SOUTH EAST ENERGY AGENCY

Comhairle Cathrach & Contae Phort Láirge
Waterford City & County Council

TIER 3 BASELINE EMISSION INVENTORY REPORT

September2023

PREPARED FOR:

WATERFORD CITY & COUNTY COUNCIL

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Glossary of Terms

ARCGIS – GIS software
BER – Building Energy Rating
BEI – Baseline Emission Inventory
WCCC – Waterford City & County Council
CIBSE – Chartered Institution of Building Energy Services Engineers
CNG – Compressed Natural Gas
CH_4- Methane
CO_2 – Carbon Dioxide
CO_2eq – Carbon Dioxide equivalent, metric for GHP
CSO – Central Statistics Office
DZ - Decarbonisation Zone
ETS - Emissions Trading Scheme
EV – Electric vehicle
F-gases – Fluorinated gases
GHG – Greenhouse Gas Emissions
GIS – Geographical Information Systems
GWh – Gigawatt-hour
GWP – Greenhouse Warming Potential
kt – kilotonne
ktoe – kilotonnes of oil equivalent
kWh – kilowatt Hour
LACAP - Local Authority Climate Action Plan
LED - Light-emitting diode
LPIS - Land Parcel Identification System
LPG – Liquid Petroleum Gas
LULUCF – Land Use, land use change, and forestry
M&R – Monitoring and Reporting
MWh – Megawatt-hour
Non-ETS - Non-Emissions Trading Scheme
N_2O- Nitrous oxide
PRTR - Pollutant Release and Transfer Register
PSVs – Public Service Vehicles
SAP-ID – Small Area Population-Identification Number
SEAI – Sustainable Energy Authority of Ireland
SEU – Significant Energy Use
SF_6- Sulphur hexafluoride
SECAP - Sustainable Energy and Climate Action Plan
TFC – Total Final Consumption
UNFCCC - United Nations Framework Convention on Climate Change
WWTP – Wastewater Treatment Plant

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Total GHG emissions from the Decarbonisation Zone in 2018 were **289.5 $ktCO_2eq$** and the energy consumption in the DZ was **1017.4 GWh**.

The national carbon reduction targets set out in the Irish Governmental "Climate Action Plan" [1]are 51% reduction by 2030, compared to 2018 levels. Under the Climate Action and Low Carbon Development (Amendment) Act 2021, Ireland is now on a legally binding pathway to net-zero emissions by no later than 2050, and to a 51% reduction in emissions by 2030. The Act provides the framework for Ireland to achieve these reduction targets. They are also supported by the National Climate Action Plan (updated annually) and the setting of Carbon Emissions Ceilings by the Climate Change Advisory Council.

Waterford City & County Council is required, under Section 16 of the Climate Action Plan [1], to prepare a Local Authority Climate Action Plan (LACAP)[1]. The LACAP will outline the pathway for Waterford City & County Council to reduce its Greenhouse Gas Emissions (GHG) by the required 51% by 2030.

The LACAP includes to identify and deliver a Decarbonising Zone (DZ) within the local authority area to act as a test bed for a range of climate mitigation, adaptation, and biodiversity measures in a specifically defined area through the identification of projects and outcomes that will assist in the delivery of the National Climate Objective.

The methodology used is in accordance with Technical Annex C: Climate Mitigation Assessment" [2] and the SEAI/CODEMA supporting guidance document "Developing CO_2 Baselines A Step-by-Step Guide For Your Local Authority (2017)" [3]. These guidelines outlined the Tier 3 approach to be taken in the development of the Baseline Emissions Inventory at local level for the Decarbonisation Zone (DZ). Tier 3 is the bottom-up special-led approach for data analysis, to look at a local level of GHG emissions across various sectors which include:

- Waterford City & County Council
- Public sector
- Commercial & Industrial
- Residential
- Social Housing
- Transport
- Agriculture
- Waste & Wastewater

[1] https://www.gov.ie/en/publication/f5d51-guidelines-for-local-authority-climate-action-plans/

The Tier 3 Baseline Emissions Inventory (BEI) outlines the GHG emissions data for the baseline year 2018, in order to establish the absolute GHG emissions target for 2030 for the Waterford City DZ. Waterford City & County Council has full accountability and obligations to reduce its own GHG emissions by 51% by 2030, and can influence, co-ordinate, facilitate and advocate for all other sectors to reduce their own GHG emissions by the same 51% by 2030.

The Decarbonisation Zone chosen is in Waterford City, as outlined in Figure 1.

WATERFORD CITY DECARBONISATION ZONE

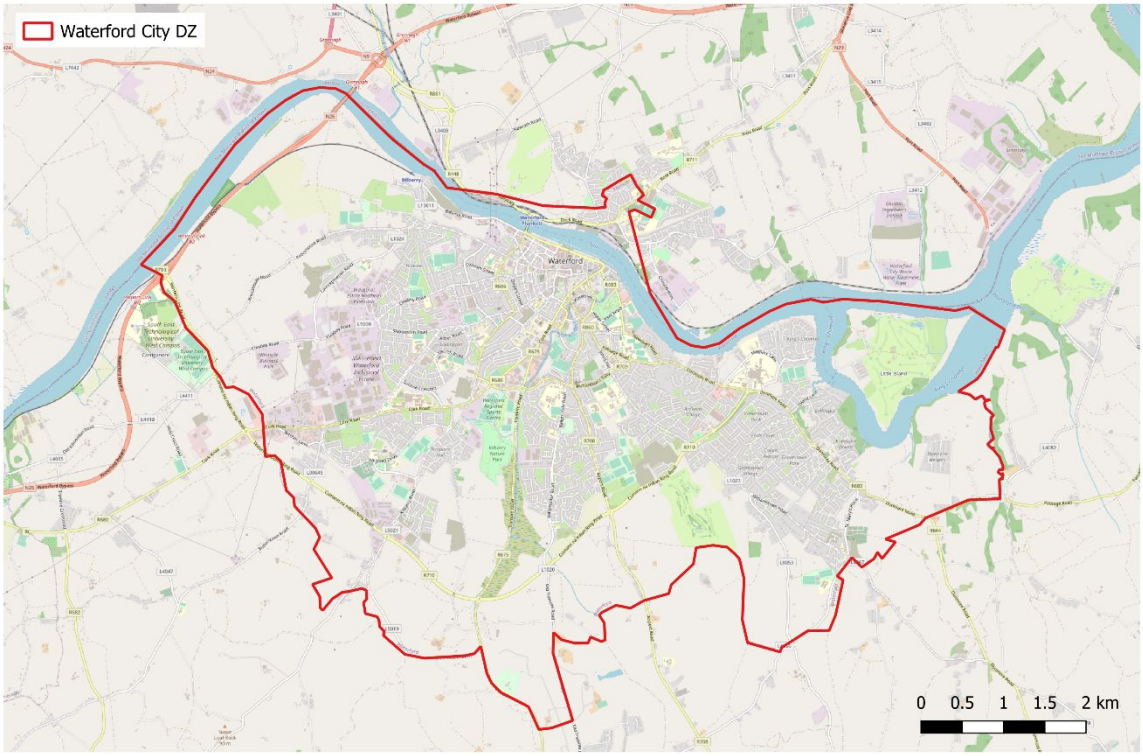


Figure 1. Decarbonisation Zone – Waterford City, County Waterford.

In order to ascertain the GHG emissions per sector, the energy consumption has also been analysed and is reported alongside the GHG data in this report. Although not the focus of the report, which is GHG emissions, the energy data has been included for reference purposes, as it is the energy data that is converted to CO_2eq. GHG emissions in some sectors (where applicable).

The breakdown of GHG emissions and energy consumption per sector from within the Decarbonisation Zone, in 2018, is shown in Figure 2, and is as follows:

Waterford City & County Council

- Total Local Authority GHG emissions produced in the Waterford City DZ were **4.6 $ktCO_2eq$**
- Total final energy consumption in the Waterford City DZ was **15.3 GWh**

Public sector

- Total Public Sector (excluding Waterford City & County Council) GHG emissions produced in the Waterford City DZ were **18.4 $ktCO_2eq$**
- Total final energy consumption in the Waterford City DZ was **66.7 GWh**

Commercial & Industrial

- Total Commercial GHG emissions produced in the Waterford City DZ were **82.1 $ktCO_2eq$**
- Total final energy consumption in the Waterford City DZ was **321.1 GWh**

Residential

- Total Residential GHG emissions produced in the Waterford City DZ were **63.1 $ktCO_2eq$**
- Total final energy consumption in the Waterford City DZ was **238.1 GWh**

Social Housing

- Total Social Housing GHG emissions produced in the Waterford City DZ were **10.5 $ktCO_2eq$**
- Total final energy consumption in the Waterford City DZ was **44.6 GWh**

Transport

- Total Transport GHG emissions produced in the Waterford City DZ were **86.0 $ktCO_2eq$**
- Total final energy consumption in the Waterford City DZ was **331.4 GWh**

Agriculture

- Total Agriculture GHG emissions produced in the Waterford City DZ were **4.5 $ktCO_2eq$**
- Total final energy consumption in the Waterford City DZ was **0.2 GWh**

Waste & Wastewater

- Total Waste & Wastewater GHG emissions produced in the Waterford City DZ were **20.3 $ktCO_2eq$**

As a result, the total GHG emissions from the Decarbonisation Zone in 2018 were **289.5 $ktCO_2eq$.,** and the energy consumption in the DZ was found to be **1,017.4 GWh.**

Waterford City DZ	Total Energy (GWh)	Total GHG Emissions (ktCO2eq.)
Waterford City & County Council	15.3	4.6
Public Sector	66.7	18.4
Commercial and Industrial	321.1	82.1
Residential	238.1	63.1
Social Housing	44.6	10.5
Transport	331.4	86.0
Agriculture	0.2	4.5
Waste & Wastewater	0.0	20.3
Totals	**1,017.4**	**289.5**

Table 1: Total Energy & GHG Emissions in the Waterford City DZ, 2018

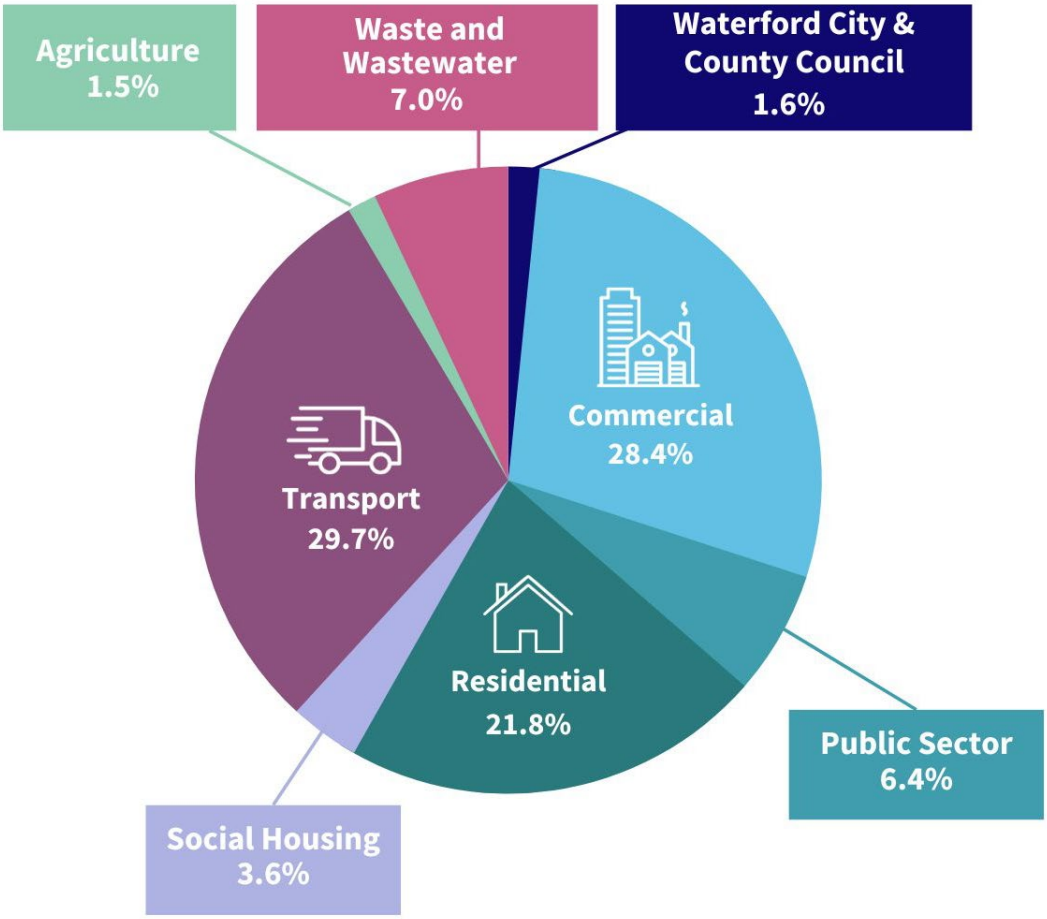


Figure 2. Total GHG emissions for Waterford City DZ by sector type in 2018

INTRODUCTION

1.0 INTRODUCTION

The 2030 Emission Reduction Target as set out in the Climate Action and Low Carbon Development (Amendment) Act 2021 [1] is a 51% absolute reduction in overall greenhouse gas emissions by 2030 and setting us on a path to reach net-zero emissions by no later than 2050, as committed to in the Program for Government.

Waterford City & County Council is required, under Section 16 of the Climate Action and Low Carbon Development (Amendment) Act 2021 [1], to prepare a Local Authority Climate Action Plan (LACAP) [4][2]. The LACAP will outline the pathway for Waterford City & County Council to reduce its Greenhouse Gas Emissions (GHG) by the required 51% by 2030. The LACAP includes identifying and delivering a Decarbonising Zone (DZ) within the local authority area.

1.1 WHAT IS A DECARBONISATION ZONE?

A Decarbonisation Zone is a spatial area identified by the local authority in which a range of climate mitigation, adaptation and biodiversity measures and action owners are identified to address local low carbon energy, greenhouse gas emissions, and climate needs to contribute to national climate action targets.

Decarbonisation Zones are a demonstration and test bed of what is possible for decarbonisation and climate action at local and community levels, to help support and realise national climate ambition. Under action 165 of the National Climate Action Plan 2019, all Local Authorities in Ireland were required to establish a zone within their remit for decarbonisation.

The Decarbonisation Zone is the focus for a range of climate mitigation, adaptation and biodiversity measures including the identification of projects and outcomes to assist in the delivery of the National Climate Objective, see Figure 3. This setup includes 4 steps:

Figure 3. Decarbonisation Zone measures step by step process

[2] https://www.gov.ie/en/publication/f5d51-guidelines-for-local-authority-climate-action-plans/

This report is part of Step 2 Building the Evidence, a **Tier 3 Bottom-up Spatially led Approach and represents a Baseline Emission Inventory (BEI)** for the dedicated Decarbonisation Zone. The GHG emission levels from various sectors from 2018 within the DZ have been identified, which has created the baseline form which 2030 savings targets are set.

For the purpose of this report and the data analysis, all GHG are converted and reported as tonnes of CO_2 equivalent, or **tCO_2eq.**

The collection and analysis of the relevant data used throughout this report was prepared in line with the methodology provided in the "Local Authority Climate Action Plan Guidelines" [4], Technical Annex C: Climate Mitigation Assessment" [2]. All data sources of this quantitative bottom-up spatially led approach BEI need to have a spatial element to allow it to be mapped in geographical information systems (GIS).

1.2 Identification of the Waterford City DZ

Following a detailed evaluation period which included engagement with key stakeholders, in April 2021 Waterford City & County Council selected the Waterford City area as the County's Decarbonisation Zone. This is a Metropolitan Area designated in the County Development Plan and which has boundary encompassing Waterford City Urban electoral division.

There are 1 Electoral Divisions linked to the DZ
There are 204 Small Area's linked to the DZ
There are 66 1km Grids linked to the DZ

The data sets available for analysing the GHG emissions within the DZ are:

1. MapEIre (available in km Grids)
2. 2016 Census Small Area Population (Available in SAP ID's)[3]
3. Census 2020 Agricultural data (available per Electoral Division)

The total population within the DZ was found to be 48,216 as per the Census 2018 Small Area Population data sets.
This equates to 42% of the total population of County Waterford (2016 Census).

The DZ boundary line dissects the three main data source boundary lines. The percentage of each area that lies within the DZ was estimated and this was used to ascertain the GHG emissions from each sector within the DZ.

[3] https://visual.cso.ie/?body=entity/ima/cop/2016&boundary=C03736V04484

The total area of the Decarbonisation Zone is 41.64km
This equates to 2.2% of the total area of County Waterford.

WATERFORD CITY DECARBONISATION ZONE

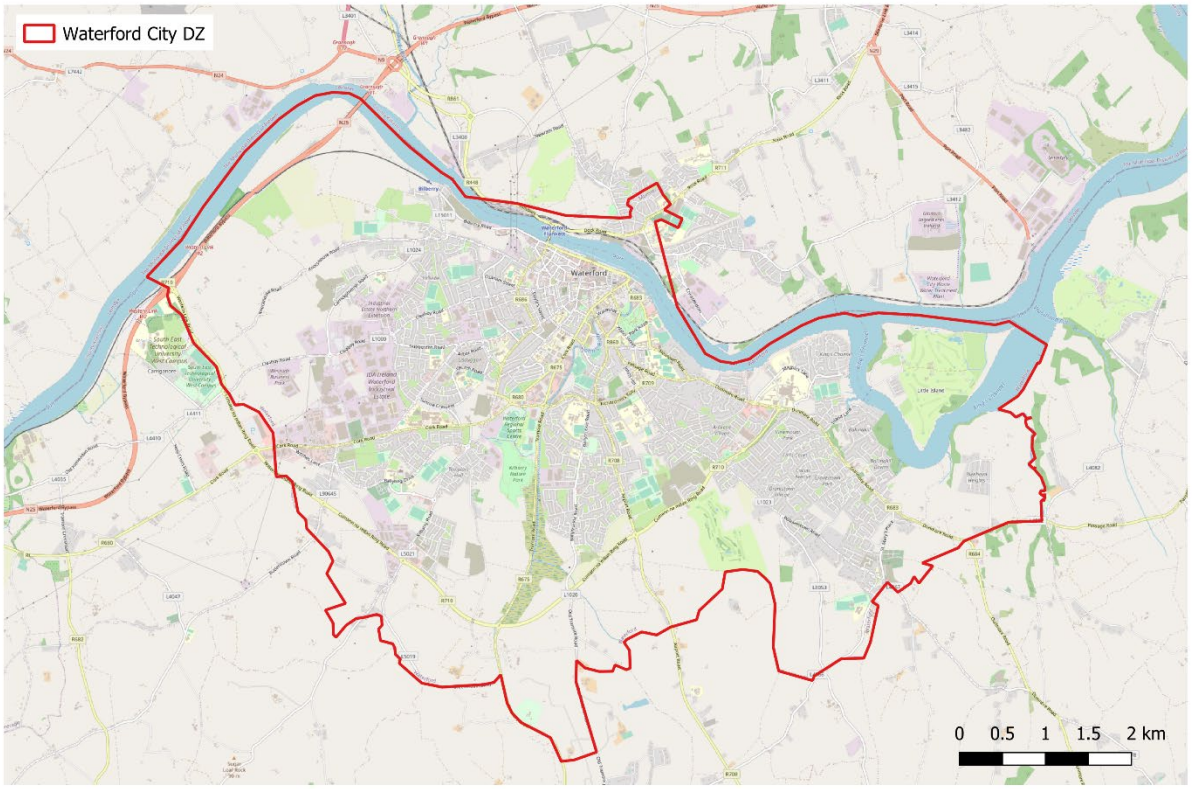
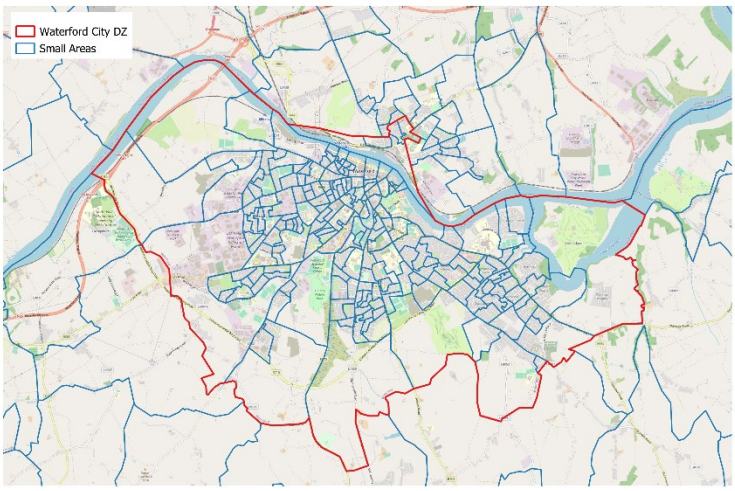
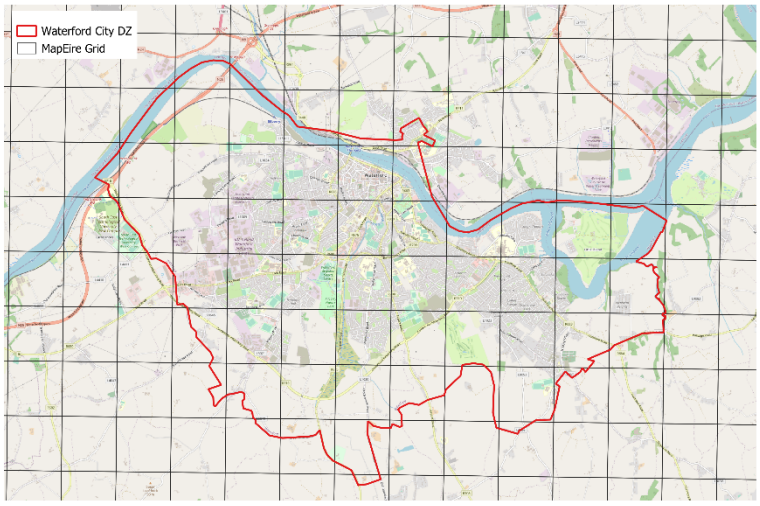


Figure 4. Waterford City Decarbonisation Zone

WATERFORD CITY DZ VS. SMALL AREAS



WATERFORD CITY DZ VS. MAPEIRE GRID



WATERFORD CITY DZ VS. ELECTORAL DIVISIONS

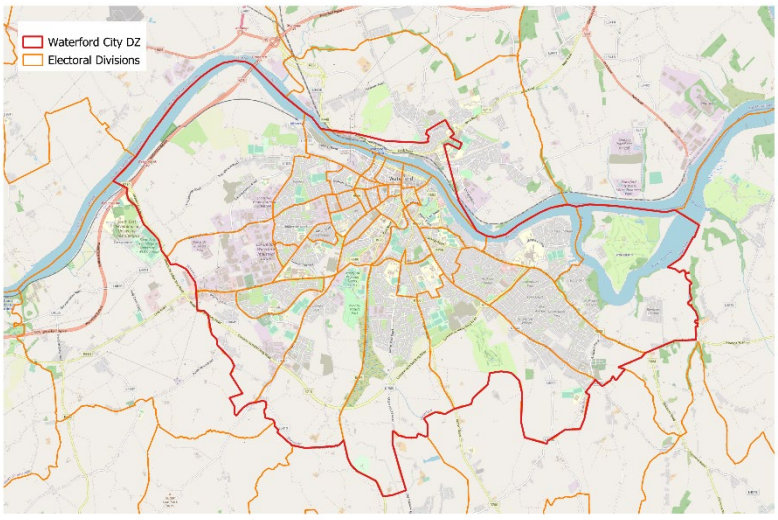


Figure 5. Waterford City DZ vs Small areas, MapEIre Grid, and Electoral Division

1.3 METHODOLOGY FOR THIS DZ

The methodology used in this report is in accordance with Technical Annex C: Climate Mitigation Assessment" [2] and the Codema supporting guidance document "Developing CO_2 Baselines - A Step-by-Step Guide For Your Local Authority (2017) [3]. These guidelines outlined the Tier 3 approach to be taken by the Local Authorities in the development of the Baseline Emissions Inventory (BEI) at local level. All data sources of this quantitative Bottom-up spatially led approach BEI have a spatial element to allow it to b\e mapped in geographical information systems (GIS).

Tier 3 is the bottom-up and spatially led approach for data analysis, which takes local-scale datasets to look at the Waterford City DZ's GHG emissions across various sectors which include:

- Waterford City & County Council
- Public Sector
- Commercial & Industrial Processes
- Residential
- Social Housing
- Transport
- Agriculture
- Waste & Wastewater

The BEI will include the extraction of Waterford City DZ's direct GHG emissions from these different sectors and will therefore shape the specific target of Waterford City Decarbonisation Zone that will feed into the Waterford City & County Council Local Authority Climate Action Plan (LACAP).

Waterford City & County Council has full accountability and obligations to reduce its own GHG emissions within the Waterford City DZ by 51% by 2030, and can influence, co-ordinate, facilitate and advocate for all other sectors to reduce their own GHG emissions by the same 51% by 2030. This Tier 3 BEI therefore outlines the 2018 baseline data for Waterford City & County Council GHG emissions within the DZ as a separate sector.

The Tier 3 approach is predominantly linked to spatial data and is therefore used to map the GHG emissions within the DZ using geographical information systems (GIS) software – this shows the areas and sectors within the DZ that produce the highest GHG emissions, allowing for engagement with the key stakeholders within the DZ.

The Tier 3 approach can only be completed where local data sources exist and are made available. This report has been completed using the data sources available at the time and can be updated as more data is made available.

Each sectoral chapter below outlines the individual methodologies used for the analysis and extraction of Energy & GHG emissions within the DZ.

