FINGAL BASELINE EMISSIONS REPORT
2016

Comhairle Contae Fhine Gall
Fingal County Council

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

codema Dublin's Energy Agency

Report prepared by Codema on behalf of Fingal County Council, with support from the Sustainable Energy Authority of Ireland.

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Table of Contents

Executive Summary

Codema conducted this analysis in order to advance energy and CO_2 emission baseline methodologies in Ireland, so that they may be replicated by other local authorities. This report follows on from Codema's summary report 'Dublin Region's Baseline Emissions Inventory 2016', which was funded under the Sustainable Energy Authority of Ireland (SEAI), Research, Development and Demonstration (RD&D) 2017 programme.

This baseline report aims to raise awareness of climate change and the impact that different sectors in the Dublin region have on Ireland's overall carbon emissions. It provides local authorities with the necessary information to make decisions on climate change actions to lower the county's carbon emissions.

This is a county-wide baseline and will be used as part of Fingal County Council's Climate Change Action Plan, which details the actions that are planned in order to curtail energy consumption and CO_2 emissions in the Dublin region. This assessment is part of the commitment that the Dublin Local Authorities (DLAs) have as signatories to the European Union's Covenant of Mayors for Climate and Energy Initiative. This involves the monitoring of county-level energy consumption and CO_2 emissions and reporting on the progress of energy and emission actions which affect the local authority area.

The baseline year for this analysis is 2016, except for transport, which was based on 2012 data from the National Transport Authority (NTA) and projected up to 2016. The sectors that have been included in this analysis are: residential, commercial, transport, municipal, social housing, agriculture, waste, and wastewater.

It was found that the total emissions from various sectors in Fingal total the equivalent of 1,976,200 tonnes of CO_2, which is equivalent to 6.7 tCO_2eq per capita. The sectors that produced the most emissions were transport, residential and commercial, producing 44%, 26%, and 25%, respectively, of the total emissions in Fingal. From this analysis, these three sectors should be the main targets of energy and emission initiatives.

Codema also calculated the total energy use in Fingal to be 7,153 gigawatt hours (GWh). This energy figure excludes energy use from waste and wastewater since a total CO_2 equivalent was estimated for these sectors. It may be noted that energy from renewables only contributed 1.6% to the total fuel mix in Fingal. Of this renewable energy, 1.2% came from biomass sources.

Residential

- Total residential emissions were 514,400 tonnes of CO_2 in 2016
- Total delivered energy for the residential sector in Fingal for 2016 was 1,991 GWh
- 60% of the housing stock was rated C3 or better, with C2 being the most common rating
- Semi-detached houses made up 46% of the total housing stock, followed by detached houses (21%), apartments (17%) and terraced houses (16%)
- Apartments were the least carbon intensive type of housing, emitting 3.85 tCO_2/apartment
- Detached houses were the most carbon intensive type of housing, emitting 9.06 tCO_2/detached house
- 53% of residential emissions came from natural gas, and 31% from electricity

Commercial

- Total emissions in 2016 were 484,900 tonnes of CO_2, 315,000 tonnes of CO_2 from the services sector and 169,800 tonnes of CO_2 from the industrial sector
- Total final energy used in 2016 by the commercial sector was 1,638 GWh
- Industrial uses (61%), retail (13%), hospitality (9%) and offices (6%) contributed the most to CO_2 emissions
- Hospitality and retail (warehouses) held the highest emissions per property, 303.0 tCO_2 and 203.5 tCO_2 respectively
- Utility, miscellaneous uses and offices had the lowest emissions per property, 5.93 tCO_2, 14.99 tCO_2 and 23.42 tCO_2, respectively

Transport

- Total final emissions from transport were 878,800 tonnes of CO_2
- Total energy use in transport was 3,365 GWh
- Fingal's modal split was made up of private and commercial transport (51%), public transport (31%), cycling (13%) and walking (5%)
- Fingal's transport emissions mainly come from diesel (75%), followed by gasoline (25%), electricity (0.2%) and LPG (0.1%)

Social Housing

- Total final emissions from social housing were 15,100 tonnes of CO_2 in Fingal
- Total delivered energy in 2016 was 63 GWh for social housing in Fingal
- 75% of the social housing stock in Fingal was rated C3 or better, with C2 being the most common BER
- Social housing units in Fingal were apartments and terraced houses, making up 5% and 95%, respectively, of the total social housing stock
- Apartments were the least carbon intensive type of housing, emitting 3.1 tCO_2 per apartment
- Houses were the highest emitters per dwelling, emitting 3.2 tCO_2/house
- 73% of total social housing CO_2 emissions in Fingal were found to be from natural gas, followed by electricity, 24%

Municipal

- Total final emissions produced by Fingal County Council in 2016 were 12,600 tonnes of CO_2
- Total final energy used in 2016 in FCC was 33 GWh
- Public lighting was the largest consumer of energy in the municipality, making use of 42% of the total energy consumption
- Public lighting contributed 52% of total emissions in FCC, followed by buildings/ facilities (35%), and municipal fleet (13%)
- FCC's carbon emissions, 76% came from electricity, 13% from diesel and 11% from natural gas

Agriculture

- Total agriculture-related emissions in Fingal were 23,100 tonnes of CO_2eq in 2016
- Total energy use in 2016 was 37 GWh
- GHG emissions produced by livestock contributed 53% to total emissions, followed by crops (22%), horticulture (16%) and energy related emissions from livestock (9%)
- 75% of emissions produced by livestock came from enteric process, made up methane and nitrous oxide

Waste

- Total emissions from landfills in Fingal were estimated at 28,200 tonnes of CO_2eq
- Methane made up 85% of total CO_2eq emissions in landfills

Wastewater

- Total emissions from wastewater in Fingal was 6,800 tonnes of CO_2eq
- Wastewater emissions per person per annum were estimated to be 23 $KgCO_2$eq

Introduction

Codema has produced the following report on behalf of Fingal County Council (FCC), and outlines the methodologies and results of Fingal's energy use and emissions in different sectors.

Codema has conducted this analysis, in order to advance energy and CO_2 emission baseline methodologies in Ireland, so that they may be replicated by other local authorities. This report follows on from Codema's summary report 'Dublin Region's Baseline Emissions Inventory 2016' which was funded under the Sustainable Energy Authority of Ireland (SEAI), Research, Development and Demonstration (RD&D) 2017 programme.

This baseline report aims to raise awareness of climate change and the impact that different sectors in Fingal have on Ireland's overall carbon emissions and energy use. It provides FCC with the necessary information to make decisions on climate change actions to lower the county's carbon emissions in the areas they have responsibility for.

Context

Climate Change Challenges

Climate change is widely recognised as the greatest environmental challenge of our time. The evidence of this can be seen globally: in Ireland this is demonstrated by rising sea levels, extreme weather events and changes in the eco-system.

A multitude of evidence and research-based reports have shown an irrefutable indication that greenhouse gas (GHG) emissions are responsible for climate change, and it is imperative to act now in order to reduce the amount of irreversible damage caused by these emissions.

The Intergovernmental Panel on Climate Change (IPCC) stated that GHG emissions have increased by 70% between 1970 and 2004, due to human activity (IPCC, 2007), meaning that human activity is the driving factor for climate change.

Ireland has committed to reduce its emissions by the year 2020 and 2030 (relative to 2005 levels). The significance of the Dublin region in the Irish economy means that it is imperative to plan and, commit to energy saving and CO_2 reductions at a local and regional level, in order to meet national level targets from a bottom-up approach.

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). 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.

The National Transport Authority (NTA) conducted National Travel Surveys in 2014 and found that 67% of domestic travel conducted by Irish residents in 2014 was in the Dublin region. Therefore, cities are one of the main sources of carbon emissions and may be the solution to leading a low-carbon economy and sustainable future.

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 county's competitiveness, and a more sustainable economy.

Changes in the Irish economy

Ireland experienced a deep economic recession between 2008 and 2011, which led to significant changes in economic activity. The downturn had an effect, as later analysed, on energy in all sectors, particularly in commercial and transport. The unemployment rate rose by 221%, when compared to 2006 levels (Central Statistics Office, 2011). Energy consumption per household also fell by 18% from 2006 levels (SEAI, 2013).

The economic recession also had an adverse effect on the amount of equity available in the public and private sector to invest in energy-saving and renewable energy projects.

Since 2011, Ireland has been slowly recovering from the recession, with unemployment figures decreasing from 295,700 at the start of 2011 to 172,900 at the end of September 2016. This represents a reduction of 41% in unemployment (Census 2011, 2016).

GDP and construction have both increased nationally, by 5.1% and 15.1% respectively, when compared to

2015 (Census 2016). Activity in Irish roads and infrastructure is once again growing.

All the evidence from national surveys points towards a growing economy that is still, however, recovering from an economic recession.

Energy and Emission Targets

2020 Energy & Emission Targets

The EU has set out targets for 2020 for all its member states. The 2020 targets for climate change and energy are:

- 20% increase in energy efficiency
- 20% of energy to be supplied by renewables
- A reduction of 20% in greenhouse gas emissions from 2005 levels

Different targets are given to different countries, depending on their energy use and amount of renewables. Therefore, the overall 2020 target for Ireland is 16% of total final energy use to come from renewable energy. This target will have to be reached by making use of renewable energy in electricity, transport and energy for both heating and cooling.

2030 Emission Reduction Targets

The 2030 Emission Reduction Targets were set by the Covenant of Mayors for Climate and Energy, of which FCC is a signatory. The 2030 target is a 40% reduction in emissions from the baseline year.

The Covenant of Mayors for Climate and Energy is a voluntary initiative made by local and regional authorities, which will implement EU targets, namely the 40% GHG reduction target by 2030. All EU states which are signatories to the CoM share the common goal of decarbonising their countries or regions by 2050. Signatories are also expected to integrate approaches to tackle climate change through mitigation and adaptation, and to increase their ability to adapt to the impacts of climate change.

Emission Sectors

This section outlines the methodologies used to update and estimate the energy consumption and associated CO_2 emissions in different sectors in Fingal.

This study has been conducted for different energy-consuming and GHG-emitting sectors for the year 2016, namely residential, commercial, transport, social housing, municipal, agriculture, waste and wastewater.

2016 was chosen as the baseline year, mainly due to the 2016 national Census. The national Census is the base of most of the methodologies developed by Codema.

Codema analysed the data for each sector in order to identify the most suitable methodology for the calculations. This took into account the fact that these methods must be accurate, simple and easy to replicate, in order to allow regular updates in the future and to facilitate the adaptation of this methodology across Ireland. The analysis focused on the current energy demand and fuels used to provide energy, and the associated CO_2 emissions and GHG emissions related to activities (agriculture, waste and wastewater) within Fingal.

Emission Factors

Emission factors are used to convert energy use to CO_2 emissions. The emission factors are dependent on the type of fuel used, as different fuels have different emission factors. For example, renewable energy sources like photovoltaics would have an emission factor of zero; this means that the total energy from renewables, when converted to CO_2 emissions, would yield no emissions. In other words, if energy use in a sector remains the same, but more energy is supplied by renewable energy, then the emissions in that sector will be lower than if the energy was sourced from fossil fuels, or non-renewables. Table 14 found in Appendix B - Emissions lists all the different types of fuels and their corresponding emissions.

Figure 1 below illustrates the emission factors for different fuel types. It should be noted that electricity has the highest emission factor, as it has the highest emissions in $kgCO_2$ for every 1 kWh of energy use.

