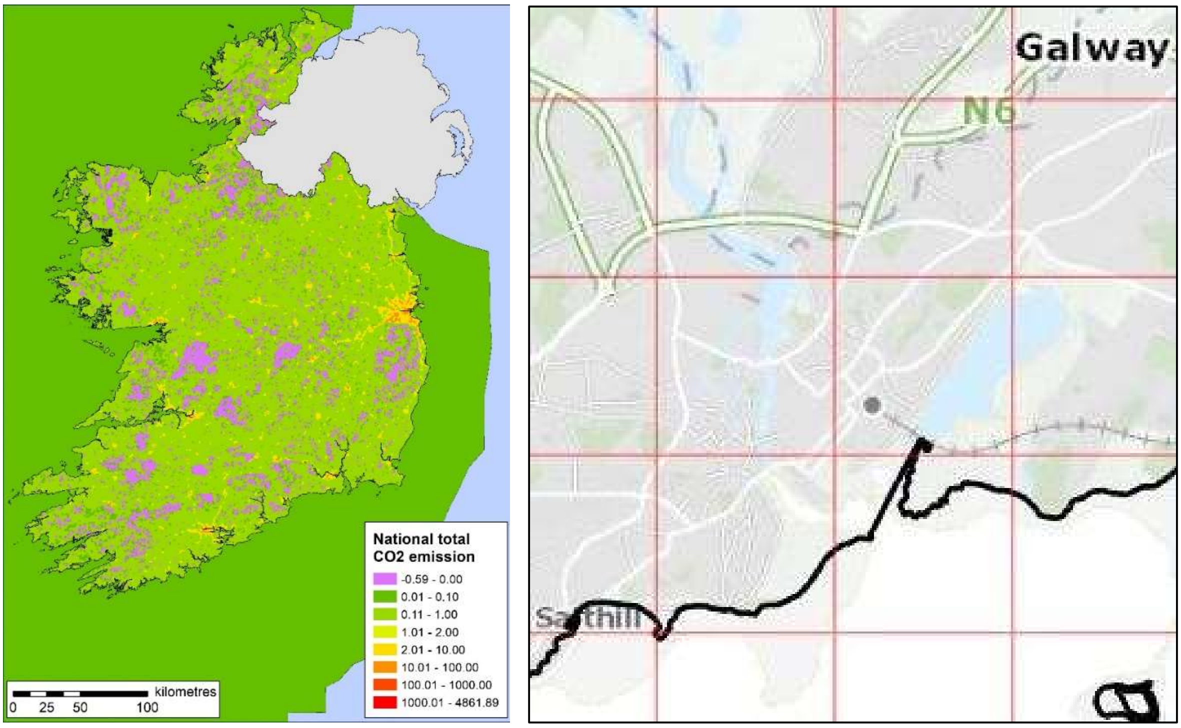


Figure 3 Sample representations of the MapEIre dataset

3.4 Local Authority Emissions Inventory Approach

The primary approach towards calculating the emissions inventory for the Local Authority's jurisdiction was through using the MapEIre dataset of Spatial GHG emissions by local authorities for 2019. This dataset contains the emissions for each Local Authority in Ireland broken down on a 1 x 1 km scale, with further classifications including the CRF Classification, the NFR codes and the pollutant names. The GHGs included in the local authority MapEIre dataset are CH_4, CO_2, N_2O and SF_6.

For this inventory, the data was filtered to only include emissions within Galway City. Then all emissions were converted to CO_2 equivalent using Sixth Assessment Report (AR6) GWP values for a 100-year time horizon[8] by multiplying the mass of the emissions by the gas' corresponding GWP. GWPs compare the global warming impacts by measuring how much energy the emissions of 1 tonne of gas will absorb over a period of time. The EPA's NIR used Fourth Assessment Report GWP values for the national inventory, which would result in small differences and should be kept in mind when comparing this inventory with the NIR.

All gases in the MapEIre dataset for Galway City were converted to CO_2 equivalent. The sum of these values broken down by sectors, subsectors and gas type is the basis of Galway's BEI. However, alternative sources were used for the Transport and Energy Industries categories. Transport emissions

[8] https://report.ipcc.ch/ar6/wg1/IPCC_AR6_WGI_FullReport.pdf

were calculated with data provided by the National Transport Authority and Energy Industries using data provided by the Central Statistics Office.

In MapEire and the associated BEI report, public sector emissions, including those from local authorities (LA), are allocated across several sectors. Transport-related emissions from the public sector, such as those from public transport services, are assigned to the transport sector. Building-related emissions from public sector buildings, such as schools, hospitals, and government offices, are assigned to the commercial sector. This includes emissions from the heating, cooling, and lighting of these buildings. However, emissions from public lighting, such as street lighting, are typically allocated to the non-residential electricity sector. It is important to note that the allocation of public sector emissions may vary depending on the specific activity and location, and the BEI report is updated regularly to reflect the latest data and methodological approaches.

According to the latest MapEire and the associated BEI report, energy-related agricultural emissions are assigned to the agriculture sector. The MapEire report provides a detailed breakdown of the emissions from various sectors, including agriculture, transport, commercial, and residential. While transport-related emissions are assigned to the transport sector and buildings-related emissions are assigned to the commercial sector, energy-related agricultural emissions are allocated to the agriculture sector. This includes emissions from the use of energy-intensive machinery and equipment in farming, as well as energy consumed in the production of fertilizers and other agricultural inputs.

Emissions are reported by mass using the International System of Units (SI). The Kilogramme (kg) is the base unit. Also used are Tonnes (equal to 1,000 kilogrammes), Kilotonnes (equal to 1,000 tonnes) and Megatonnes (equal to 1 million tonnes). All values have been rounded for display purposes.

3.4.1 Electricity Consumption

There are limitations to the MapEIre data in regard to providing actionable information for a Local Authority planning climate action to reach emissions reduction targets. The greatest of these is that emissions from electricity are assigned to the power plants where the electricity is generated, not the homes, businesses, etc., where it is consumed. The inventory derived directly from MapEIre will result in an inventory of emissions broken down into the following sectors: Agriculture, Commercial Services, Energy Industries, Industrial Processes, LULUCF, Manufacturing Combustion, Residential, Transport, and Waste. Under this version of the inventory, all emissions would be Scope 1 emissions, or direct GHG emissions that occur from fuel combustion. This results in all emissions from electricity being assigned to Energy Industries, rather than where the electricity is consumed. However, it is of more value for local authorities to understand where electricity is being consumed than generated to develop appropriate and specific mitigation actions. Therefore, the electricity emissions in this BEI are Scope 2 emissions, which are indirect GHG emissions associated with the purchase of electricity for own use.[9]

Therefore, for this inventory, the Energy Industries category has been removed and replaced with electricity consumption data that have been assigned to the Residential, Manufacturing, and

[9] The third classification of GHG emissions, Scope 3, goes deeper into the supply chain of emissions and would include emissions from production processes for goods produced outside of Galway that are consumed within the city. On a national scale, consumption-based emissions for Ireland are 69% higher than production-based emissions, primarily due to the import of goods for household consumption, according to the Economic and Social Research Institute (Link: https://www.esri.ie/publications/the-global-emissions-impact-of-irish-consumption).

Commercial sectors. The national total of emissions from Public Electricity and Heat Production under the Energy Industries category in 2019, according to the NIR, was 8,985 kt CO_2 (about 14% of the total).

Metered electricity consumption statistics for 2019 are available from the CSO on a county level and divided into categories of 'Residential' and 'Non-Residential.'[10] The emissions factor from Ireland's 2019 grid (0.3245 kg CO_2/kWh), as provided by the SEAI, was then used to convert electricity consumption into CO_2 equivalent as depicted below.[11] Multiplying the kWh of electricity by this factor results in a measure of the CO_2 equivalent emitted by the generation of the electricity. The emissions from residential electricity are calculated directly this way, as that is one of the sectors in question for this report. However, the Non-Residential emissions were split further into Manufacturing and Commercial sectors using Gross Value Added as a proxy measure for electricity consumption.[12] Gross Value Added is an economic indicator provided by the CSO on a sub-regional basis. The emissions from electricity for Manufacturing and Commercial sectors were therefore estimated by applying the ratio of Gross Value Added by sector to the total Non-Residential electricity emissions for the Local Authority area. In terms of the national level, this methodology yields emissions that are only 4% different from the electricity emissions reported in the National Inventory Report (NIR).

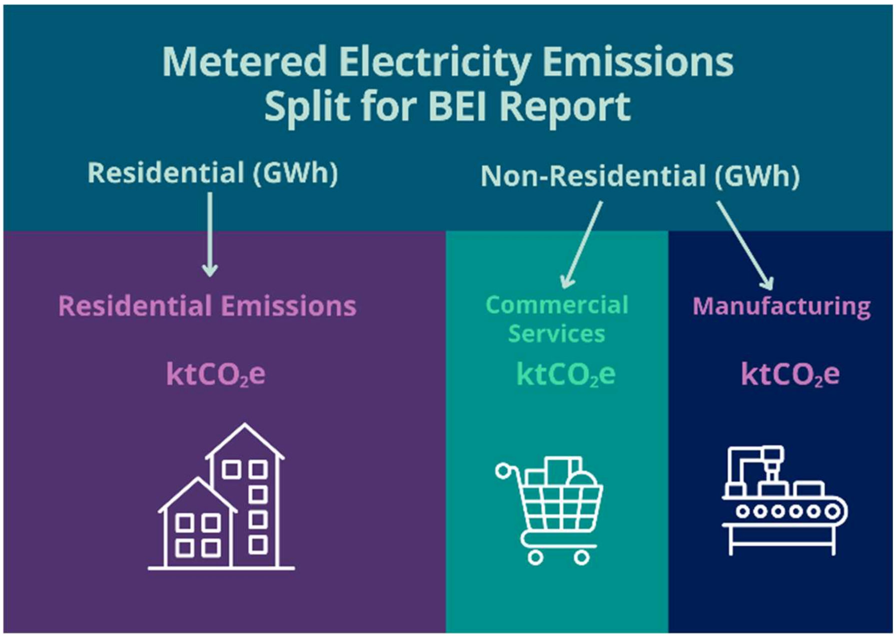


Figure 4 Metered Electricity Emissions Split for BEI Report

There is a significant portion (24%) of national non-residential electricity consumption that is not coded by the CSO for confidentiality reasons, meaning it was not assigned to any county. This consumption is from very large energy users, such as data centres. However, none of this consumption is within the Local Authority area and is therefore not included in this inventory.

Electricity Calculations Summary for the BEI:

- Gwh res (Gigawatt-hours residential) from CSO: obtained the residential electricity consumption data from the Central Statistics Office (CSO).

[10] https://www.cso.ie/en/releasesandpublications/er/mec/meteredelectricityconsumption2020/
[11] https://www.seai.ie/publications/Low-Carbon-Heating-and-Cooling-Technologies.pdf
[12] [12] https://www.cso.ie/en/releasesandpublications/er/cirgdp/countyincomesandregionalgdp2019/

- Gwh non-res (Gigawatt-hours non-residential) from CSO: Similarly, sourced the non-residential electricity consumption data from the CSO.
- Conversions to CO_2e (Carbon dioxide equivalent) for each: To estimate the carbon emissions associated with electricity consumption, the appropriate CO_2e conversion factors were applied. These factors were derived from region-specific emission data and represent the amount of carbon dioxide equivalent emissions associated with each unit of electricity consumed.
- Split of non-residential electricity between Commercial and Manufacturing using GVA (Gross Value Added): The allocation of non-residential electricity consumption between the commercial and manufacturing sectors was determined using the Gross Value Added (GVA) methodology. By analyzing GVA data, which quantifies the value of goods and services produced by each sector, the estimated proportion of non-residential electricity consumed by commercial and manufacturing activities was estimated.

3.4.2 Transport

3.4.2.1 Background and Introduction of MapEIre

MapEIre is a comprehensive dataset that provides a breakdown of transport emissions at the local authority level. The dataset covers a range of transport types, including national navigation (shipping), railways, and Road Transport (heavy-duty vehicles and buses, light-duty vehicles, mopeds & motorcycles, and passenger cars).

The methodology used for estimating road transport emissions in MapEIre is based on traffic count data, which is obtained from the National Road Authority's traffic counters. This methodology uses available mileage data for national roads and estimates the mileage for other roads by subtracting the national road mileage from the total mileage. The method creates a map of all the roads, excluding national roads, by using road width as a measure of mileage. To calculate the number of vehicles on the road, the method uses traffic count data and groups together certain vehicle categories. The residual of the national total mileage is allocated to the remaining roads. In MapEIre, the road network area is used as a proxy for mileage and makes use of population density to approximate emissions accumulation in urban and rural areas.

3.4.2.2 Background and Introduction of National Transport Authority (NTA) Regional Modelling System

The National Transport Authority (NTA) is a statutory non-commercial entity in the Republic of Ireland that operates under the Department of Transport, Tourism and Sport.