It is important to note that the TIER 3 BEI is a 'snapshot in time' of an area's GHG emissions sources, and it is not an inventory of emission reduction opportunities [2, pp. 6, 16]

CONTEXT

2.0 CONTEXT

2.1 CLIMATE CHANGE CHALLENGE

Climate change is recognised as the greatest environmental challenge of our time with evidence which is witnessed globally. Climate change challenges for Ireland, as highlighted by the EPA, include: an increase in extreme weather events, adverse impacts on the distribution of flora, fauna and their associated habitats; water stress for crops and pressures on water supply, an increase in temperature ranges (hotter summers, colder winters).

Ireland has committed to reduce current emissions levels with 2018 as a baseline year to achieve set targets. It is particularly important for urban regions to focus on their reduction in emissions, as more than 70% of global emissions are caused by activities in urban areas, such as manufacturing, transportation and energy demand (Shaoqing et al. 2015)[4]. Carbon sinks tend to be limited in cities, given the amount of built-up areas, and the limited amount of natural eco-systems, which have the ability to absorb CO_2.

There are many significant additional benefits to reducing CO_2 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 city's competitiveness, and a more sustainable economy.

2.2 ENERGY AND EMISSION TARGETS

2030 Energy & Emission EU Targets[5]

The EU Commission has set out key targets for 2030 for all its member states[6].

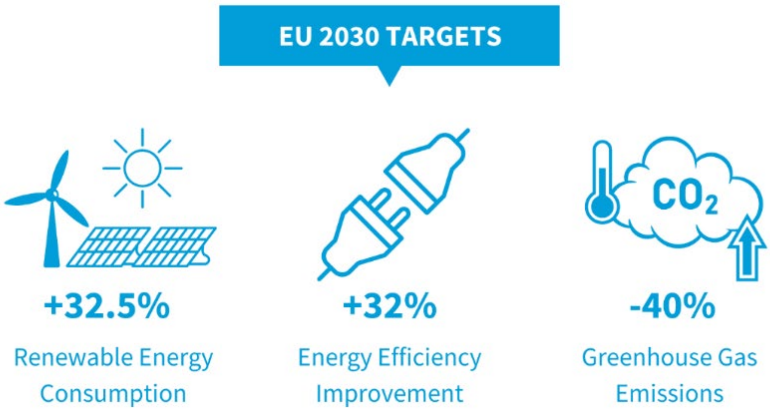


Figure 6: EU 2030 Energy & Emission Targets

[4] Shaoqing, C., Bin C.,, 2015 Urban energy consumption: Different insights from energy flow analysis, input-output analysis and ecological network analysis. Beijing Normal University, China.

[5] https://climate.ec.europa.eu/eu-action/european-green-deal/2030-climate-target-plan_en

[6] https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2030-climate-energy-framework_en

Objectives are to set a more ambitious and cost-effective path to achieving climate neutrality by 2050, stimulate the creation of green jobs and continue the EU's track record of cutting greenhouse gas emissions whilst growing its economy, and encourage international partners to increase their ambition to limit the rise in global temperature to 1.5°C and avoid the most severe consequences of climate change.

The 40% greenhouse gas target is implemented by the EU Emissions Trading System the Effort Sharing Regulation with Member States' emissions reduction targets and the Land use, land use change and forestry Regulation. In this way, all sectors will contribute to the achievement of the 40% target by both reducing emissions and increasing removals.

2030 Energy & Emission Targets for Ireland [5] [6]**:**
The government has reached agreement on Sectoral Emissions Ceilings, which set maximum limits on greenhouse gas emissions for each sector of the Irish economy.

An "*overall target of 51% reduction by 2030 can only be met if all sectors work together".*

These Sectoral Emissions Ceilings have been set for the electricity, transport, buildings, industry and agriculture sectors, delivering on a key Programme for Government commitment.

Sector	Reduction	2018 *	2030 ceiling *
Electricity	75%	10.5 MtCO2eq	3 MtCO2eq
Transport	50%	12 MtCO2eq	6 MtCO2eq
Buildings (Commercial and Public)	45%	2 MtCO2eq	1 MtCO2eq
Buildings (Residential)	40%	7 MtCO2eq	4 MtCO2eq
Industry	35%	7 MtCO2eq	4 MtCO2eq
Agriculture	25%	23 MtCO2eq	17.25 MtCO2eq
Other**	50%	2 MtCO2eq	1 MtCO2eq

* = Figures for MtCO2eq for 2018 and 2030 have been rounded. This may lead to some discrepancies.

** = F-gases, Petroleum Refining and Waste

Table 2: Average sectorial emission ceilings for 2030 for Ireland [7]

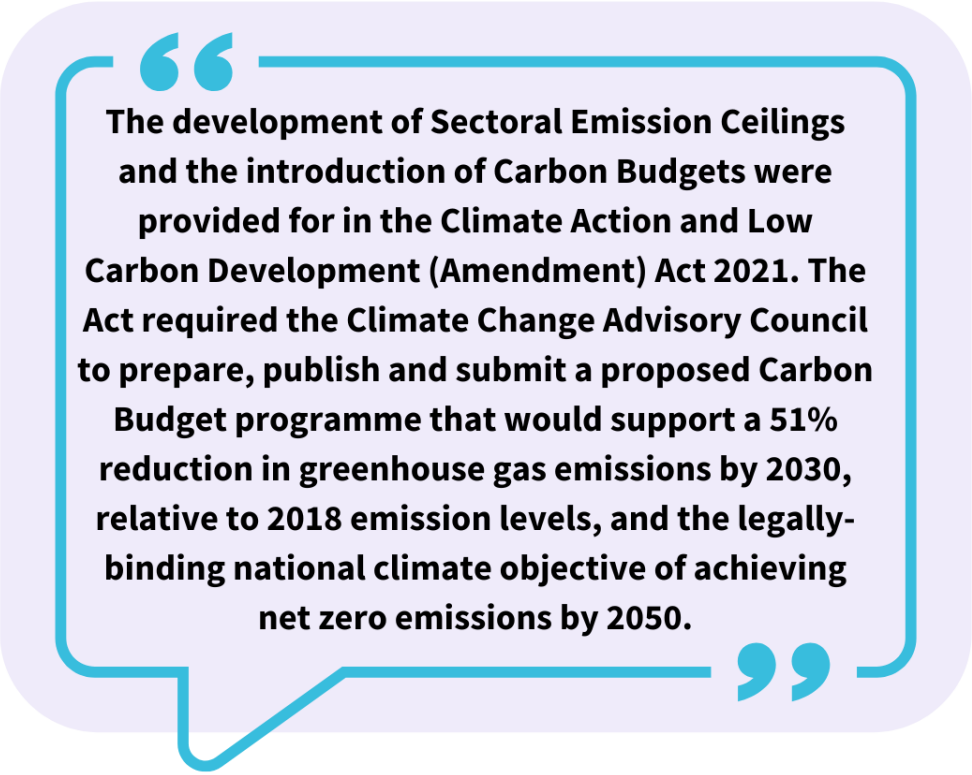


Figure 7. Section of press release of the Department of the Taoiseach 2022 [7] [7]

[7] https://www.gov.ie/en/press-release/dab6d-government-announces-sectoral-emissions-ceilings-setting-ireland-on-a-pathway-to-turn-the-tide-on-climate-change/

SCOPE OF REQUIREMENTS AND TARGETS

3.0 Scope of Requirements & Targets

3.1 Requirements

The following elements for the Tier 3 Baseline Emissions Inventory (BEI) were for the Waterford City DZ required by Waterford City & County Council, as outlined in Annex C [2][8] of the Local Authority Climate Action Plan Guidelines [4]

- A calculation of the Greenhouse Gas (GHG) emissions resulting from activity within the geographical boundary of the DZ area.
- Visual representation of the resulting GHG emissions baseline, broken down as far as possible
- A detailed report outlining the methodology, assumptions and all data sets used to formulate the BEI, and an executive summary customised for a non-technical audience.
- A calculation of the emissions reduction required, based on the baseline, to meet the national climate action plan 2030 targets.
- Presenting the findings to Waterford City & County Council Climate Action Team.

3.2 Emissions Scope

The GHG Protocol Corporate Standard categorise greenhouse gas emissions as Scope 1, Scope 2, and Scope 3 emissions. This report analyses Scope 1 emissions, which are direct emissions associated with the direct consumption and activity. This does not include emissions associated with the purchase of energy (Scope 2) or indirect emissions from the value chain (Scope 3).

- **Scope 1 emissions –** This includes the GHG emissions that are generated directly owned or controlled by an organisation – for example use of natural gas for running boilers or liquid fuels to run a fleet of vehicles.
- **Scope 2 emissions –** This includes all indirect GHG emissions from the generation of the electricity purchased and used by an organisation at local or international sites – for example the average fuel mix of grid-based electricity.
- **Scope 3 emissions –** This includes the indirect GHG emissions that occur in an organisation's value chain of downstream and upstream activities.

The emissions accounted for in the MapEIre data source includes both 'emissions trading scheme' (ETS) and 'non-emissions trading scheme' (non-ETS) sectors and emissions. This includes all emissions locally produced from sectors, those produced by large industries, buildings (residential and commercial), industrial processes, waste, transport, agriculture, and land-use. Domestic aviation is also accounted for however, it does not include emissions from intra-EU aviation as those are not considered part of Ireland's total reportable greenhouse gas emissions. More detail can be found in the EPA 2022 Report [8].

[8] https://assets.gov.ie/250051/e165c6b5-3eed-487d-b4ec-1db46dcec7e1.pdf

- **Emissions Trading Scheme (ETS) –** This means that GHG from certain sectors are treated as a commodity or product that can be traded on the EU carbon market. This includes emissions from large industries, electricity generators, and the aviation industry.
- **Non-Emissions Trading Scheme (Non-ETS) –** This means that GHG from sectors that cannot be traded on the EU carbon market. Non-ETS emissions include greenhouse gas emissions from homes, cars, small businesses, and agriculture.

3.3 Emission Targets

The methodology on how to complete the Climate Mitigation Assessment is outlined in "Technical Annex C: Climate Mitigation Assessment [2]" of the Local Authority Climate Action Plan Guidelines" published in March 2023 [4].

The Baseline Emissions Inventory (BEI) is a key instrument that will enable Waterford City & County Council to measure the impact of all actions related to emission reductions across its own operations as well as varying sectors of society. The BEI represents an evidence-based approach to not only inform appropriate emission reduction actions, but also measure progress overtime.

It is important to note that the BEI is a 'snapshot in time' of an area's GHG emissions sources, and it is not an inventory of emission reduction opportunities [2, pp. 6, 16]

3.4 Carbon-Offsetting

Calculations on 'carbon offsetting' are not included in this analysis [2, p. 9] as currently offsetting cannot be used to meet the public sector's mandatory emissions and energy targets. Carbon offsetting is a practice which involves an organisation removing or offsetting the same amount of carbon emissions from the atmosphere to compensate for the carbon emissions that it emits.

Large renewable energy projects like wind and solar farms that are connected to the national electricity grid contribute to the reduction of emissions at a national level and are reflected in reduced emissions intensity of electricity generation. Therefore, the associated reductions cannot be counted separately at a local level, as this would be 'double counting' the emission reduction.

3.5 EMISSION FACTORS

Emission factors are used to convert energy use to CO_2eq emissions. Emissions factors for different fuel types are published by SEAI annually and the 2018 factors were used for this report as the baseline year is 2018[9]. The emission factors are dependent on the type of fuel used, as different fuels have different emission factors. Table 2: SEAI Emission Factors 2018 below illustrates the emission factors for different fuel types. It should be noted that Peat has the highest emission factor, as it has the highest emissions in kgCO_2eq for every 1 kWh of energy use.

	t CO_2/TJ (NCV)	g CO_2/kWh (NCV)
Liquid Fuels		
Motor Spirit (Gasoline)	70.0	251.9
Jet Kerosene	71.4	257.0
Other Kerosene	71.4	257.0
Gas/Diesel Oil	73.3	263.9
Residual Oil	76.0	273.6
LPG	63.7	229.3
Naphtha	73.3	264.0
Petroleum Coke	92.9	334.5
Solid Fuels and Derivatives		
Coal	94.6	340. 6
Milled Peat	116.7	420.0
Sod Peat	104.0	374.4
Peat Briquettes	98.9	355.9
Gas		
Natural Gas	56.9	204.7
Electricity		
(2018)	104.2	375.2

Table 3: SEAI Emission Factors 2018

3.6 CO_2 EQUIVALENTS

Each greenhouse gas (GHG) has a different **global warming potential (GWP)** and persists for a different length of time in the atmosphere. The following Table 4 shows the **100-year global warming potential** for greenhouse gases reported by the United Nations Framework Convention on Climate Change (UNFCCC).[10]

[9] https://www.seai.ie/publications/Energy-Emissions-Report-2020.pdf

[10] https://climatechangeconnection.org/emissions/co2-equivalents/

Greenhouse Gas	Formula	100-year GWP (AR4)
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298
Sulphur hexafluoride	SF_6	22,800
Hydrofluorocarbon-23	CHF_3	14,800
Hydrofluorocarbon-32	CH_2F_2	675
Perfluoromethane	CF_4	7,390
Perfluoroethane	C_2F_6	12,200
Perfluoropropane	C_3F_8	8,830
Perfluorobutane	C_4F_{10}	8,860
Perfluorocyclobutane	c-C_4F_8	10,300
Perfluoropentane	C_5F_{12}	13,300
Perfluorohexane	C_6F_{14}	9,300

Table 4: CO_2 equivalents Climate Change connection[11]

3.7 Assumptions & Limitations

It is important to note that there are assumptions used in all methodologies for local level emissions baseline. These are required as it is impossible to create a completely accurate picture of all emissions.

All data from the Central Statistical Office come from the 2016 (population), 2020 (agriculture) otherwise 2018 (baseline year) census datasets. This is as per the Technical Annex C: Climate Mitigation Assessment" of the Local Authority Climate Action Plan Guidelines" [2] and referring to Developing_CO_2_Baseline_-_A_Step-by-Step_Guide_for_your_Local_Authority (2017)[12] [3].

A full list of Assumptions and data sources can be found in Appendix A of this report.

[11] https://climatechangeconnection.org/emissions/co2-equivalents

[12] https://www.codema.ie/images/uploads/docs/Developing_CO2_Baseline_-_A_Step-by-Step_Guide_for_your_Local_Authority.pdf

WATERFORD CITY DZ SECTORIAL RESULTS

4.0 Waterford City Decarbonisation Zone Sectorial Results

This section outlines the GHG emissions assocaited with the indivudal sections highlighted in the Tier 3 Methodology. Specific methodologies, analysis and maps of GHG emissions associated with each sector within the DZ are included. They are presented in the following order:

1. Waterford City & County Council
2. Commercial & Industrial Processes
3. Residential
4. Social Housing
5. Transport
6. Agriculture
7. Waste & Wastewater

Figure 8: Sectors GHG emissions that are covered within this report

WATERFORD CITY & COUNTY COUNCIL

5.0 Waterford City & County Council

Along with the energy use of their buildings and facilities, local authorities are also responsible for public lighting in their area, and their fleet vehicles. This section describes the steps to find the energy use and emissions for the local authority DZ area. This reporting is done through the public sector SEAI Monitoring and Reporting System (M&R).

5.1 Methodology

The main data source is the SEAI M&R system, where the energy consumption can be extracted for Waterford City DZ. This was broken down by type of energy use, electricity, thermal (LPG, natural gas, kerosene, gas oil and wood) and transport (diesel, petrol, and biofuels). The energy use was then broken down into three categories of Significant Energy Users (SEU):

- Buildings / Facilities
- Public Lighting
- Transport

Figure 9: Local Authority Methodology (Codema 2017)

Source	Data Description
SEAI, Public Sector Monitoring & Reporting System [9]	Database of all the local authority's energy use for different sectoral activities, by fuel type
SEAI, Emission Factors[13]	Converting energy use by fuel type into CO_2 emissions

Table 5: Local Authority Sector Data Sources

The detailed methodology used based on the guidance report, *Developing CO_2 Baselines A Step-by-Step Guide For Your Local Authority (2017)* [3].

[13] https://www.seai.ie/publications/Energy-in-Ireland-2019-.pdf

5.2 Analysis & Mapping

Energy consumption for the different buildings was obtained from the Monitoring & Reporting system of the SEAI and subsequent application of SEAI emission factors for the type of fuel used in such facilities.

Regarding local authority fleet, a weighted average which is based on population served for Waterford City & County Council and Waterford City DZ was applied to obtained public fleet that serves Waterford City DZ area. This weighted-average was applied for all fleet that are powered by the different fuel types – electricity, fossils, and renewables – and amount of energy consumed with equivalent carbon emissions obtained based on SEAI factors.

There is available data on number of public lights and their corresponding power ratings within the DZ area. All public lights within the area are powered by electricity and for each rated power, the total number of lamps and poles were utilized to obtain the total energy consumed.

From the M&R system, there were 38 Local Authority buildings/facilities within the DZ area

WATERFORD CITY DZ - COUNCIL BUILDINGS

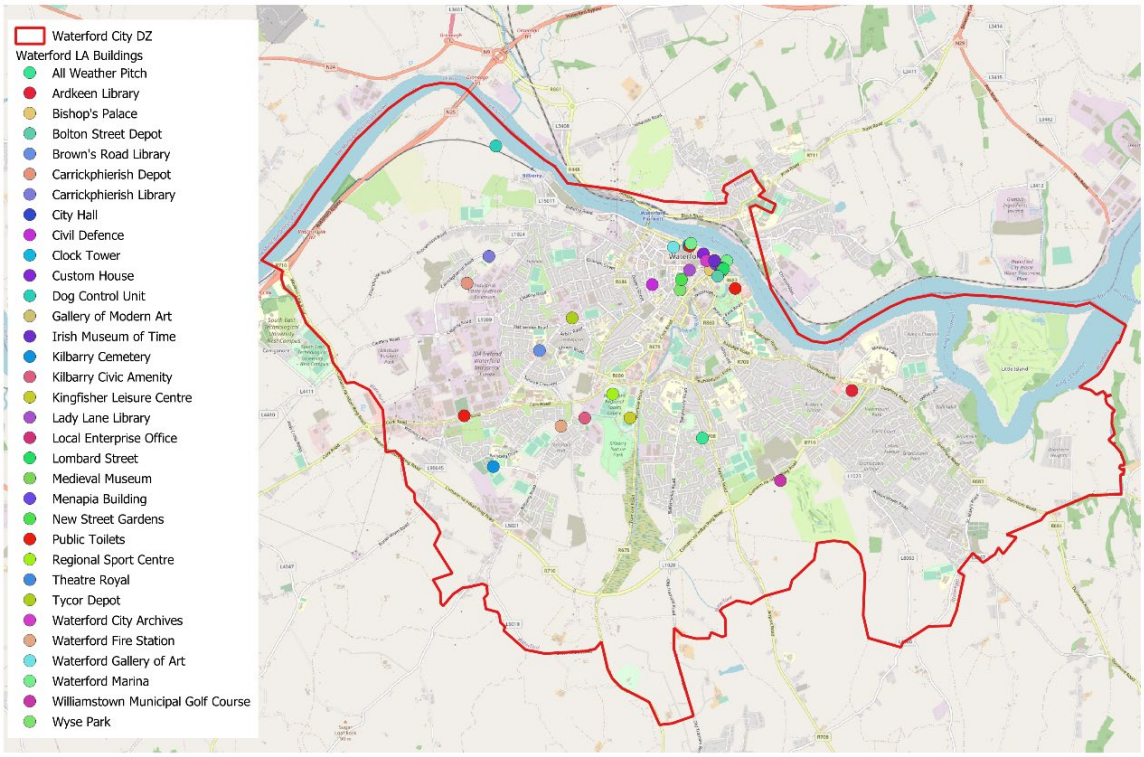


Figure 10. Waterford City DZ - Waterford City & County Council Buildings

There are a total of **9,130** public lights within the DZ area, consisting of a mixture of LED and non LED lamps.

7.2% of public lights are LED

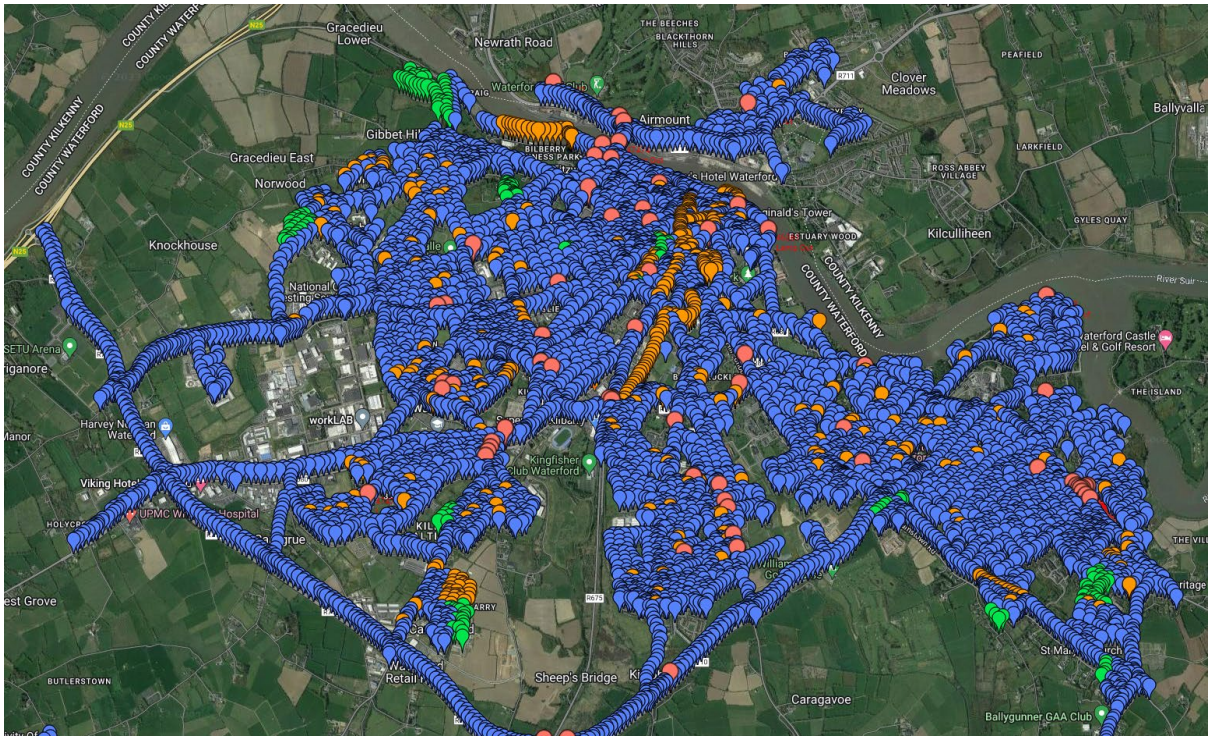


Figure 11. Public Lighting Location – Waterford City DZ

5.2.1 ENERGY

Total energy consumption by Waterford City & County Council within the Decarbonisation Zone use in 2018 was **15,313.3 MWh (15.3GWh)**

- Building & facilities were the highest energy consumer, accounting for 6,317.29 MWh (41%) of the total energy consumption.
- Public lighting accounted for 4,890.3 MWh of energy (32%)
- Transport fuels accounted for 4,105.8 MWh of energy (27%)

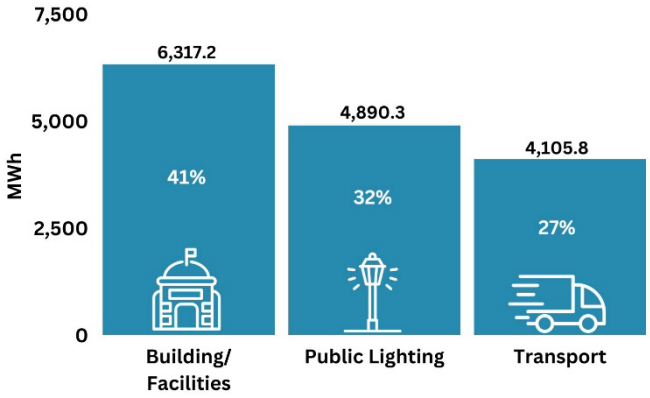


Figure 12. 2018 energy consumption, in MWh, by Waterford City & County Council by SEU Category

5.2.2 GHG EMISSIONS

When energy use was converted into GHG emissions, Waterford City & County Council within the Decarbonisation Zone's total emissions amounted to **4,579.4 tCO_2eq (4.6 $ktCO_2eq$).**

- Buildings/facilities accounted for 1,697.3 tCO_2eq (37%)
- This was followed by Public Lighting with 1,834.9 tCO_2eq (40%)
- Transport accounted for 1,047.2 tCO_2eq (23%)