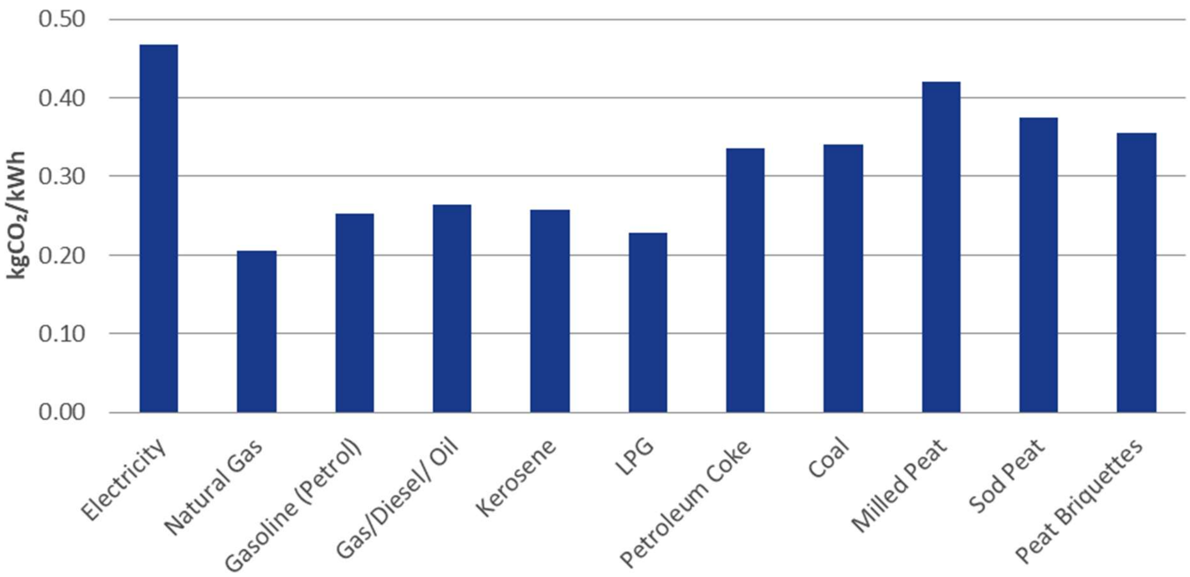

Figure 1 Emission Factors for Different Fuel Types

Residential

This section looks at the emissions arising from the residential sector. It excludes social housing units, as social housing is analysed separately in the Social Housing Section.

In Ireland, the residential sector accounted for 24% of overall energy consumption in 2015 (SEAI, 2016). Nationally, this is the second largest energy user after transportation, thus monitoring energy use and emissions in this sector is crucial.

Methodology

This methodology is based on two main data sources: Census 2016 and the Building Energy Rating (BER) Research Tool.

The Census data for the entire Fingal residential sector was provided by the Central Statistics Office (CSO). This data was broken down into: location, type of housing and period built. This was then applied to the averages calculated from the BER database, which were broken down into four dwelling types and seven periods, providing a total of 28 subsets. Residential units were broken down into:

- Detached
- Semi-detached
- Terraced
- Apartments

This breakdown allows a higher level of accuracy when applying the averages to all housing.

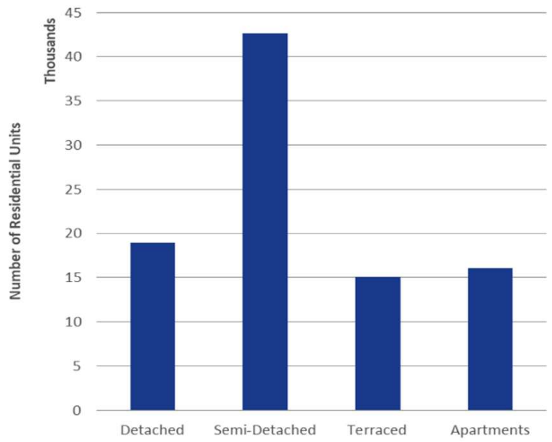

Figure 2 Total Number of Residential Units in Fingal

The BER Research Tool was developed by SEAI and is used in this analysis for the calculation of energy required for normal use of space heating, hot water, ventilation and lighting per metre squared area of a residential unit. The final energy rating given to a household is in kWh/m^2/year and an energy efficiency scale from A to G. It also provides an insight into other data, such as type of household, year of construction, location, floor area and fuel use.

The BERs analysed in this report were broken down by location and included the BERs pertaining to Fingal. This was done by filtering the data by postcode and was then broken down further by type of dwelling (detached, semi-detached, terraced and apartments) and period built. These categories were defined as such to match the information available from the Census for the entire residential housing stock in Fingal. As can be seen in Figure 3, there is a high representation of BERs for each housing type.

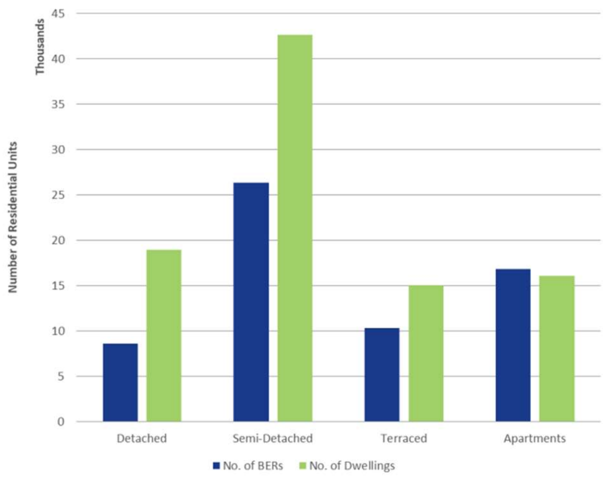

Figure 3 Representation of Fingal's Residential Households in BER Database

The drawback of the BER is that a certificate is only required if a house is being sold or rented out after January 1st 2009. This means that it will not give a complete representation of all the housing stock in Fingal. However, the Dublin region will have a higher percentage of sales and rentals than any other region, especially given the current housing and rental market. In Fingal, Codema analysed a total of 61,953 BERs.

A disadvantage of using the BER as a main dataset is that it does not differentiate between different users and their energy use and does not account for electrical energy used by appliances. This is because the BER is an asset-based rating rather than an operational rating. A detailed list of assumptions and limitations may be found in Appendix A - Assumptions & Limitations.

Analysis

At a regional level, the number of dwellings constructed in 2016 accounted for 5% of total residential units in Fingal. This is a 6% decrease in residential construction when compared to the period between 2006 and 2011. This reduction in construction is directly related to the economic recession in 2008, as the construction industry was one of the worst to be affected.

As can be seen from Figure 4 below, the majority of residential units were built in the period between 1971 and 1990. From 2001 onwards, apartments were the main type of housing built.

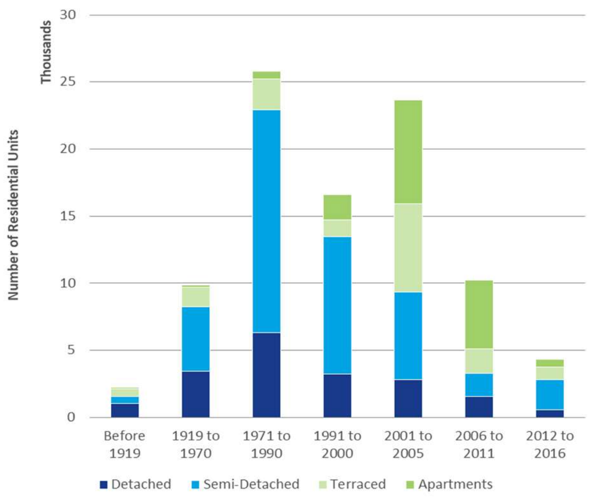

Figure 4 Fingal's Total Residential Stock by Type and Period Built

In 2016, the largest share of residential units were semi-detached houses, making up 46% of the total residential housing stock in Fingal. This was followed by detached houses (21%) and apartments (17%), whilst the lowest share of housing type were terraced houses, comprising 16% of Fingal's housing stock.

Fingal's residential sector emitted a total of 514,400 tonnes of CO_2 in 2016. Figure 5 depicts the total emissions by different dwelling types. Semi-detached houses had the highest emissions, accounting for 222,600 tonnes of CO_2. This was followed by detached houses, terraced houses and apartments, all of which contributed to 171,300, 61,900 and 58,600 tonnes of CO_2, respectively, of the total residential sector emissions in 2016.

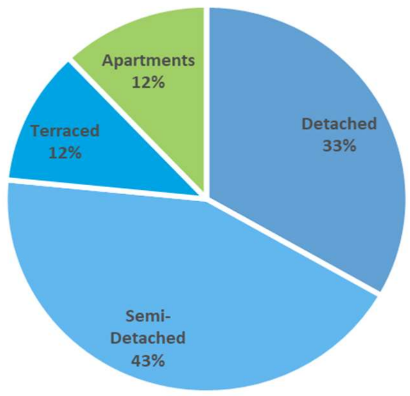

Figure 5 Fingal's Residential Emissions by Dwelling Type

Figure 6 below shows the share of emissions produced by the different types of dwellings and the corresponding number of residential units.

It can be seen that apartments had the least emissions per unit, at 3.85 tCO_2 per apartment. This was followed by terraced, semi-detached and detached houses, emitting 3.90, 5.22 and 9.06 tonnes of CO_2 per dwelling, respectively.

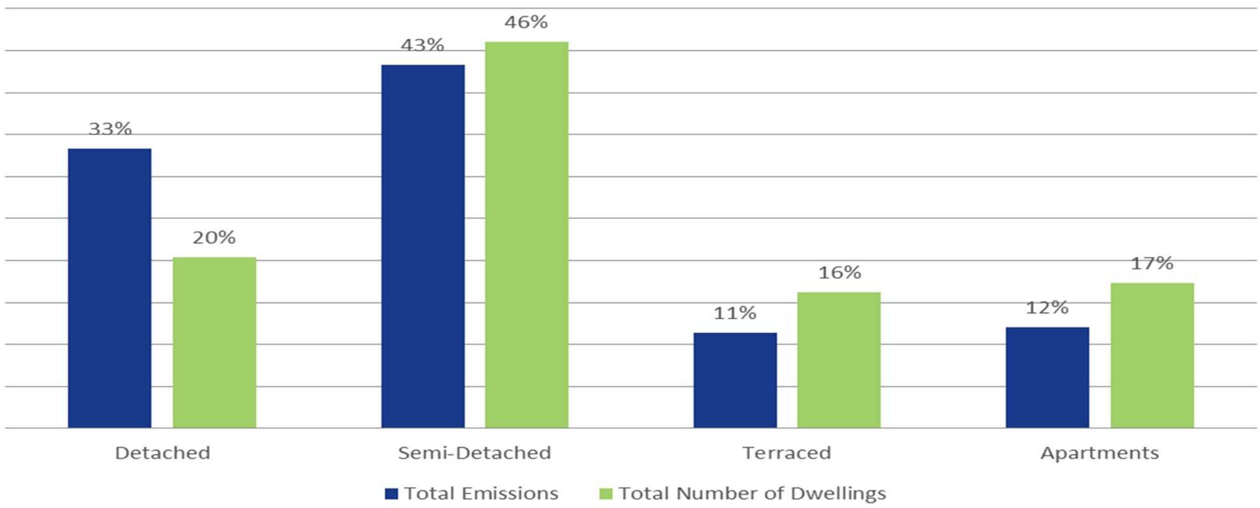

Figure 6 Share of Total Emissions and Number of Residential Units for Each Housing Type

Therefore, in terms of CO_2 per unit apartments performed the best, while detached houses performed the worst.