NTA follows a complex model that requires numerous precise, reliable, and comprehensive datasets to calculate carbon emissions. The organization's carbon emission impact is informed by regional models with full geographic coverage, detailed representations of travel demand, a comprehensive road network, and a public transport network that includes Park & Ride, along with active modes like walking and cycling.

The NTA Model uses various factors such as emission rate calculation coefficients, the National Atmospheric Emissions Inventory 2013, fuel scaling parameters, fleet split data, degradation factors, and tire break and abrasion emissions rates. The NTA Model then calculates emissions based on fleet make-up and vehicle speed for each link in the model. Calculations are carried out by ENEVAL using COPERT 5 emission rates.

The NTA Model outputs emissions data by link, zone, sector, or grid, which allows results to be mapped in GIS. By doing so, the results are presented in a visual format, making it easier for NTA to analyse and interpret the data. This comprehensive methodology enables NTA to accurately assess the carbon emissions produced by various sectors.

The NTA model process estimates greenhouse gases (GHG) such as nitrous oxides, particulate matter, hydrocarbons, methane, carbon monoxide, and carbon dioxide. However, for the purpose of this BEI, the GHG emissions used by the NTA include only carbon dioxide and methane. To facilitate comparison, the AR6 GWP values were used to convert the current emissions into CO_2 equivalents. It should be noted that nitrous oxide (N_2O) is not measured in the NTA methodology.

3.4.2.3 Transport Baseline Emission Inventory Methodology

Although the National Transport Agency and MapEIre employ distinct methodologies, the total national CO_2 equivalent calculated using both methods in 2019 is roughly similar. In the EPA National Inventory, the total GHG emissions for 2019, which include Road Transport, Railways System, and Shipping, were 12,196 $ktCO_2$, with Road Transport accounting for 11,371 $ktCO_2$. Meanwhile, the National Transport Agency reported that the Road Transport sector produced 9,503 $ktCO_2$ in the same year. For establishing an accurate Baseline Emission Inventory for the Transport Sector, two methodologies, MapEIre and NTA, are combined to provide a comprehensive picture of transport emissions:

- The MapEIre dataset is used to determine GHG emissions for national navigation (shipping) and railway subsectors. The NTA methodology does not measure the national navigation (shipping) and railway subsector.
- The NTA dataset is used to determine GHG emissions for all vehicles in the road network. This methodology is more robust due to more recent datasets and accuracy with the inclusion of additional factors. Specifically, the NTA methodology includes Degradation Factors NAEI 2013 and Catalytic Converter Failure rates, as well as fleet, split data based on work done in 2012 by SYSTRA and pivoted off 2016 observed fleet data. These additional factors make the NTA methodology more accurate compared to the MapEIre methodology.

By combining these two datasets, a comprehensive and accurate picture of transport emissions can be obtained, which is essential for developing effective strategies to reduce GHG emissions in the transport sector.

3.4.3 Local Authority

Another category of emissions that is included in this report for the purposes of the Local Authority Baseline Emissions Inventory is the emissions from the Local Authority's own activities. This data is required to be reported annually to the SEAI's Monitoring and Reporting system. There are no additional calculations required, but the emissions are presented in this report as an additional category for the Local Authority to consider when planning mitigation activities. It should be noted that these emissions are included in the MapEIre inventory distributed among the various sectors. For example, the Local Authority's fleet emissions would be included in the MapEire and NTA transport emissions data. They are therefore not added to the broader GHG inventory but rather presented in an additional section as a closer look into Local Authority emissions in Galway City.

3.4.4 Galway City Bottom-up Inventory

Galway City Council has commissioned parallel inventories with different methodologies and baseline years.

How do the emissions inventories relate to each other?

- Arup's top-down inventory according to the CoM methodology was used to set a precedence for the bottom-up Baseline Emissions Inventory for Galway City. This Baseline Inventory is indicative, to provide an initial starting point of the emissions proportions in the city.
- Following this, Arup's bottom-up inventory is comprised of more granular data (generally based on Codema/SEAI methodology, adjusted as necessary) and data collected directly from stakeholders, providing a greater level of detail than the top-down inventory. This inventory was prepared for the baseline year (2018) in accordance with national targets. This inventory is considered to have the greatest level of detail, thus providing a better representation of the City's emissions and is used to inform the subsequent plans.
- Bable's top-down assessment is used to verify Arup's bottom-up inventory, though acknowledging differences in the baseline year, demonstrating similar emissions proportions, and confirming the applicability of the bottom-up baseline. This inventory was prepared for consistency with other local authorities for comparability of results.

The three methodologies differ in their approach and assumptions, with varying levels of uncertainty. As acknowledged in the CARO Mitigation Guidance for Local Authorities all methodologies for local-level emissions baselines will require assumptions, as it is not possible to create a completely accurate picture of emissions (even national-level inventories must include assumptions). Each methodology has pros and cons utilising the best available information, but are deemed fit for their purpose, in providing a means of identifying areas for improvement and inspiring action.

3.4.4.1 Arup – Top-Down Emissions Inventory

The Covenant of Mayors (CoM) provides a common reporting framework for cities to assess GHG emissions by applying a standardised approach, which has been developed by multi-disciplinary experts and in consultation with a variety of stakeholders. This inventory was prepared prior to the development of the CARO Local Authority Guidance and was deemed the preferable approach for the Irish context at the time of preparation. The CoM approach enables comparison across international cities.

3.4.4.2 Arup – Bottom-Up Emissions Inventory:

The Codema/SEAI bottom-up inventory is based on the Codema Guidance (2017) "Developing CO_2 Baselines: A Step-by-step Guide for your Local Authority" developed in partnership with the Sustainable Energy Authority of Ireland (SEAI). This inventory was prepared prior to the development of the CARO Local Authority Guidance and was deemed the preferable approach for the Irish context at the time of preparation. However, the Codema methodology has been adjusted as appropriate, given the availability of data, to ensure a comprehensive analysis as potential gaps were identified, with the differences specified in Arup's baseline report. Crucially this approach has been supported by stakeholder engagement whereby 'direct data' was obtained by high-energy users and fed into the bottom-up baseline.

4.GHG Emissions Inventory for Galway City

Baseline Emissions Inventory Results

Entire Local Authority Area

4.1 Local Authority Profile

This report measures the GHG emissions for Galway City in 2019. The city, with a population of 79,934, is located on the west coast of Ireland in the province of Connacht. Although a city, Galway has highly favourable natural sites, amongst them coastline, river and canal systems, woodlands and protected wildlife habitats. Through active management, it has been ensured that a fifth of Galway City's total land area is designated for such protected habitats, as well as recreational and agricultural areas. This 'green and blue infrastructure' helps provide nature-based solutions to sustainability issues as well as sources of well-being, leisure and recreation to the communities of the city.[13]

4.2 Galway City Scope 1 Emissions

As set out in Section 3.2, the MapEire dataset contains the emissions for each Local Authority in Ireland broken down on a 1 x 1 km scale, with further classifications including the CRF Classification, the NFR codes and the pollutant names.

For this inventory, the data was filtered to only include emissions within Galway City, with all emissions converted to CO_2 equivalent using Sixth Assessment Report (AR6) GWP values for a 100-year time horizon by multiplying the mass of the emissions by the gas' corresponding GWP.

The inventory derived directly from MapEIre is broken down into the following sectors: Agriculture, Commercial Services, Energy Industries, Industrial Processes, LULUCF, Manufacturing Combustion, Residential, Transport, and Waste.

Under this version of the inventory, all emissions would be Scope 1 emissions, or direct GHG emissions that occur from fuel combustion. Emissions from electricity are assigned to the power plants where the electricity is generated, rather than where the electricity is consumed (homes, businesses, etc.)

[13] https://www.galwaycity.ie/gccfiles/?r=/download&path=L0RlcGFydG1lbnRzL1BsYW5uaW5nL0RldmVsb3BtZW50IFBsYW4vMjAyMy0yMDI5L0RSQUZUL1BsYW4vMTE5MTIgR0NDIERldmVsb3BtZW50IFBsYW5fSGlSRVMucGRm

The results of the MapElre inventory for Galway City are provided in Figure 5 below.

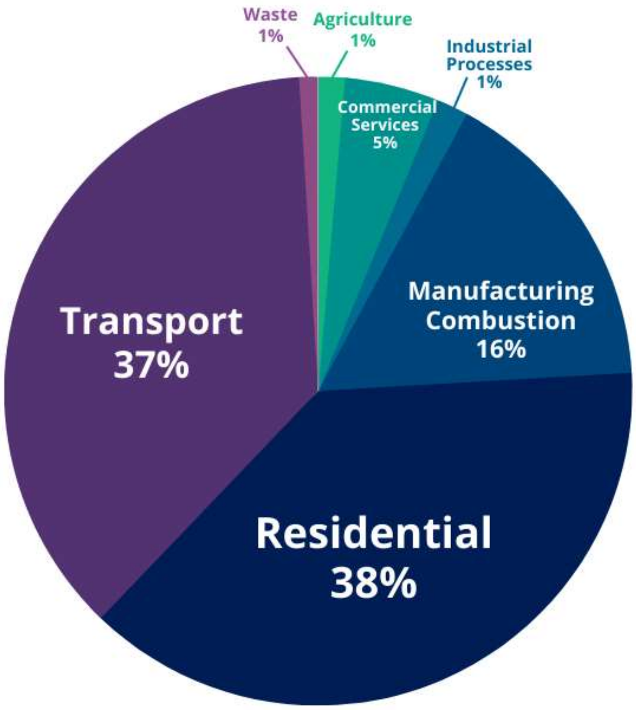


Figure 5 Galway City Sectoral Breakdown of Scope 1 Emissions (2019)

4.3 Galway City Emissions Breakdown by Gas Type

The following chart breaks down Galway GHG emissions by type of GHG emitted, rather than by the global warming potential of the sector. However, because Energy Industries is removed, this breakdown does not include any emissions from electricity, thus having a smaller overall total than the main inventory.

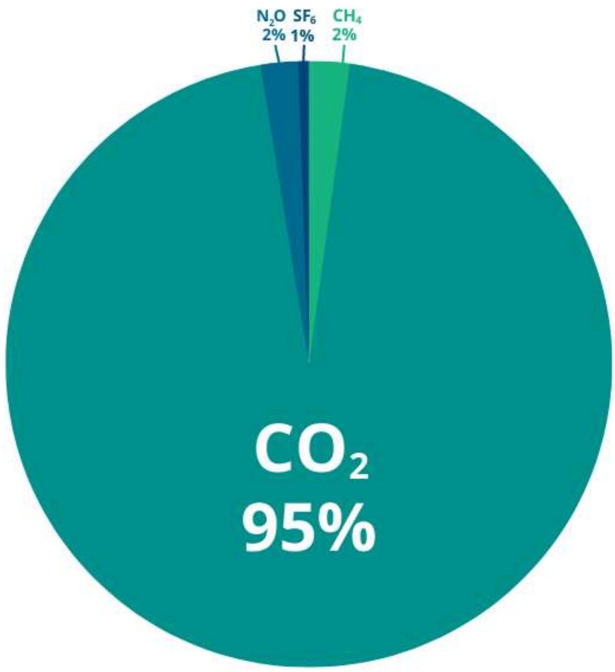


Figure 6 Scope 1 Galway City Emissions by Gas Type (2019)

4.4 Galway City Emissions: Sectoral Breakdown

The inventory derived directly from MapEIre provides an inventory of Scope 1 emissions broken down into the following sectors: Agriculture, Commercial Services, Energy Industries, Industrial Processes, LULUCF, Manufacturing Combustion, Residential, Transport, and Waste. All emissions from electricity are assigned to Energy Industries, rather than where the electricity is consumed.

It is of more value for Local Authority Climate Action Plans to understand where electricity is being consumed than generated to develop appropriate and specific local mitigation actions. Therefore, as detailed in Section 3.3.1, the Energy Industries category has been removed from this inventory, and replaced with electricity consumption data that have been assigned to the Residential, Manufacturing, and Commercial sectors. Also, as detailed in Section 3.3.2, the transport emissions are based on NTA modelling rather than the methodology used in MapEIre.