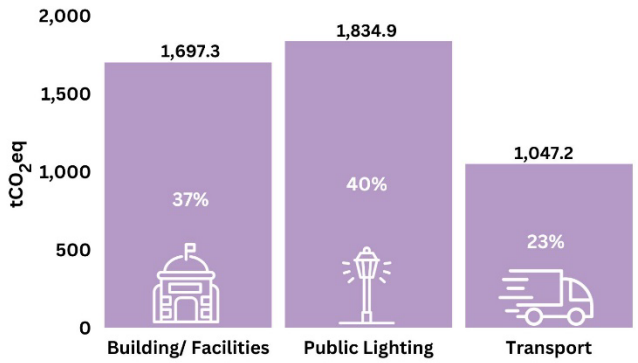
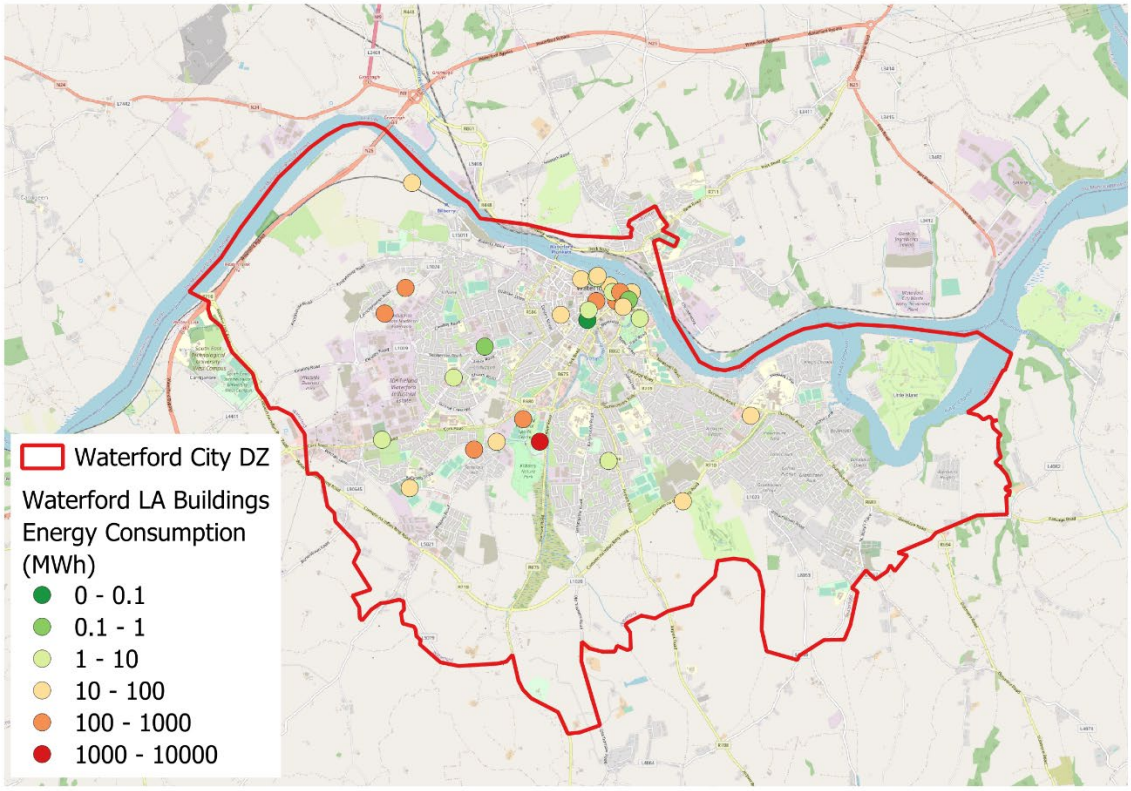


Figure 13. 2018 GHG emissions in tCO_2eq, by Waterford City & County Council by SEU Category

WATERFORD CITY DZ - COUNCIL BUILDINGS



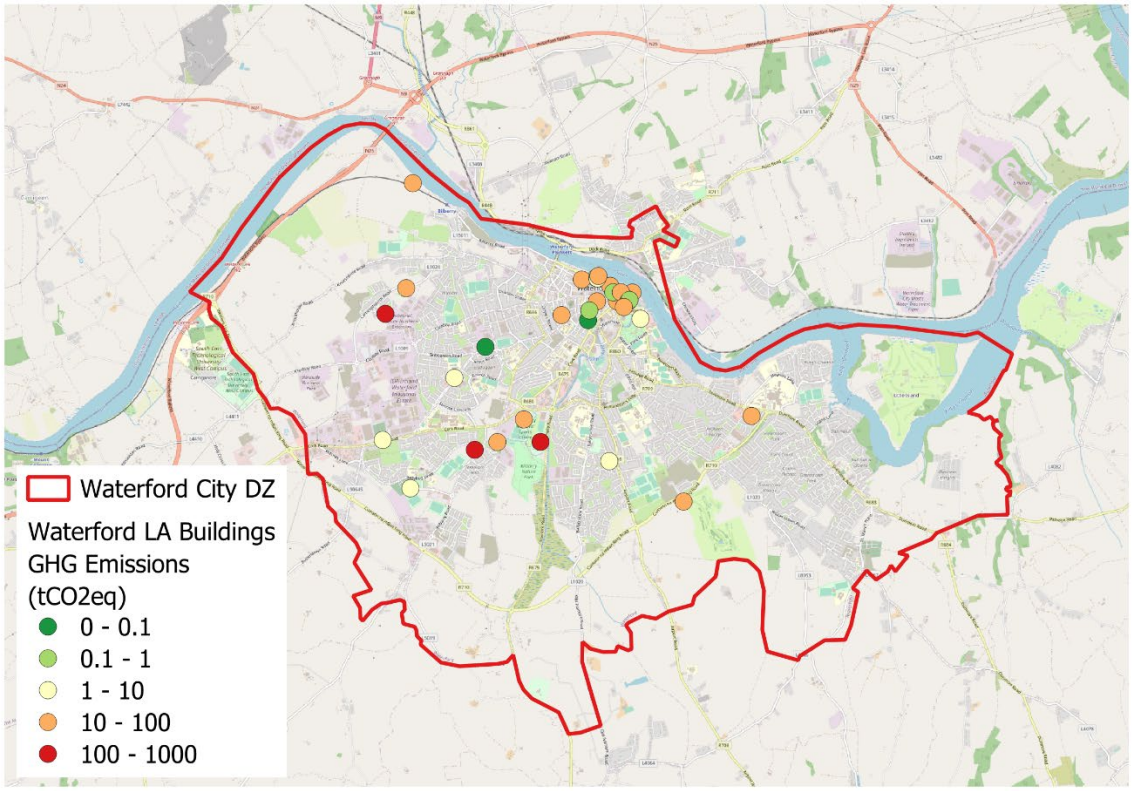


Figure 14. Energy and Emissions Waterford City & County Council Buildings

Key Findings

The final energy used by Waterford City & County Council in 2018 was

15.3 GWh

Total final emissions generated by Waterford City & County Council in 2018

4.6 $ktCO_2eq$

Energy and GHG Emissions from Waterford City & County Council

Waterford City DZ	Electricity	Fossil Fuels					Renewable Energies		Total
		Thermal			Transport		Electricity	Transport	
		Natural Gas	Heating Oils	LPG	Road Diese	Petrol	Solar PV	Biofuels	
Building/ Facilities (MWh)	2,411.8	3,905.4					-		6,317.2
Public Lighting (MWh)	4,890.3								4,890.3
Transport (MWh)					3,951.7	17.9		136.2	4,105.8
Total Energy (MWh)	**7,302.2**	**3,905.4**	**-**	**-**	**3,951.7**	**17.9**	**-**	**136.2**	**15,313.3**
Buildings / Facilities (tCO_2eq)	904.9	792.4							1,697.3
Public Lighting (tCO_2eq)	1,834.9								1,834.9
Transport (tCO_2eq)					1,042.7	4.5		0	1,047.2
Total Emissions (tCO_2eq)	**2,739.8**	**792.4**	**-**	**-**	**1,042.7**	**4.5**	**-**		**4,579.4**

Table 6: Waterford City DZ BEI Inventory, Energy and CO_2eq Emissions

Public Sector

6.0 PUBLIC SECTOR

This Chapter outlines the energy and GHG emissions associated with public sector organisations other than the Local Authority, which is reported in Chapter 5. These other public sector bodies include government organisations and businesses under government control but not classified as part of the government sector.

A total of **59** Public sector organisations, and **239** public sector buildings were identified within the DZ area and they are grouped as follows:

- Very Large Energy Users (VLEU's)
- Transport
- Education
- Central government
- Health (HSE)
- Small & Medium Energy Users (SMEUs)
- Health (38/39)

6.1 METHODOLOGY

The main data source is the SEAI M&R system, where the energy consumption can be extracted for public sector bodies within Waterford City DZ. A Freedom of Information request was made to SEAI and only MPRN and GPRN data was provided. This was broken down by type of energy use as electricity and thermal (with the only thermal energy data being natural gas). There was no transport data provided.

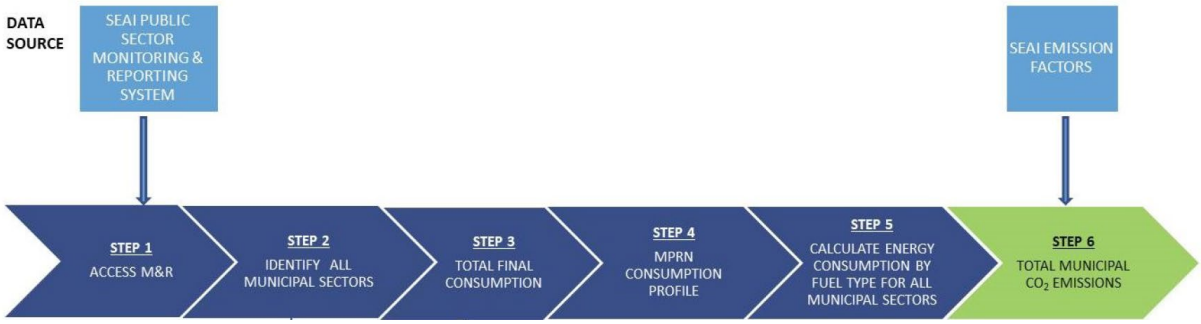


Figure 15. Local Authority Methodology (Codema 2017)

Source	Data Description
SEAI, Public Sector Monitoring & Reporting System [9]	Database of all the local authority's energy use for different sectoral activities, by fuel type
SEAI, Emission Factors[14]	Converting energy use by fuel type into CO_2 emissions

Table 7: Public Sector Data Sources

[14] https://www.seai.ie/publications/Energy-in-Ireland-2019-.pdf

6.2 DATA ANALYSIS

The Monitoring & Reporting system of the SEAI was utilized to gather energy, and the SEAI emission factors were then used for the kind of fuel used in such facilities. Note that this is attributable total final consumption (for lighting, heating and appliance use) and expressed as annual energy consumption for the earlier mentioned energy sources.

6.2.1 ENERGY

Total energy consumption by the public sector within the Decarbonisation Zone use in 2018 was **66,703.5 MWh (66.7 GWh).** A breakdown is of this is presented in Figure 16 below:

- 43% was from electricity.
- 57% of energy was from natural gas

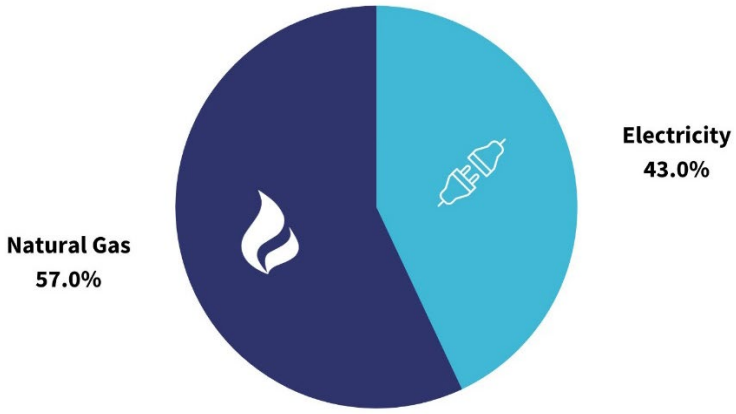


Figure 16. Public Sector energy consumption by source in DZ

6.2.2 EMISSIONS

When energy use was converted into GHG emissions, the total emissions attributable to energy consumed by public sector bodies is **18,413.3 tCO_2eq (18.4 $ktCO_2eq$).**

- 59% from electricity
- 41% from natural gas

Figure 17. Public Sector GHG emissions by source in DZ

The GHG emissions were also attributed to the individual categories within the Public Sector. It showed that 45.1% of emissions came from HSEs, 30.8% from education and 16.0% from VLEUs.

Further breakdown for all categories is depicted in Figure 18 below.

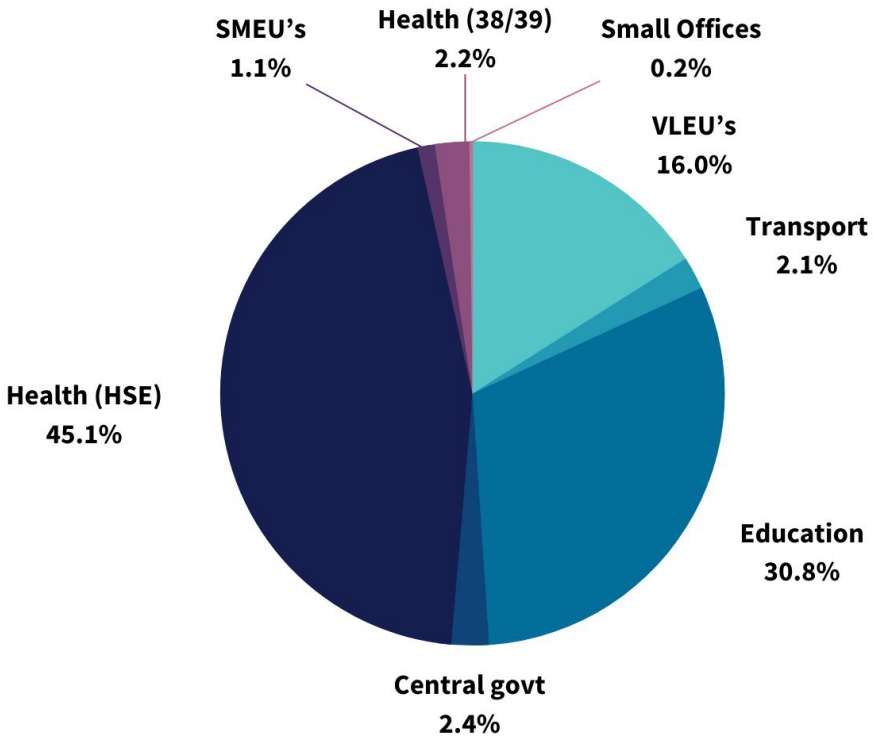


Figure 18. GHG Emissions from Public Sector Categories in DZ

Key Findings

Total energy consumed by the public sector in 2018 was

66.7 GWh

Total emissions from the public sector in 2018 were

18.4 $ktCO_2eq$

Energy and GHG Emissions from the Public Sector

Public sector					Total
	Electricity	Fossil Fuels	Renewables	CH_4/N_2O	
Total Energy (MWh)	28,758.1	37,945.4	-	-	**66,703.5**
Total Emissions (tCO_2eq)	10,790.0	7,623.2	-	-	**18,413.3**

Table 8: Public Sector DZ BEI Inventory, Energy and CO_2eq Emissions

COMMERCIAL & INDUSTRIAL PROCESSES

7.0 COMMERCIAL & INDUSTRIAL PROCESSES

The Commercial sector includes both the commercial and the industrial sectors data. Typical fuels used here are solid fuels (such as coal, peat) and petroleum fuels (such as diesel, heating oil, kerosene).

In Tier 3, Industrial Processes is included within the Commercial Sector.

7.1 METHODOLOGY

Two main data sources were used, which were: data from the Valuation Office and energy consumption benchmarks for different building categories from the Chartered Institution of Building Services Engineers (CIBSE).

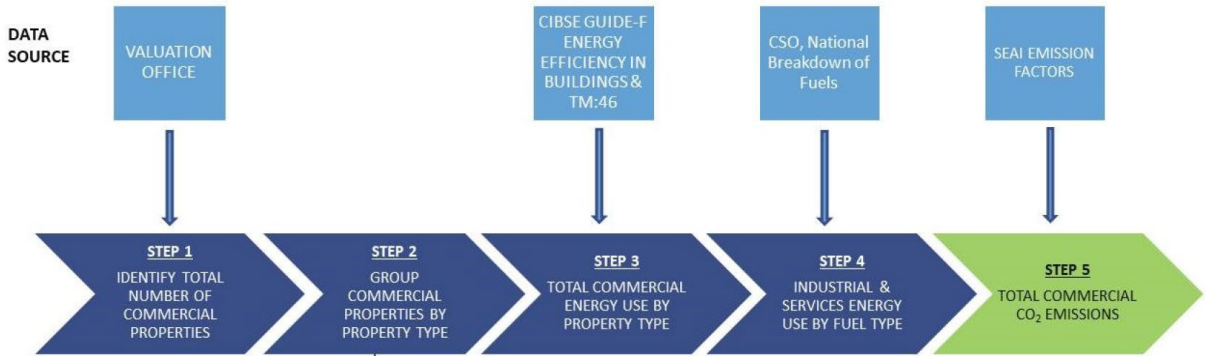


Figure 19. Commercial Methodology (Codema 2017)

Data from the Valuation Office provides the floor area of industries and commercial business within Waterford City DZ, which can be applied to the energy consumption benchmarks from CIBSE for typical energy used by the building.

The Industrial Processes emissions is extracted directly from the MapEIre data. This is non energy related emissions, as energy related emissions are calculated as per the above methodology. The MapEIre data for industrial Processes was added to the total Commercial data and is reported in this Chapter together.

Source	Data Description
Valuation Office [10]	Database of all commercial properties in a local authority area, and their respective floor areas
CIBSE Guide F-Energy Efficiency in Buildings & TM:46 [11]	Energy consumption benchmarks for different commercial categories and property use
MapEIre [12]	Industrial Processes data from within the DZ
SEAI, Emission Factors[15]	Converting energy use by fuel type into CO_2 emissions

Table 9: Commercial Sector Data Sources

[15] https://www.seai.ie/publications/Energy-in-Ireland-2019-.pdf

The detailed methodology used based on the guidance report, *Developing CO_2 Baselines A Step-by-Step Guide For Your Local Authority (2017)* [3] .

Additional necessary measures are explained in more detail in the analysis.

7.2 Analysis & Mapping

Based on data from the Valuation Office, the commercial properties within the DZ area are grouped as outlined below.

- **Industrial Uses** includes (warehouse, workshops, factory, livestock mart, showrooms, workshop offices)
- **Office** includes (business parks, industrial offices, studio)
- **Retail (Warehouse)** includes (garden yard, motor showroom yard)
- **Hospitality** includes (pubs, night clubs, guesthouse, funeral homes, caravan parks, Hostel, Hotels)
- **Health** includes (privately-managed nursing homes, clinics, surgery centers/offices)
- **Fuel/Depot** includes (oil/fuel depot store, service station, motorway service station, oil/fuel depot yard)
- **Miscellaneous** includes (crèche, car park, advertising station)
- **Retail (Shops)** includes (retail shops, supermarket, restaurant, post office, department store, café, bank, ATM, pharmacy)
- **Leisure** includes (clubhouse, community hall, stable, stadium, swimming pool, gymnasium/fitness centre, cinema, equestrian centre, theatre)
- **Minerals** includes (quarries)

There are a total of 2060 properties in the DZ area, with a total floor area of

1,353,520m^2

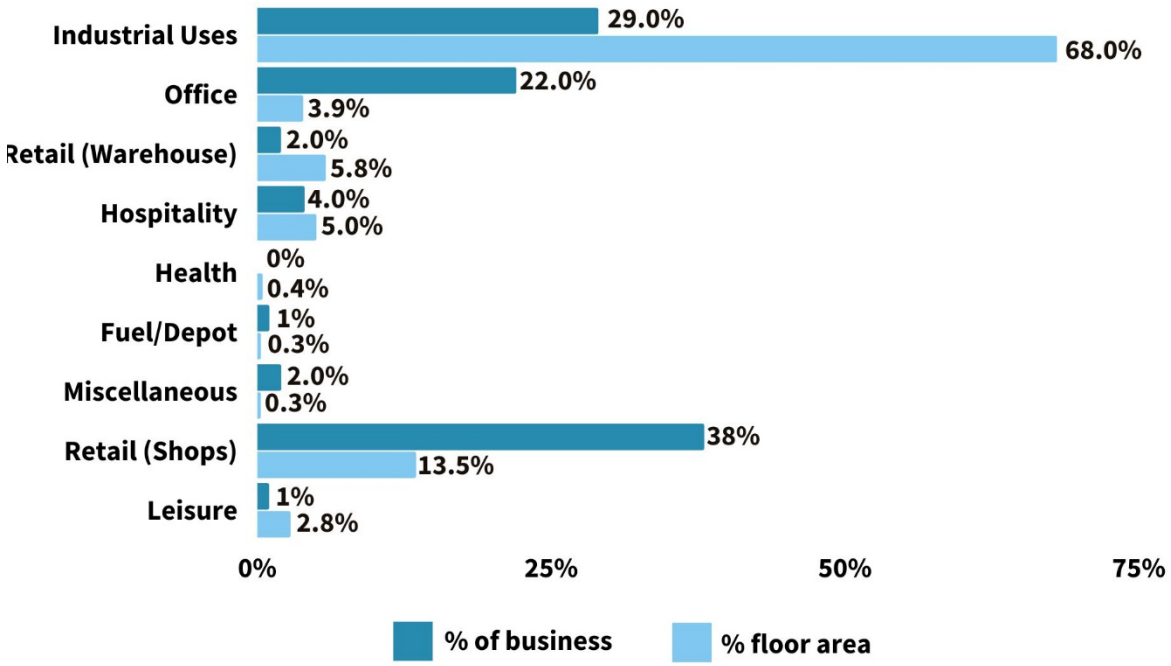


Figure 20. Category of commercial properties in Waterford City DZ

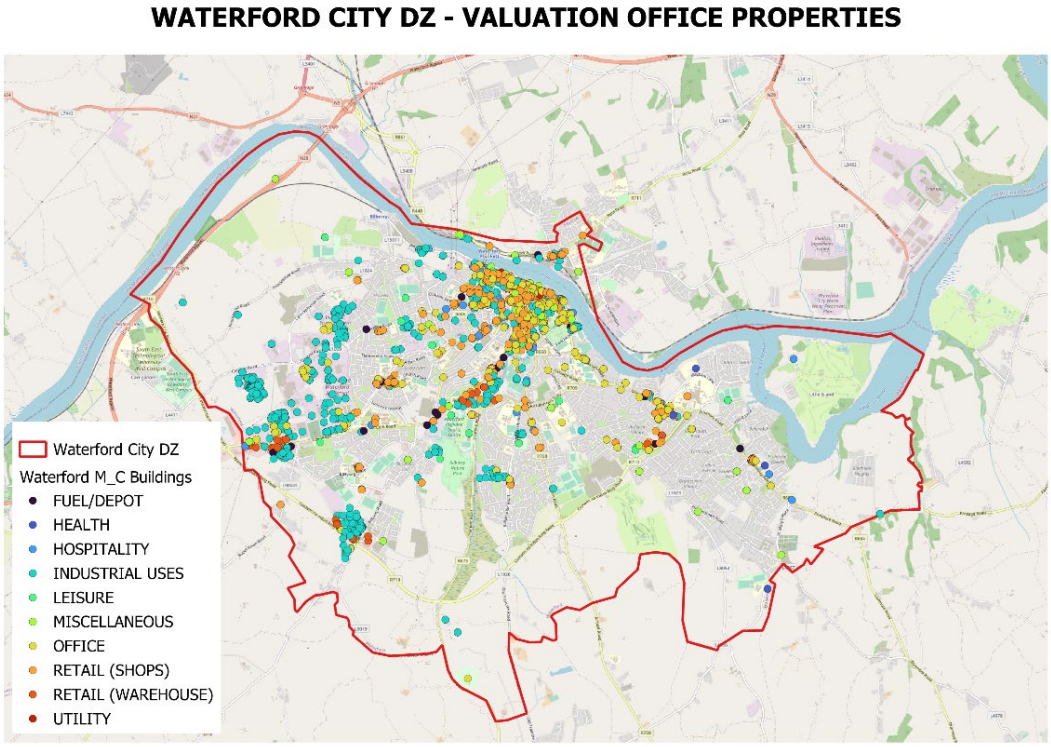


Figure 21. Waterford City DZ- Properties registered to Valuation Office

he Chartered Institute for Building Service Engineers (CIBSE) [11] produce benchmarks, given in kilowatt-hours per meter squared floor area (kWh/m^2) for heat and electricity, in each building category. This was then used to obtain the electrical and thermal energy consumed and GHG emissions for each category and therefore the Sector as a whole.