The reasons for these findings are that apartments have less exposed areas, when compared to detached or semi-detached houses. They are also the type of dwellings which have been built most recently, resulting in more efficient buildings due to modern materials and new building energy regulations. Detached, semi-detached and terraced houses make up the majority of the housing stock built before 2001 in Fingal.

Figure 7 shows the total emissions for the residential sector in Fingal, grouped by fuel and dwelling type.

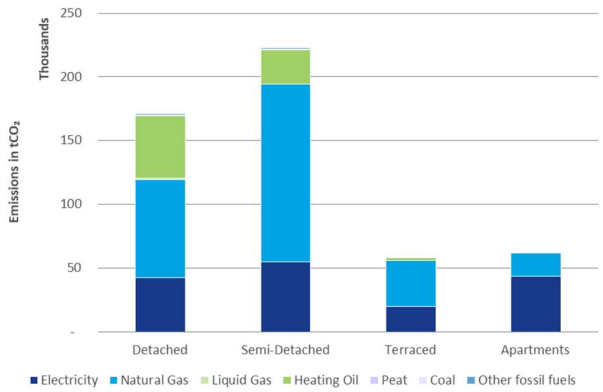

Figure 7 Total Emissions in tCO_2 in the Residential Sector by Fuel Mix and Dwelling Type

The highest emissions in the residential sector came from natural gas and electricity, which contributed 53% and 31% respectively. There was very little peat and coal used in the residential sector, only contributing to 0.11% of total emissions. Other fossil fuels include multi-fuel stoves that have no particular specified fuel for use, accounting for 0.5% of total residential emissions.

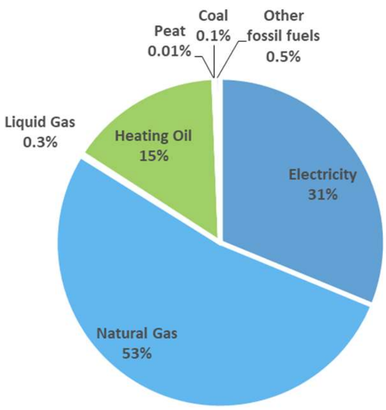

Figure 8 Share of Total Emissions in the Residential Sector by Fuel Type

Total energy use in Fingal's residential sector was 1,991 GWh. The residential fuel split mainly came from natural gas, which made up 67% of the total energy use in Fingal, due to the density of the gas grid in this region. Electricity was the second highest fuel in demand, making up 17% of the fuel mix, followed by heating oil, at 15%.

Total renewable fuels only accounted for 0.1% of the final energy consumption. The majority of this came from biomass sources (mainly wood).

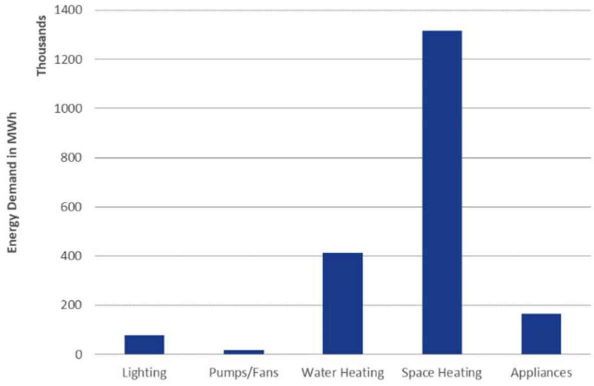

Figure 9 Residential Energy Demand in MWh in Fingal

Figure 9 shows the total final energy use broken down into the different energy demand areas. Most of the energy used was for space heating. Space heating had by far the highest energy demand, accounting for 66% of the total. This is followed by water heating at 21%. Heating overall in the residential sector has the highest energy demand by far and creates potential for heat recovery from waste heat and district heating, as a way of catering for this high heat demand. Lighting and pumps/fans are the least energy intensive, making up just 4% and 1% of the total demand, respectively.

Figure 10 shows the percentage of low energy lighting, analysed from the BER research tool, and broken down by house type and period built.

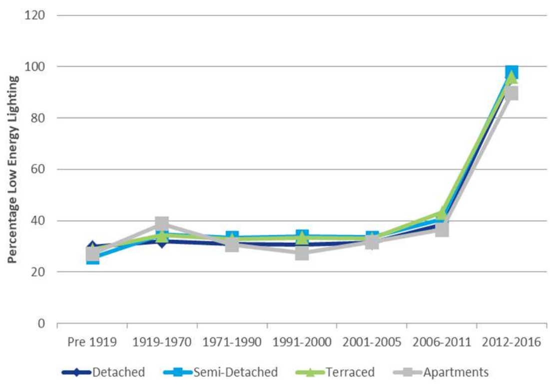

Figure 10 Percentage of Low Energy Lighting by Building Type and Period Built

The overall average percentage of low energy lighting in Fingal's residential sector was 37%, with newer built dwellings having higher levels. The highest percentage is found in newly built semi-detached houses, with 98% of these having low energy lighting. This shows that there is still room for improvement for the other dwelling types.

Figure 11 and 12 show the total building energy ratings (BERs) for all residential housing in Fingal, after the averages for each dwelling type and period built were applied to the entire housing stock. The most common rating was C2, making up 15% of the area's residential housing. 60% of residential units in 2016 were C3 or better. The majority of better ratings (i.e. A and B ratings), came from newly built or refurbished apartments.

There were 4,173 A rated residential units in Fingal, of which 3,809 units were apartments. Three of these A rated units were A1 rated in 2016.

The residential housing stock in Fingal is ageing, and as a result, newly built or refurbished dwellings would generally perform better.

6% of the housing stock was F or G rated, mainly comprising of detached and semi-detached houses that were constructed in the period between 1919 and 1990.

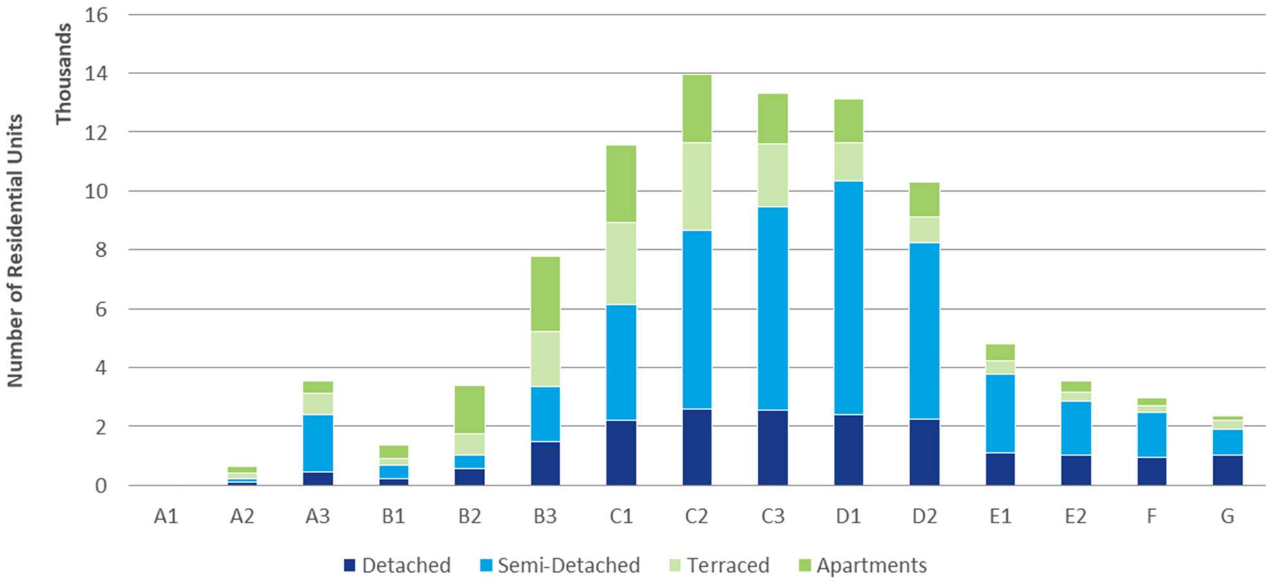

Figure 11 Building Energy Ratings for all the Fingal's Residential Stock by Dwelling Type

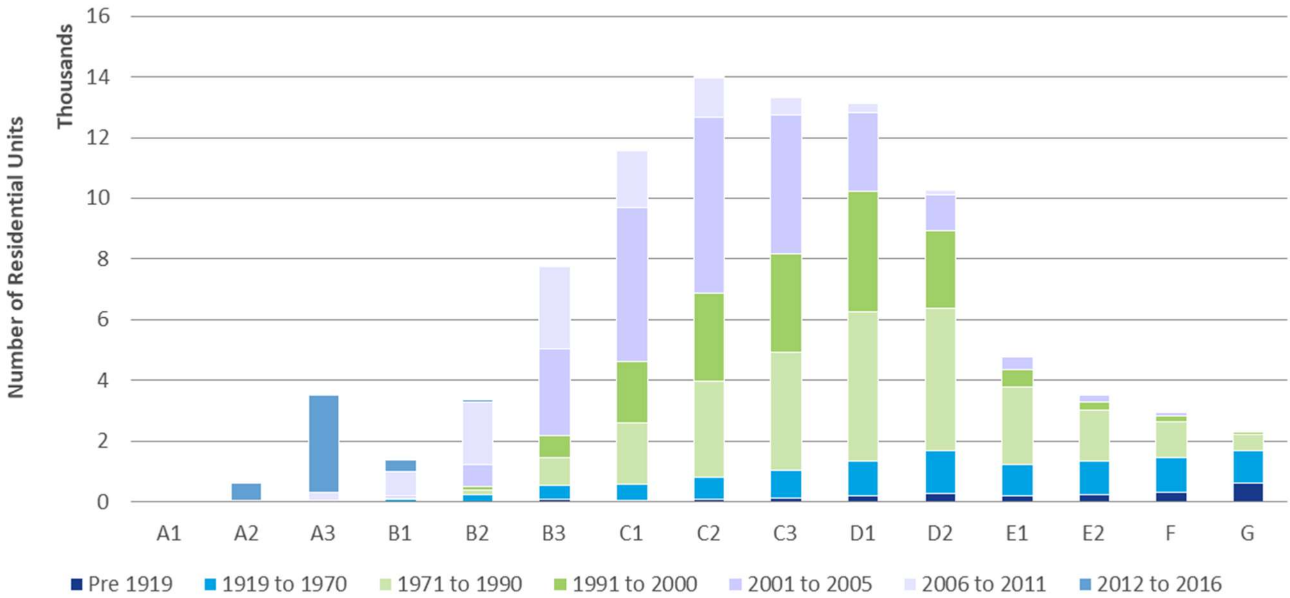

Figure 12 Building Energy Ratings for all Fingal's Residential Units by Construction Period

Key Findings

- Total residential emissions were 514,400 tonnes of CO_2 in 2016
- Total delivered energy for the residential sector in Fingal for 2016 was 1,991 GWh
- The majority of residential units were constructed between 1971 and 1990
- Apartments were the least carbon intensive type of housing, emitting 3.85 tCO_2/apartment
- Detached houses were the most carbon intensive type of housing, emitting 9.06 tCO_2/detached house
- Residential developments constructed between 2012 and 2016 made up 5% of the total housing stock
- 60% of the housing stock was C3 rated or better, with C2 being the most common rating
- Semi-detached houses made up 46% of the total housing stock, followed by detached houses (21%), apartments (17%) and terraced houses (16%)
- Semi-detached houses produced 43% of total residential emissions in Fingal, followed by detached houses, apartments and terraced houses, which made up 33%, 12% and 12% respectively, of total residential emissions
- 53% of residential emissions came from natural gas, and 31% from electricity
- Space heating had the highest energy demand in the residential sector, at 66% of total energy demand
- The highest percentage of low energy lighting was for newly built semi-detached houses at 98%
- 67% of the residential fuel mix was made up of natural gas, followed by electricity (17%) and heating oil (15%)