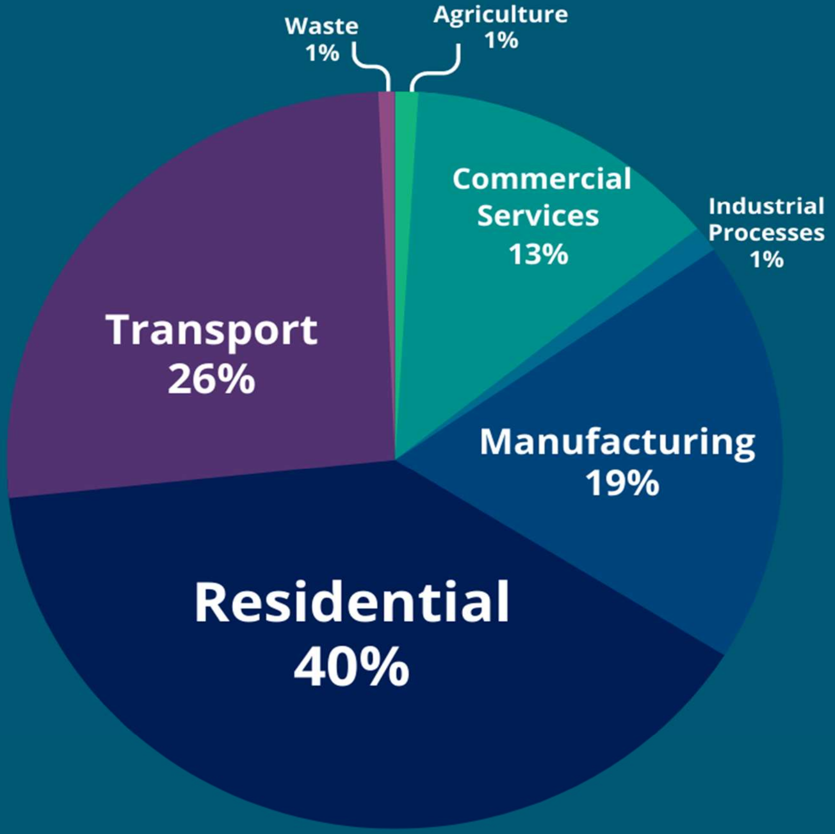
The resulting output is the Baseline Emission Inventory for Galway City that will be used to inform the development of the Local Authority Climate Action Plan for Galway City. A full-page summary can be found on the next page.

Galway City

Baseline Emissions Inventory Results 2019

Total Emissions: 356 $ktCO_2$ equivalent (0.6% of national total)

National Emissions 65,152 $ktCO_2$ equivalent



3 $ktCO_2e$ **Agriculture**	**-4** $ktCO_2e$ **LULUCF**	**67** $ktCO_2e$ **Manufacturing**	**142** $ktCO_2e$ **Residential**
94 $ktCO_2e$ **Transport**	**2** $ktCO_2e$ **Waste**	**48** $ktCO_2e$ **Commercial Services**	**4** $ktCO_2e$ **Industrial Processes**

Note: Energy industry emissions have been allocated to the categories where they are consumed.

4.5 Residential

4.5.1 Category Description

The Residential sector accounts for emissions from activities in people's homes. On a national level, the Residential sector accounts for about 15% of total energy-related emissions, with the average dwelling emitting 5 tCO_2 per annum[14]. This includes emissions from space and water heating, as well as from electricity consumption.

4.5.2 Baseline Data

In Galway City, heating accounted for 40% of emissions in the Residential sector, while electricity consumption accounted for 60% and The national split is 76% direct fuels and 24% electricity.

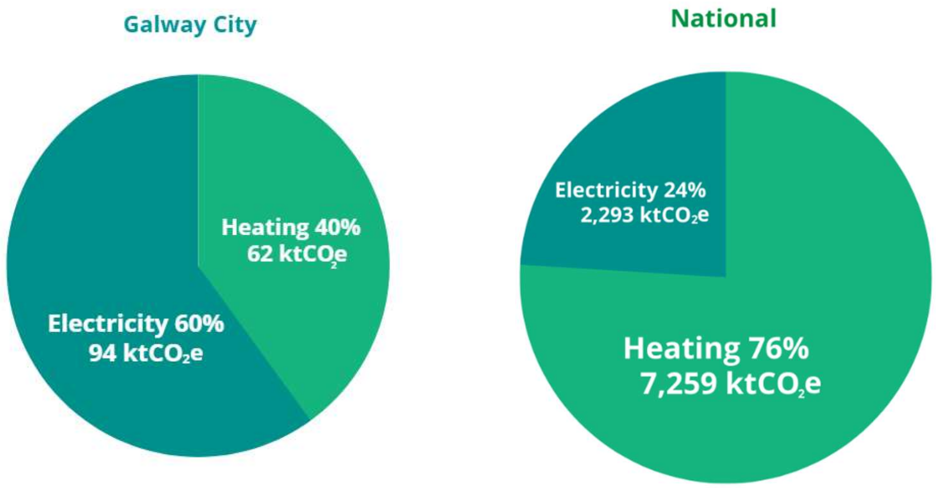


Figure 7 City and National split of household energy usage

The following table shows the GHG breakdown of Residential emissions from direct fuels only. Direct fuels refer to Scope 1 fuels (e.g. oil, gas, solid fuel) burned on-site, such as for heating purposes. However, Figure 2 on page 9 shows the breakdown in primary energy supply for electricity generation broken out by fuel type and energy source at the national level.

[14] https://www.seai.ie/publications/Energy-in-Ireland-2020.pdf

GAS	$ktCO_2e$
CH_4	5
CO_2	125
N_2O	0.3
Total	**130**

Table 3 Gas Breakdown of Residential Sector Scope 1 Emission

4.5.3 Supporting Information

4.5.3.1 Local Authority Area Housing Stock

According to Census 2022 data, there are 35,594 units in Galway City,[15] 8% of which were vacant in 2022. The main central heating fuel is oil (14,275 households), followed by electricity (5,715) and natural gas (4,396)[16]. Further insights into Galway City housing are presented in the tables below. As the 2022 Census has not been fully published as of this report's writing, these tables are from Census 2016. As the 2022 Census has not been fully published as of this report's writing, these tables are from Census 2016. Additionally, it is noted that there is a lack of information on the housing stock specifically regarding the central heating fuel, and not all households possess that data. Therefore, the total of units presented below does not match the Census 2022 Total.

Oil	Natural gas	Electricity	Coal	Peat	LPG	Wood	Other
14,275	4,396	5,715	1,484	390	225	187	133

Table 4 Central Heating Fuel in Occupied Private Households (Census 2016)

Housing stock and household size statistics are important factors that influence the amount of energy used for heating, cooling and electricity in homes. This information can provide insights into the residential emissions in the Local Authority area and the context as to why they occur.

[15] https://data.gov.ie/dataset/fp012-preliminary-housing-stock-and-vacant-dwellings/resource/a6cf240e-d11a-4958-a4bf-2945843b7b81

[16] https://www.cso.ie/en/releasesandpublications/ep/p-copep/thecensusofpopulationfromanenvironmentperspective2011and2016/mainresults/

Existing Housing Stock

City	Housing Stock	Holiday Homes	Other Vacant	% Vacancy
Galway	33,847	183	1,329	13%

Table 5 Existing Housing Stock[15]

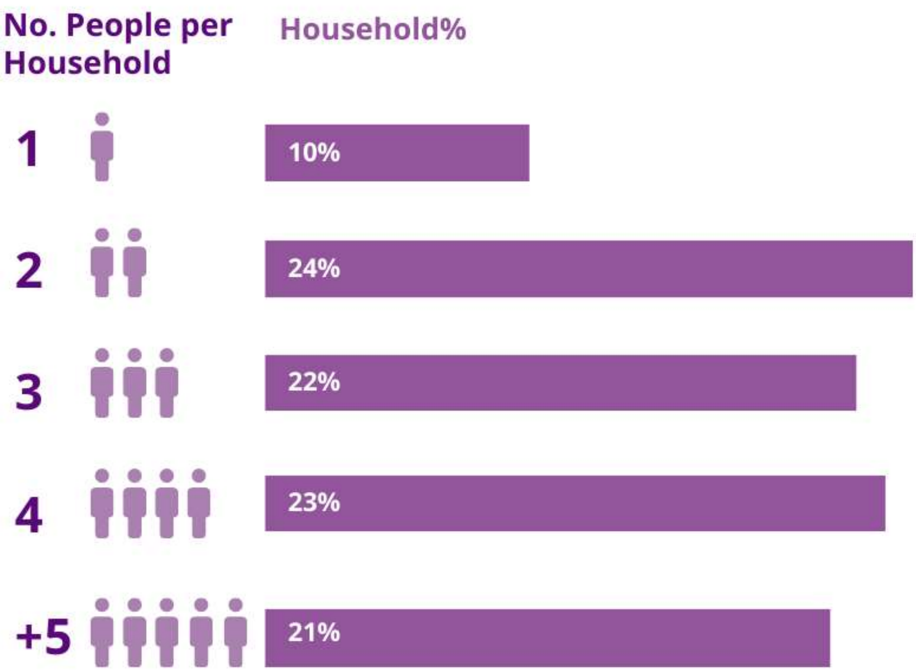


Table 6 Household Size Cohorts[17]

Housing tenure and occupancy type also give valuable insights into residential emissions. For example, rented houses carry a split incentive regarding energy efficiency improvements where the landlord may be responsible for upgrades and renovations, but the tenant would be the one benefitting from the resulting energy savings. It should be noted that the CSO uses different source data for different tables - hence the inconsistent totals. For instance, some tables include total housing stock, others include only occupied housing stock.

[17] https://data.gov.ie/dataset/fp012-preliminary-housing-stock-and-vacant-dwellings/resource/a6cf240e-d11a-4958-a4bf-2945843b7b81

Housing Tenure

	Households	Persons	Household %
Social Housing	3,350	NA	NA
Rented (Privately)	10,241	28,506	36%
Owner Occupied (All)	7,386	16,044	47%

Table 7 Housing Tenure[16]

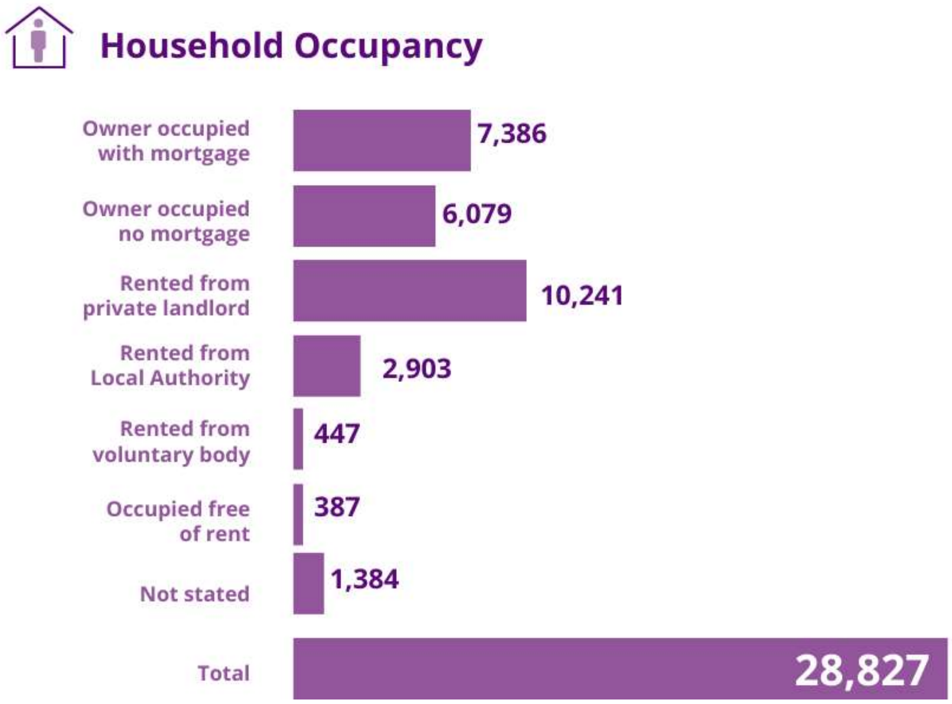


Figure 8 Household Occupancy[16]

4.5.3.2 Building Energy Ratings

A BER measures the energy performance of a home. They range from A1 (most efficient) to G (least efficient). They are calculated based on the energy required by the building for heating, cooling, ventilation and lighting by SEAI-registered BER assessors. The National Climate Action Plan aims to retrofit 500,000 homes to a B2 BER or better by the end of 2030. Below is the current distribution for Galway. It should be noted that not all homes have undergone a BER assessment, and the distribution may not be representative of the entire housing stock. Galway City has 16,205 (46% of total) domestic buildings with BERs as of Q3 of 2022[18].