7.2.1 ENERGY

Total energy consumption by the Commercial Sector within the Decarbonisation Zone use in 2018 was **321,091.6 MWh (321.1 GWh).**

- 46.7% of energy used was from natural gas
- 27.2% was electricity
- 9.7% was heating oils
- 8.3% was renewable energy
- 4.4% was LPG
- 3.7% was coal/peat

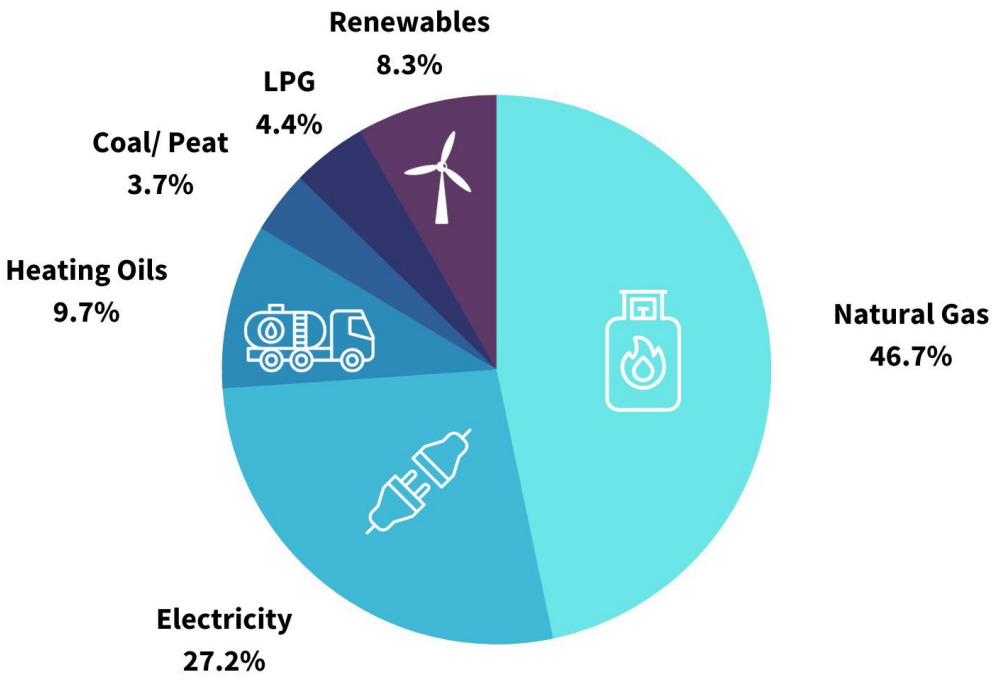


Figure 22. Breakdown of commercial sector energy use in Waterford City DZ

7.2.2 GHG EMISSIONS

When energy use was converted into GHG emissions, the Commercial sector within the Decarbonisation Zone's total emissions amounted to **82,076.3 tCO_2eq (82.1 $ktCO_2eq$).**

- 39.9% were from electricity
- 37.1% from natural gas
- 9.9% from heating oil
- 5.5% came from coal/peat
- 3.9% came from LPG
- 3.7% from non-direct energy emissions (CO_2, CH_4, N_20 & SF_6)

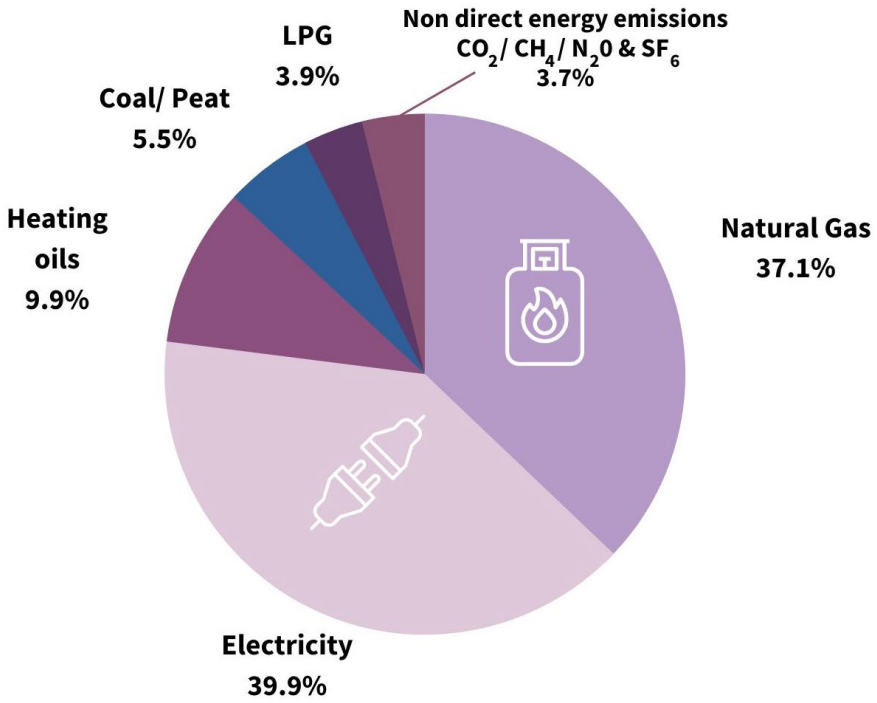


Figure 23. Breakdown of commercial sector GHG emissions in Waterford City DZ

The GHG emissions were also attributed to the individual categories within the Commercial Sector from the Valuations Office data. It showed that 51.4% of emissions came from industrial users, 14.6% from leisure and 14% from retail (shops). Further breakdown for all categories is depicted in Figure 24 below.

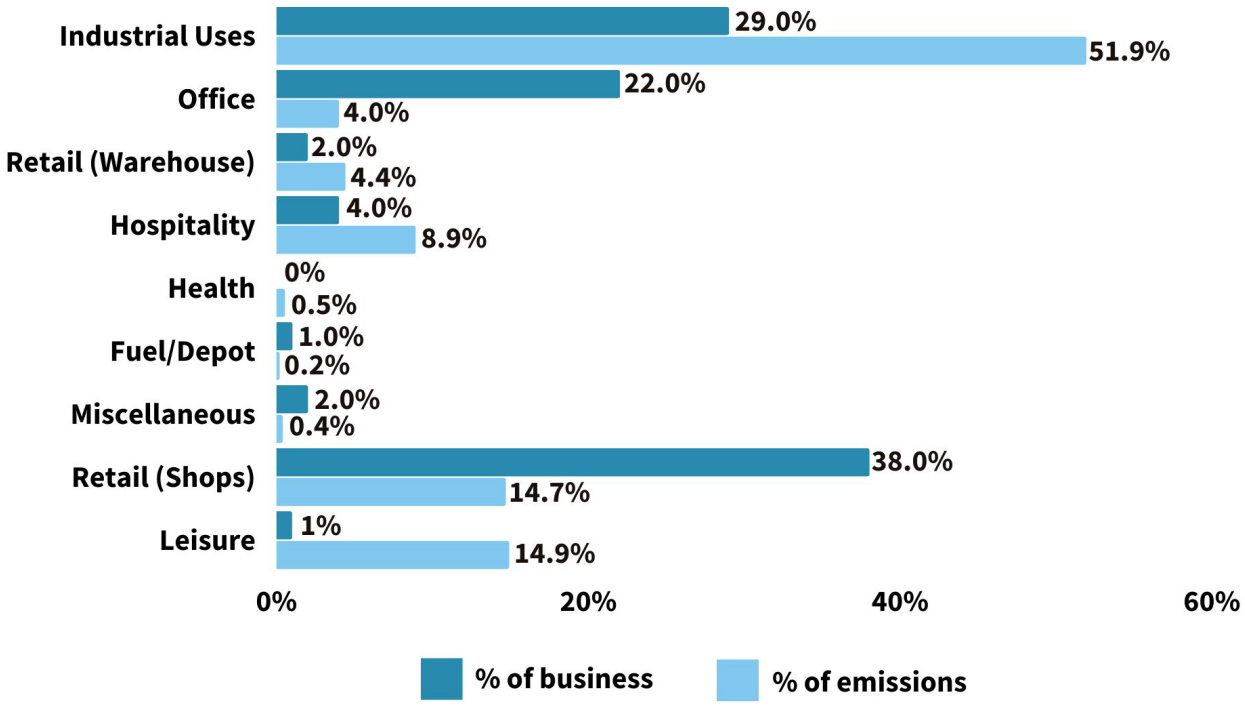


Figure 24. Emissions split by commercial entities in Waterford City DZ

WATERFORD CITY DZ - COMMERCIAL SECTOR

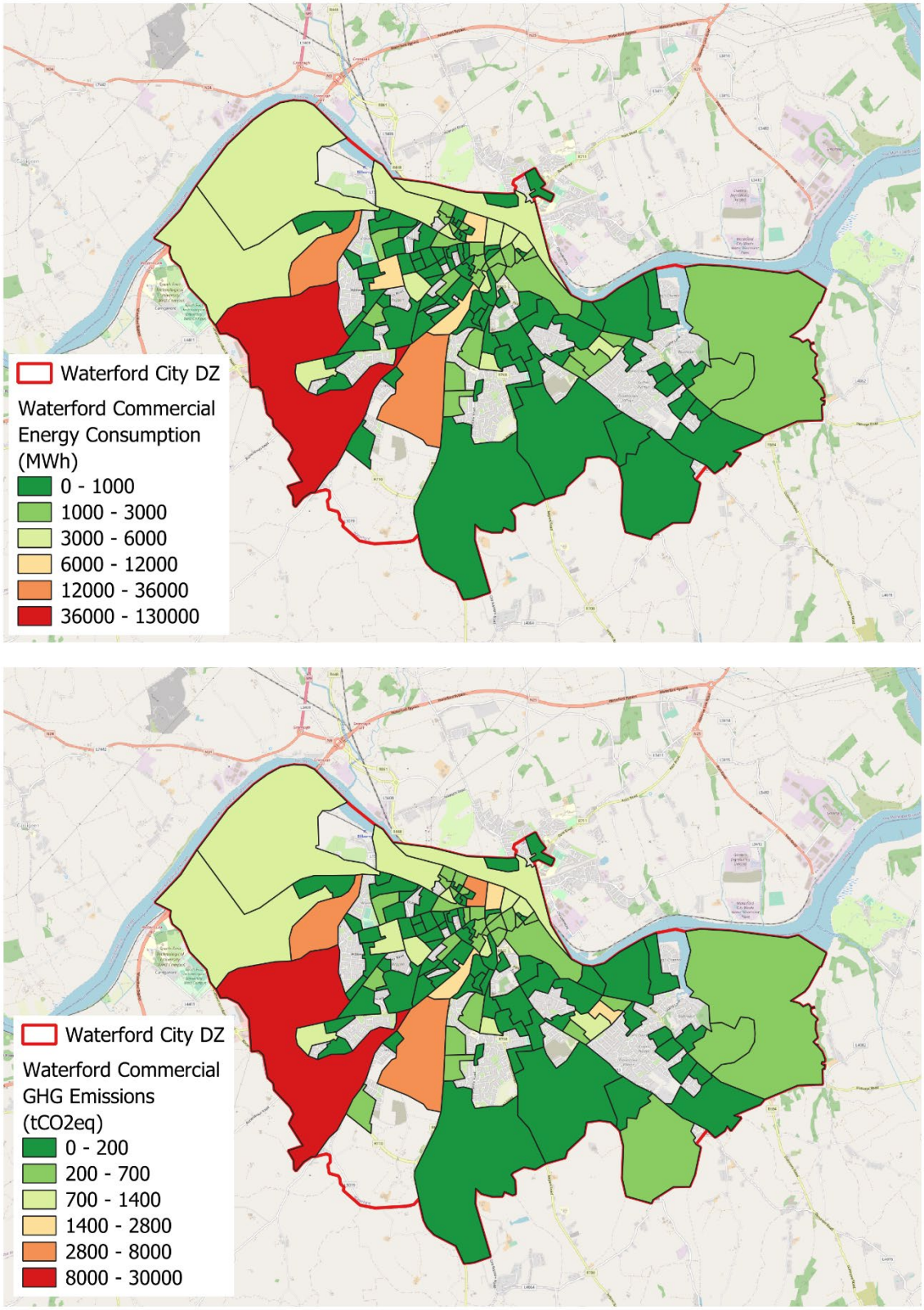


Figure 25. Energy consumption and GHG emission by Commercial sector for Waterford City DZ area

Key Findings

Total energy consumed by the commercial sector in 2018 was

321.1 GWh

Total emissions from commercial sector in 2018 were

82.1 $ktCO_2eq$

Energy and GHG Emissions from the Commercial Sector

Commercial				GHGs	Total
	Electricity	Thermal	Renewables		
Total Energy (MWh)	87,252.7	207,080.2	26,758.7	-	321,091.6
Total Emissions (tCO_2eq)	32,737.2	46,285.6	-	3,053.5	82,076.3

Table 10: Energy and GHG emissions – Commercial sector, 2018 Waterford City DZ

RESIDENTIAL

8.0 RESIDENTIAL

This section looks at the emissions arising from the residential sector as the second largest sector (SEAI, 2016). It excludes Local Authority owned social housing, as social housing is analysed separately, as per the Tier 3 Guidelines.

8.1 METHODOLOGY

This methodology is based on two main data sources: the 2016 National Census and the SEAI BER Research Tool. Steps 1-3 addresses the method of data collection and processing, Steps 4 and 5 deal with calculating the energy consumption associated with each property type, and Step 6 deals with the conversion of this data to CO_2 emissions.

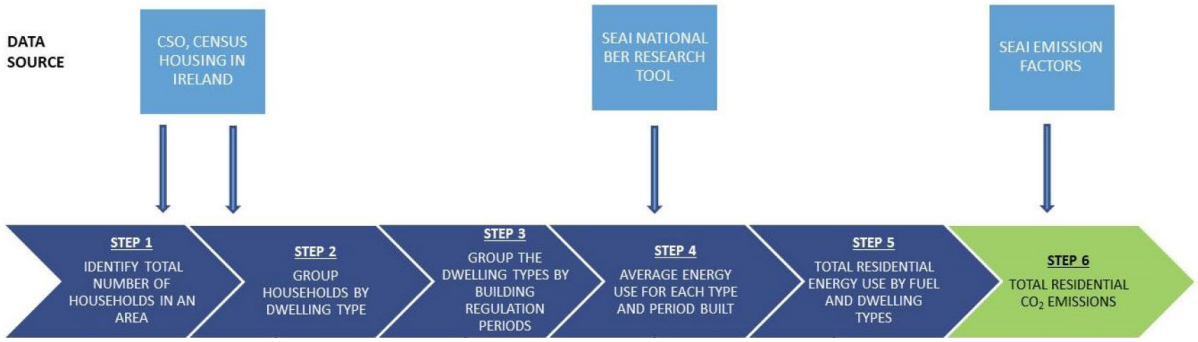


Figure 26. Residential Methodology (Codema 2017)

Two main data sources are Census 2016 (CSO) and the asset based BER research tool (SEAI). The BER rating method is an assessment and not performance based. Therefore, assumptions for the operational energy used were needed.

Source	Data Description
CSO, Census Housing in Ireland [13]	Lists all the residential units by; location, type of construction and period built
SEAI, National BER Research Tool [16]	Database of all BERs includes; the final energy rating given to a household is in kWh/m2/year and an energy efficiency scale from A to G, type of household, year of construction, location, floor area and fuel use.
SEAI, Emission Factors[17]	Converting energy use by fuel type into CO_2 emissions

Table 11: Residential Sector Data Sources

The detailed methodology used based on the guidance report, *Developing CO_2 Baselines A Step-by-Step Guide For Your Local Authority (2017)* [3]

Additional necessary measures are explained in more detail in the analysis.

[16] https://ndber.seai.ie/BERResearchTool/ber/search.aspx

[17] https://www.seai.ie/publications/Energy-in-Ireland-2019-.pdf

8.2 Analysis & Mapping

From the Central Statistics Office (CSO) 2016 Housing census data, the total number of residential units in Waterford City DZ (excluding social housing units) are **15,481.** A breakdown of this data is as follows:

- 3,201 (21%) are detached
- 7,743 (50%) are semi detached
- 2,318 (15%) are terraced
- 1,896 (12%) are apartments
- 322 (2%) are not stated

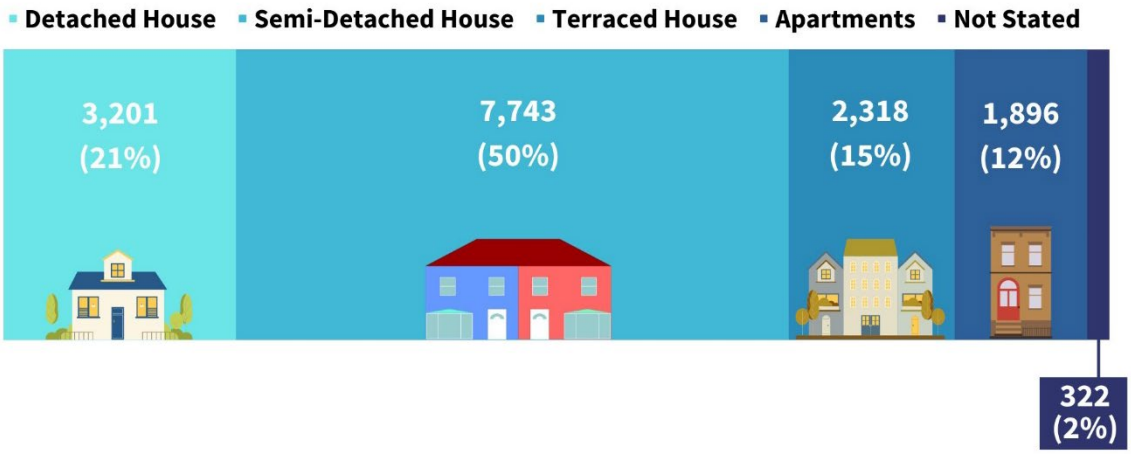


Figure 27. Types of residential properties in Waterford City DZ

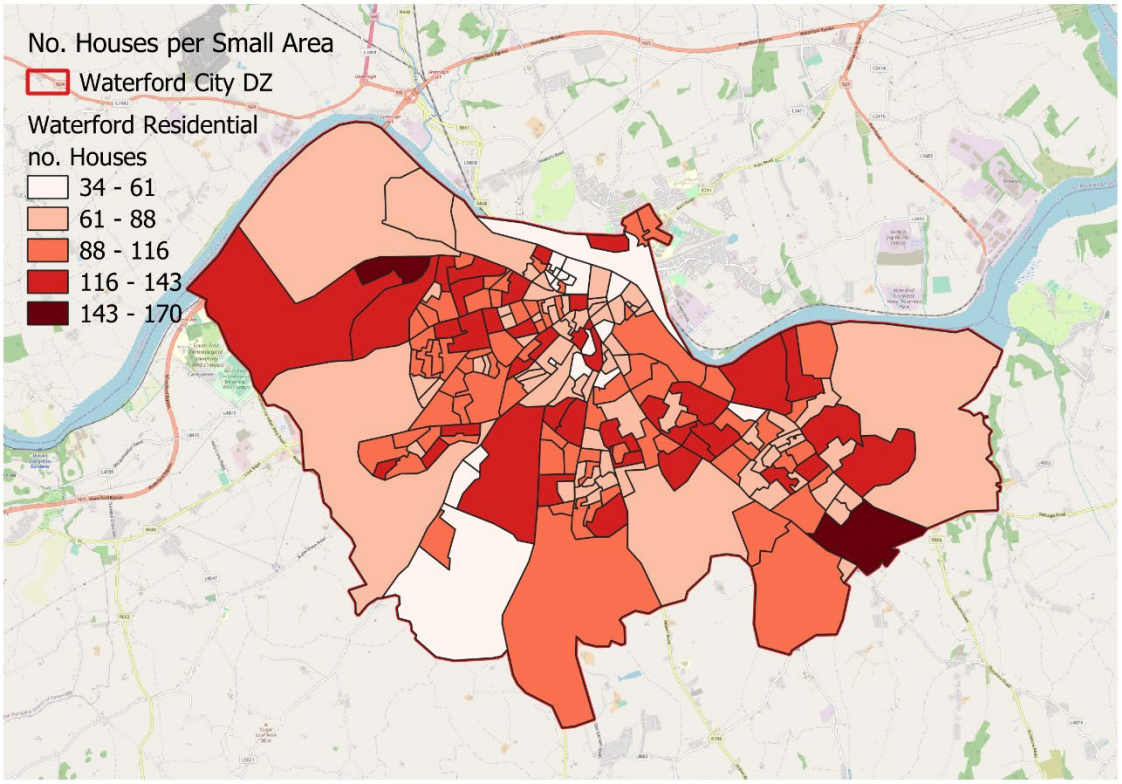
For the purpose of obtaining energy consumed and emissions information, this requires correlating these house types to SEAI categorization of residential units. Residential units in Waterford City DZ having BERs certificates are **10,207** in which the breakdown are as follows:

- 1, 697 (17%) are detached
- 4,292 (42%) are semi detached
- 2,460 (24%) are terraced
- 1,758 (17%) are apartments

The average BER data for each Small Area Population was used to ascertain the total energy and GHG emissions from each SAP ID. On the average, the average BER rating of the homes in Waterford City DZ was D1.

MapEIre data set provides additional emissions produced in the form of Methane (CH_4) and Nitrous Oxide (N_2O) by residential sectors, i.e., in addition to CO_2 emissions from the combustion of fossil fuels such as natural gas, heating oil, coal, etc. These emissions are converted into CO_2eq using the conversion factors.

WATERFORD CITY DZ -RESIDENTIAL SECTOR



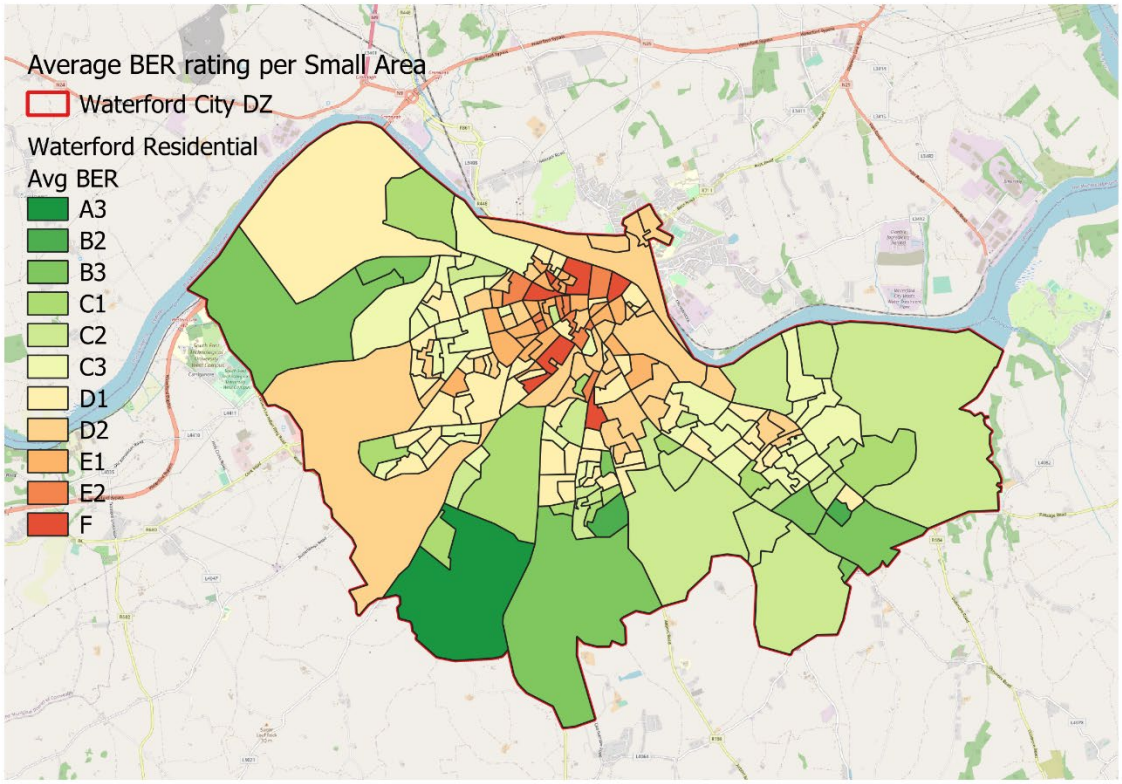


Figure 28. Number of houses and average BER rating per Small Area in Waterford City DZ

8.2.1 ENERGY

Total energy consumption by the Residential Sector within the Decarbonisation Zone use in 2018 was **238,099.7 MWh (238.1 GWh).**

- 55.5% of energy used was natural gas
- 26.3% was electricity
- 16.1% was heating oils
- 1.9% was coal/peat
- 0.2% LPG

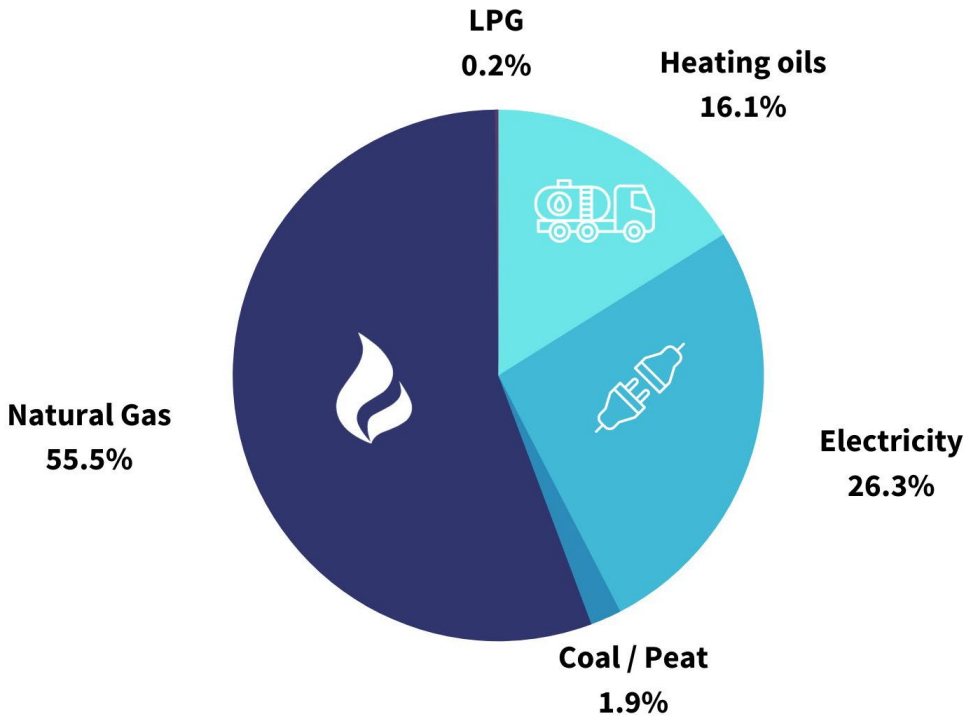


Figure 29. Breakdown of residential sector energy use by fuel type, 2018 Waterford City DZ

8.2.2 GHG Emissions

When energy use was converted into GHG emissions, the residential sectors total emissions within the Decarbonisation Zone's amounted to **63,109.4 tCO_2eq (63.1 $ktCO_2eq$).**

- 42.0% of GHG emissions came from natural gas
- 37.3% came from electricity
- 16.7% came from heating oils
- 2.6% came from coal/peat
- 0.2% came from LPG
- 1.2% were non direct energy emissions (CH_4 & N_20)