Table 1 Fingal's Residential Inventory; Energy and CO2 Emissions

Residential Sector	Electricity	Fossil Fuels					Renewable Energies		Total
		Natural Gas	Liquid Gas	Heating Oil	Peat	Coal	Other Fossil Fuels	Biofuel	Other Biomass	
Detached (MWh)	90,674	376,568	4,560	191,343	74	578	5,110	-	1,108	670,014
Semi-Detached (MWh)	117,588	680,127	1,020	104,529	77	838	3,897	-	427	908,503
Terraced (MWh)	42,108	177,323	108	8,688	-	182	1,142	-	26	229,578
Apartments (MWh)	93,037	89,039	80	425	-	-	73	3	5	182,662
Total Energy (MWh)	**343,407**	**1,323,058**	**5,768**	**304,985**	**151**	**1,597**	**10,222**	**3**	**1,565**	**1,990,756**
Detached (tCO_2)	42,390	77,083	1,046	49,175	26	197	1,349	-	-	171,266
Semi-Detached (tCO_2)	54,973	139,222	234	26,864	28	285	1,028	-	-	222,634
Terraced (tCO_2)	19,686	36,298	25	2,233	-	62	301	-	-	58,605
Apartments (tCO_2)	43,495	18,226	18	109	-	-	19	-	-	61,868
Total Emissions (tCO_2)	**160,543**	**270,830**	**1,323**	**78,381**	**54**	**544**	**2,698**	**-**	**-**	**514,372**

Commercial

The commercial sector includes both the services and the industrial sector. The changes in the Irish economy, briefly described in the introduction, have had a large impact on commercial activity in Ireland. As the Irish economy recovers, new businesses are once again emerging across the Dublin region.

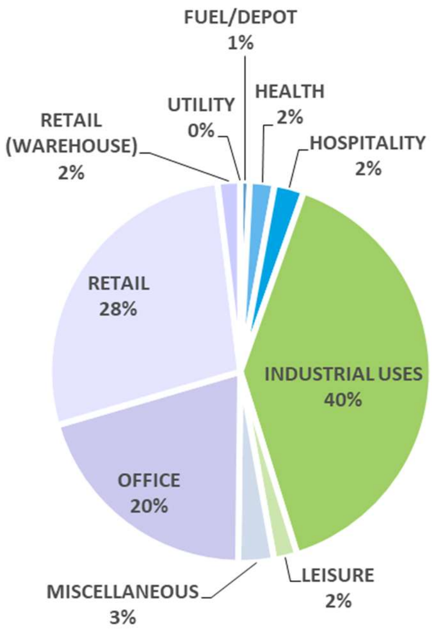

Figure 13 Fingal's Commercial Properties by Category

Over three quarters of Fingal's commercial properties can be categorised as industrial uses, retail and offices.

Methodology

The methodology used for the calculation of the commercial baseline includes two main data sources - data from the Valuation Office and energy consumption benchmarks from the Chartered Institution of Building Services Engineers (CIBSE).

The Valuation Office provided a list of all the commercial properties and their respective floor areas in Fingal. These properties were also broken down into different categories, type of use, and location.

Currently, there is no energy data available for commercial properties, as there is no formal energy reporting required. Therefore, in order to assign energy use to each property, Codema used energy benchmarks from the UK CIBSE Guide F: Energy Efficiency and TM46 (CIBSE, 2012). These sources provide typical energy usage per square metre of floor area for different business categories, amalgamated from numerous UK surveys. A detailed list of assumptions and limitations may be found in Appendix A - Assumptions & Limitations.

Codema matched the property uses provided by the Valuation Office with the building descriptions given in the CIBSE guides. The floor areas listed by the Valuation Office were based on the different business requirements. This can be found in the Valuation Office's Code of Measuring Practice (Valuation Office Ireland, 2009). If the measured floor area from the Valuation Office did not match that in the CIBSE guides (gross floor area to net floor area), then a conversion factor was applied. Codema then applied energy figures to all the commercial properties, depending on their use. There were over 230 different property types listed in Fingal.

The CIBSE energy figures are only split into either fossil fuels or electricity. Therefore, due to a lack of data at a local level, the 2011 national breakdown of fossil fuels and electricity for energy use in the industrial sector was used instead (SEAI, 2012). However, this presents a limitation, as it is not an accurate representation of fuel use in the commercial sector in the Dublin region.

The advantage of using CIBSE energy benchmarks is that they are based on a large sample set, and as Irish building regulations follow the UK regulations, the energy figures are applicable in the Irish context. There are certain limitations, however; climate in the UK is more severe than in Ireland and can affect results when applied to the Irish sector. Most of the benchmarks used by CIBSE guides are outdated, with some surveys dating back to 1992. Therefore, these figures might not reflect energy efficiency measures and buildings complying with new building regulations.

Analysis

The different commercial property categories outlined in this section are:

- Fuel/Depot
- Health
- Hospitality
- Industrial Uses
- Leisure
- Miscellaneous
- Office
- Retail
- Retail (Warehouse)
- Utility

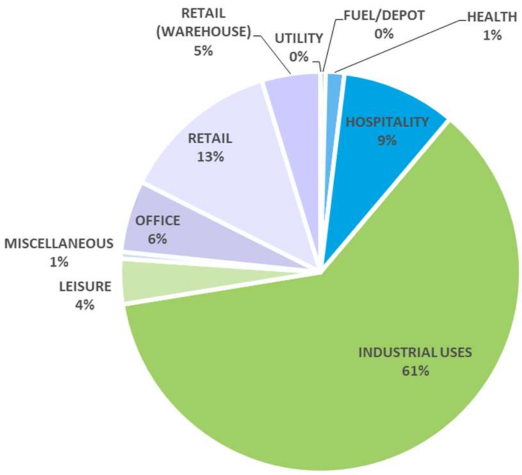

Figure 14 Commercial Emissions by Property Category in Fingal

Total emissions from the commercial sector in 2016 were calculated at 484,900 tonnes of CO_2.

As can be seen from Figure 14, the commercial properties that produced the most emissions were:

- Industrial uses: 297,100 tCO_2
- Retail: 62,200 tCO_2
- Hospitality: 44,800 tCO_2
- Offices: 28,100 tCO_2

Figure 15 gives an indication of emissions in comparison to the number of buildings for different commercial properties in Fingal.

Industrial uses, retail, hospitality and offices are the main CO_2 emitters, as altogether they made up 89% of the commercial sector's emissions. From this analysis, these four categories should be the main targets of energy and emission reduction initiatives within the commercial sector.

By comparing buildings of different uses to their total emissions and number of businesses in each category, a clearer picture can then be gained of the businesses with the highest and lowest emissions per property.

When comparing emissions to the number of commercial properties, hospitality and retail (warehouse) sectors had the highest shares of emissions, at 303 tCO_2 and 203.5 tCO_2 per building, respectively. Conversely, utility, miscellaneous uses and offices had the lowest emissions per commercial property, at 5.93 tCO_2, 14.99 tCO_2 and 23.42 tCO_2, respectively.

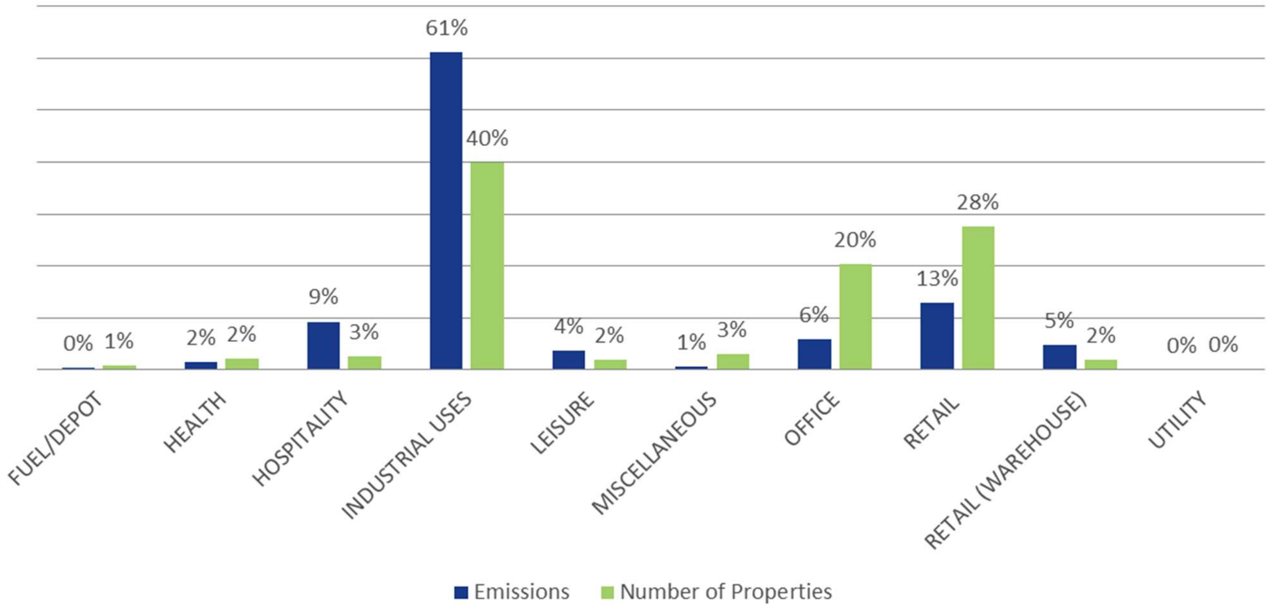

Figure 15 Share of Total Emissions and Number of Commercial Properties in Fingal

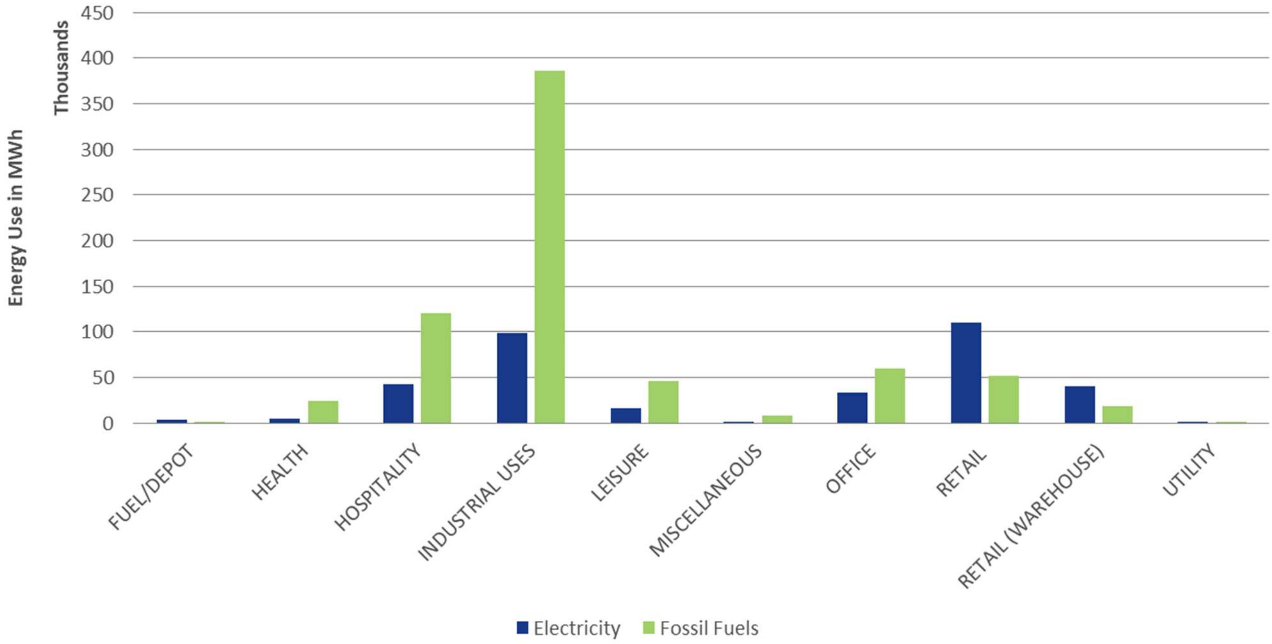

Figure 16 Fingal's Electricity and Fossil Fuel Use in MWh in the Commercial Sector by Category

Figure 16 shows the electricity and fossil fuel consumption of commercial buildings by category. These figures are representative of the CIBSE energy benchmark fuel breakdown. Industrial uses held the highest share of fossil fuels, at 54%, while retail had the highest share of electricity use (31%).