[18] https://www.cso.ie/en/releasesandpublications/ep/p-dber/domesticbuildingenergyratingsquarter32022/

Domestic BER Distribution (%): Galway City

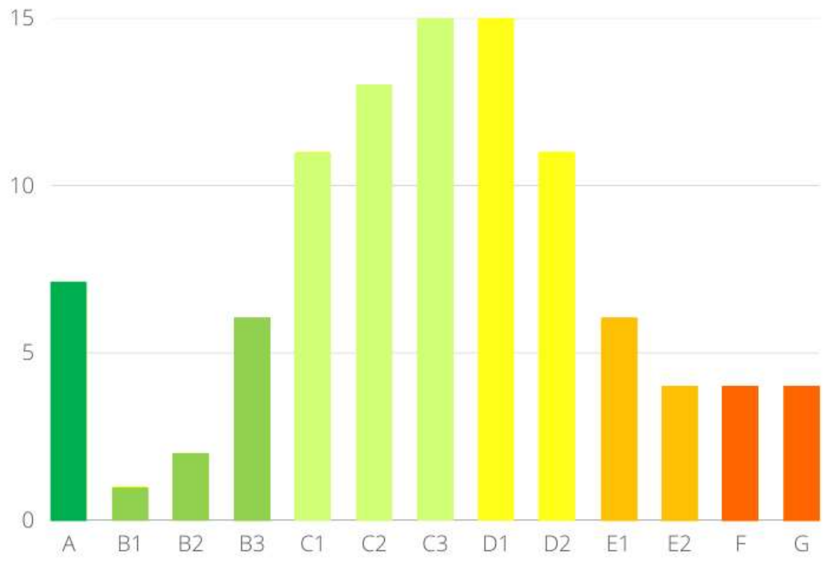


Figure 9: Domestic BER Distribution (%): Galway City

National Domestic BER Distribution (%)

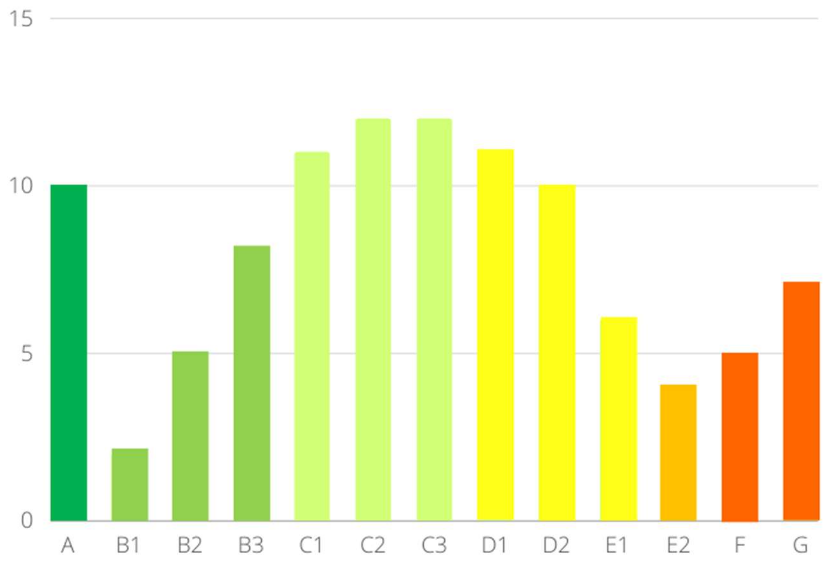


Figure 10: BER National Breakdown

In 2016, 98% of dwellings nationally that were constructed in the BER database achieved an 'A' rating, indicating high energy efficiency. The following map depicts the spatial distribution for Galway City of median BER rating by small area.[19]

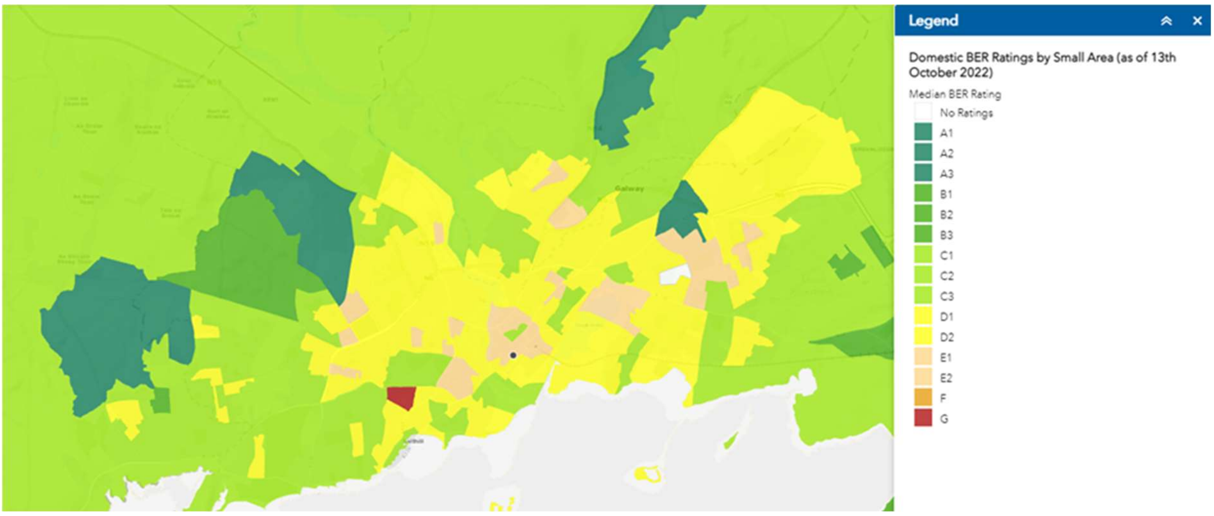


Figure 11 Median Domestic BER Ratings by Small Area- October 2022

4.5.3.3 Social Housing

There are 3,444 social housing dwellings in Galway, 84% of which have measured BERs.[20] Emissions from social housing are not a part of the emissions reported to the SEAI under the M&R system.

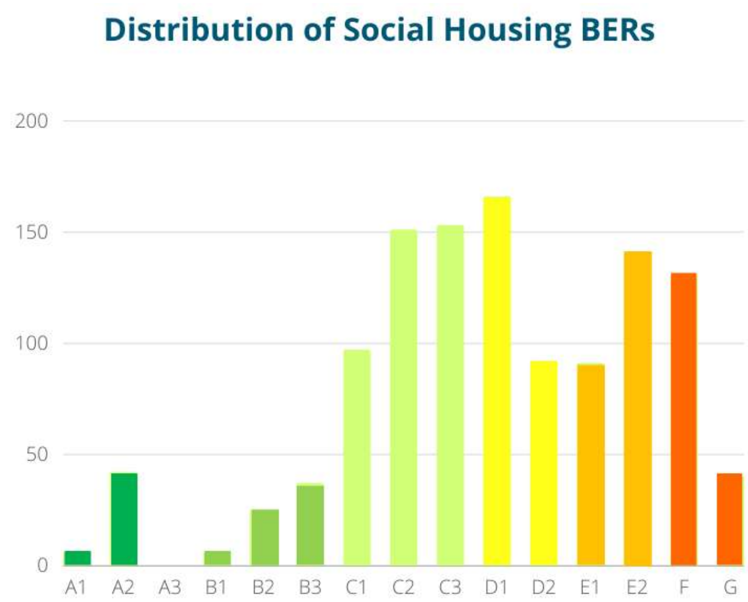


Figure 12: Distribution of Social Housing BERs

[19] https://gis.seai.ie/ber/

[20] https://noac.ie/noac_publications/report-50-noac-performance-indicator-report-2021/

4.5.3.4 National Context

A comprehensive retrofit programme is a key measure in the CAP23 to reduce Residential emissions. The National Residential Retrofit Plan aims to achieve the equivalent of 500,000 homes retrofitted to a Building Energy Rating of B2/cost optimal or carbon equivalent. Another aim is the installation of 400,000 heat pumps in existing premises to replace older, less efficient heating systems by 2030. A total of 18,400 home retrofits were completed in 2020. However, just 4,000 were to a B2 standard and 1,600 installed a heat pump. Rollout of the Social Housing National Retrofitting Programme in 2021 with retrofitted properties was required to reach BER B2 or equivalent.

The SEAI estimates 17.7 MW of installed solar PV capacity in the Residential sector in Ireland in 2018 and that 44kt oil equivalent of renewable ambient energy from heat pumps was used.[21]

The national emissions ceiling for 2030 for residential buildings is 4MtCO_2 equivalent. For electricity, of which residential consumption made up 31% in 2019[22], the ceiling is 3 MtCO_2 equivalent.

[21] https://www.seai.ie/publications/2020-Renewable-Energy-in-Ireland-Report.pdf

[22] https://www.cso.ie/en/releasesandpublications/ep/p-mec/meteredelectricityconsumption2021/

4.6 Non-residential Emissions: Commercial, Manufacturing Combustion, Industrial Processes

Baseline Emissions Inventory Results

Galway City: **119 ktCO₂e (33%)** National: **13,622 ktCO₂e (20%)**

Commercial Services	Manufacturing Combustion	Industrial Processes

4.6.1 Background

Within the Non-residential emissions sector, there are three main categories: Commercial, Manufacturing, and Industrial Processes. Each category encompasses a unique set of activities and processes that contribute to greenhouse gas emissions.

Commercial emissions are a significant contributor to greenhouse gas emissions and are often a major focus of efforts to reduce carbon footprints. Commercial entities such as businesses, offices, and industrial complexes require a lot of energy to operate, which often comes from fossil fuels. The burning of these fossil fuels releases greenhouse gases such as carbon dioxide, methane, and nitrous oxide, which trap heat in the atmosphere and contribute to climate change. In the commercial sector, energy consumption is largely driven by activities such as heating, cooling, ventilation, lighting, cooking, and refrigeration.

Manufacturing Combustion processes involve a range of activities, such as heating, cooling, and processing materials, and often require the use of large machinery and equipment. These processes can consume significant amounts of energy and produce large quantities of emissions, particularly in industries such as iron and steel, non-ferrous metals, and chemicals.

The **Industrial Processes** sector estimates GHG emissions occurring from industrial processes, from the use of GHG in products and from non-energy uses of fossil fuel carbon. These processes include, but are not limited to, cement production, lime production, ceramics, solvent use, as well as the food and beverage industry. The emissions in this category are from Industrial Processes rather than combustion. It is important to note that the GHG emissions estimated in the Industrial Processes sector are not related to space or water heating.

In the Irish national inventory, commercial emissions, manufacturing processes, and industrial processes are three separate categories that are accounted for individually. These categories represent different sources of greenhouse gas emissions and are reported separately to provide a detailed understanding of the country's emissions profile. However, in this particular case, these categories are being combined into a broad non-residential category. Emissions from commercial, manufacturing combustion, and industrial sources that are not related to residential activities are being reported together under this category.

In the non-residential sector, activity emissions and electricity emissions are added and calculated together. This is because non-residential activities often require a significant amount of electricity to operate, and the emissions associated with that electricity consumption must be included in the overall emissions from those activities.

The electricity emissions are based on metered consumption. This means that the amount of greenhouse gas emissions associated with electricity consumption is calculated based on the amount of electricity used as measured by a meter. The emissions associated with generating that electricity are allocated to the end-use sector based on this consumption data.

Based on the CSO metered electricity figures for non-residential consumption in Galway City, it has been estimated that the combined commercial and manufacturing sectors produce approximately 35 $ktCO_2e$ and 26 $ktCO_2e$ of electricity emissions, respectively (see Section 3.4.1). This amounts to a total of approximately 61 $ktCO_2e$ of non-residential electricity emissions for both sectors combined.

4.6.2 Galway City: Baseline Inventory for Non-residential Emissions

The Non-residential sector in Galway City is a significant source of greenhouse gas (GHG) emissions. To better understand the sector's emissions profile, Figure 13 displays both activity and electricity emissions, providing a comprehensive overview of the total GHG emissions for the sector. The data shows that the Manufacturing Combustion subsector is responsible for the largest proportion of emissions at 56%, followed by Commercial Services and Industrial Processes. The Industrial Processes category contains no electricity element.

Breaking down the data further, Figure 14 shows emissions exclusively from the activity of the Non-residential sector, excluding electricity emissions. This information can be useful in identifying specific sources of emissions within the sector and guiding targeted reduction strategies.

Similarly, Figure 15 displays the emissions attributed solely to electricity consumption within the Non-residential sector, excluding activity emissions. Understanding the proportion of emissions from electricity consumption can help develop effective energy management and efficiency strategies.