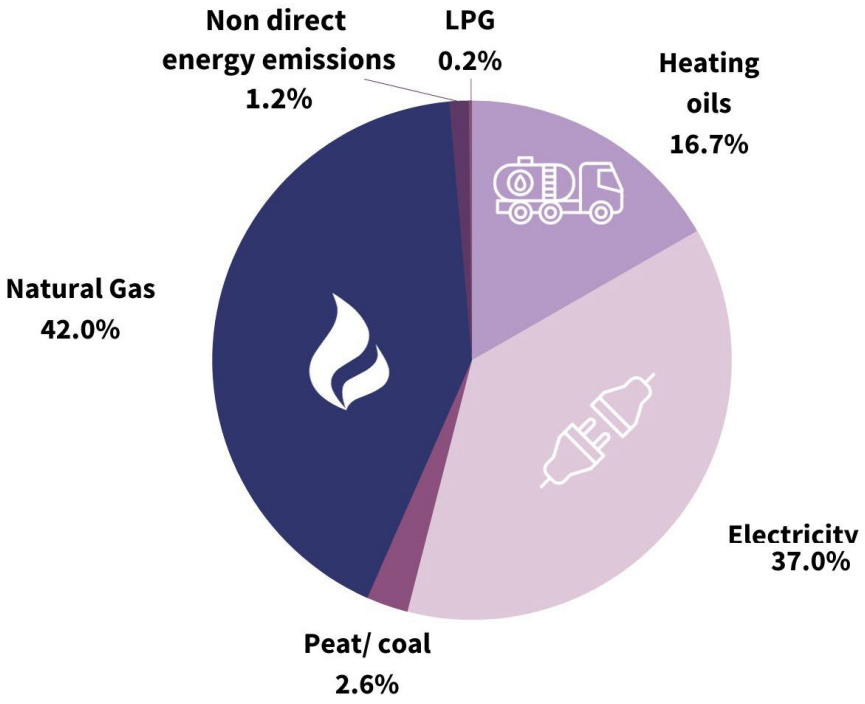
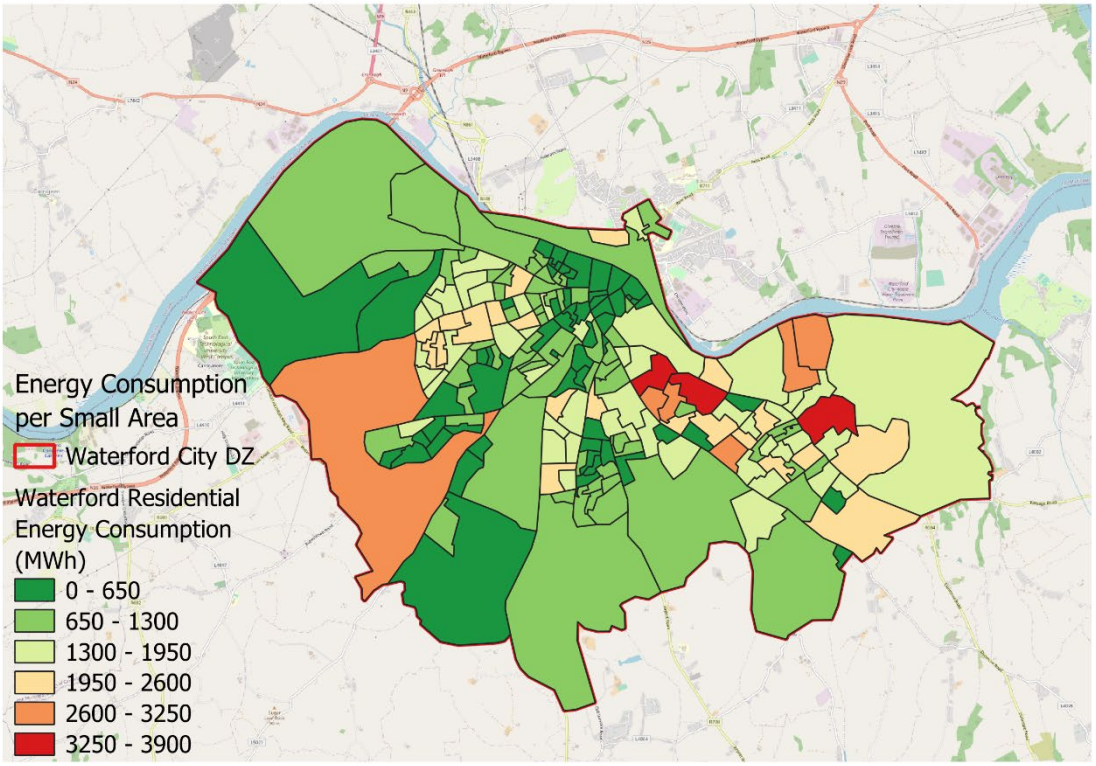


Figure 30. Breakdown of residential sector GHG emissions in tCO_2eq, 2018 Waterford City DZ

WATERFORD CITY DZ -RESIDENTIAL SECTOR



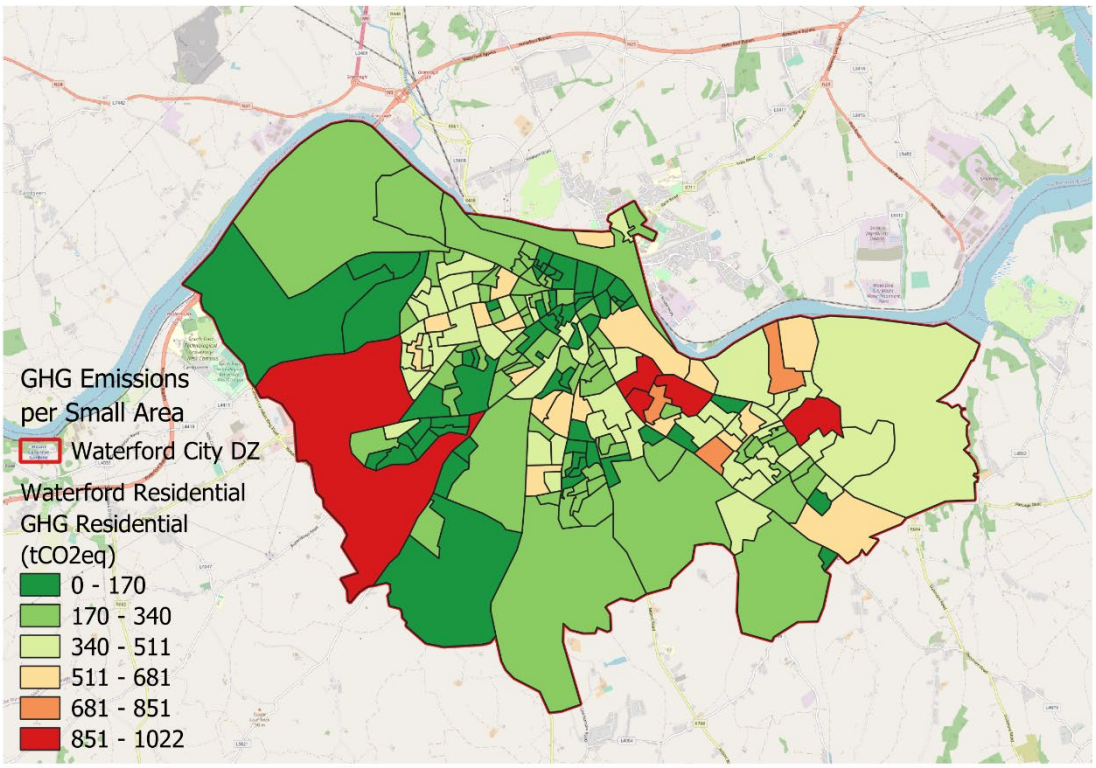


Figure 31. Residential Sector: Energy consumption and GHG emission per Small Area in Waterford City DZ

Key Findings

Total energy consumed by the residential sector in 2018 was

238.1 GWh

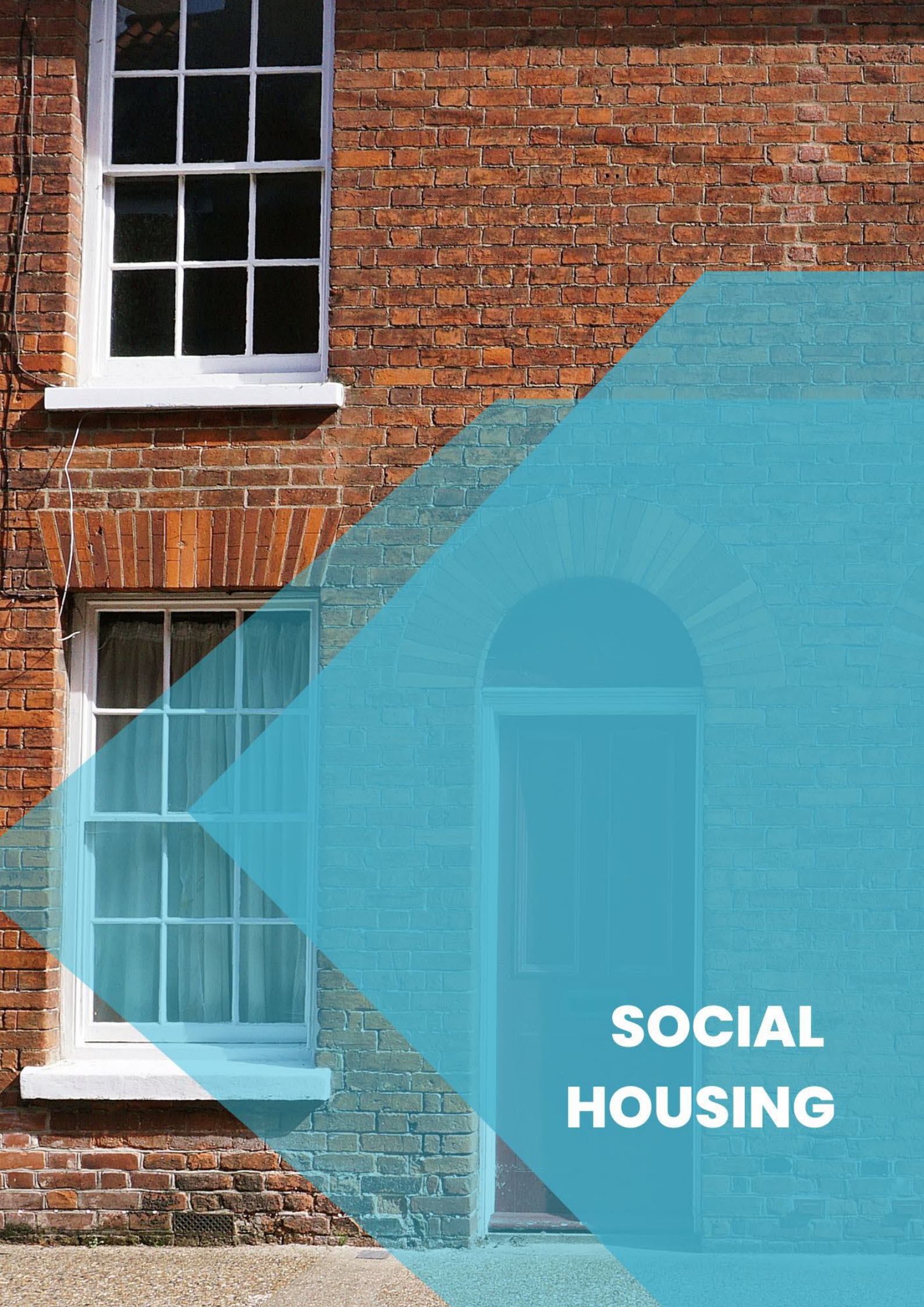
Total emissions from residential sector in 2018 were

63.1 $ktCO_2eq$

Energy and GHG Emissions from the Residential Sector
(not including Local Authority Social Housing)

Residential					Total
	Electricity	Fossil Fuels	Renewables	CH_4/N_2O	
Total Energy (MWh)	62,667.9	175,429.7	2.0	-	**238,099.7**
Total Emissions (tCO_2eq)	23,513.0	38,775.9	-	820.5	**63,109.4**

Table 12: Energy and GHG emissions – Residential sector, 2018 Waterford City DZ



SOCIAL HOUSING

9.0 SOCIAL HOUSING

Waterford City & County Council in conjunction with the Waterford City DZ are providing social housing units and are responsible maintenance and refurbishment of those. The energy consumption and emission depend partly on the status of the social housing stock and partly on user behaviour of the social housing tenants.

9.1 METHODOLOGY

The main data source was the Waterford City & County Council social housing database and the SEAI BER Research tool. The data was broken down in Dwelling type and year of built.

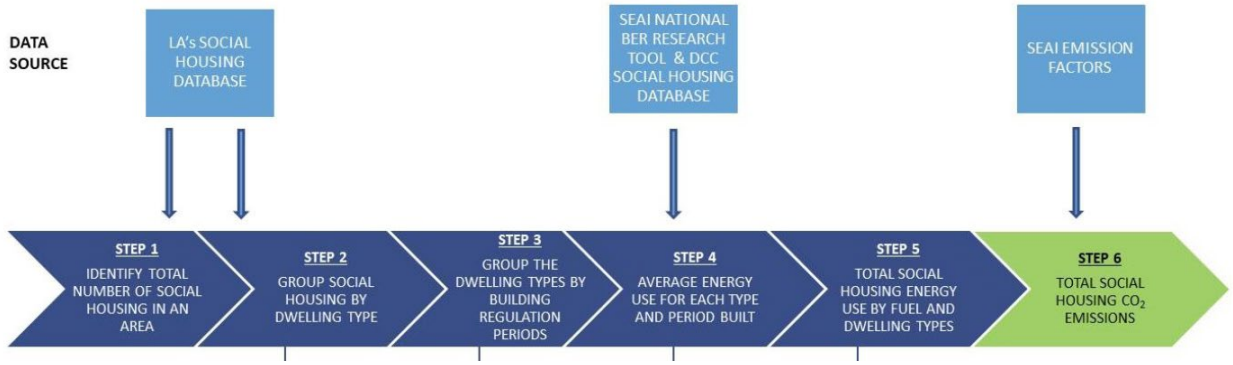


Figure 32. Social Housing Methodology (Codema 2017)

Source	Data Description
CSO, Census Housing in Ireland [13]	Lists all the residential units by; location, type of construction and period built
SEAI, National BER Research Tool[18]	Database of all BERs includes; the final energy rating given to a household is in kWh/m2/year and an energy efficiency scale from A to G, type of household, year of construction, location, floor area and fuel use.
LAs Social Housing Database	Lists all the social housing units in a LA area by; type of construction, floor area, period built and BER if available
SEAI, Emission Factors[19]	Converting energy use by fuel type into CO_2 emissions

Table 13: Social Housing Sector Data Sources

The detailed methodology used based on the guidance report, *Developing CO_2 Baselines A Step-by-Step Guide For Your Local Authority (2017)* [3]

[18] https://ndber.seai.ie/BERResearchTool/ber/search.aspx

[19] https://www.seai.ie/publications/Energy-in-Ireland-2019-.pdf

9.2 Analysis & Mapping

9.2.1 Available Data

The Waterford City DZ area contains **3,482** social housing units across the electoral divisions with corresponding breakdown according to the type of accommodation presented in Figure 33 below. Note that the following analysis is based on limited data available on social housing.

- 68 (2%) are Detached houses
- 526 (15%) are Semi-Detached houses
- 2,421 (70%) are Terraced houses
- 467 (13%) are Apartments

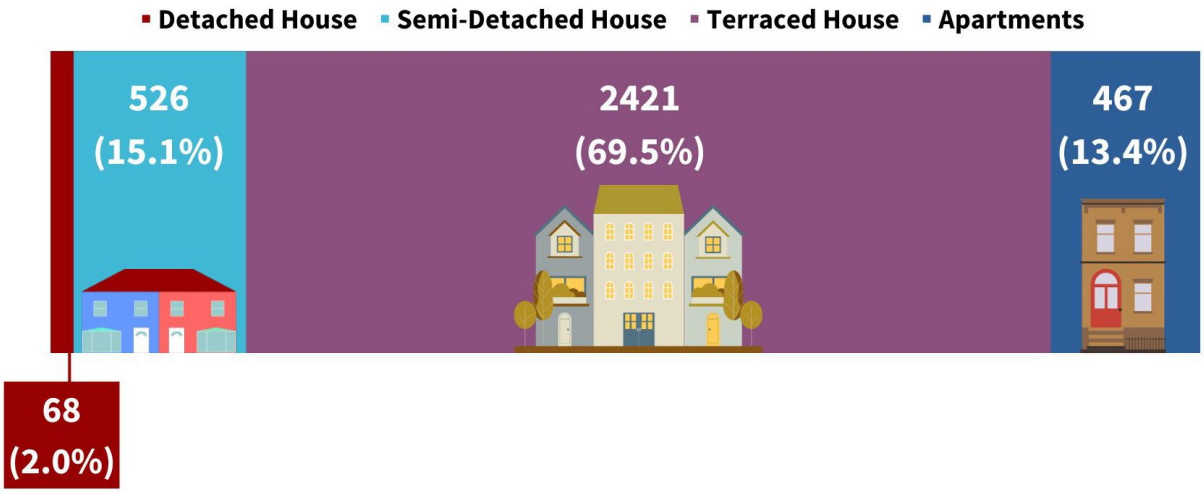
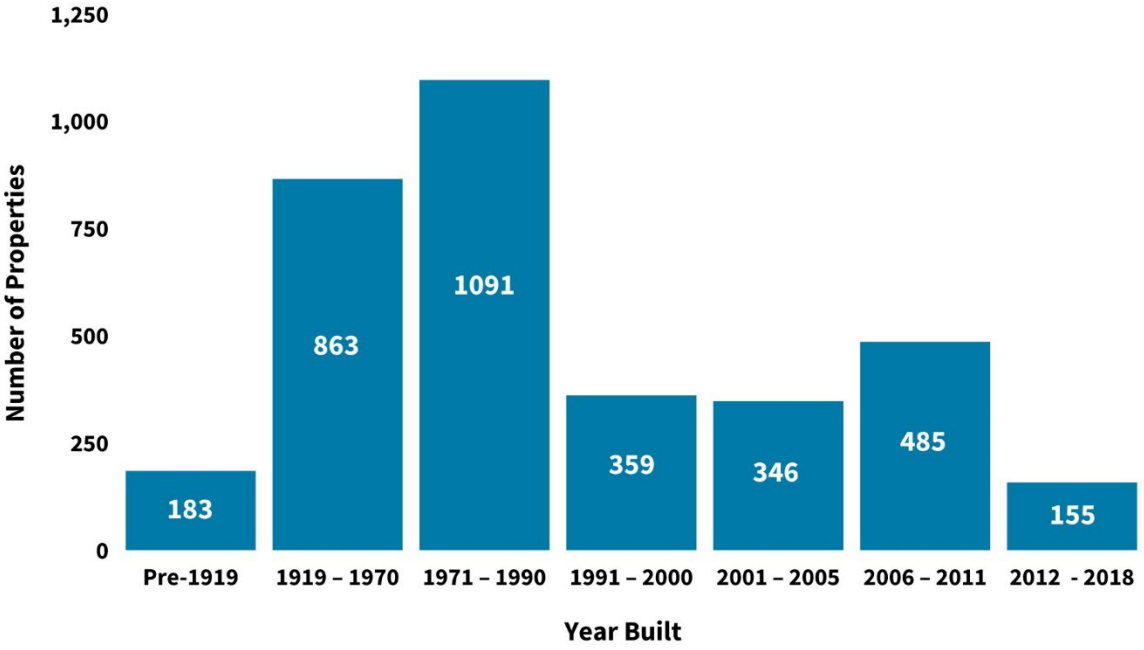


Figure 33. Breakdown of social housing units by building type, 2018 Waterford City DZ



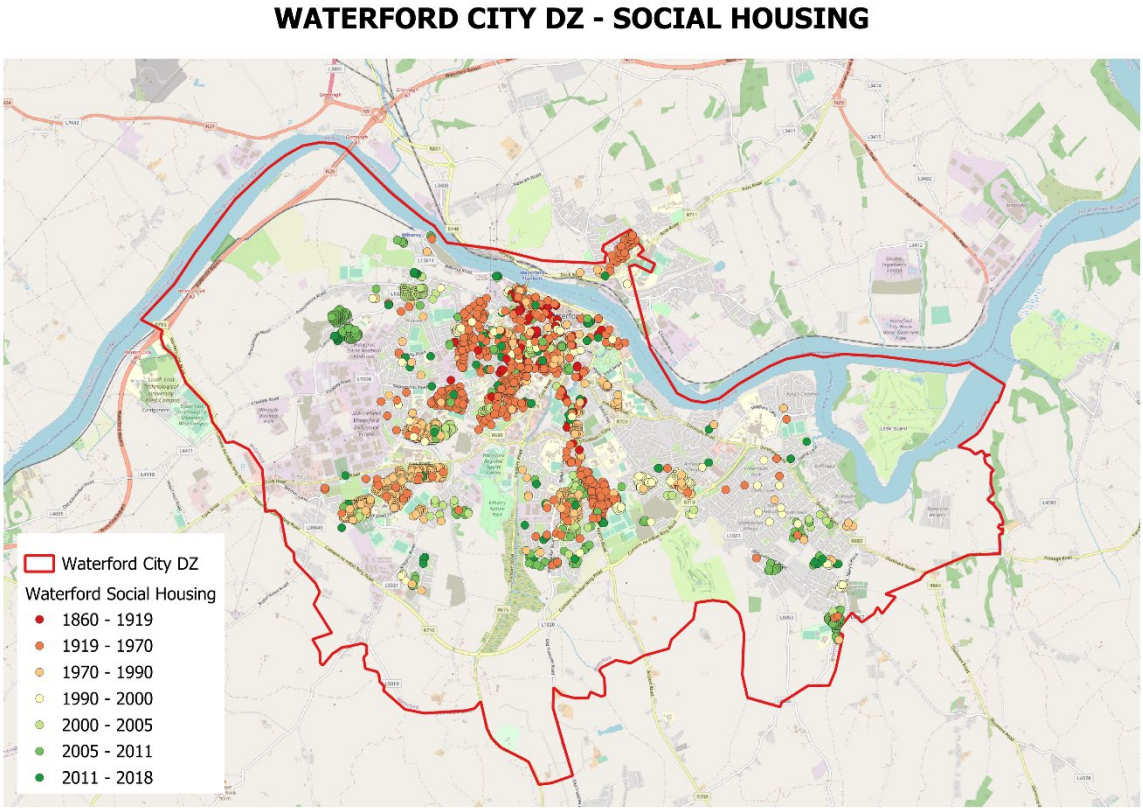


Figure 34. Social Housing in Waterford City DZ per year of construction

9.2.2 ENERGY

Total energy consumption by the Residential Sector within the Decarbonisation Zone use in 2018 was **44,629.2 MWh (44.6 GWh).**

- 81.9% was natural gas
- 18.1% was electricity

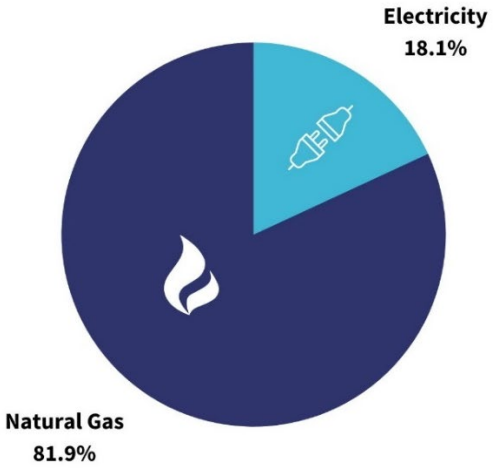


Figure 35. Breakdown of energy use by fuel type in Social Housing, 2018 Waterford City DZ

9.2.3 GHG EMISSION

When energy use was converted into GHG emissions, the residential sectors total emissions within the Decarbonisation Zone's amounted to **10,510.8 tCO_2eq (10.5 $ktCO_2eq$).**

- 69.9% was from natural gas
- 28.8% was from electricity
- 1.3% was from non-direct energy emissions

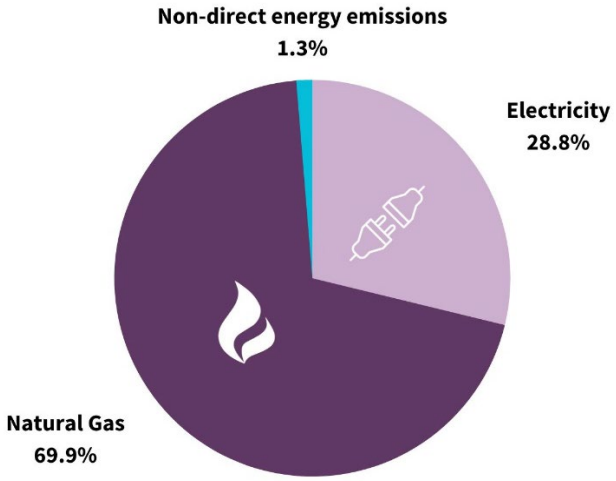
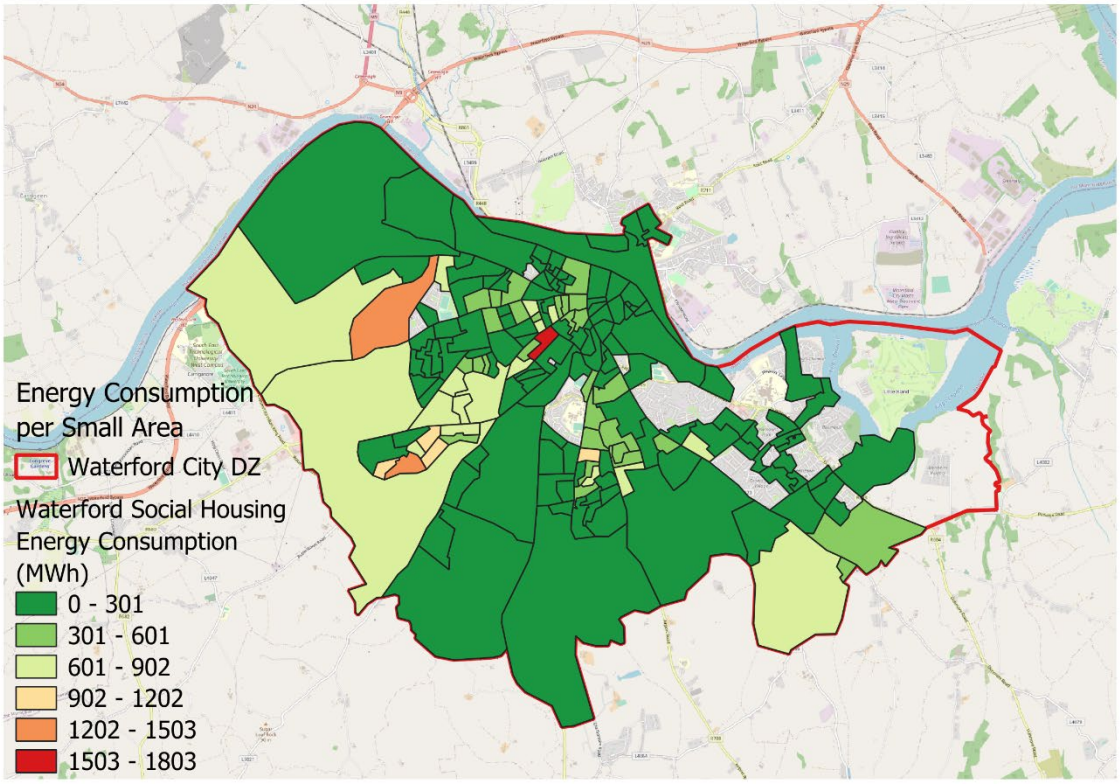