The high electricity consumption figure for retail could be due to the widespread use of electric air heating/cooling ventilation systems, and the high volume of lighting required in retail units.

CIBSE only breaks down fuel use into fossil fuels and electricity. However, for this study, the fuel use has been further broken down using the SEAI national fuel split for the services and industrial sectors.

Services Sector

The biggest energy users in the services sector are:

- Hospitals
- Hotels
- Large entertainment theatres

In the case of the services sector, Codema calculated the electricity use using CIBSE energy figures. The remaining energy split is based on national figures, as there is currently no data available specifically for the Dublin region.

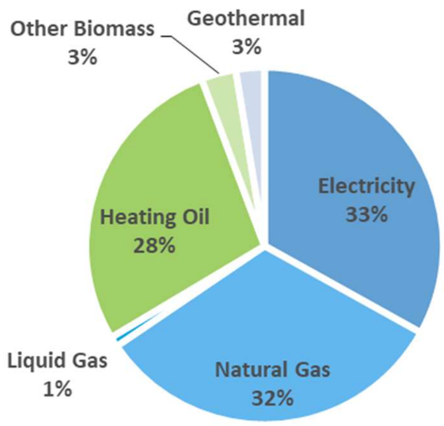

Figure 17 Percentage Energy Use in Fingal's Services Sector

The total energy used by the services sector was calculated at 1,069 GWh. This energy mostly came from electricity (354 GWh) and natural gas (347 GWh). Heating oil also had a high energy use in the services sector, making up 297 GWh of the total energy mix.

Renewables contributed to 61.5 GWh of the total fuel mix, split into 33.7 GWh of biomass and 27.8 GWh of geothermal energy.

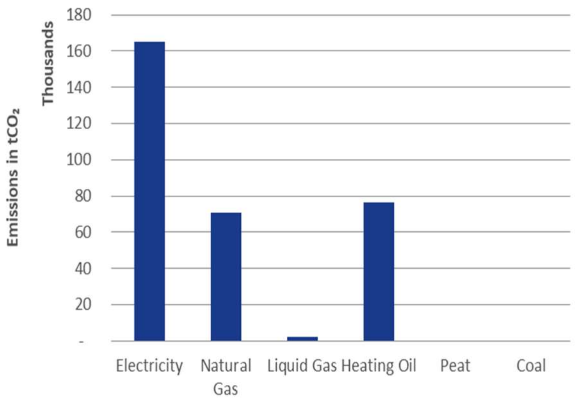

Figure 18 Total Emissions in the Services Sector in tCO_2

Fingal's services sector emitted a total of 315,000 tonnes of CO_2 in 2016. Figure 18 shows that the highest emissions were from electricity (52%), heating oil (24%) and natural gas (23%) in the services sector.

Industrial Sector

Industrial buildings and their processes consume a high share of both electricity and fossil fuels. The main industrial property uses in Fingal are:

- Factories
- Stores
- Workshops
- Warehouses

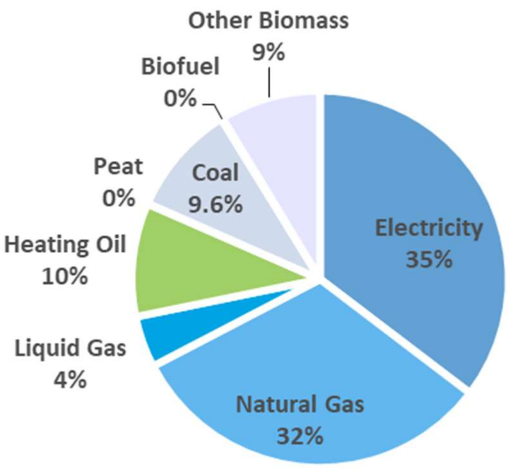

Figure 19 Percentage Energy Use in the Industry Sector

The total energy used in the industrial sector was 568 GWh. Electricity (201 GWh) and natural gas (182 GWh) accounted for the main share of this energy use. The industrial sector had a high use of renewables, with biofuel and biomass making up 50 GWh of the total fuel mix.

Total emissions from the industrial sector were 169,800 tonnes of CO_2 in 2016. As can be seen from Figure 20, electricity accounts for the largest share of the total emissions (55%), followed by natural gas at 22%. Coal and heating oil also produce significant emissions, contributing 11% and 9% to the total, respectively.

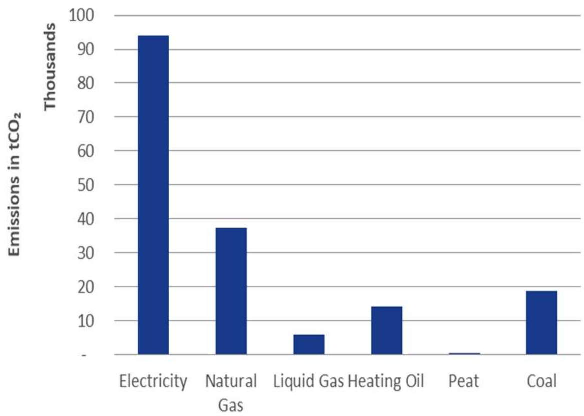

Figure 20 Total Emissions in the Industrial Sector in tCO_2

Electricity and natural gas were the main energy sources for both the services and the industrial sector. However, as the statistics used on the fuel split were not specific to the Dublin region, gas would probably hold a larger share in reality, due to the prevalence of the gas grid in the county.

Key Findings

- Total emissions in 2016 were 484,900 tonnes of CO_2 - 315,000 tonnes of CO_2 from the services sector and 169,800 tonnes of CO_2 from the industrial sector
- Total final energy used in 2016 by the commercial sector was 1,637 GWh
- Over three quarters of commercial properties were categorised as industrial uses, retail outlets and offices
- Industrial uses (61%), retail (13%), hospitality (9%) and offices (6%) contributed the most to CO_2 emissions
- Hospitality and retail (warehouses) held the highest emissions per property, at 303.0 tCO_2 and 203.5 tCO_2, respectively
- Utility, miscellaneous uses and offices had the lowest emissions per property, at 5.93 tCO_2, 14.99 tCO_2 and 23.42 tCO_2, respectively
- 31% of total commercial sector electricity was used by retail outlets
- 54% of total commercial fossil fuel was used by industrial uses
- Electricity (52%), heating oil (24%) and natural gas (23%) were the main contributors to CO_2 emissions in the services sector
- Electricity (55%) and natural gas (22%) were the highest contributors to CO_2 emissions in the industrial sector

Table 2 Fingal's Commercial Inventory; Energy and CO_2 Emissions

Commercial Sector	Electricity	Fossil Fuels						Renewable Energies			Total
		Natural Gas	Liquid Gas	Heating Oil	Peat	Coal	Other fossil fuels	Biofuel	Other Biomass	Geothermal	
Services Sector (MWh)	353,641	346,949	9,913	297,384	-	-	-	-	33,704	27,756	**1,069,346**
Industry Sector (MWh)	200,878	181,905	25,139	55,496	237	54,548	-	711	49,330	-	**568,244**
Total Energy (MWh)	**554,518**	**528,853**	**35,052**	**352,881**		**54,548**	**-**	**711**	**83,034**	**27,756**	**1,637,353**
Services Sector (tCO_2)	165,327	71,020	2,273	76,428	-	-	-	-	-	-	**315,048**
Industry Sector (tCO_2)	93,910	37,236	5,764	14,263	84	18,579	-	-	-	-	**169,837**
Total Emissions (tCO_2)	**259,237**	**108,256**	**8,037**	**90,690**	**84**	**18,579**	**-**	**-**	**-**	**-**	**484,885**

Transport

In 2014, the transport sector was responsible for the largest share of energy consumption than any other sector in the Irish economy (SEAI, 2014). The Central Statistics Office (CSO) recently published 'Census 2016, Commuting in Ireland'; which show that commuting has increased nationally, which and is in line with the changes and growth in the Irish economy.

Comparing 2016 and 2011 Census data, the number of people commuting to work in Ireland increased by 11%. Nationally, commuting by car increased by 8%, public transport rose by 21%, walking increased by 3% and cycling (which had the highest recorded increase) was up by 43% in 2016.

The national Cycle-to-Work Scheme influenced the increased number of cyclists in the country, as the scheme allows employees to claim tax relief up to 52% on the purchase of bicycles and accessories. So far, the Cycle-to-Work scheme has contributed towards 5,000 bikes in Ireland (Cyclescheme.ie, 2017).

Significant improvements have been made to the sustainability of the transport system in recent years, both nationally and at a regional level in Dublin. The national vehicle road tax system was revised, and as of July 2008, the system moved away from assessing vehicles based on their engine size to one that is based on CO_2 emissions per kilometre. In 2016, the number of new vehicles registered in Ireland increased by 17.5%, when compared to 2015 data (SIMI, 2016). Around 67% of new cars in 2014 were rated in the A band, which means that their emissions would be less than 110g of CO_2 per kilometre (SEAI, 2014).

Methodology

Codema contacted the National Transport Authority (NTA) to assess the CO_2 and GHG emissions associated with transportation in the Dublin region. The NTA provided Codema with data that included total emissions in different road links in the Dublin region and the transportation mode used. This data is a part of Appraisal Modules, which form part of the Regional Modelling System (RMS) for Ireland. A detailed list of assumptions and limitations may be found in the Appendix section.

The RMS was developed using a wide range of data sources to represent travel demand and patterns as accurately as possible. 2012 was used as the base year for the data. This is determined by the CSO Census, which is used to calculate population growth and travel patterns. The data sources used to develop the RMS may be found in the table below.

Table 3 Data Sources Used by the NTA's RMS

RMS Data Sources	
The CSO Census	Port Passenger Data
The NTA National Household Travel Survey	MyPlan Landuse Database
The GeoDirectory	Over 6,000 Traffic Counts - NTA, TII, Local Authorities Nationwide
The Valuation Office Parking data	Journey Time Data
CSO HGV Data	Automatic Vehicle Location Data for Public Transport
NTA Ticketing Data	Public Transport Surveys
NTA Airport Surveys	GTFS Public Transport Network Data
HERE Road Network Data	NAPTAN Bus Stop Database
Traffic Signal Data from a Range of Urban Traffic Control Systems	

The RMS consists of three main components:

- National Demand Forecasting Model
- Five Regional Multimodal Models
- Appraisal Modules

The **National Demand Forecasting Model** (NDFM) provides demand forecasts, which were inputted into the Regional Multimodal Model. This model makes use of planning data to predict levels of travel demand at the smallest spatial data available (known as a Census Small Area). NDFM produces an average 24-hour weekday demand, and also forecasts travel patterns for Heavy Goods Vehicles (HGVs).