Total Non-Residential Emissions (Activity emissions + Electricity emissions)

Sectors	$ktCO_2e$
Commercial Services	48
Manufacturing Combustion	67
Industrial Processes	4
Total	119

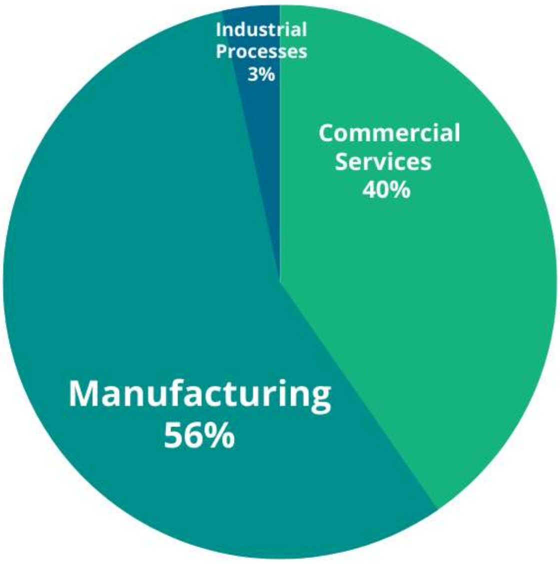


Figure 13 Total Non-Residential Emissions (Activity emissions + Electricity emissions)

Activity emissions

Sectors	$ktCO_2e$
Commercial Services	12
Manufacturing Combustion	41
Industrial Processes	4
Total	57

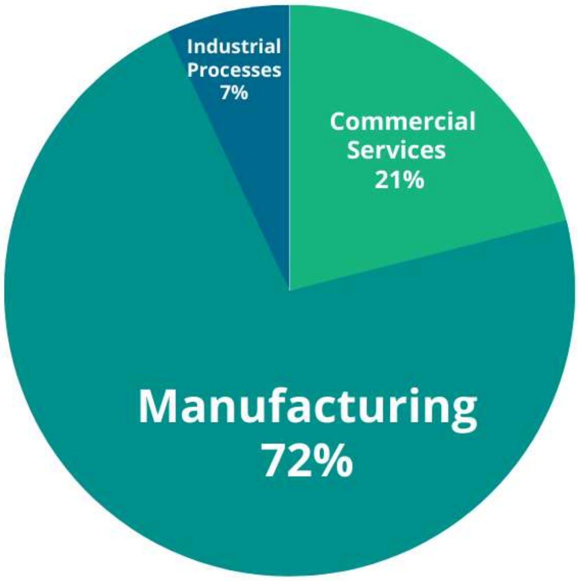


Figure 14 Activity- only emissions (no electricity)

Electricity Emissions

Sectors	$ktCO_2e$
Commercial Services	35
Manufacturing Combustion	26
Total	61

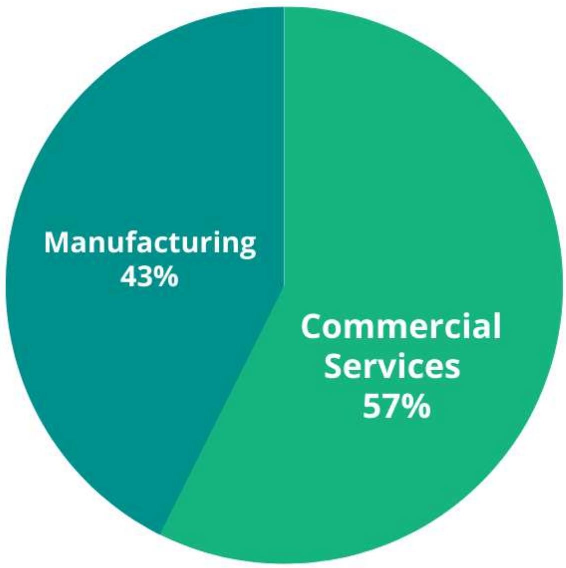


Figure 15 Electricity Emissions

4.6.3 seSupporting Information

Non-residential emissions largely align with economic trends. National emissions have remained relatively stable in recent years. Fuel switching from more carbon-intensive oil and coal to lower-carbon natural gas has been one of the drivers for the reduction in this area.

As discussed before, Building Energy Ratings measure the energy performance of a building. They range from A1 (most efficient) to G (least efficient). They are calculated based on the energy required by the building for heating, cooling, ventilation, and lighting by SEAI-registered BER assessors. Only 7% of non-domestic buildings in Galway City that have been BER assessed have a B2 BER or better, though this is in line with the national average of 8%. In Galway City, 653 Non-Domestic Buildings have received Building Energy Ratings [23].

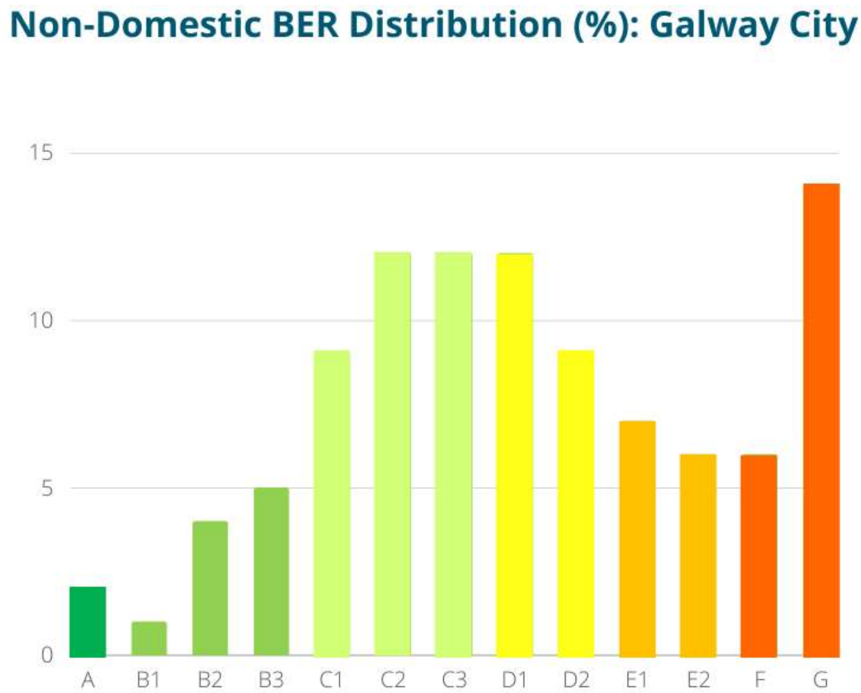


Figure 16: Regional Non-domestic Buildings BER Distribution (%)

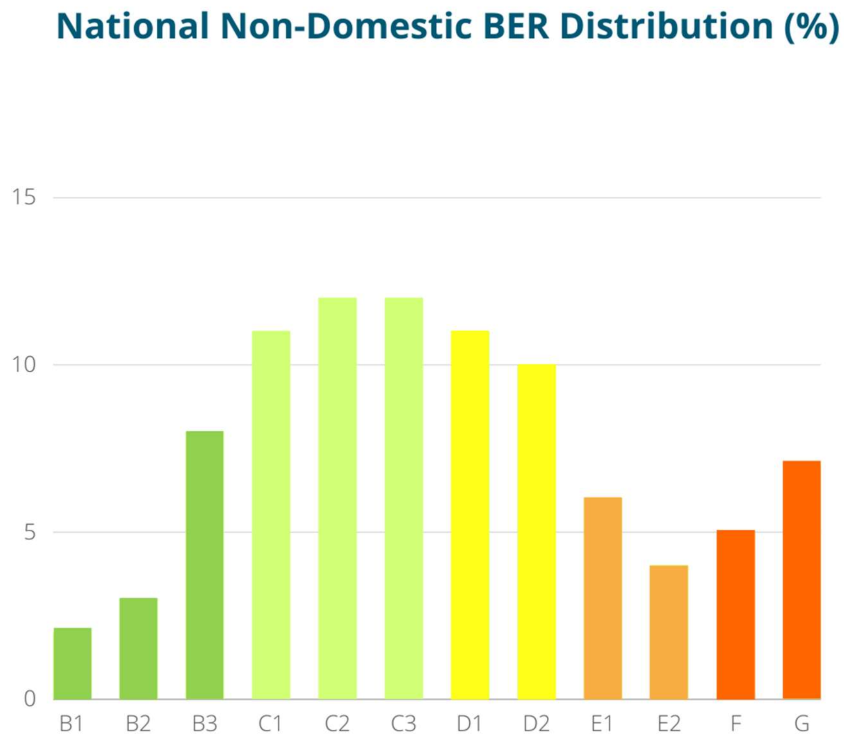


Figure 17: National Non-Domestic BER Distribution (%)

[23] https://www.cso.ie/en/releasesandpublications/er/ndber/non-domesticbuildingenergyratingsq22020/

The following table presents the Carbon Dioxide (CO_2) Emissions by Type of Building for Galway in the year 2019. The emission values are measured in kilogrammes of CO_2 per square meter per year ($kgCO_2$/m2/year). They show how many kilogrammes Non-Domestic Buildings are emitted per square meter in a year. It is noticed that retail buildings, offices and restaurants are the highest emitting non-residential buildings by area, while hospitals and schools are the lowest emitting non-residential buildings.

City	Retail	Office	Restaurant	Hotel	Warehouses	Workshops
GALWAY	249	127	272	111	189	175

City	Hospitals	Community centre	Nursing home	Schools	Sports facilities	Other
GALWAY	75	73	64	30	223	199

Table 8 Carbon Dioxide Emissions ($kgCO_2/m_2$/year) by Building Type (non-residential)[24]

[24] https://www.cso.ie/en/releasesandpublications/er/ndber/non-domesticbuildingenergyratingsq12022//

4.7 Transport

Baseline Emissions Inventory Results

Galway City: **94 ktCO$_2$e (26%)**

National: **12,196 ktCO$_2$e (19%)**

Transport

4.7.1 Background

Transport in 2019 accounted for approximately 19% of Ireland's greenhouse gas (GHG) emissions which is equivalent to 11 MtCO$_2$e, with road transport responsible for 94% of those GHG emissions. The emissions coming from the transport sector are primarily sourced by the burning of diesel and petrol in combustion engines (passenger cars, light-duty vehicles, heavy-duty vehicles and buses) and are also directly responsible for a range of air pollutants that negatively impact both human health and the environment.

Between 1990 and 2019, Transport shows the greatest overall increase in GHG emissions at 112%, from 5,143 ktCO$_2$e in 1990 to 10,915 ktCO$_2$e in 2019, with road transport increasing by 115%.[25] The increase in emissions up to 2007 can be attributed to general economic prosperity and increasing population with a high reliance on private car travel, as well as rapidly increasing road freight transport.

This sector accounts for emissions from the combustion of fuel for all transport activity, including domestic aviation, road, railway, water-borne navigation, and other transportation (which includes gas pipeline transportation). Emissions from road transport were relatively stable for the period 2015-2019, at an average of 11.6 Mt CO$_2$eq but reduced to 9.7 Mt CO$_2$eq in 2020 due to the COVID-19 implications.[26] Domestic aviation emissions are included in the national inventory but make up less than 1% of transport emissions. International aviation and maritime navigation are reported as "memo items" in the national emission inventory. This means they are not counted as part of Ireland's national total emissions but are reported by Ireland to the UNFCCC and EU for information purposes.

Transport has been the sector most responsive to changes in economic growth in Ireland. Transport energy use and CO$_2$ emissions peaked in 2007, before falling sharply during the recession[27]. It returned to growth in 2013, but by 2019 total Transport energy use was still 8.5% below the 2007 peak, mostly due to heavy goods vehicles remaining 31% below 2007 levels (see Figure 17 below).

[25] https://www.seai.ie/data-and-insights/seai-statistics/key-statistics/transport/

[26] https://www.seai.ie/data-and-insights/seai-statistics/key-statistics/transport/

[27] https://www.seai.ie/publications/Energy-in-Ireland-2021_Final.pdf

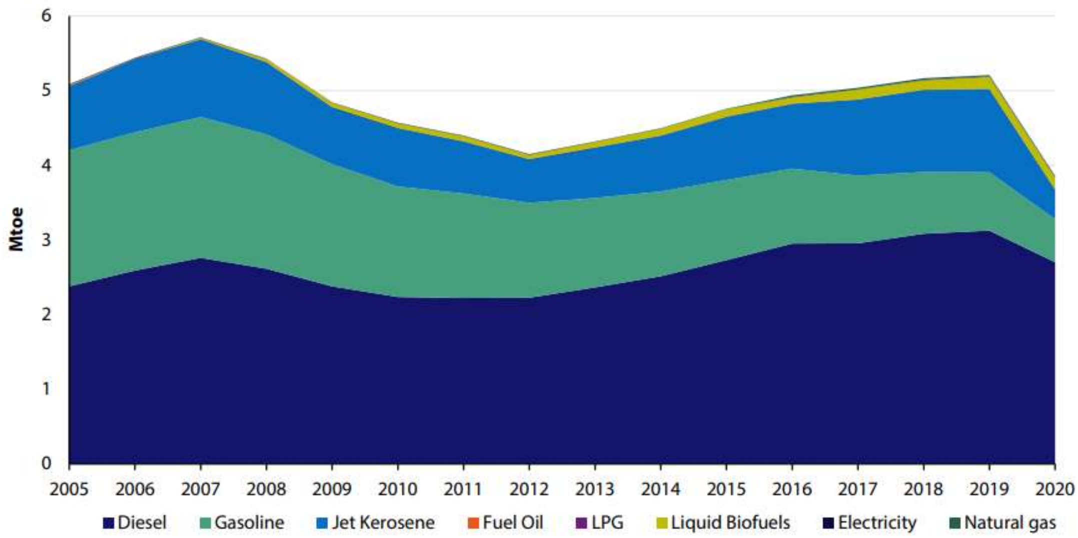


Figure 8 Transport Fuel Usage over Time in Ireland

Fuel consumption in Transport is often closely aligned to the mode used: jet kerosene is used for air transport, fuel oil for shipping, with petrol and LPG almost exclusively used for road transport. Diesel consumption is used for road transport, navigation and rail. The most important point to note is that Transport remains almost completely dependent on fossil fuels, particularly oil products. This lack of fuel diversity is unique among the energy-using sectors. Renewables made up just 4% in 2019, which scores very low in comparison with other European Countries.[28]

This has meant that there has been very little decarbonisation of the Transport fuel mix to date, with Transport CO_2 emissions remaining tightly coupled to energy use. In 2019, Transport CO_2 emissions were the same as they had been in 2005.