Figure 36. Breakdown of GHG emissions by fuel type for social housing, 2018 Waterford City DZ

WATERFORD CITY DZ - SOCIAL HOUSING



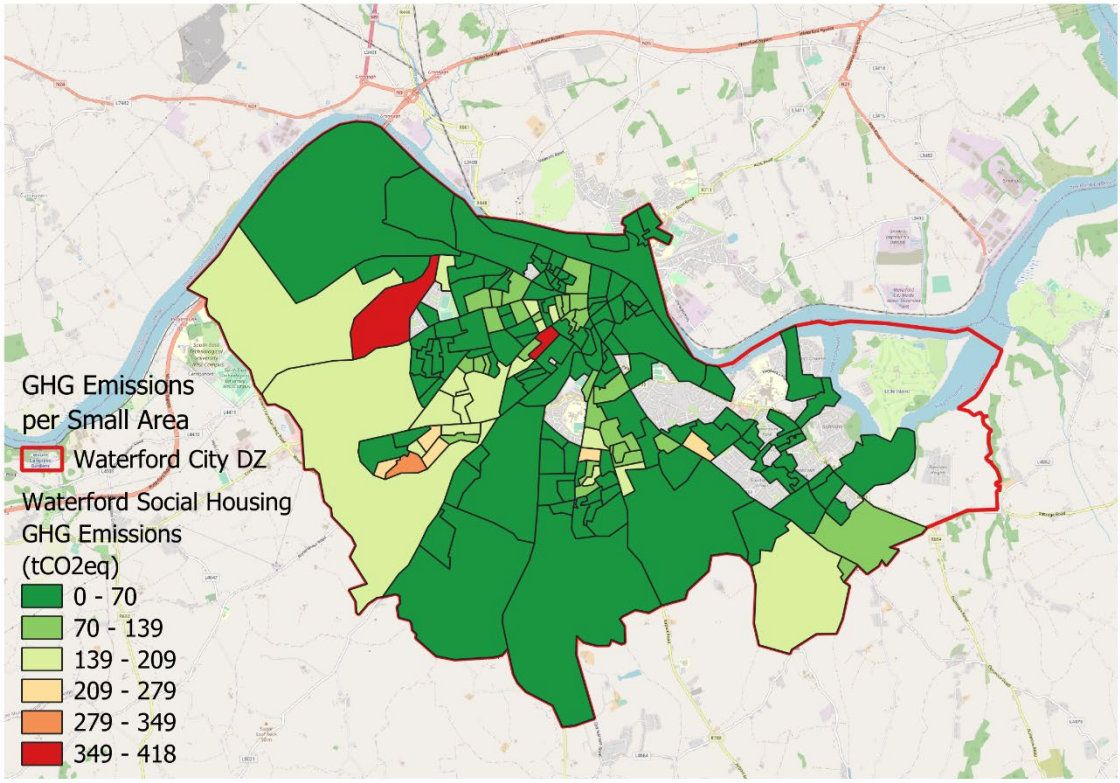


Figure 37. Social Housing: Energy consumption and GHG emission per Small Area

Key Findings

Total energy consumed by the social housing sector in 2018 was

44.6 GWh

Total emissions from social housing sector in 2018 were

10.5 $ktCO_2eq$

Energy and GHG Emissions from the Social Housing Sector

Social Housing					Total
	Electricity	Fossil Fuels	Renewables	CH_4/N_2O	
Total Energy (MWh)	8,078.0	36,551.2	-	-	**44,629.2**
Total Emissions (tCO_2eq)	3,030.9	7,343.1	-	136.8	**10,510.8**

Table 14: Energy and GHG emissions – Social Housing sector, 2018 Waterford City DZ

TRANSPORT

10.0 TRANSPORT

This section does not include Waterford City & County Councils direct transport emissions from within the DZ as these are presented separately in Section 5 of this report. This data was subtracted from the total transport emissions for this sector to avoid 'double-counting'.

10.1 METHODOLOGY

The three steps outlining the data needed and the process of how to find the final emissions for the transport sector. The National Transport Authority did not provide a breakdown of data for the Waterford City DZ when requested. Therefore, other data sources were used as shown below.

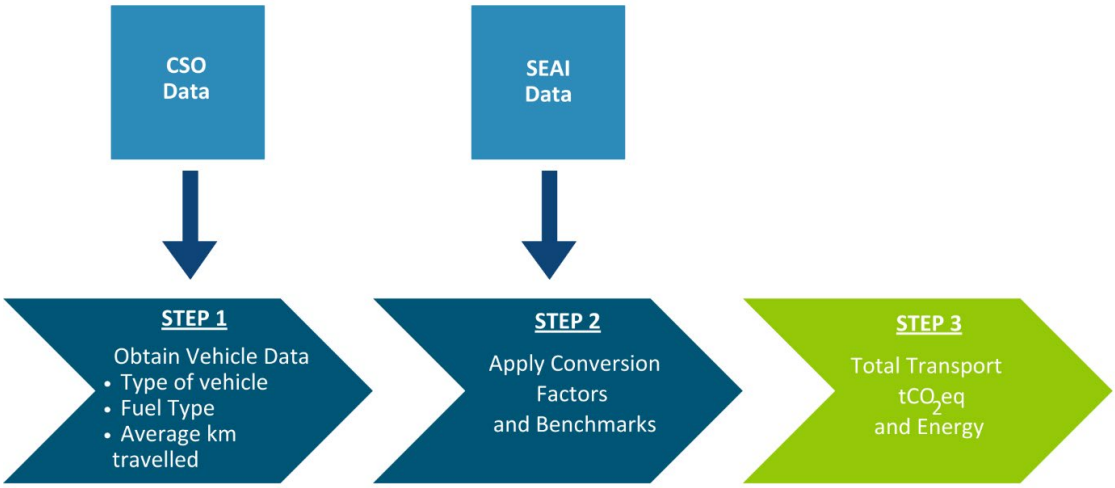


Figure 38. Transport Methodology (Codema, 2017)

Source	Data Description
MapEIre [12]	National GHG data for the DZ Area
CSO Vehicle Licence Data[20]	Data of mechanically propelled vehicles under current license in 2018
SEAI Transport sector analysis[21] and emissions factors [22]	Transport sector energy analysis and carbon emissions based on fuel types.

Table 15: Transport Sector Data Sources

The detailed methodology used based on the guidance report, *Developing CO_2 Baselines A Step-by-Step Guide For Your Local Authority (2017)* [3] The detailed methodology used based on the guidance report, *Developing CO_2 Baselines A Step-by-Step Guide For Your Local Authority (2017)* [3] . Additional necessary measures are explained in more detail in the analysis.

[20] https://data.cso.ie/table/TEA11

[21] Transport | Energy Statistics In Ireland | SEAI

[22] https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/

10.2 Analysis & Mapping

From the CSO database, the number of registered mechanically-propelled vehicles within Waterford City & County licensing area was obtained. An estimated number of vehicles in Waterford City DZ was obtained based on population ratio to vehicles in Waterford City & County as there is no available small area data of vehicles within the DZ area. An estimated number of vehicles in Waterford City DZ was obtained based on population ratio to vehicles in Waterford city & County as there is no available small area data of vehicles within the DZ area. Consequently, it is estimated that approximately **13,939** mechanically-propelled are within the area.

Vehicle types	Number	%
Private cars	27,347	82.2%
Goods vehicles	3,907	11.7%
Motorbikes/Mopeds	609	1.8%
Tractors/Machinery	1,184	3.6%
Small PSVs	147	0.4%
Large PSVs	86	0.3%
	33,280	

Table 16: Vehicle types in Waterford City DZ area

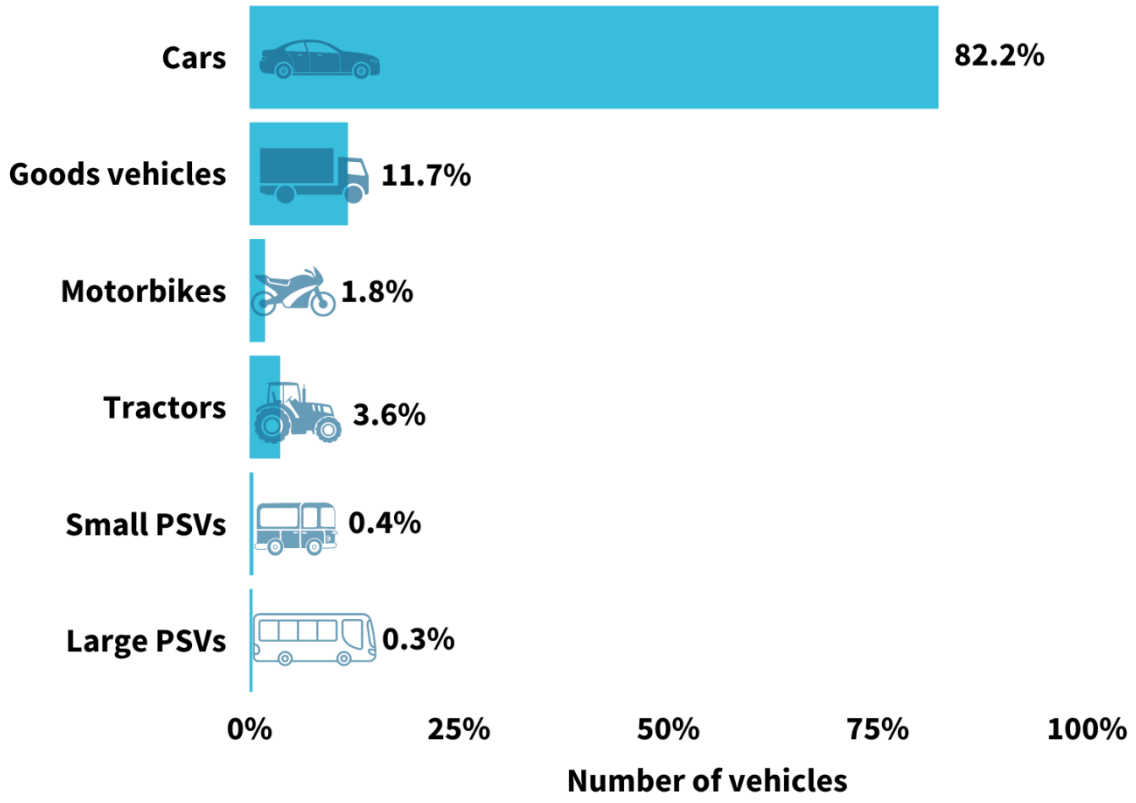


Figure 39. Type and number of vehicles, 2018 Waterford City DZ

The CSO data also provides the fuel type of each vehicle, split between Diesel, Petrol or 'Other'. 'Other' is split between electric vehicles (EVs) and Compressed Natural Gas (CNG vehicles) at a national level. There is no specific breakdown of these fuel types within the DZ area and therefore the national average was used to estimate the fuel breakdown within the DZ:

- Diesel – 59%
- Petrol – 40%
- EV – 0.2%
- CNG – 0.8%

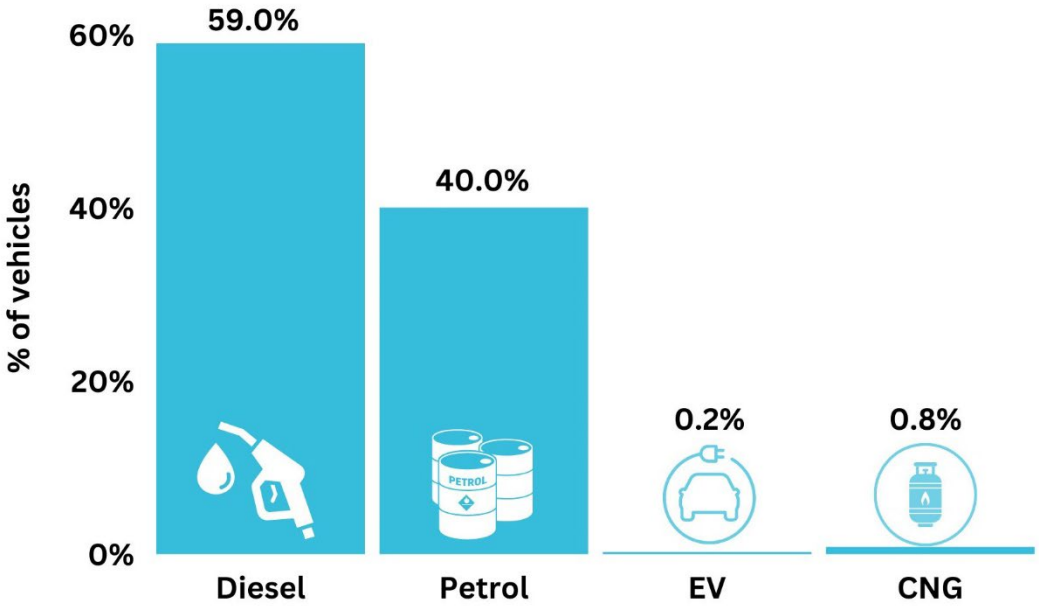


Figure 40. Number of Vehicles by fuel type, 2018 Waterford City DZ

The average km travelled by each vehicle type is also provided by the CSO data. Using the SEAI's conversion factor for $gCO_2eq./km$ travelled emitted per vehicle type the total CO_2 emissions for each category was found. The emissions were then split by fuel type and associated energy was obtained.

The Local Authority transport data was removed from the final energy and emissions data to avoid double counting.

GHG emissions associated with Rail comes directly from MapEIre so there is no breakdown of energy per fuel type obtained.

The results are reported by fuel type and by vehicle type. This is so measures to target reduction in privately owned vehicles and a move away from fossil fuel vehicles can be targeted and tracked.

10.2.1 Energy

Total energy consumption by the Transport Sector within the Decarbonisation Zone use in 2018 was **331,365.0 MWh (331.4 GWh).** The transport results are displayed in two ways:

1. By Fuel type
2. By Vehicle Type

FUEL TYPE

- 59.8% of energy used was diesel
- 39.0% was petrol
- 1.2% was other (CNG and Electricity)

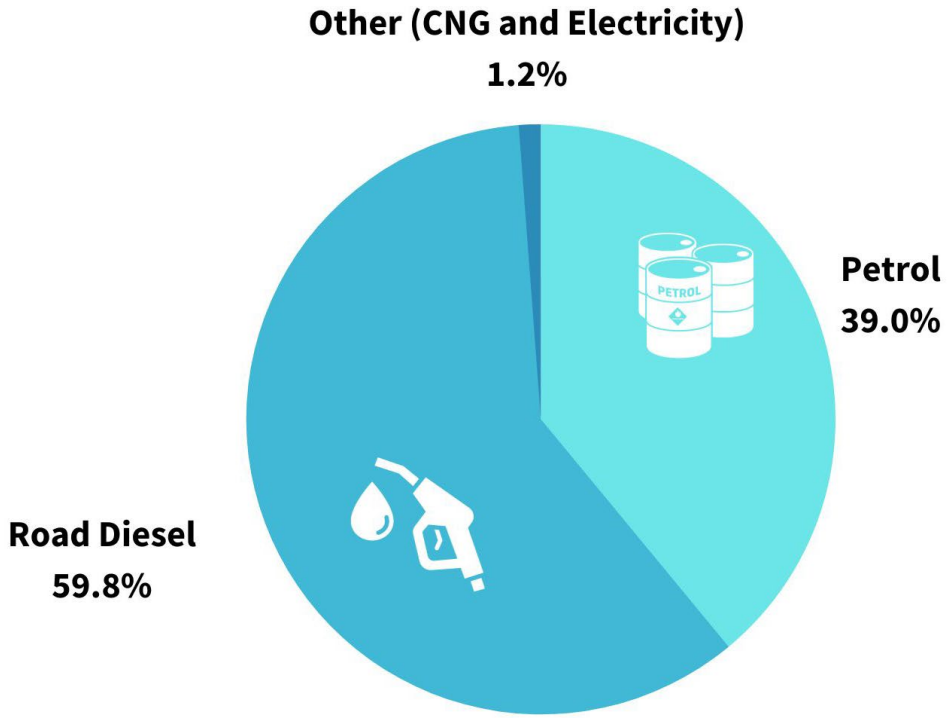


Figure 41. Breakdown of Transport sector energy use by fuel type, 2018 Waterford City DZ

VEHICLE TYPE

- 80.3% of transport energy are by privately owned cars
- 11.4% are goods vehicles
- 6.5% was by tractors/machinery
- 1.6% was by public transport (road & rail)
- 0.2% was by motorbikes

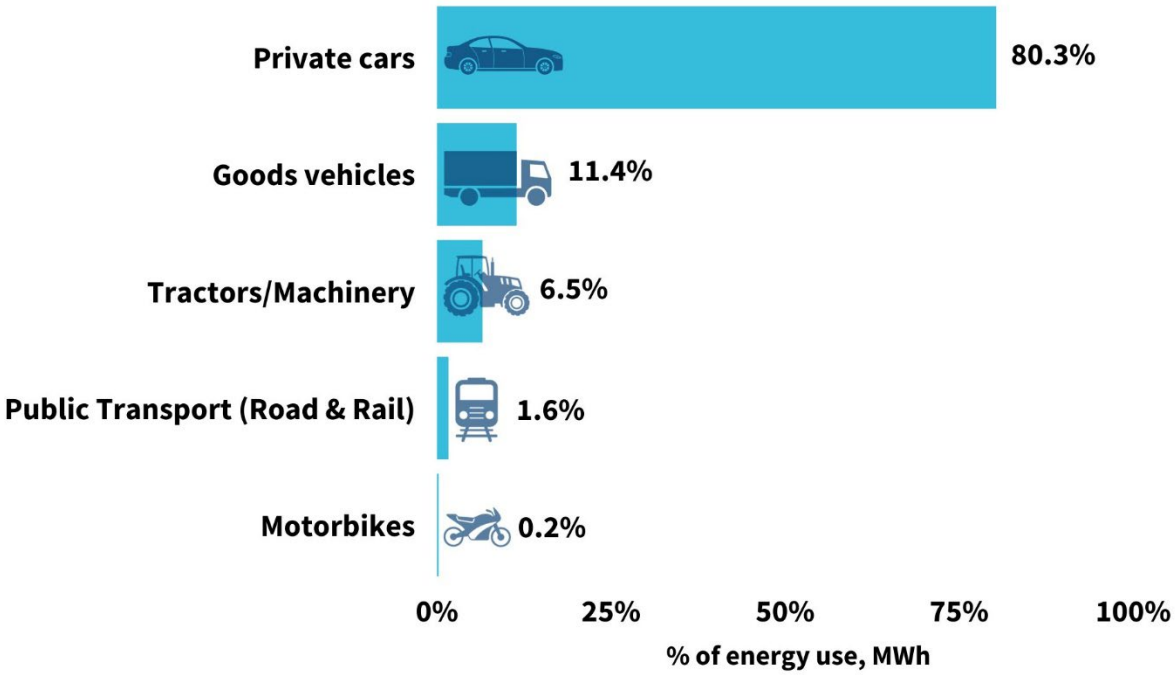


Figure 42. Breakdown of Energy use by Vehicle Type, 2018 Waterford City DZ

10.2.2 GHG Emissions

The Transport sectors total emissions within the Decarbonisation Zone's amounted to **86,030.4 tCO_2eq (86.0 $ktCO_2eq$).** The transport results are displayed in two ways:

1. By Fuel type
2. By Vehicle Type

FUEL TYPE

- 60.8% of energy used was diesel
- 37.8% was petrol
- 1.1% was other (CNG and Electricity)
- 0.3% was non direct energy related emissions (CH_4 & N_20)

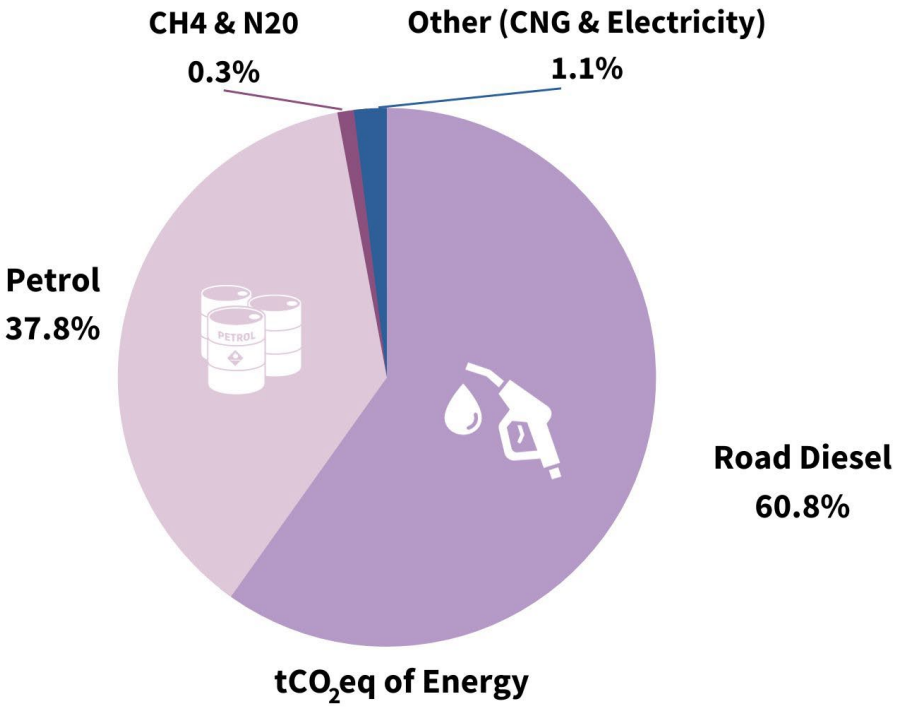


Figure 43. Breakdown of transport sector GHG emissions in tCO_2eq, 2018 Waterford City DZ

VEHICLE TYPE

- 80.3% of emissions were from privately owned cars
- 11.4% was by goods vehicles
- 6.5% was by tractors/machinery
- 1.6% was by public transport (road & rail)
- 0.2% was by motorbikes

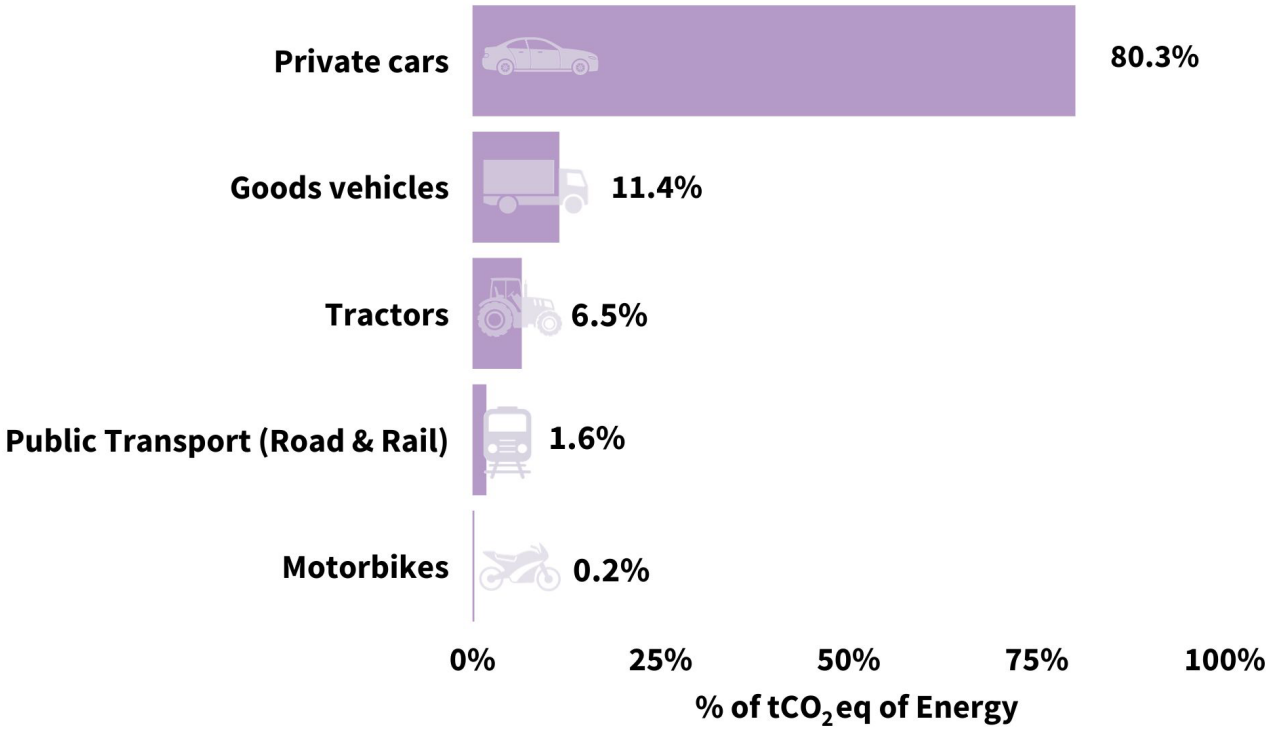


Figure 44. Breakdown of GHG emissions by vehicle type in tCO_2eq, 2018 Waterford City DZ

10.2.3 Public Transport

There are a number of public transport routes within the DZ including rail and buses, both national and local. As outlined above there is a total of 223 public service vehicles (small and large), which equates to 0.7% of all mechanically propelled vehicles registered within the Waterford City DZ.