The **Regional Multimodal Models** (RMM) are multi-modal network-based transport models, including all modes of transport (car, bus, light rail, rail, cycling and walking). The five Regional Multimodal Models are made up of five main cities: Dublin, Cork, Galway, Limerick and Waterford.

The NDFM produces travel demand outputs that are used in the RMM for iteration through assignment modules.

The RMM converts the 24-hour demand into time, mode and destination. In addition to typical trip behaviours (time, destination and mode), this model also includes impacts that affect decision-making, such as availability and costs of parking.

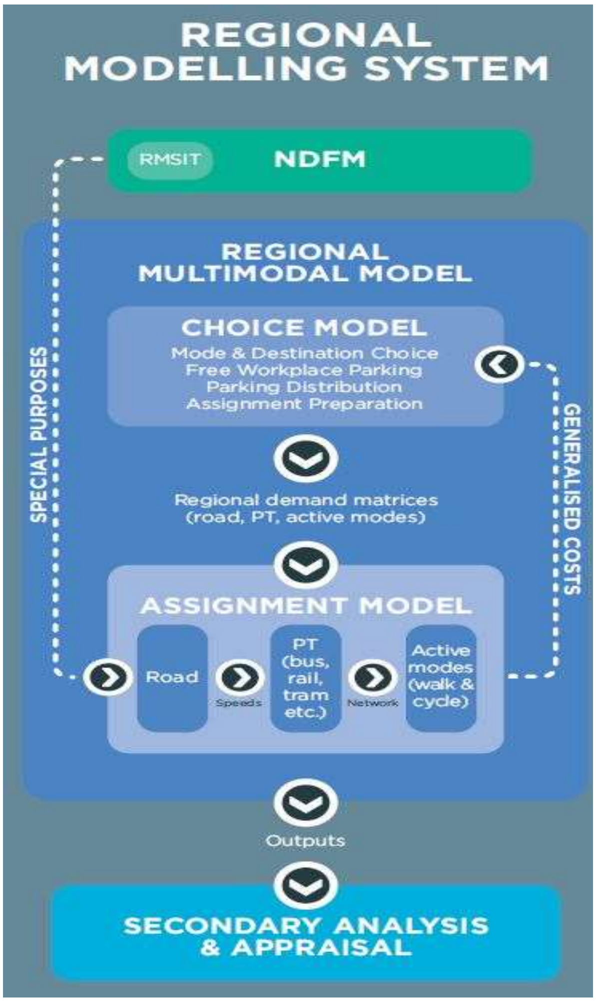

Figure 21 RMM Structure. Source : NTA, 2017

The Appraisal Modules work in conjunction with the Regional Multimodal Model, as they provide appraisal tools in line with national guidelines. This model uses RMM outputs needed to appraise schemes, policies and strategies.

The transportation model includes impacts on:

- Emissions of local air quality pollutants
- Emissions of global GHG gasses

The emissions which are estimated by the Appraisal Modules are the following:

- Nitrogen Oxides (NO_x)
- Nitrogen Dioxide (NO_2)
- Particulate Matter (PM10)
- Fine Particulate Matter (PM 2.5)
- Hydro Carbons (HC)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO_2)
- Benzene (C_6H_6)
- Methane (CH_4)
- Butadiene (C_4H_6)

The model is a Geographical Information System (GIS) based process for automating the process of calculating link proportions. The emissions tool uses three main variables to estimate emissions: fleet type, vehicle type and link type. To appraise the emissions, the software would also need the modelled year, annualisation factors to combine emissions from different time periods and speed-based emissions by vehicle type and emission category.

Emissions of all pollutants may be displayed by link (includes all the links in the model), by zone and by grid (a default national 1km^2 grid along with a used defined grid).

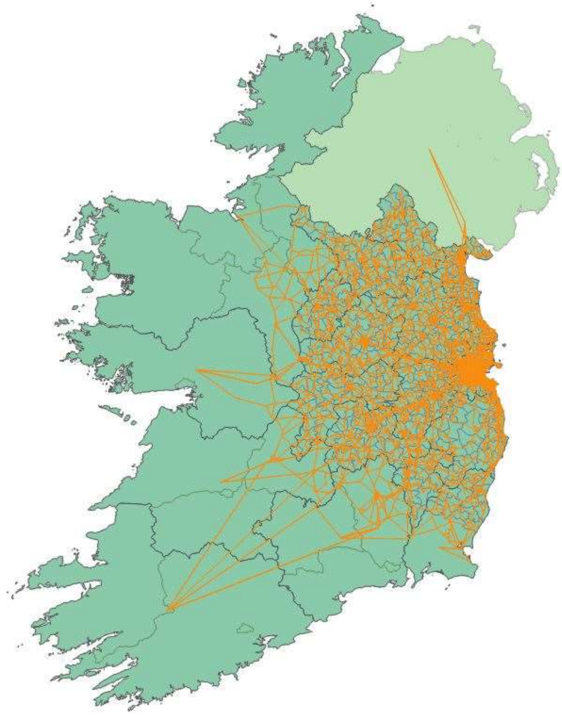

Figure 22 East Regional Model in GIS, Including all the Different Road Links

Analysis

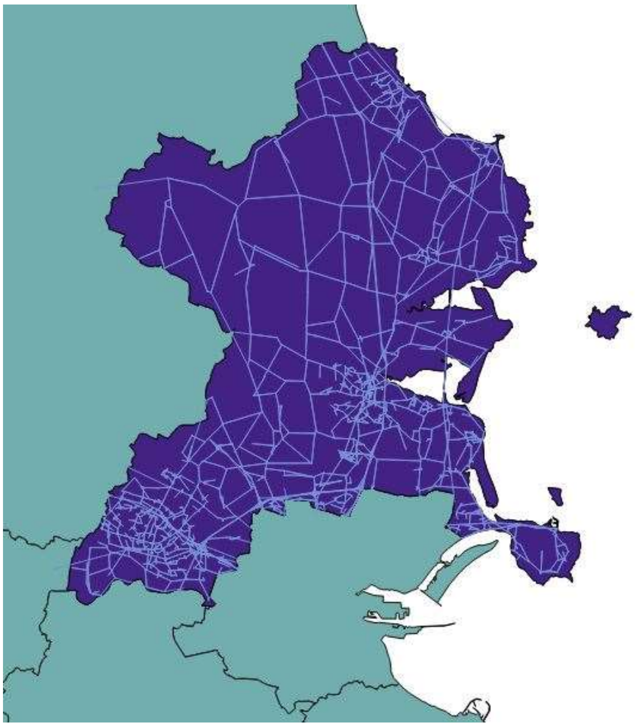

Figure 23 Fingal Road Links

From the GIS model provided by the NTA, the total GHGs were extracted for different road links in Fingal. Figure 23 above shows all the different road links in Fingal. Some road links might be located in more than one local authority area; for example, a road link might be in both Fingal and Dublin City. The road links were attributed to a local authority area depending on the length of the road link in the respective area. Road links were also attributed to Fingal if they started and ended in the local authority area.

The GIS models provided by the NTA included projections of transportation emissions and fuel mix for different transportation modes. Projections are based on the 2012 data and are projections for the year 2018 and 2035.

From the GIS model, the total GHGs were extracted and then converted to CO_2 equivalent, to find the total emissions from the transport sector.

From these projections, Codema could estimate Fingal's transport emissions for 2016, and these were also broken by different GHG emissions.

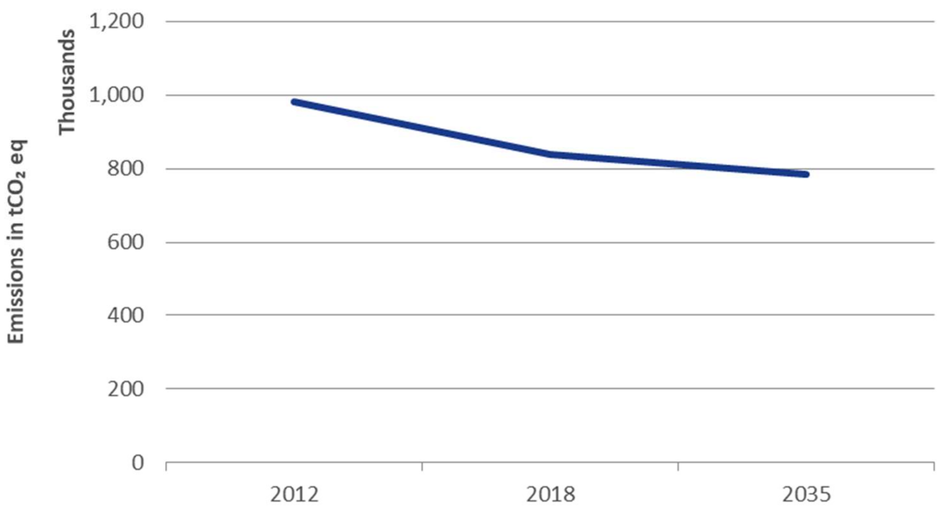

Figure 24 GHG Emission Projections for Fingal's Transport

Based on the 2012 data, the modal split for Fingal was calculated. 18% of total transportation journeys were made by cycling and walking, which have no emissions attributed to them. The rest of the county's transportation needs, 82%, were met by public transport and private/commercial transport.

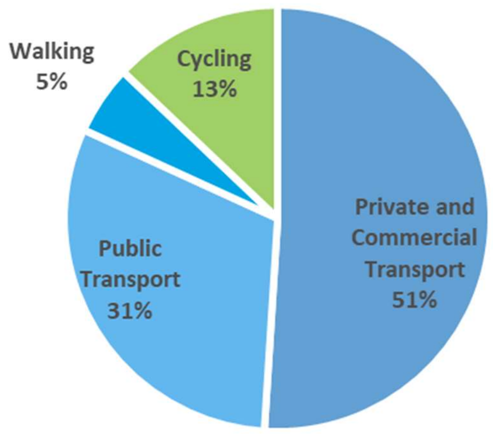

Figure 25 Fingal's Transport Modal Split in Journeys

From SEAI's Energy in Ireland 1990 – 2016, Share of Emissions in Transport a breakdown of fuel use in Ireland in 2016 was found. The 2016 fuel mix and the CO_2 emissions from the GIS maps were used to find the associated energy use from transportation.

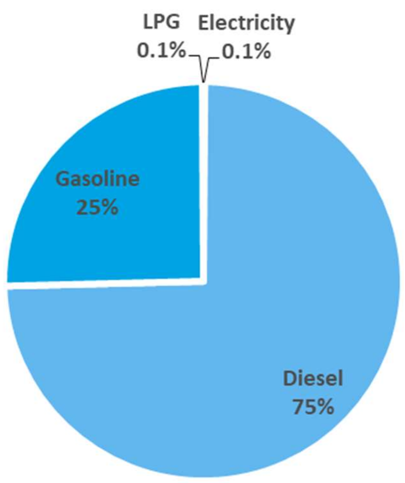

Figure 26 Fingal's Transport Energy Use

The total energy use from the transport sector in Fingal amounted to 3,365 GWh. This energy mainly came from diesel (2,508 GWh) and gasoline (852 GWh). Electricity and LPG only made up 0.2% of the total energy use, which is equivalent to 5.8 GWh.