[28] https://www.seai.ie/publications/Energy-in-Ireland-2021_Final.pdf

	2020		2005		2019-2020		2015-2020		2005-2020	
	Quantity (ktoe)	Share (%)	Quantity (ktoe)	Share (%)	Absolute change (ktoe)	Overall change (%)	Overall change (%)	Average annual change (%)	Overall change (%)	Average annual change (%)
Private car	1,637	42%	1,891	37%	-443	-21.3%	-24.1%	-5.4%	-13.5%	-1.0%
HGV	725	19%	1,112	22%	-65	-8.2%	15.7%	3.0%	-34.8%	-2.8%
LGV	301	8%	0	0%	-33	-9.8%	-20.3%	-4.4%	-	-
Domestic aviation	2	0%	27	1%	-4	-59.7%	-53.3%	-14.1%	-90.9%	-14.8%
International aviation	396	10%	832	16%	-714	-64.3%	-53.0%	-14.0%	-52.4%	-4.8%
Public passenger	117	3%	157	3%	-21	-15.3%	-11.9%	-2.5%	-25.4%	-1.9%
Rail	36	1%	45	1%	-8	-19.0%	-8.8%	-1.8%	-20.1%	-1.5%
Navigation	104	3%	50	1%	15	16.4%	45.5%	7.8%	109.2%	5.0%
Gas pipeline	15	0%	2	0%	15	-	-	-	588.7%	13.7%
Fuel tourism	80	2%	387	8%	80	-	-	-	-79.2%	-9.9%
Unspecified	461	12%	581	11%	461	-	-	-	-20.6%	-1.5%
Total	**3,875**	**100%**	**5,084**	**100%**	**-1,359**	**-26.0%**	**-19.0%**	**-4.1%**	**-23.8%**	**-1.8%**

Source: SEAI

Figure 19 National Transport Data Through the Years

A core objective of the National Planning Framework is the need for more sustainable forms of Transport to reduce energy demand and greenhouse gas emissions, such as active modes of travel, electric vehicles and increase the usage of public transportation. The National Planning Framework for Transport also places a strong emphasis on enhanced regional accessibility in Local Authorities.[29] The national emissions ceiling for Transport for 2030 is 6 $MtCO_2e$.

The levels of noise, accidents, and congestion associated with road transport reduce the quality of life, deter active travel, and costs society hundreds of millions of euros per annum in wasted time.

Behavioural change and promoting cleaner, safer and more sustainable mobility are critical for climate policy, and it also represents an opportunity to improve our health, boost the quality of our lives, meet the needs of our growing urban centres, and connect our rural, urban and suburban communities.

The recently revised CAP23 sets out the required level of decarbonisation for transport in quantitative terms as summarised in Table 15 below:

2018 Emission $MtCO_2e$	Indicative Target for 2025 Emission $MtCO_2e$	Indicative Target % Reduction for 2025 $MtCO_2e$	2021 Emissions $MtCO_2e$	% Increase (+)/ Reduction (-) to date $MtCO_2e$
12	10	20%	11	-11

Table 9 Required Level of Decarbonisation for Transport [30]

[29]https://www.gov.ie/en/press-release/cc07e-new-national-investment-framework-for-transport-in-ireland/#:~:text=The%20National%20Investment%20Framework%20for,and%20the%20National%20Development%20Plan.

[30] (https://www.gov.ie/en/publication/7bd8c-climate-action-plan-2023/)

4.7.2 Galway City: Baseline Inventory for Transport

Galway City: Transport Subsectors

Transport Subcategories	$ktCO_2e$
National navigation (shipping)	0.1
Railways	0.6
NTA Road transport (all vehicles)	93
TOTAL	94

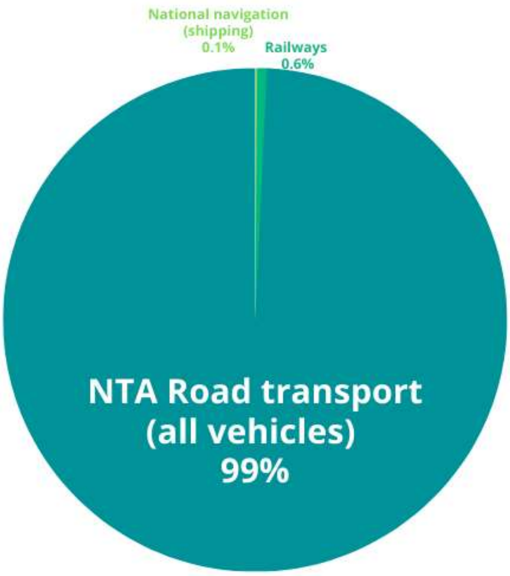


Figure 20 Emissions from Transport Subsectors

The Transport sector in Galway accounted for 94 $ktCO_2eq$, which makes 26% of the total city's emissions. As seen in Figure 20, Road Transport is the highest emitting subcategory in the transport sector. The graph below shows the breakdown of road transport for the city between different types of vehicles (private cars; heavy-duty vehicles and buses; light-duty vehicles).

Domestic aviation is a subcategory included in the national inventory but not in the MapEIre dataset used for these calculations.

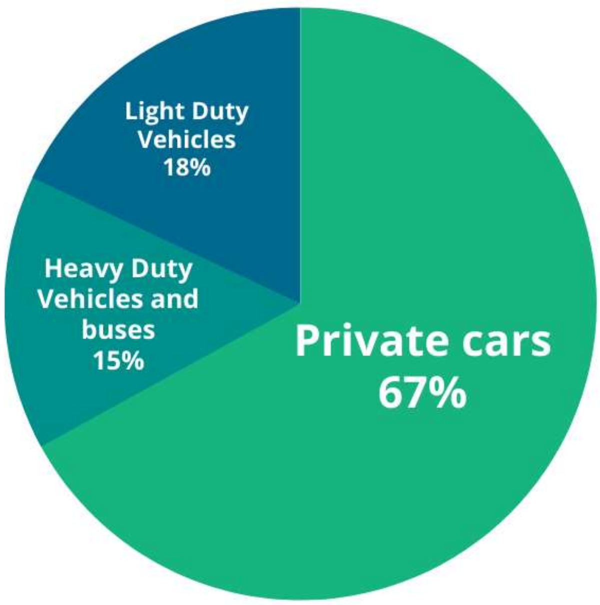


Figure21: Breakdown of Road Transport per type of vehicle per MapEIre

4.7.3 Supporting Information

Galway City is strategically located along the western seaboard, with an international airport in close proximity, a railway and high-quality national, regional and local road networks. The city has a significant advantage within the north-west region, in terms of its location and economic assets. Galway City plans to take these advantages in tandem with the sustainable transportation transition and the development of other essential public infrastructure, whilst complying with both national and European environmental legislation.

Over 60,000 vehicles commute back and forth from the city on an average weekday. 90% of commuters travel by car. There is also a high dependence on car usage for school trips and for getting to work for those who live directly in the city.[31] In Galway Central, however, the main form of commute is by foot or bicycle, and average journey times for work or study are less than 15 minutes. Across the City, 32% of households have two or more cars.[32]

Responding to the National Planning Framework goals will demand immediate action from Galway City. This particularly pertains to an increase in public transport users. For instance, only around 10% of commuters in Galway City use public transport. Whilst this is high compared to the national average of 9.3%, it is low for a city.[33]

The state-owned bus and coach operator, Bus Éireann, had a fleet of 39 buses in 2019 in Galway City, which provided for 5.7 million passenger journeys in the same year.[34]

In 2016, the number of those who commute to work via private cars dropped down very slightly from 2011 levels, from 63% to 61.4%. This may well relate to the similarly slight increase in bus users, from 5.4% to 5.9%, as well as the 2.3% to 3% increase in bicycle usage for commuting.[35] Whilst the number of commuter cyclists seems low, it still represents an increase from 39,803 to 56,837, a 43% increase in these 5 years.

Public transport usage is still behind historical highs, with bus and train transport combined being used by just less than 10% of commuters, compared to 12% in 1986.[36]

[31]https://www.galwaycity.ie/uploads/downloads/development_plan/2017-2023/Galway_City_Council_dev_plan_2017_2023.pdf
[32] https://galwaycitycommunitynetwork.ie/wp-content/uploads/2015/11/Galway-City-LECP.pdf
[33] https://www.cso.ie/en/statistics/transport/
[34] https://www.cso.ie/en/releasesandpublications/ep/p-tranom/transportomnibus2019/publictransport/
[35] https://www.cso.ie/en/releasesandpublications/ep/p-cp6ci/p6cii/p6mtw/
[36] https://www.cso.ie/en/releasesandpublications/ep/p-cp6ci/p6cii/p6mtw/

4.8 Waste

4.8.1 Background

The Waste sector includes emission estimates from solid waste disposal, composting, waste incineration (excluding waste to energy), open burning of waste and wastewater treatment and discharge. The largest of these sources is solid waste disposal on land (landfills) where methane (CH_4) is the gas concerned. In contrast with the other sectors, the greenhouse emissions coming from Waste have been decreasing rapidly throughout the years due to the improved management of landfill activities, including increased recovery of landfill gas utilised for electricity generation and flaring is a core driver in decreased emissions from the Waste sector. This can be seen in the figure below:

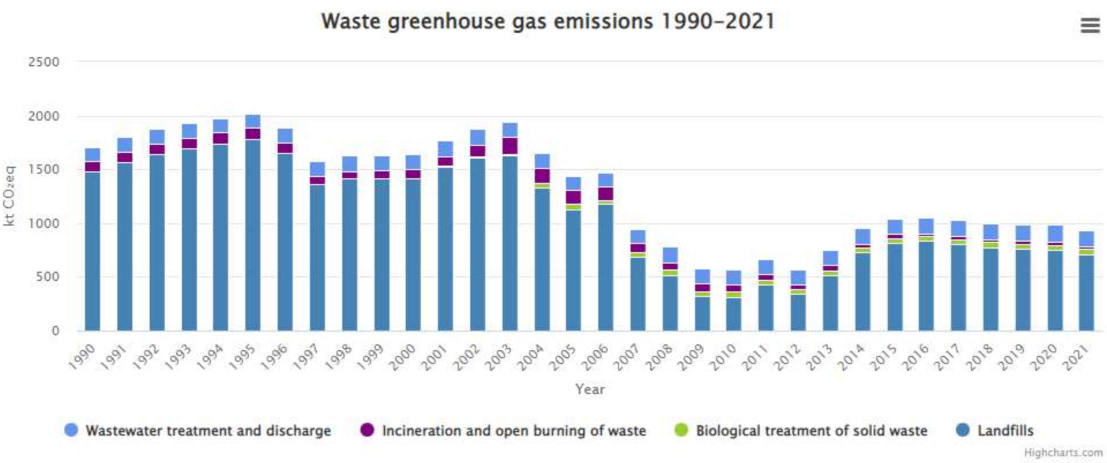


Figure22: Waste greenhouse gas emissions from EPA [37]

Waste emissions per head are lower in Ireland compared to the EU average and emissions have fallen since 2005. Ireland has made significant progress in managing waste streams, particularly in improving recycling rates and diversion from landfill.

4.8.2 Galway City: Baseline Inventory for Waste

As seen below, the majority of the Waste Emissions come from the *Biological Treatment of Waste-Solid waste disposal on Land,* which account for 92% of the total Waste Emissions. The vast majority

[37] https://www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/waste/

of this category is managed in landfilled sites. This is followed by the emissions caused by composting, which accounts for roughly 8% of the total Waste Emissions sector.