The GHG emissions are calculated using the distance traveled and the gCO_2eq/km travelled. Total kilometers travelled by privately owned vehicles equate to 81.3% of the total km travelled, compared to just 1.4% of the total distance travelled by public transport vehicles. If there was a modal shift to public transport, then GHG emissions would be reduced from the transport sector.

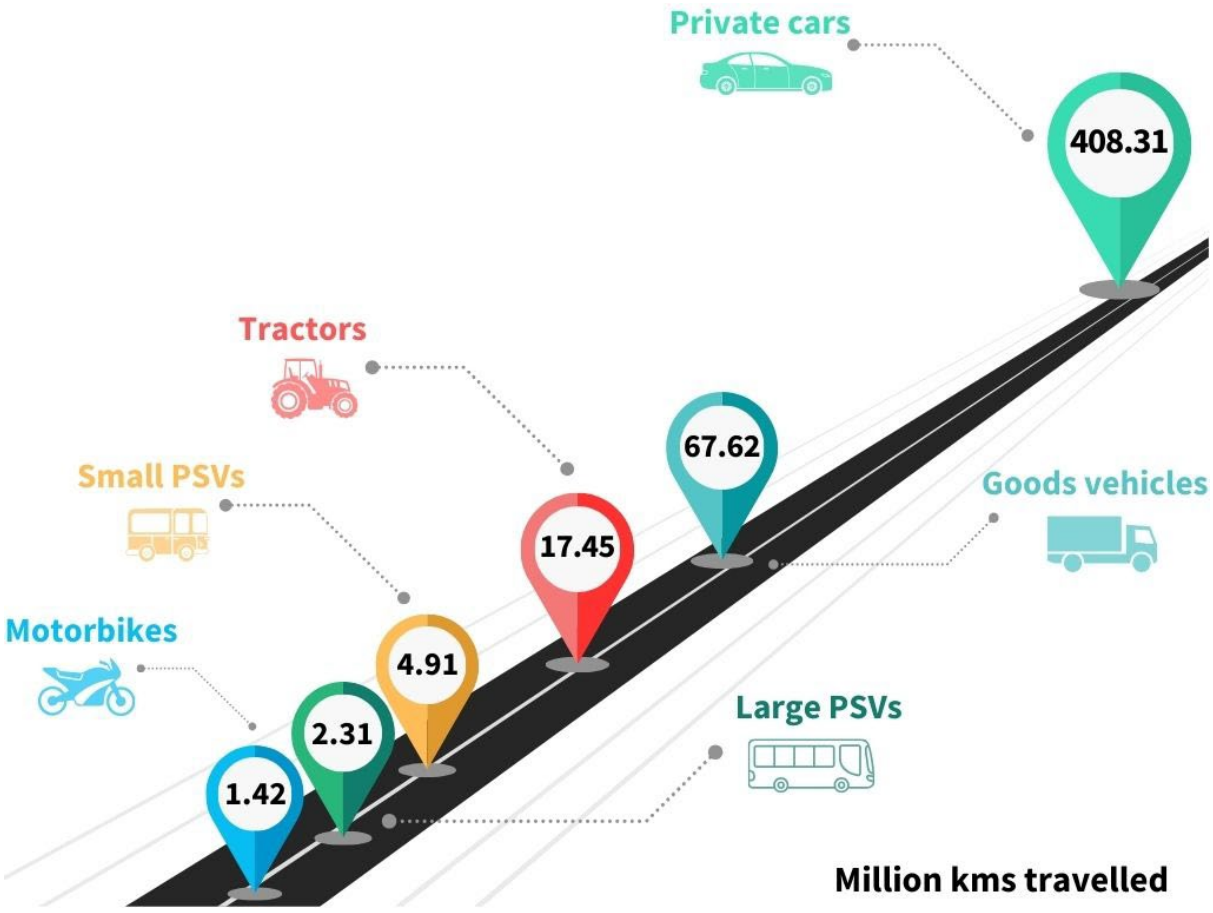


Figure 45. Breakdown of distance travelled by vehicle type in million kms, per year, 2018 Waterford City DZ

As shown above in Figure 41 the public transport vehicles only contribute 1.8% of the GHG emissions within the DZ. The % share of public transport needs to increase in order to decrease emissions from other categories of vehicle types within the DZ area.

Existing public transport routes are shown below in Figure 47 and Figure 48.

WATERFORD CITY DZ - PUBLIC TRANSPORT - OUTSIDE DZ

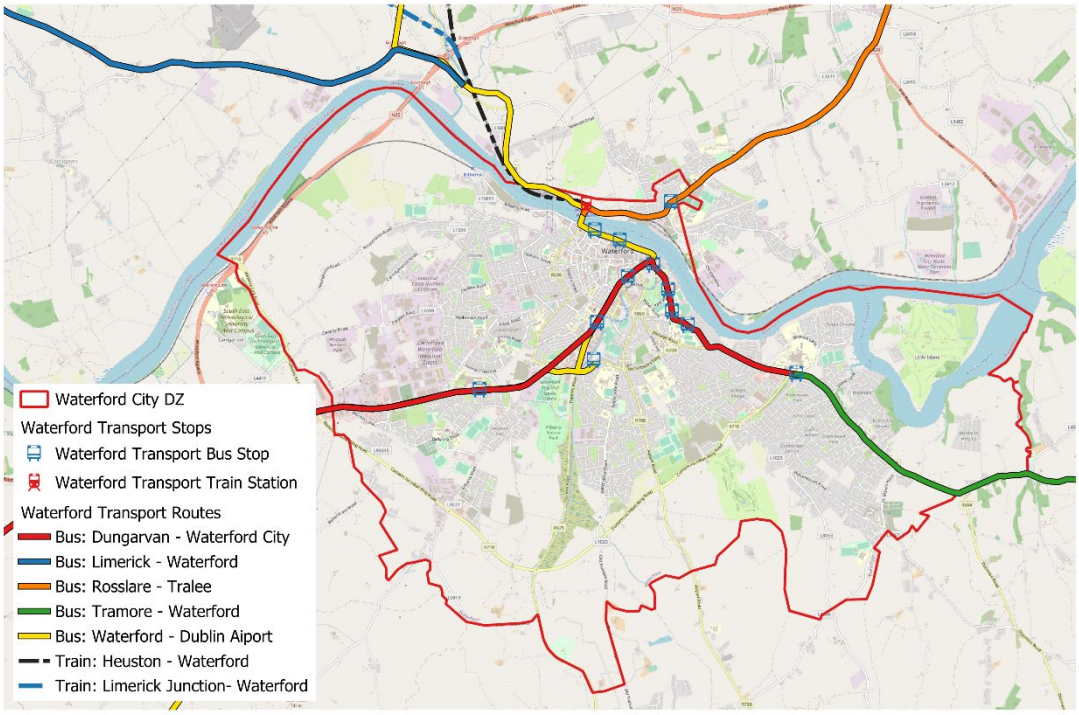


Figure 46. Public Transport routes from/to Waterford City DZ

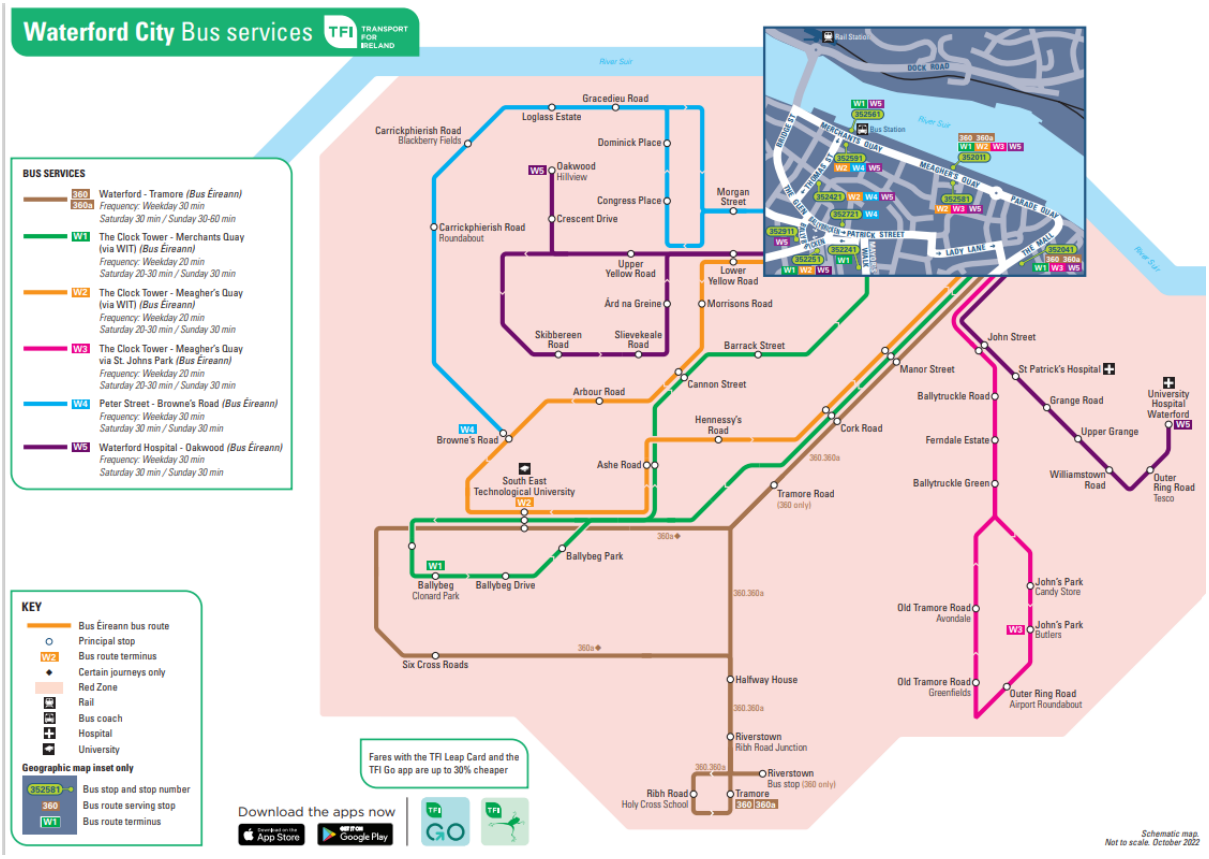


Figure 47. Public Transport routes in Waterford City DZ

Key Findings

Total energy consumed by the transport sector in 2018 was

331.4 GWh

Total transport emissions in 2018 were

86.0 $ktCO_2eq$

Energy and GHG Emissions from the Transport Sector

Transport Sector	Electricity	Fossil Fuels			Other Emissions		Total
		CNG	Road Diesel	Petrol	CH_4	N_2O	
Total Energy (MWh)	437.8	3,625.0	196,504.1	130,798.1	-	-	331,365.0
Total Emissions (tCO_2eq)	164.3	755.6	51,857.6	32,948.0	19.3	285.6	86,030.4

Table 17: Energy and GHG emissions - Transport sector, 2018 Waterford City DZ

AGRICULTURE

11.0 AGRICULTURE

This sector's emissions are from both energy and non-energy related actions. The non-energy related emissions come from a range of sources, including, livestock units (cattle), enteric fermentation, manure management, agricultural soils, liming, and use of fertilisers and urea.

Energy related emissions are for electricity and fuels used within the agricultural sector. Energy related benchmarks were obtained from Teagasc[23] for farm animals and tillage. Within the DZ area, the typical farm animals identified are cattle and sheep while the typical crops are cereals.

11.1 METHODOLOGY

2020 Census of Agricultural produce was considered as this is closest to the baseline year, 2018. Hence, the main data sources were EPA's MapEIre, for the greenhouse gas emissions, and CSO Census of Agriculture, for number of farm animals and crops. Due to GDPR regulations, the Land Parcel Identification System (LPIS) data which maps farm holdings and GHG emissions from farmlands utilized in crop production were not available at the time of this analysis. Therefore, numbers for cereals (tillage) as reported on the CSO were served as a representative of crops in the DZ area with energy and carbon emissions obtained based on Agricultural benchmarks stated by Teagasc.

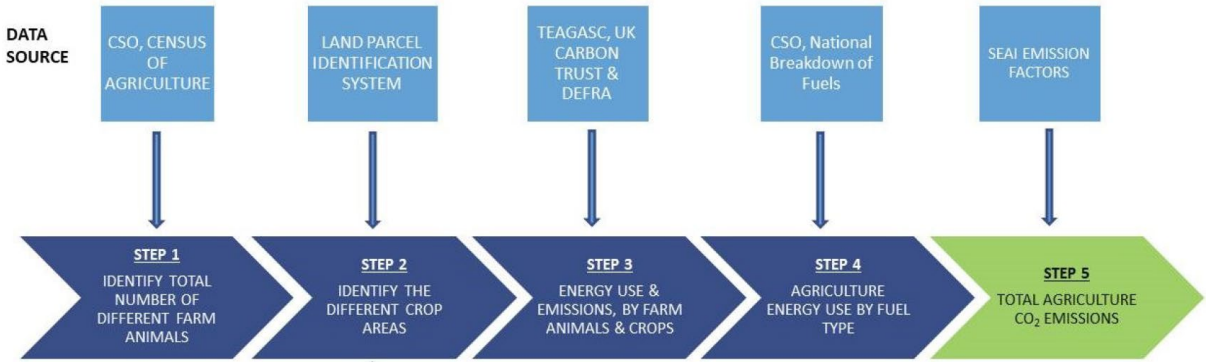


Figure 48. Agriculture Methodology (Codema 2017)

Source	Data Description
Census of Agriculture[24]	Census of all farm animals and crops typical in the electoral divisions of the DZ area
Land Parcel Information System [25]	Database of all BERs includes the final energy rating given to a household is in kWh/m2/year and an energy efficiency scale from A to G, type of household, year of construction, location, floor area and fuel use.
Teagasc [14] [15] [16]	Energy use benchmarks for farm animals and crops
SEAI emission factors	This contains carbon conversion factors for various fuel types.

Table 18: Agriculture Sector Data Sources

[23] https://www.teagasc.ie/rural-economy/rural-development/diversification/energy-auditing-in-agriculture/

[24] https://visual.cso.ie/?body=entity/ima/coa

[25] https://www.gov.ie/en/service/1eb4d-land-parcel-identification-system-lpis/#:~:text=The%20LPIS%20is%20the%20Department's,Natural%20Constraint%20Scheme%20(ANC).

The detailed methodology used based on the guidance report, *Developing CO_2 Baselines A Step-by-Step Guide For Your Local Authority (2017)* [3]

Additional necessary measures are explained in more detail in the analysis.

11.2 Analysis & Mapping

The LPIS did not provide us with a breakdown of data for the Waterford City DZ on request. Therefore, MapEIre and CSO AgriMap were used as the main data sources for analysis of agricultural sector within the DZ area. MapEIre data was the source for identifying the non-energy related GHG emissions. Firstly, MapEIre was filtered based on grid cell IDs for the DZ area to identify GHGs such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and sulphur hexafluoride (SF_6). The categories within the DZ area were as follows:

- Agriculture/ Forestry/ Fishing: Stationary
- Agriculture/ Forestry/ Fishing: National Fishing
- Non-dairy Cattle
- Manure management - Non-Dairy Cattle
- Inorganic N-fertilizers
- Animal manure applied to soils
- Sewage sludge applied to soils
- Urine and dung deposited by grazing animals
- Crop residues applied to soils
- Mineralization
- Atmospheric deposition
- Nitrogen leaching and run-off
- Liming
- Urea application

The CSO AgriMap[26] contains livestock, crop and farmland data within an area which is depicted based on the different electoral divisions in the country. The following livestock within the DZ was found to be all cattle. A total of 654 cows were within the Waterford City DZ.
The hectares of farmed land were as follows:

[26] https://visual.cso.ie/?body=entity/ima/coa

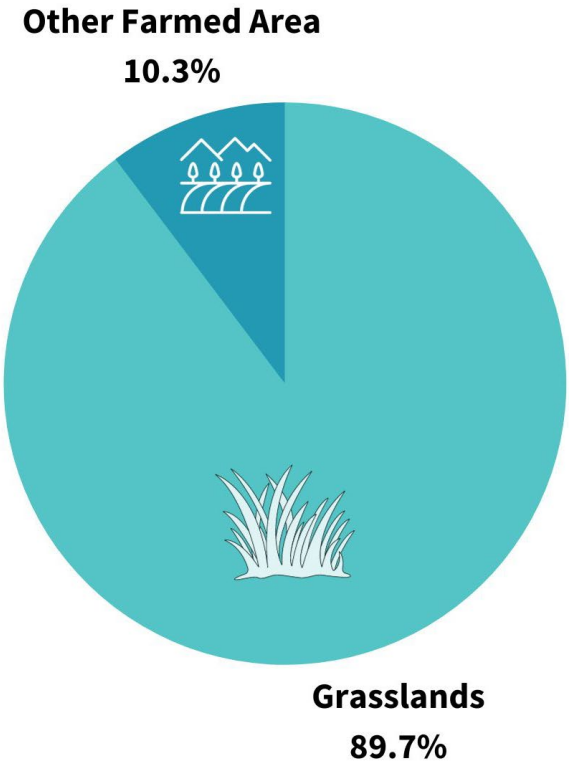


Figure 49. Type of crop per area farmed (ha), 2018 Waterford City DZ

Benchmarks from Teagasc and SEAI were used to estimate typical energy consumed in a farm holding and emissions for different fuel types, respectively. Average energy consumed are:

- 10,500kWh of electricity and 8,500 litres of diesel per 150 ha of tillage farm[27]
- 30,000kWh per 100-cow dairy unit on annual basis[28]

The energy related emissions calculated from the CSO data, Teagasc and SEAI benchmarks were aggregated with the emissions from MapEIre to give energy and non-energy related carbon dioxide equivalent (CO_2 eq.) for the agricultural sector.

[27] https://www.teagasc.ie/media/website/rural-economy/rural-development/diversification/Energy-7-Energy-Auditing-in-Agriculture.pdf

[28] https://www.teagasc.ie/media/website/rural-economy/rural-development/diversification/Energy-7-Energy-Auditing-in-Agriculture.pdf

WATERFORD CITY DZ - AGRICULTURAL LAND

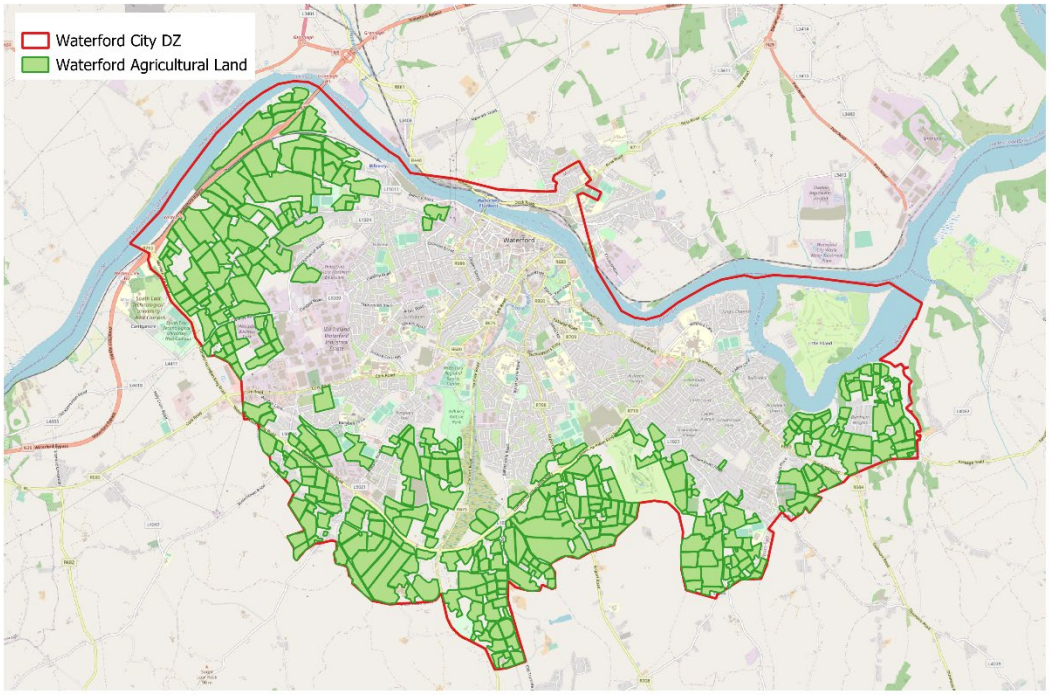


Figure 50. Agricultural Land in Waterford City DZ

11.2.1 Energy

Total energy consumption by the Agricultural Sector within the Decarbonisation Zone use in 2018 was **214.3 MWh (0.2 GWh).**

- 62.3% of energy used was used for cattle rearing
- 37.7% was associated with farming land (tillage)

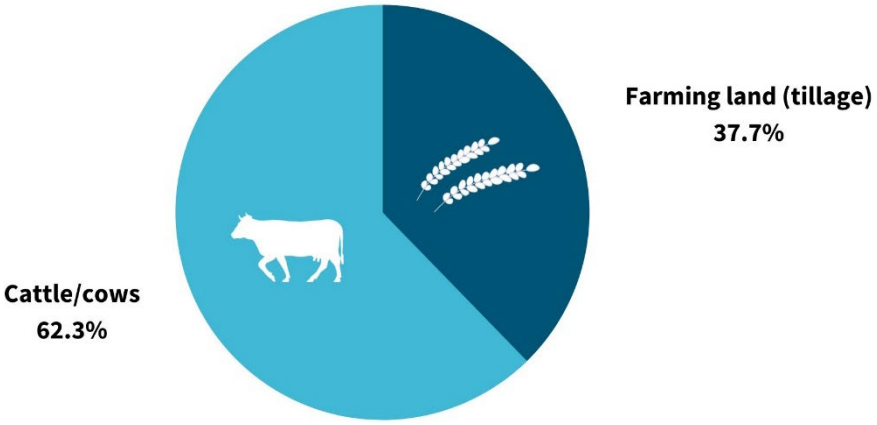


Figure 51. Energy consumption by the Agricultural Sector, 2018 Waterford City DZ

11.2.2 GHG Emissions

The energy related Agricultural sectors GHG emissions within the Decarbonisation Zone's amounted to 72.4 tCO_2eq. The non energy related GHG emissions were 4,385.3 tCO_2eq. Therefore, the total GHG emissions from Agriculture within the DZ area was **4,457.7 tCO_2eq (4.5 $ktCO_2eq$).**

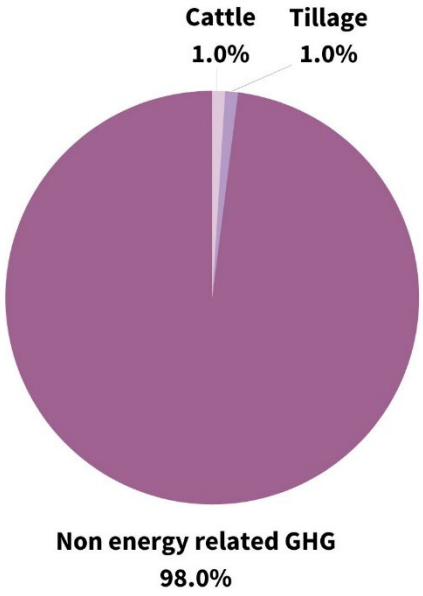
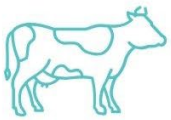


Figure 52. GHG Emissions by Source, Agriculture Sector, 2018 Waterford City DZ

Key Findings



Total energy consumed by the agriculture sector in 2020 was

0.2 GWh

Total agriculture emissions in 2020 were

4.5 $ktCO_2eq$

Energy and GHG Emissions from the Agriculture Sector

Agriculture	Electricity	Fossil Fuels / Heating Oils	CO_2	CH_4	N_2O	SF_6	Total
Total Energy (MWh)	142.3	72.0	-	-	-	-	214.3
Total Emissions (tCO_2eq)	53.4	19.0	334.2	1,783.0	2,268.1	-	4,457.7

Table 19: Energy and GHG Emissions from Agriculture Sector, 2018 Waterford City DZ

WASTE & WASTEWATER

12.0 WASTE & WASTEWATER

This sector is responsible from handling of waste, incineration of waste (without energy utilisation), composting, and wastewater handling [17]. This sector accounts for non-energy related emissions. The Kilbarry Civic amenity, a landfill site within the DZ, accepts non-hazardous wastes and small amounts of municipal wastes. Flares from the facility comprises mainly methane (CH_4) and carbon dioxide (CO_2).

This sector is responsible from handling of waste, incineration of waste (without energy utilisation), composting, and wastewater handling [17]. This sector accounts for non-energy related emissions. The Kilbarry Civic amenity, a landfill site within the DZ, accepts non-hazardous waste and small amounts of municipal waste with flares mostly comprising of methane (CH4) and carbon dioxide (CO2). Flares from the facility

12.1 METHODOLOGY

Typical data sources are the EPA's MapEIre data and Pollutant Release and Transfer Register (PRTR), and population data from CSO. MapEIre data contained emissions from waste recycling which include the following:

- Solid waste disposal on land
- Compositing
- Open burning of waste (incineration)
- Domestic waste-water handling

PRTR is a publicly accessible database or inventory of chemicals or pollutants released to air, water and soil and transferred off-site for treatment.