The total emissions from transport in 2016 were 878,800 tonnes of CO_2eq, and were made up of carbon dioxide, methane and nitrous oxide.

Diesel was the main fuel source in both public and private/ commercial transport, accounting for 75% of total emissions. This was followed by petrol at 25%, and electricity at 0.2% of total emissions.

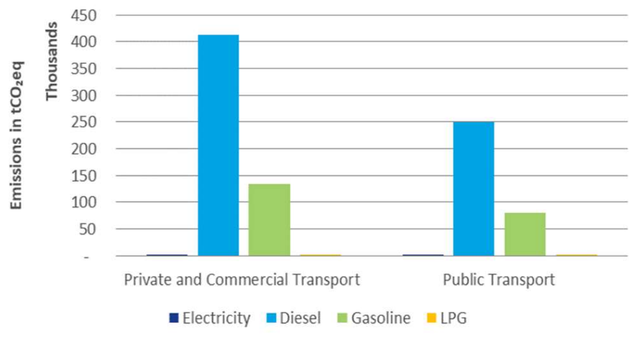

Figure 27 Fingal's CO_2 Emissions From Transportation

It is important to note that the data available in the timeframe of this report was for 2012. This report will be updated once the 2016 model is made available, including the emissions, energy use and modal split in Fingal.

Key Findings

- Total final emissions from transport were 878,800 tonnes of CO_2
- Total energy use in transport was 3,365 GWh
- Fingal's modal split was made up of 51% private/commercial transport, public transport (31%), cycling (13%) and walking (5%)
- Fingal's transport emissions mainly come from diesel (75%), followed by petrol (25%), electricity (0.2%), and LPG (0.1%)

Table 4 Fingal's Transport Inventory, Energy and CO_2 Emissions

Transport Sector	Electricity	Fossil Fuel				Renewable Energies	Total
		Natural Gas	Diesel	Gasoline	LPG	Biofuel	
Private and Commercial Transport (MWh)	2,241	-	1,562,851	530,934	1,393	-	2,097,419
Public Transport (MWh)	1,355	-	944,659	320,921	842	-	1,267,776
Total Energy (MWh)	**3,596**	**-**	**2,507,510**	**851,855**	**2,234**	**-**	**3,365,195**
Private and Commercial Transport (tCO_2eq)	1,048	-	412,593	133,795	319	-	547,755
Public Transport (tCO_2eq)	633	-	249,390	80,872	193	-	331,088
Total Emissions (tCO_2eq)	**1,681**	**-**	**661,983**	**214,667**	**512**	**-**	**878,843**

Social Housing

Fingal County Council (FCC) is responsible for the general maintenance and refurbishment of the social housing in the county. This means that much of the energy consumption and emission reductions made by Fingal's social housing stock are dependent on the upgrades and retrofitting that the local authority has carried out in recent years. The behaviour of social housing tenants is also a factor in this energy consumption, as they are responsible for the amount of energy that they consume.

Methodology

This methodology, which is similar to the residential sector's methodology, is based on two main data sources: FCC's social housing database and the Building Energy Rating (BER) Research Tool. A detailed list of assumptions and limitations may be found in Appendix A - Assumptions & Limitations.

The social housing data for the entire Fingal housing stock was provided by Fingal County Council. This data was broken down into location, type of housing, period built and energy rating (if available). This breakdown allows a higher level of accuracy, as social housing was divided into seven periods and two dwelling types, adding up to a total of 14 subsets. Social housing units were broken down into the following categories:

- Houses[1]
- Apartments

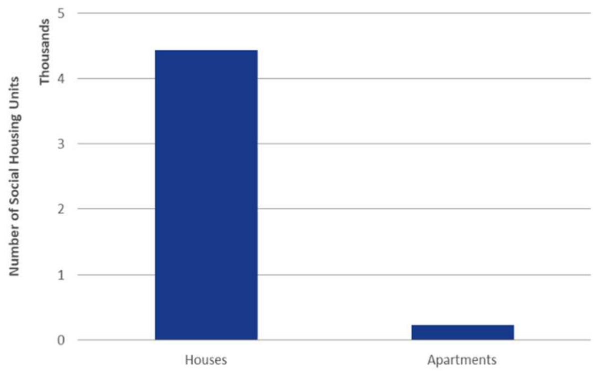

Figure 28 Breakdown of Total Social Housing Units by Construction Type in Fingal

The BERs analysed in this chapter only represent social housing. The data was filtered by postcode to obtain location-specific data for Fingal and social housing. The data was then broken down by type of dwelling (houses and apartments), period built and energy rating (A-G). These categories were defined as such to match the information available from the local authority for the entire social housing stock in Fingal. There is a high representation of BERs for each type of housing, Codema analysed a total of 3,328 BERs.

Analysis

At a regional level, the greatest numbers of social housing units were built in Fingal between 1971 and 1990. The period between 2012 and 2016 accounted for 2% of Fingal's total social housing dwellings. The decrease in the construction of social housing units over this period may be related to the economic downturn.

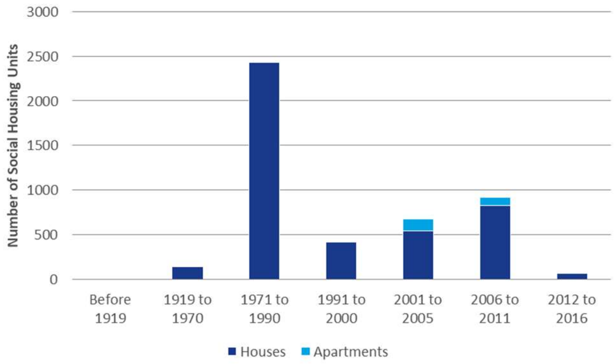

Figure 29 Fingal's Total Social Housing Stock by Type and Period Built

In 2016, the majority of social housing dwellings were houses; which made up 95% of the total social housing stock.

Total emissions from the social housing sector in Fingal amounted to 15,100 tonnes of CO_2 in 2016. Figure 30 depicts the total social housing emissions by dwelling type. Houses had the highest emissions, contributing 95% - 14,300 tonnes of CO_2 – of the total emissions. These were followed by apartments, which contributed 700 tonnes of CO_2.

[1] The term 'houses' was used to represent: detached, semi-detached and terraced houses. 'Houses' is used as the data was not broken down further into the different house types.

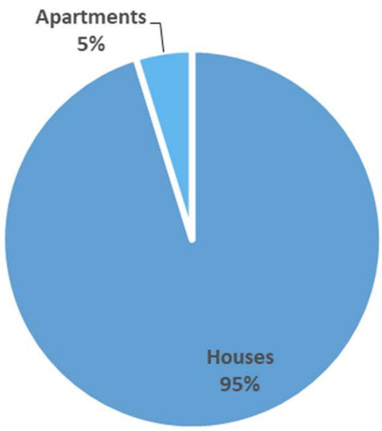

Figure 30 Fingal's Social Housing Emissions in tCO_2 by Dwelling Type

Figure 31 shows the share of emissions produced by the two different dwelling types, and their corresponding share of social housing units.

Apartments produced the least emissions per unit, at 3.1 tonnes of CO_2 per apartment. These were followed by houses, which emitted 3.2 tonnes of CO_2 per dwelling.

Therefore, from this analysis, apartments were the least CO_2 emitting type of dwelling. Meanwhile, houses produced the most CO_2 per dwelling in 2016.

Apartments are more efficient as they tend to lose less energy from the building envelope and thus produce fewer emissions. However, houses such as terraced, semi-detached and detached houses, which have more exposed areas, will tend to have higher energy losses.

As explained in the previous section, Residential Sector, apartments are also the type of dwelling that would have been recently constructed (their construction was found to be the highest in 2001-2011), using more modern building techniques and more efficient materials, and to new building regulations.

Houses, the majority of which were built in an earlier period, would result in less efficient buildings, unless they are being continuously upgraded.

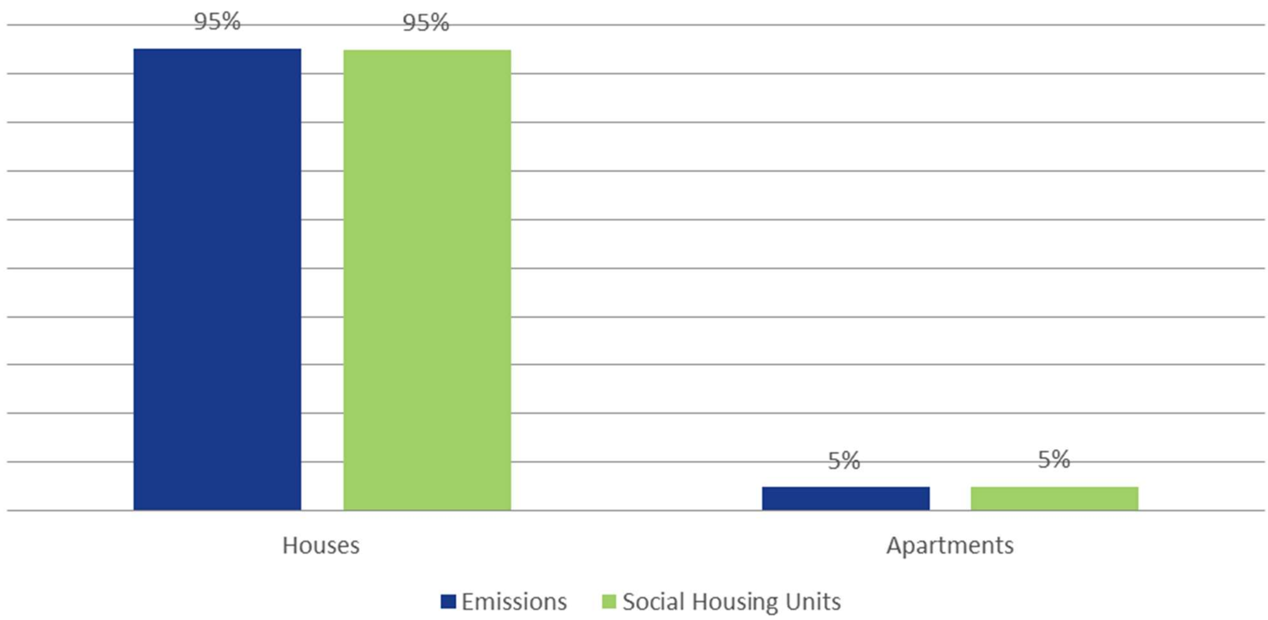

Figure 31 Share of Total Emissions and Number of Units for Each Social Housing Type in Fingal

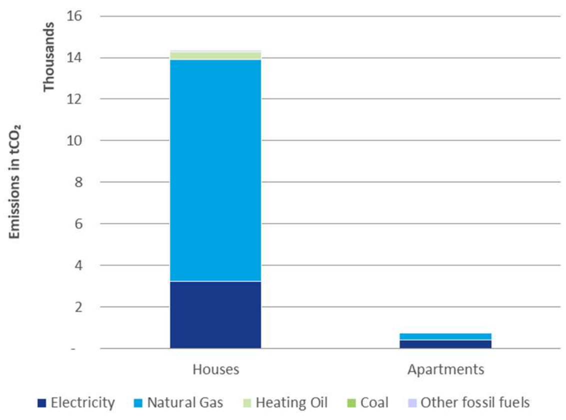

Figure 32 Total Emissions in tCO_2 in the Social Housing Sector by Fuel Mix and Dwelling Type

Figure 32 shows the total emissions for the social housing sector in Fingal, grouped by dwelling type.