Sector	$ktCO_2e$
Composting	0.2
Solid Waste	2
Domestic Wastewater Handling	0
Open Burning	0
Total	2

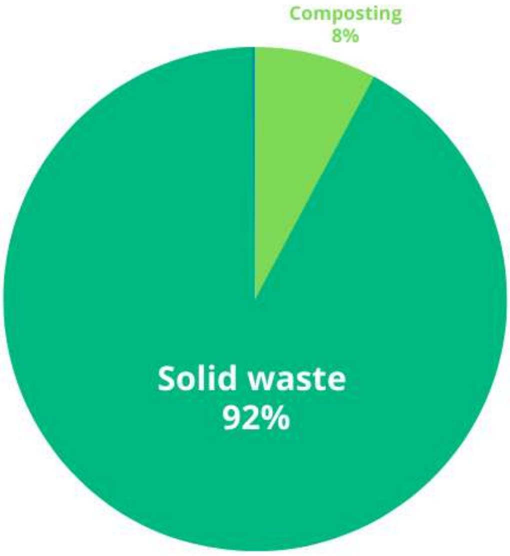


Figure23: Waste Subsector Emissions

4.8.3 Supporting information

Galway City has currently 1 active wastewater treatment plant and 1 recycling centre in which waste is processed.[38] [39]

The most dominant greenhouse gas emitted in the Waste sector is Methane which occurs primarily from landfills (CH_4), followed by Nitrous Oxide (N_2O), as shown below:

GAS	$ktCO_2e$
CH_4	2
CO_2	0
N_2O	0.07
Total	2

Table 10 Waste Sector Emissions by Gas Type

[38] https://www.water.ie/docs/aers/2018/Non-Priority-AERS/D0050-01_2018_AER-Galway-City-RPS.pdf
[39] https://www.galwaycity.ie/recycling-centre

4.9 Agriculture

4.9.1 Background

Agriculture emissions are greenhouse gases (GHG) released into the atmosphere during farming activities, including livestock rearing, crop production, and land use change. These emissions are primarily composed of methane (CH_4) and nitrous oxide (N_2O), which have significantly higher global warming potentials than carbon dioxide (CO_2). Agriculture emissions are responsible for a considerable portion of global GHG emissions, and the sector has a crucial role to play in addressing climate change.

In Ireland, agriculture is the highest emitting sector, contributing to 34% of the country's total GHG emissions in 2019. The primary source of emissions is methane from livestock, which accounts for about 63% of the total agriculture emissions. Livestock such as cows, sheep, and pigs produce methane through enteric fermentation, a digestive process that breaks down feed in their stomachs, leading to the production of methane gas. The use of nitrogen fertilizers and manure management is another significant source of agriculture emissions in Ireland [40]. The application of nitrogen fertilizers and the handling of animal manure can lead to the release of nitrous oxide, a potent greenhouse gas that is over 300 times more powerful than CO_2.

Reducing agriculture emissions is a critical challenge for Ireland, given the sector's importance to the country's economy. Agriculture is a vital part of Ireland's economy, generating 8% of the country's gross value added and providing over 8.5% of national employment in 2019[41]. To address the challenge, ambitious targets have been set for Irish agriculture to reduce GHG emissions by 25% by 2030. The national emissions ceiling for 2030 is 17.25 $MtCO_2$ equivalent for Agriculture.

4.9.2 Galway City: Baseline Inventory for Agriculture

This sector's emissions range from enteric fermentation, manure management, agricultural soils, liming, and the use of fertilisers and urea. MapEIre data provides a breakdown of emissions within this sector, covering a wide range of sub-categories. According to the latest MapEIre and the associated BEI report, energy-related agricultural emissions are assigned to the agriculture sector. The MapEIre report provides a detailed breakdown of the emissions from various sectors, including agriculture, transport, commercial, and residential. While transport-related emissions are assigned to the transport sector and buildings-related emissions are assigned to the commercial sector, energy-related agricultural emissions are allocated to the agriculture sector. This includes emissions from the use of

---

[40] https://www.teagasc.ie/rural-economy/rural-economy/agri-food-business/agriculture-in-ireland/
[41]https://www.gov.ie/en/publication/6223e-climate-action-plan-2021/f

energy-intensive machinery and equipment in farming, as well as energy consumed in the production of fertilizers and other agricultural inputs such as off-road Agriculture Transport.

The MapElre dataset breaks down the Agriculture sector into several sub-sectors, which have been grouped further for ease of understanding. A visual depiction of this is provided below:

Subsector	$ktCO_2e$
Livestock Enteric Fermentation	1
Soil Applications	0.2
Inorganic fertilizer	0.1
Soil processes	1
Cultivation of organic soils	0.1
Manure management	0.1
Machinery and Vehicles	0.3

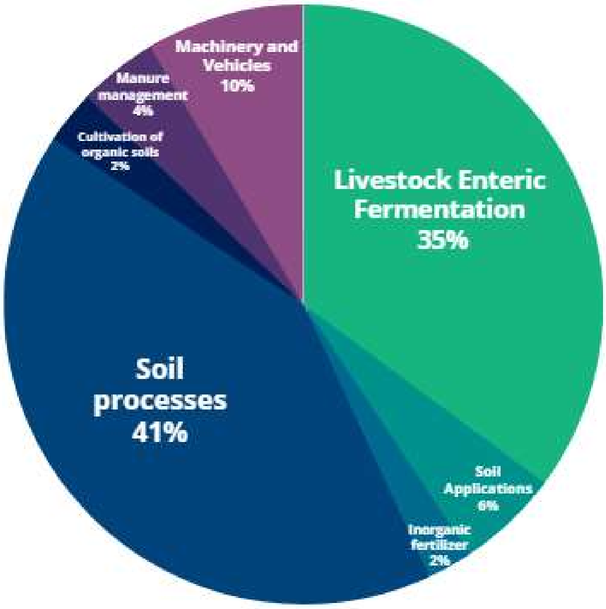


Figure24: Breakdown of Agriculture Emissions by Subsector

Raw Subcategories

SUBCATEGORY	$ktCO_2e$
Livestock	
Dairy cattle	0.1
Goats	0
Horses	0.03
Sheep	0.02
Swine	0
Mules and asses	0
Non-dairy cattle	0.9
Urine and dung deposited by grazing animals	0.1
Manure Management	
Manure management - Dairy cattle	0.01
Manure management - Goats	0
Manure management - Horses	0
Manure management - Mules and asses	0
Manure management - Non-dairy cattle	0.1
Manure management - Other poultry	0
Manure management - Sheep	0
Manure management - Swine	0
Cultivation of organic soils	
Cultivation of organic soils	0.1

SUBCATEGORY	$ktCO_2e$
Machinery and vehicles	
National fishing	0
Off-road vehicles and other machinery	0.1
Stationary	0.03
Agriculture	0.2
Inorganic fertilizer	
Inorganic N-fertilizers (includes also urea application)	0.1
Soil Processes	
Liming	0.1
Mineralization	0
Nitrogen leaching and run-off	1
SOIL APPLICATIONS	
Urea application	0
Sewage sludge applied to soils	0
Animal manure applied to soils	0.2
Atmospheric deposition	0.2
Crop residues applied to soils	0
TOTAL	**3**

Table 11 Emissions by Subcategory extracted from MapEIre dataset

4.9.3 Supporting Information

As a city, Agriculture does not play a leading role in the direct economy. However, as it is surrounded by rural areas, the presence of Agriculture in the economy is still felt.

Being a predominantly urban area, it is not a surprise that the sector only emits around 1% of the total carbon emissions in the city. The most dominant greenhouse gas emitted in the Agriculture sector is Nitrous Oxide, followed by Methane (see Table).

Livestock in the Galway City area are directly responsible for about 34% of the carbon emitted in the Agriculture sector. The various elements corresponding to soil processes are responsible for the most emissions in the Agricultural sector, adding up to roughly 41% of these.

The most dominant greenhouse gas emitted in the Agriculture sector is Methane (CH_4), followed by Nitrous Oxide (N_2O), as shown below:

GAS	$ktCO_2e$
CH_4	1
CO_2	0.2
N_2O	2
Total	**3**

Table 12 Agricultural Sector Emissions by Gas Type

4.10 Land Use, Land Use Change and Forestry

Baseline Emissions Inventory Results

Galway City **-4 ktCO₂e (-1%)**

National: **6,657 ktCO₂e (10%)**

LULUCF

4.10.1 Background

Land Use, Land Use Change and Forestry (LULUCF) is responsible for emissions as well as carbon sinks, related to land use change and forestry. It involves the emissions and removals from land use, land use change and forestry, including forest land, cropland, grassland, wetlands, settlements and other land types, as well as through the harvesting of wood products. Land management has a key role in the response to climate change. Ireland has significant and healthy biosystems, including grassland, hedgerows and forests, which sequester or absorb carbon dioxide (CO_2). This is a separate category from Agriculture because while LULUCF primarily deals with land use and forestry practices to enhance carbon sequestration and mitigate emissions, Agriculture involves the production and management of crops and livestock, and includes emissions and removals associated with agricultural activities such as enteric fermentation, manure management, and soil management.

Since 1990, Ireland's forest area has expanded by approximately 300,000 ha[42]. As these forests grow and mature, they represent an important CO_2 sink and long-term carbon storage in biomass and soil. However, low forest planting rates in recent years are a future risk in terms of national forest estate continuing to act as a significant carbon sink. In 2019 the LULUCF sector accounted for 3,210 $ktCO_2$ equivalent removed and 9,867 $ktCO_2$ equivalent emitted [43]. In 2019, the national net emissions for LULUCF accounted for 6,657kt CO_2.

Land use and land-use change contribute significantly to global greenhouse gas emissions. Deforestation, conversion of natural ecosystems to agriculture, and other land use changes result in the release of carbon dioxide (CO2) into the atmosphere, which contributes to the greenhouse effect and climate change.

On the other hand, land use and management practices can also offer significant potential for reducing emissions. Land-based activities can contribute to the sequestration of carbon, or the removal of CO2 from the atmosphere and its storage in soil, vegetation, and other organic matter. For example, reforestation and afforestation efforts can help sequester carbon from the atmosphere, acting as a natural sink for greenhouse gases. In addition, sustainable agriculture practices such as conservation tillage, agroforestry, and cover cropping can improve soil health, increase soil carbon sequestration, and reduce greenhouse gas emissions.

[42] https://www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/lulucf/
[43] https://www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/lulucf/

4.10.2 Galway City: Baseline Inventory for LULUCF

LULUCF is responsible for removing 1% of the total GHG emissions in Galway City, with about 4 $ktCO_2$ equivalent sequestered. As seen in Figure 25, Galway's Cropland, Forestland and Harvested Wood Product serve as a store of carbon and were responsible for the sequestration of about 10 $ktCO_2e$ of emissions, whilst the areas of Grassland, Settlements, Wetlands and Other Land were responsible for emitting about 7 $ktCO_2$ equivalent of emissions.

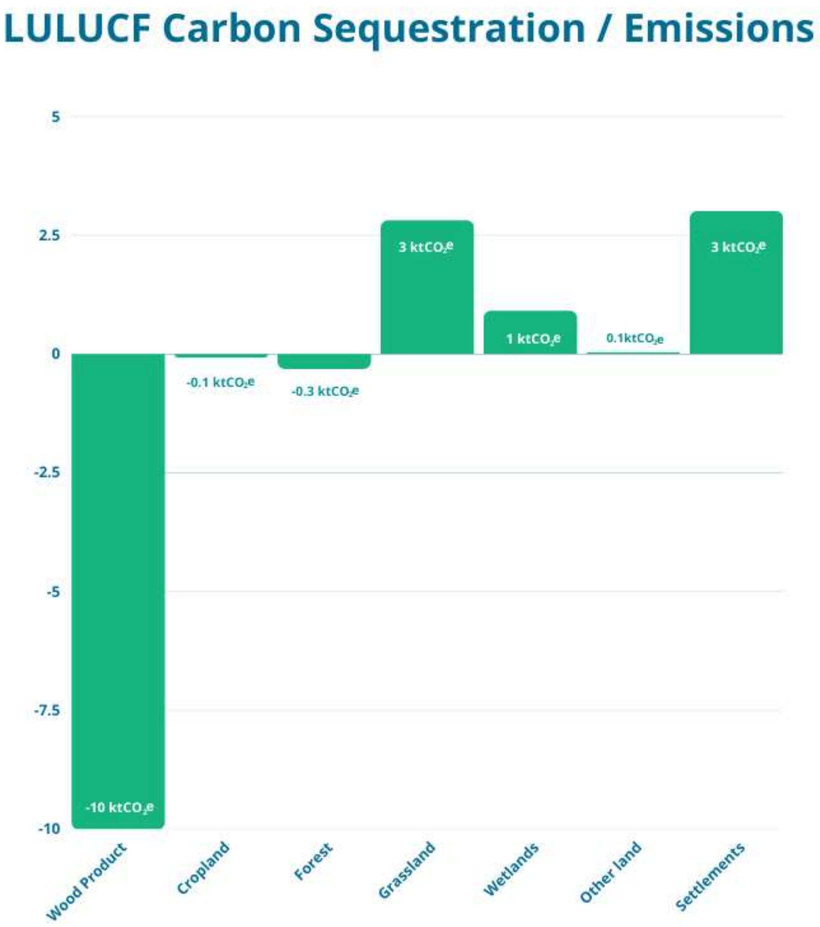


Figure 25 Carbon Sequestration and Emissions from LULUCF

4.10.3 Supporting Information

Galway City contains a wide variety of wetlands, grasslands and forestry, which support many flora and fauna species of high conservation concern. Due to the varying topography, geology, hydrology, climate and soil present, Galway has a wide variety of habitats.