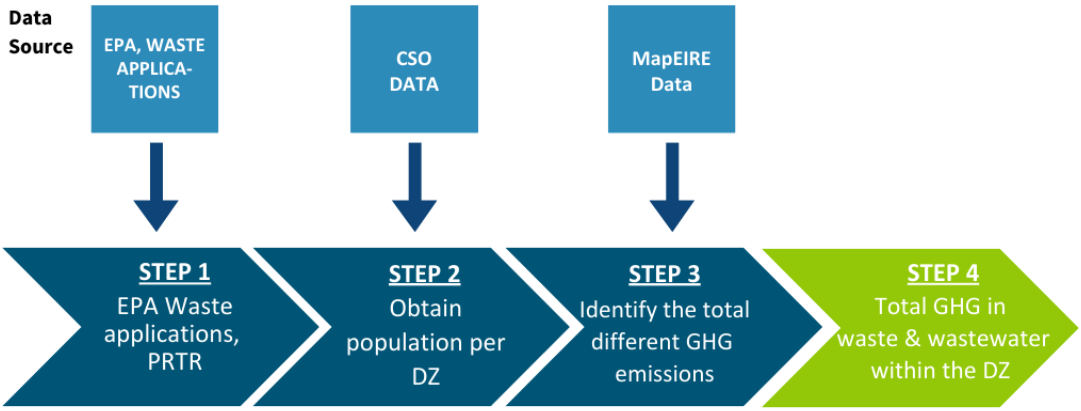


Figure 53. Waste Methodology (Codema 2017)

Source	Data Description
EPA, Waste Applications[29]	Lists all the licenced landfills by county
PRTR - Pollutant Release and Transfer Register[30]	Lists all the emissions and types of pollutant and their total air releases
CSO, Census of Populations [13]	Total population in each local authority area
MapEIre [12]	GHG emissions in the DZ area per category of Waste

Table 20: Waste Sector Data Sources

The detailed methodology used based on the guidance report, *Developing CO_2 Baselines A Step-by-Step Guide For Your Local Authority (2017)* [3]

12.2 Analysis & Mapping

There is no carbon emissions data available on the EPA's PRTR portal for either waste management facility or in Irish Water's annual environmental report for the wastewater treatment plant (WWTP). EPA's greenhouse gas emissions report covering 1990 – 2018 was used in this sectoral analysis. This provided the national GHG emissions in 2018 associated with the Waste Sector, which when divided by the national population of Ireland, gave a benchmark figure of GHG/head of population. This was applied on a per capita basis since the emissions were reported from waste treatment facilities.

However, it was felt that using a simple benchmark based on national data and applying it to the population of the Decarbonisation Zone was not as accurate or detailed as using the km Grid information provided by MapEIre. To obtain the GHG emissions within the DZ zone, MapEIre data was used which provided a breakdown of emissions in each waste category as outlined above. The accuracy of each kmGrid square within the DZ further allowed for a more accurate figures to be calculated for the Waterford City DZ.

There were 21 Bring Banks for bottle recycling within the DZ area and a waste management facility at Kilbarry Civic Amenity Site for disposal of all types of domestic waste.

There was 1 wastewater treatment plant (WWTP) outside the Waterford City DZ area; Waterford City WWTP. It is part of the Waterford Main Drainage Scheme to cater for the needs of Waterford City and the Environs of South Kilkenny and designed to population capacity of 190,000.

12.2.1 GHG Emissions

The Waste & Wastewater sectors non-energy related GHG emissions within the Decarbonisation Zone's was **20,333.4 tCO_2eq (20.3 $ktCO_2eq$).**

[29] https://epawebapp.epa.ie/terminalfour/waste/index.jsp

[30] https://www.epa.ie/our-services/compliance--enforcement/whats-happening/pollutant-release-and-transfer-register/

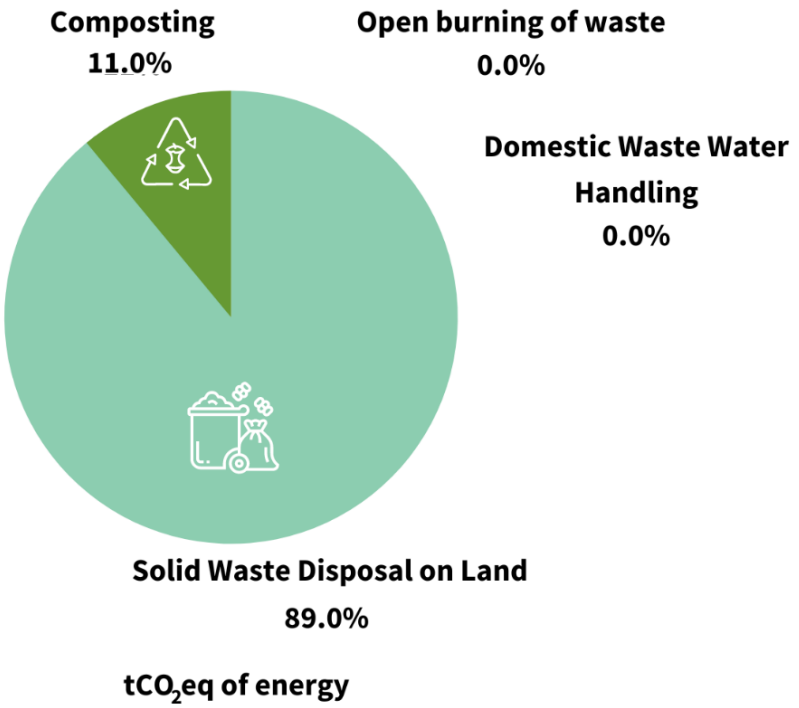


Figure 54. Waste & Wastewater sectors non-energy related GHG emissions, 2018 Waterford City DZ

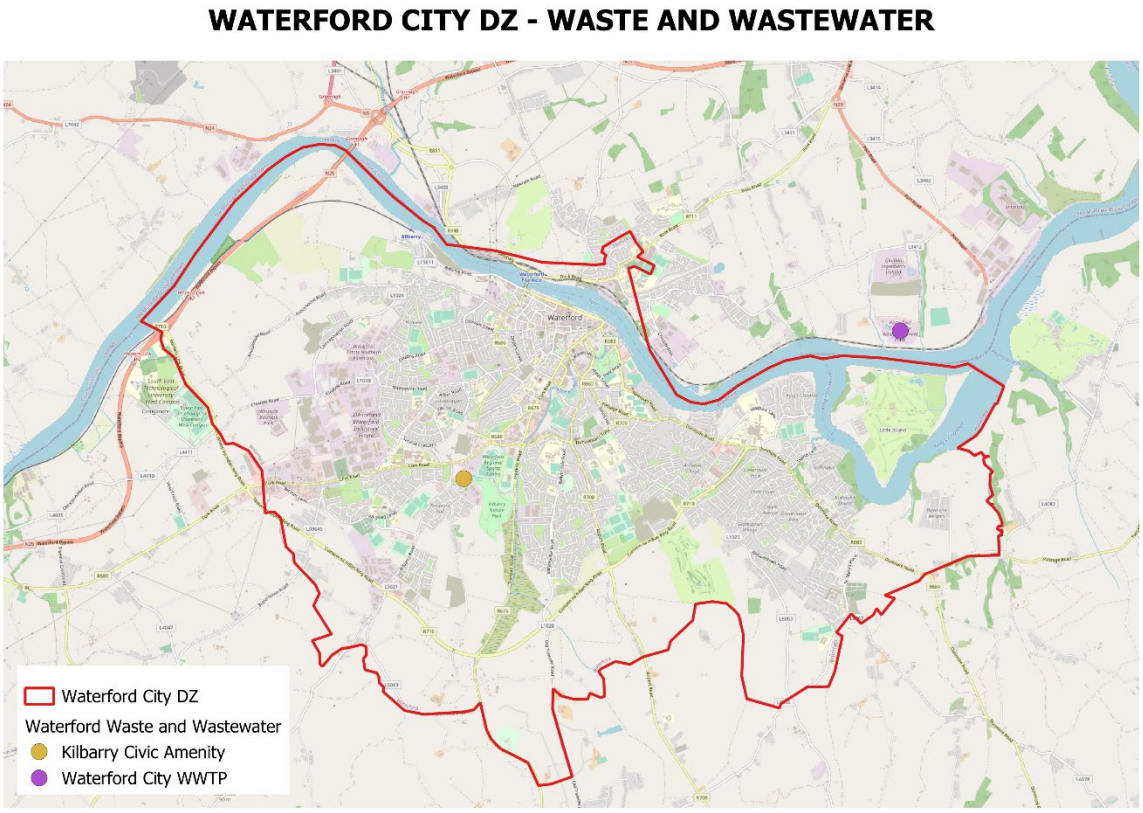


Figure 55. Waterford City DZ Waste and Wastewater Facilities

Breakdown of household waste data showed that mixed domestic waste account for over 40% of all wastes from households. A breakdown of this data is presented in Figure 53 below.

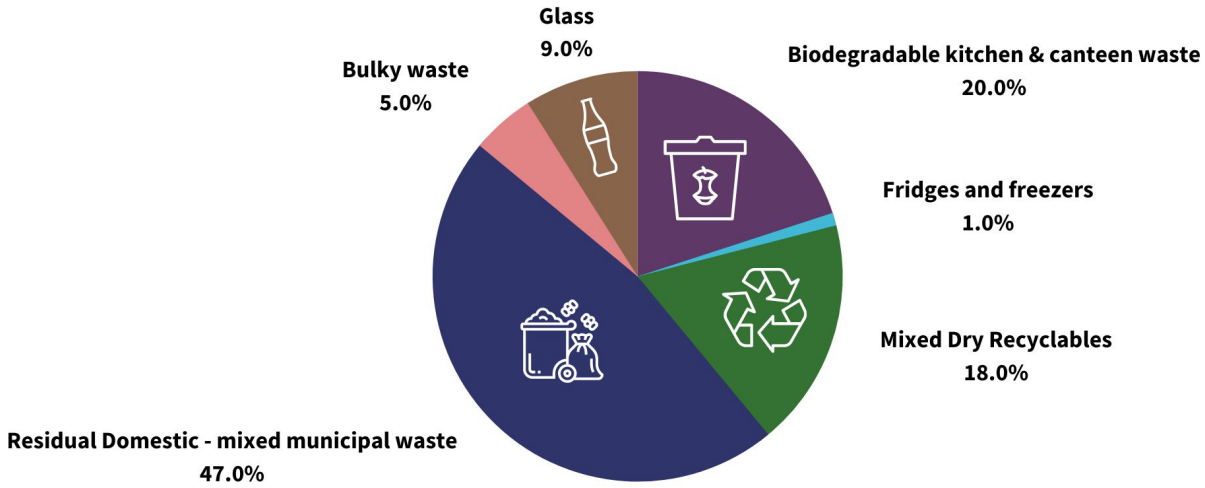


Figure 56. Breakdown of household waste data in Waterford DZ

On the other hand, mixed municipal waste and commercially bulky waste make up over 90% of all commercial wastes. A breakdown of waste components from business entities are shown in Figure 54**.**

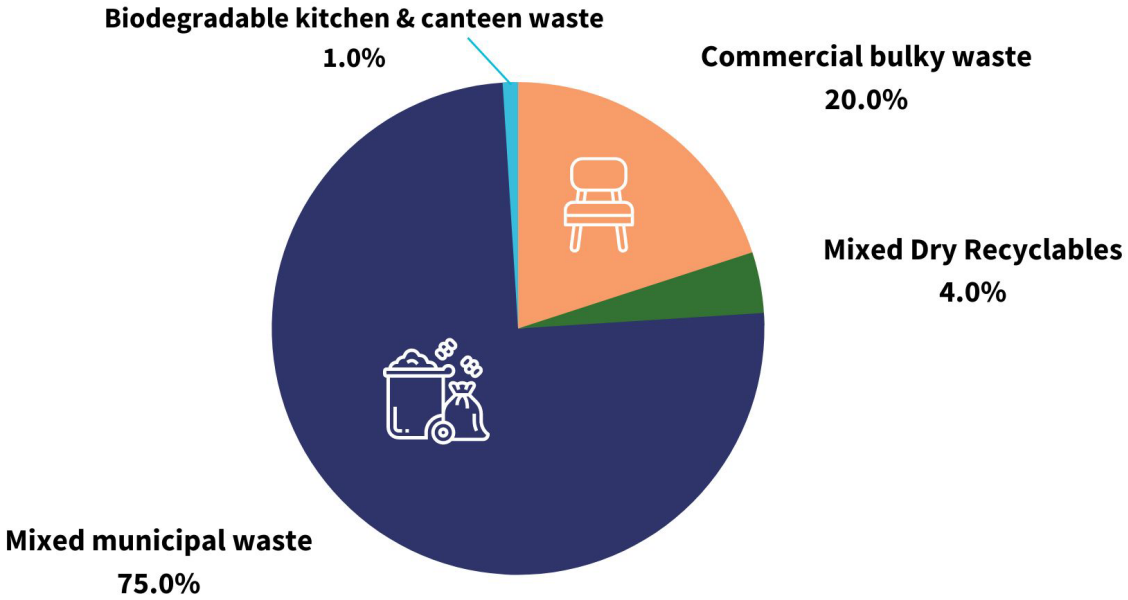


Figure 57. Breakdown of Commercial waste data in Waterford DZ

Key Findings

Total GHG emissions produced by the waste & wastewater sector in 2018 was

20.3

$ktCO_2eq$

GHG Emissions from the Waste Sector

Waste & wastewater	Solid waste disposal on land	Domestic wastewater handling	Composting	Open burning of waste	Total
Emissions ($tCO_2eq.$)	17,994.9	3.3	2,318.2	0.3	20,316.7
Waste & wastewater sector	**CO_2**	**CH_4**	**N_2O**	**SF_6**	**Total**
Emissions ($tCO_2eq.$)	0.3	19,349.7	966.6	-	20,316.7

Table 21: GHG Emissions from Waste and Wastewater Sector, 2018 Waterford City DZ

RESULTS SUMMARY

13.0 Results Summary

This section summarises the total GHG emissions from the different carbon emitting sectors in the Waterford City Decarbonisation Zone, as outlined in Chapters 5 – 12.

The total energy consumption in the Waterford City Decarbonisation Zone in 2018 was **1,017.4 GWh.**

The total baseline GHG emission for Waterford City Decarbonisation Zone in 2018 was **289.5 $ktCO_2eq$.**

At 29.7%, transport sector accounted for the greatest percentage of total emission in the DZ area. This was followed by commercial sector (28.4%) and Residential sector (21.8%).

Waterford City & County Council was responsible for 1.6% of the total GHG emissions within the Waterford City Decarbonisation Zone in 2018.

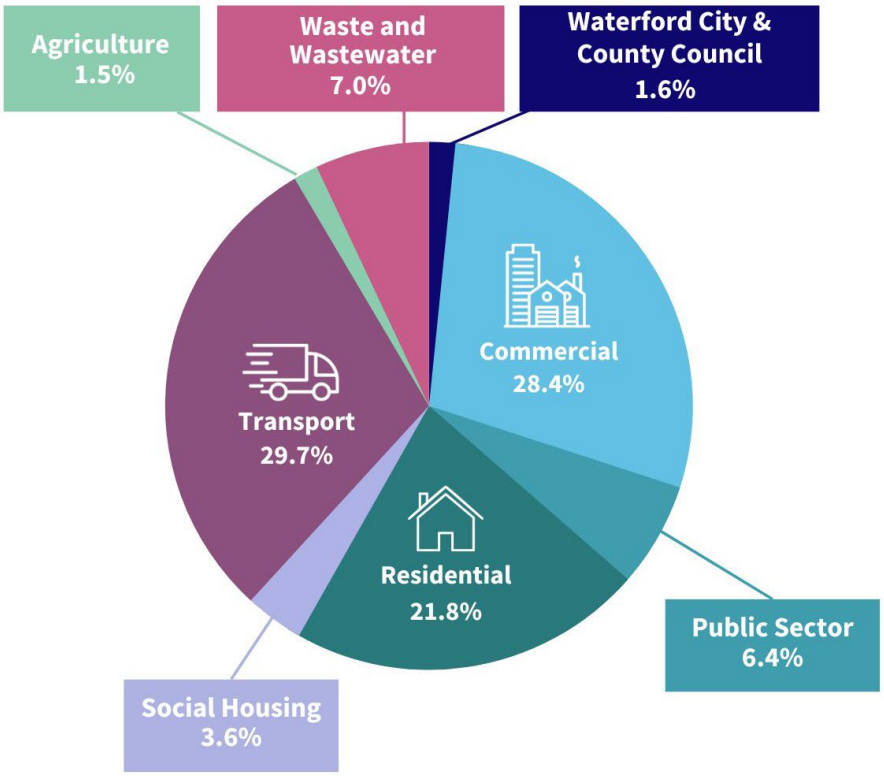


Figure 58. Total Waterford City Decarbonisation Zone GHG Emissions in 2018

Waterford City DZ	Electricity	Fossil Fuels						Renewables	Total (MWh)	Total (GWh)
		Natural Gas	Heating Oil	Diesel	Petrol	LPG	Coal/Peat			
Waterford City & County Council (MWh)	7,302.2	3,905.4	-	3,951.7	17.9	-	-	136.17	15,313.3	15.3
Public sector (MWh)	28,758.1	37,945.4	-	-	-	-	-	-	66,703.5	66.7
Commercial and Industrial (MWh)	87,252.7	149,944.8	31,033.1	-	-	14,110.0	11,992.3	26,758.7	321,091.6	321.1
Residential (MWh)	62,667.9	131,868.1	38,497.9	-	-	441.6	4,622.2	2.0	238,099.7	238.1
Social Housing (MWh)	8,078.0	36,551.2	-	-	-	-	-	-	44,629.2	44.6
Transport (MWh)	437.8	3,625.0	-	196,504.1	130,798.1	-	-	-	331,365.0	331.4
Agriculture (MWh)	142.3	-	-	72.0	-	-	-	-	214.3	0.2
Waste & Wastewater (MWh)	-	-	-	-	-	-	-	-	-	-
Total Energy consumed (MWh)	**194,639.0**	**363,839.8**	**69,531.0**	**200,527.9**	**130,816.0**	**14,551.6**	**16,614.5**	**26,896.9**	**1,017,416.6**	**1,017.4**

Table 22: Share of Total Energy used per Sector, 2018 Waterford City DZ

Waterford City DZ	Electricity	Fossil Fuels						CO_2	CH_4	N_2O	SF_6	Total (tCO2 eq.)	Total (ktco2 eq.)
		Natural Gas	Heating Oil	Diesel	Petrol	LPG	Coal/Peat						
Waterford City & County Council (tCO_2eq)	2739.8	792.4	-	1,042.7	4.5	-	-	-	-	-	-	4,579.4	4.6
Public sector (tCO_2eq)	10,790.0	7,623.2	-	-	-	-	-	-	-	-	-	18,413.3	18.4
Commercial and Industrial (tCO_2eq)	32,737.2	30,423.8	8,136.4	-	-	3,235.4	4,489.9	1,188.8	249.6	514.0	1,101.1	82,076.3	82.1
Residential (tCO_2eq)	23,513.0	26,492.3	10,533.0	-	-	101.3	1,649.3	-	702.9	117.6	-	63,109.4	63.1
Social Housing (tCO_2eq)	3,030.9	7,343.1	-	-	-	-	-	-	117.1	19.6	-	10,510.7	10.5
Transport (tCO_2eq)	164.3	755.6	-	51,857.6	32,948.0	-	-	-	19.4	298.7	-	86,043.6	86.0
Agriculture (tCO_2eq)	53.4	-	-	19.0	-	-	-	334.2	1,783.0	2,268.1	-	4,457.7	4.5
Waste & Wastewater (tCO_2eq)	-	-	-	-	-	-	-	0.3	19,349.7	966.6	-	20,316.7	20.3
Total Emissions (tCO_2eq)	**73,028.6**	**73,430.5**	**18,669.5**	**52,919.3**	**32,952.5**	**3,336.7**	**6,139.2**	**1,523.3**	**22,221.8**	**4,184.6**	**1,101.1**	**289,507.0**	**289.5**

Table 23: Share of Total Emissions per Sector, 2018 Waterford City DZ

CONCLUSION

14.0 Conclusion

The 2030 target for GHG emissions by 2030 is 51% reduction from the baseline year of 2018.

The total baseline GHG emission for 2018 for Waterford City Decarbonisation Zone was **289.5 ktCO$_2$eq**.

Therefore, the allowable GHG emissions in 2030 will be **141.9 ktCO$_2$eq.**

The total baseline GHG emission associated with Waterford City & County Council in 2018 for Waterford City Decarbonisation Zone was **4.6 ktCO$_2$eq**.

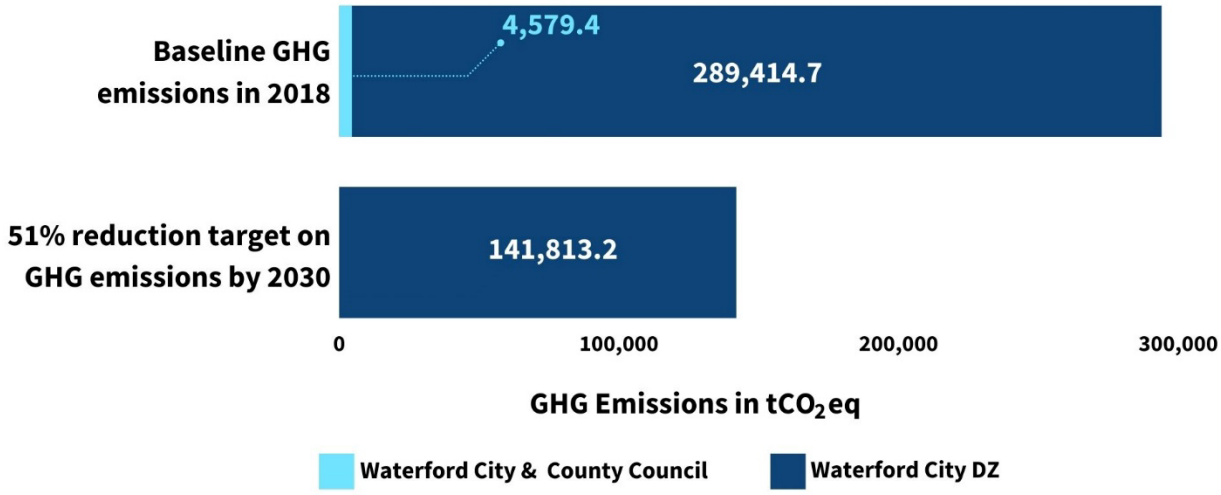


Figure 59. Baseline 2018 GHG emission and Target GHG emission for 2030, Waterford City DZ

The resulting Climate Action Plan for the Waterford City Decarbonisation Zone must define and outline a clear pathway to achieve this reduction. As part of the climate action plan the individual local authority will be responsible for reducing greenhouse gas emissions from across its own assets and infrastructure, whilst also taking on a broader role of influencing and facilitating others to meet their own targets. This is necessary to ensure the environmental, social and economic benefits that come with climate action can be fully realised.

Waterford City Decarbonisation Zone in conjunction with Waterford City & County Council must demonstrate alignment with the key principles of the Local Authority Climate Action Planning Guidelines to ensure that the local authority climate action plan is: **Ambitious, Action-focused, Evidence-based, Participative** and **Transparent.**

Appendix A - Assumptions and Limitations

Local Authority Waterford City DZ

- Data for the municipality was gathered from the Monitoring & Reporting System; this is updated manually and can give rise to human error.

Commercial

- There are no energy benchmarks available in Ireland for commercial properties, so a CIBSE UK Guide was used; this was based on numerous surveys in the UK for different commercial property types.
- Most of the benchmarks used by CIBSE are outdated; some surveys data back to 1992, which might not reflect the energy usage nowadays.
- All energy figures used are 'Typical Practice' figures as described by CIBSE.
- Retail energy use is based on sales floor area, therefore no energy was allocated for storage or back of house uses.
- All offices are taken as 'naturally ventilated open plan', as described in CIBSE.
- Hairdressing/salons are taken as 'high street agencies', due to their higher energy use when compared to 'general retail'.
- Any properties without a specific property use are taken as 'general retail'.
- An 80% space efficiency was assumed for conversion from net internal area to gross internal area.
- All treated floor area to gross floor area conversions were based on a 95% conversion factor, given by CIBSE for 'Offices Naturally Ventilated'.
- National breakdown of fossil fuel and electricity had to be used due to lack of data in CIBSE, as energy figures in CIBSE were either fossil fuel or electricity.
- Data from the Valuation Office is subject to human error, as the area figures are input manually.

Residential

- Location of dwellings in the BER database are in terms of postcodes; this is done to preserve the identity of the homeowners. However, there are certain cases were a postcode might overlap, that is, a postcode might be common for more than one local authority area. This might result in certain.
- BERs that are in other local authority regions to be used for statistical averages for other local authority areas, as they share a common postcode.
- BER certificates are only required if a house is being sold, let, is a new build, or has had an energy grant from SEAI. This results in a database that is not completely representative of all housing.
- The BER dataset does not differentiate between different users and their energy use, nor does it account for energy use by appliances, as it is an 'asset'-based rating rather than a 'user' rating.

Transport

- The NTA model is based on the Census publications. When this report was produced, the Census 2016 data was not available to the NTA and therefore the main data used for this research was Census 2011.
- The fleet makeup was taken from Northern Ireland's databases, and it is assumed that the fleet makeup in Ireland will remain the same as the Northern Irish fleet.
- Fuel split (petrol/diesel) of vehicles will remain unchanged over time.
- It was assumed that no improvement in vehicle emission technology will be achieved, therefore future emissions will be overestimated.
- Output emissions from links take into consideration emissions from traffic at a standstill at the end of links, and thus the estimate of average link speeds would be lower, as this junction delay is accounted for.
- Emissions were not adjusted to take into account the gradient links.

Agriculture

- The agricultural sector in Ireland has very little data publicly available and as such, approximate energy use was based on the best available data.
- 2020 Census of Agriculture was used as the closest year to 2018 – the baseline year for this Tier 3 analysis.
- Due to privacy protection concerns, any electoral division (ED) containing less than ten farms are not included in the CSO data breakdown. This may include some double-

counting for farms which border two EDs and again may vary slightly for each local authority area.

- Electricity and fossil fuel benchmarks developed by Teagasc were obtained for tillage crops; however, there were no fossil fuel data for livestock.
- Energy consumed in tillage farms are essentially for grain drying purposes, even in a relatively dry year.

Waste

- Waste and wastewater emissions are integrated together.
- A benchmark of waste related carbon emissions was obtained on a per capita basis from the EPA 2018 report and population figures of 2016 Census.

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