Peatlands and wetlands on a per unit-area basis, hold the greatest volume of carbon and therefore are an important nature-based solution. Peat-forming plants such as sphagnum moss and sedges remove carbon from the atmosphere. Globally, they store vast amounts of carbon—twice as much carbon as all the world's forests. One hectare of Irish-raised bog in near natural condition stores 3,000 tonnes of carbon.[44] When drained or burned for agriculture (as wetlands often are) they go from being a carbon sink to a carbon source, releasing into the atmosphere centuries of stored carbon.

The Agricultural land category includes pastures and land principally occupied by agriculture, with significant areas of natural vegetation. Below is information about the different types of land in Galway City and the corresponding area covered in hectares. The table below outlines the area for agricultural land.

Subcategory	Area (ha)
Pastures	1,594
Land principally occupied by agriculture, with significant areas of natural vegetation	414
Total Agricultural Land	2,008

Table 13 Agricultural Land Use Distribution

Below is information about the different types of Forest land in Galway City and the corresponding area covered in hectares. The table below outlines the area for forest land.

Subcategory	Area (ha)
Mixed forest	40
Total Forest Land	40

Table 14 Forest Land Use Distribution

The Wetland category includes peat bogs, inland marshes, and different water bodies. Below is information about the different types of wetlands in Galway and the corresponding area covered in hectares. The table below outlines the area for wetlands.

Subcategory	Area (ha)
Peat Bogs	114
Inland marshes	140
Sea and ocean	26
Water bodies	0.2
Water courses	53
Coastal Lagoons	42
Total Wetland	375

Table 15 Wetland Land Use Distribution

[44]https://www.ucd.ie/earth/newsevents/news/body,605604,en.html#:~:text=affect%20GHG%20emissions.-,Dr.,of%20rain%20forest%20ecosystem!).

The Other Land Uses category includes the rest of the land use in Galway. Below is information about the different types of Other Land Uses in Galway City and the corresponding area covered in hectares.

Subcategory	Area (ha)
Discontinuous urban fabric	2,028
Industrial units	307
Sport and leisure facilities	55
Continuous urban fabric	82
Green urban area	22
Mineral extraction sites	0.1
Sparsely vegetated areas	133
Intertidal flats	19

Table 16 Other Land Use

The most dominant greenhouse gas emitted in the LULUCF sector is carbon dioxide (CO_2), followed by methane (CH_4), shown in the table below:

GAS	$ktCO_2e$
CH_4	0.2
CO_2	-5
N_2O	1
Total	-4

Table 17 Land Use, Land Use Change and Forestry Emissions by Gas Type

5.Other Inventories

5.1 Fluorinated Gases

Fluorinated gases are artificially produced gases used in a range of industrial applications. They are often used to substitute gases that deplete the ozone, as they do not damage the atmospheric ozone layer. However, they are greenhouse gases with high GWPs, thus contributing to climate change. They were not included as their sector in the Chapter 3 Inventory (present in Industrial Processes) but are added here.

Hydrofluorocarbons are typically found in applications such as refrigeration, air-conditioning, aerosols, and foams.[45] SF_6, however, is used primarily in the electricity and electronics supply industries, e.g. the semiconductor industry, where it is used as an electronic insulator due to its inertness[46].

F-gases in Ireland are controlled by European Regulation (EC) No. 517/2014. This Regulation aims to cut EU emissions of F-gases by two-thirds of 2014 levels by 2030. It is a legal requirement in Ireland that all businesses that install, maintain or service stationary refrigeration, stationary fire protection systems and extinguishers, air conditioning and heat pump equipment containing or designed to contain F-Gas refrigerants, obtain an F-Gas Company Certificate.

5.1.1 City Galway: Baseline Inventory for F-gases

Using MapEIre's CRF Geospatial Dataset, two types of F-gases were identified in Galway City: hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6). The CO_2 equivalent of the SF_6 is included in the 3.1.1 results section as part of the overall GHG emissions, thus the SF_6 presented in the table below is double counted and is only presented to show the extent of SF_6 gases in the city. However, the CO_2 equivalent of the HFCs is not included in the overall GHG emissions, thus counted for the total GHG emissions. The NRF MapEIre GIS files were used to inform the data for the Fluorinated gases. The total mass of both is listed below:

F-gas	CO_2e
HFCs	13,350
SF_6	0
Total	13,350

Table 18 Measured Emissions from F-gases

5.2 Local Authority own Emissions

All public bodies in Ireland must achieve a 51% reduction in energy-related GHG emissions and a 50% improvement in energy efficiency by 2030. This is tracked through the SEAI's Monitoring and Reporting (M&R) system, in which each public sector organisation reports the following:

- Annual energy consumption for all energy types.
- The annual value quantifies the level of activity undertaken by the organisation each year. This is referred to as the activity metric.

[45] https://www.ccacoalition.org/fr/slcps/hydrofluorocarbons-hfcs
[46] https://library.wmo.int/index.php?lvl=categ_see&id=10223#.Y3-3eXaZOUk

- Details of energy-saving projects implemented and planned.
- Summary of the approach adopted for reviewing the organisation's energy management programme.

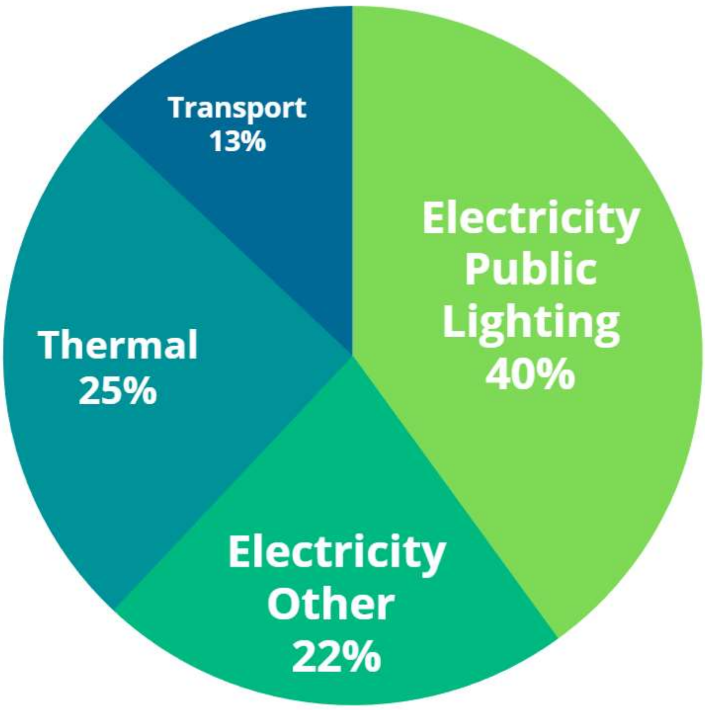
As of 2020, public bodies have saved €1.8 billion and 6 million tonnes of CO_2 emissions through avoided energy use between 2009 and 2020. The public sector is 34% more energy efficient than in 2009 and exceeded its 33% energy efficiency target for 2020.[47] In 2019 approximately two-thirds of LA electricity consumption was for Public Lighting. The remaining third was primarily used in LA buildings.

The total emissions from the public sector in Galway City are 4 $ktCO_2e$. This represents about 1% of the total emissions for Galway City. These emissions are not separated from the broader MapEIre inventory but rather provide a closer look at the emissions the LA is directly responsible for. Electricity consumption represents the bulk of the LA's emissions reported to the SEAI M&R system, followed by Heating and Transport emissions.

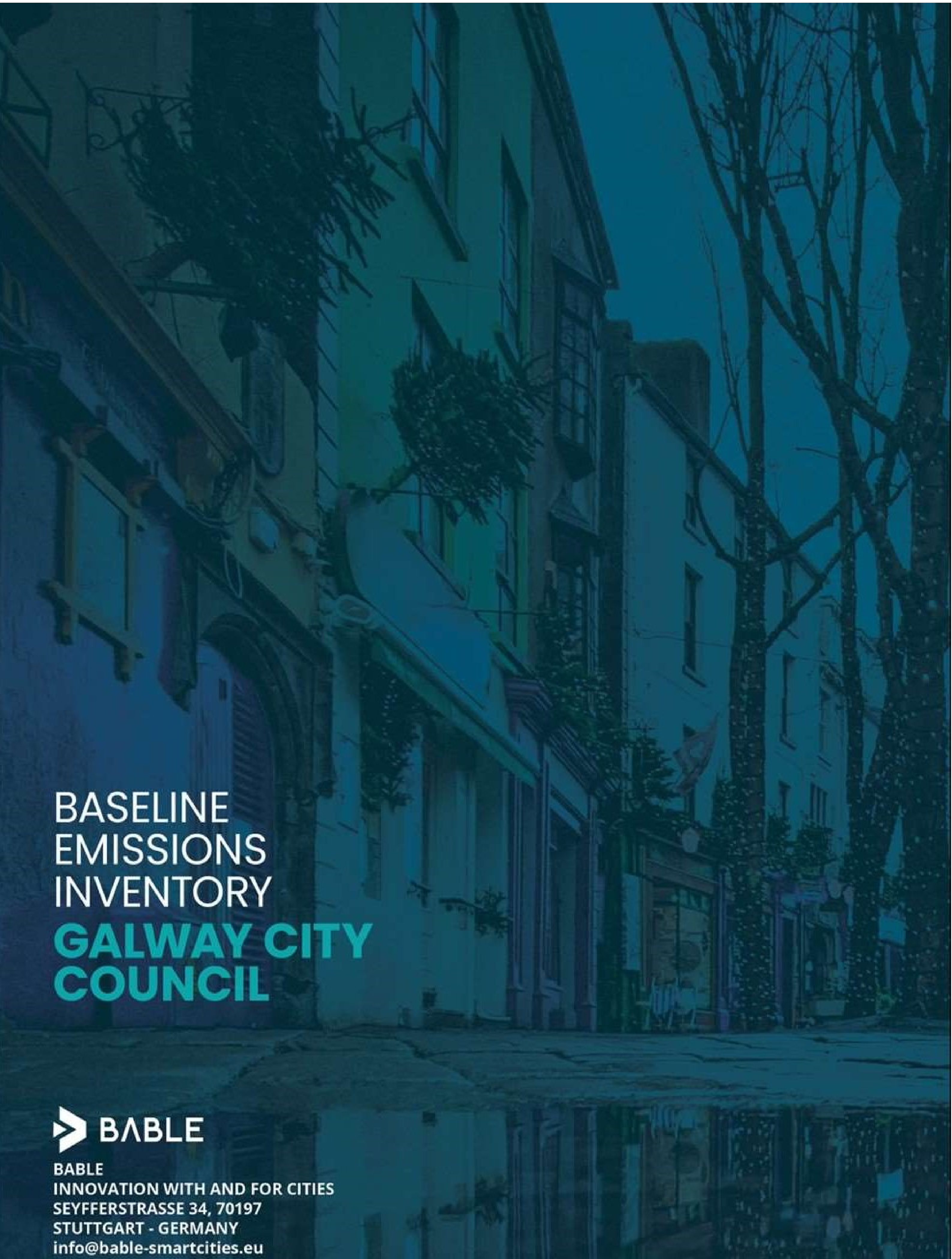
Electricity emissions come entirely from purchased electricity in 2019, the largest fuel source for Heating is gas, and the largest fuel source for the Transport fleet is road diesel.

Galway City Council own Emissions

Energy	Energy Category	Energy Type	$kgCO_2$
Electricity			2,516,188
	Electricity		2,516,188
		Net Electricity Imports (MPRN data)	2,516,188
		Net Electricity Imports (non-MPRN data	0
Thermal			1,014,541
	Heating Oils		4,796
		Kerosene	4,796
		Gasoil	0
	Gas		1,009,745
		Natural Gas (GPRN data	953,490
		LPG (purchased by volume)	56,256
Transport			530,124
	Transport Fuels (Mineral Oil Fuels)		530,124
		Petrol (excl. blended bioethanol)	3,049
		Road Diesel (DERV) (excl. blended biodiesel)	353,214
		Marked Diesel (non-thermal)	173,860
	Transport Biofuels		0
		Biodiesel (incl. all blended biodiesel)	0
		Bioethanol(incl.all blended bioethanol)	0
Total CO2 Emissions			4,060,852



[47] https://www.seai.ie/business-and-public-sector/public-sector/monitoring-and-reporting/introduction-to-mr/



BASELINE EMISSIONS INVENTORY
GALWAY CITY COUNCIL

BABLE
INNOVATION WITH AND FOR CITIES
SEYFFERSTRASSE 34, 70197
STUTTGART - GERMANY
info@bable-smartcities.eu