As can be seen in Figure 33 below, the highest percentage of emissions came from natural gas and electricity, which accounted for 73% and 24% of the total, respectively. Heating oil, coal and other fossil fuels contributed to 3.4% of total emissions. Other fossil fuels include multi-fuel stoves that have no particular fuel specified, and account for only 0.4% of the fuel mix.

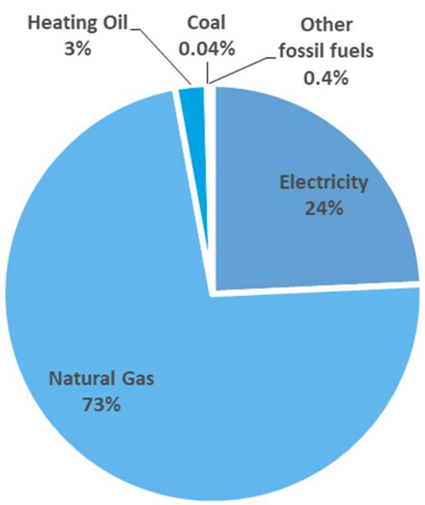

Figure 33 Share of Total Emissions from Social Housing by Fuel Type

Total energy used by Fingal's social housing sector amounted to 63 GWh in 2016. The majority of energy used in social housing was from natural gas, accounting for 85% of the total fuel use. This may be due to the density of the gas grid in the Dublin region. Electricity contributed 13% to the fuel mix, which made it the second highest type of energy used. Heating oil, coal and other fossil fuels made up 2.4% of the total energy use.

From this analysis, renewables, namely biomass, only contributed to 0.04% of the total energy used in Fingal's social housing stock.

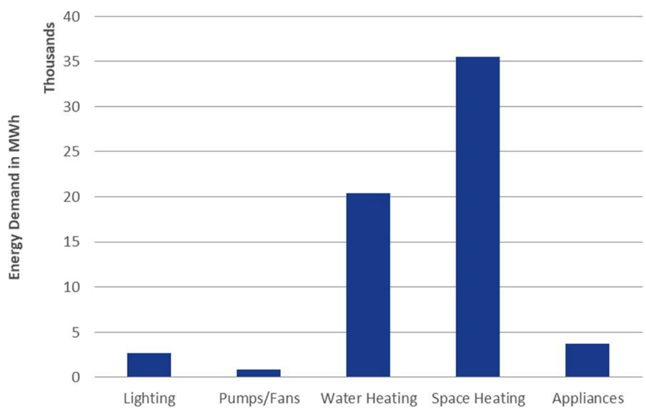

Figure 34 Social Housing Energy Demand in MWh in Fingal

Figure 34 shows that most of the energy demand was for space heating. At 56%, space heating had the highest energy demand, followed by water heating at 32%. This shows that most of the energy use is for heating generally (i.e. both space and water heating).

Lighting, and pumps/fans were the least energy intensive, making up 4% and 2%, respectively, of the total energy demand.

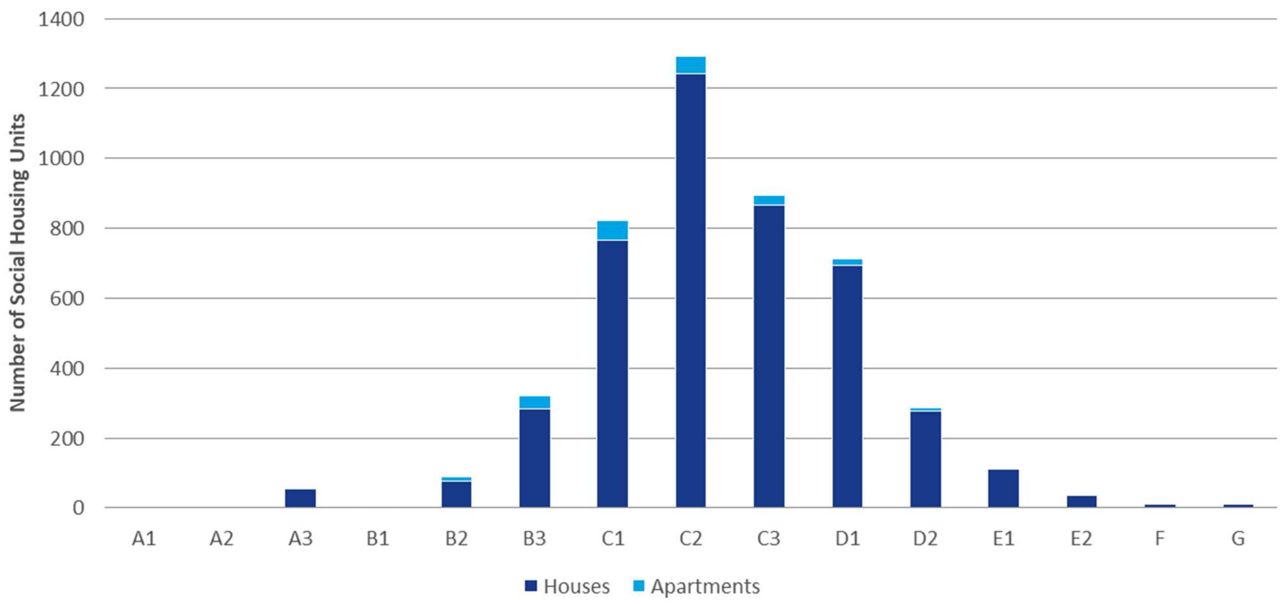

Figure 35 Building Energy Ratings for all the Fingal's Social Housing Stock by Dwelling Type

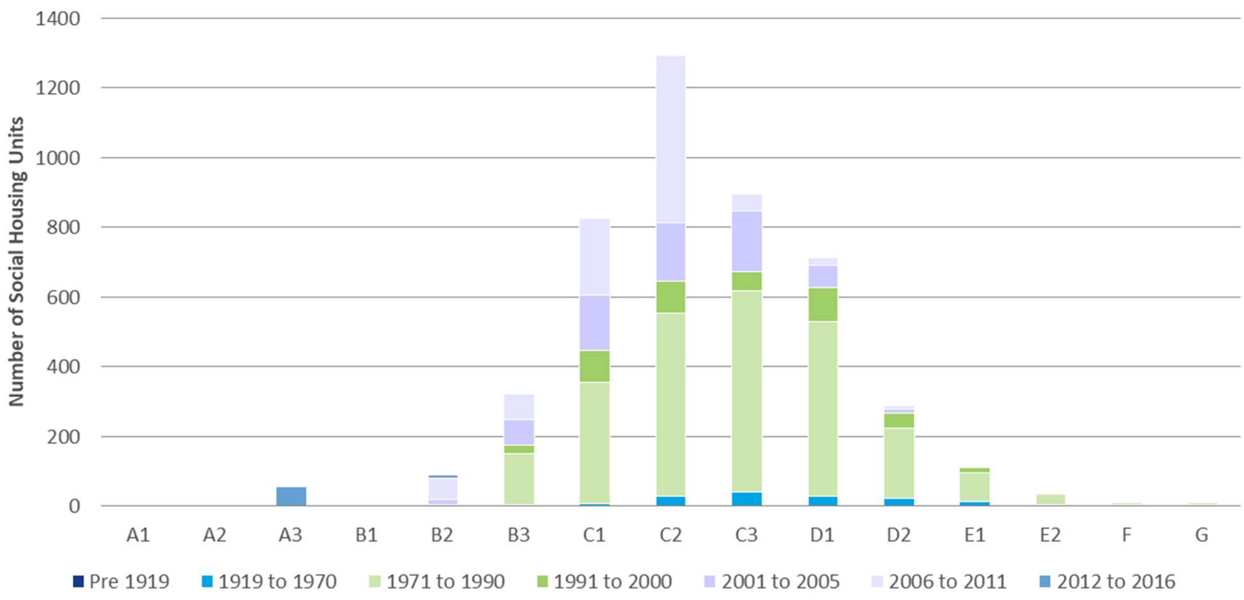

Figure 36 Building Energy Ratings for all Fingal's Social Housing Units by Construction Period

Figure 35 and 36 show the total building energy ratings for all the social housing in Fingal, for each dwelling type and period built.[2]

It can be seen that the most common rating was C2, which makes up 28% of the total social housing stock in Fingal. The majority of buildings with a C2 rating were houses constructed between 2006 and 2011. From this analysis, it was found that 75% of the social housing stock in Fingal was of a C3 rating or better. Of these, 56 houses were found to have an A3 rating; however, no A1 or A2 dwellings could be found in Fingal in 2016.

There were very few F and G rated houses; they made up less than 1% of the total social housing stock in Fingal.

[2] It may be noted that should the actual BERs for the total social housing stock in Fingal be available, then this would yield a different result. This might result in a housing stock with the most common BER being worse than the one shown in this analysis.

Key Findings

- Total final emissions from social housing were found to be 15,100 tonnes of CO_2 in Fingal
- Total delivered energy in 2016 amounted to 63 GWh for social housing in Fingal
- Construction of social housing in Fingal was the highest between 1971 and 1990
- Apartments were the least carbon intensive type of housing, emitting 3.1 tCO_2 per apartment
- Houses were the highest emitters per dwelling, emitting 3.2 tCO_2/house
- 75% of the social housing stock in Fingal were rated C3 or better, with C2 being the most common BER type
- The majority of social housing units were houses, making up 95% of the housing stock, followed by apartments (5%)
- Houses had the highest emissions, emitting 95% of total emissions, followed by apartments, which contributed 5% to total emissions
- 73% of total social housing CO_2 emissions in Fingal were found to be from natural gas, followed by electricity at 24%
- Space heating and water heating had the highest energy demand, accounting for 56% and 32%, of total energy demand, respectively
- Natural gas accounted for 85% of total energy consumption, followed by electricity at 13%

Table 5 Fingal's Social Housing Inventory; Energy and CO_2 Emissions

Social Housing	Electricity	Fossil Fuels						Renewable Energies		Total
		Natural Gas	Liquid Gas	Heating Oil	Peat	Coal	Other fossil fuels	Biofuel	Other Biomass	
Houses (MWh)	6,926	52,144	-	1,436	-	16	222	-	26	60,769
Apartments (MWh)	895	1,480	-	-	-	-	-	-	-	2,375
Total Energy (MWh)	**7,821**	**53,625**	**-**	**1,436**	**-**	**16**	**222**	**-**	**26**	**63,144**
Houses (tCO_2)	3,238	10,674	-	369	-	5	58	-	-	14,345
Apartments (tCO_2)	418	303	-	-	-	-	-	-	-	721
Total Emissions (tCO_2)	**3,656**	**10,977**	**-**	**369**	**-**	**5**	**58**	**-**	**-**	**15,066**

Municipal

Fingal County Council (FCC) is responsible for the energy use and emissions[3] from its buildings and facilities, its public lighting and its vehicle fleet.

Methodology

In Ireland, public sector bodies are required to report on their annual energy use and performance to the Sustainable Energy Authority of Ireland (SEAI). This is done through the Monitoring and Reporting system (M&R), which is used to track the local authorities' energy progress towards an energy efficiency improvement target of 33% by 2020, compared to the baseline year.

From the M&R system, Codema was able to extract the energy consumption for FCC, which 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 converted into the different energies' corresponding CO_2 emissions, which may be found in Appendix B – Emissions.

The energy use was then broken down into three categories:

- Municipal Buildings / Facilities
- Public Lighting
- Municipal Fleet

Analysis

From the results obtained from the M&R system, FCC's total energy use in 2016 was 33 GWh, of which public lighting was the highest energy consumer, accounting for 42% of the council's overall energy use. This was followed closely by municipal buildings/facilities (40%) and municipal fleet (18%).

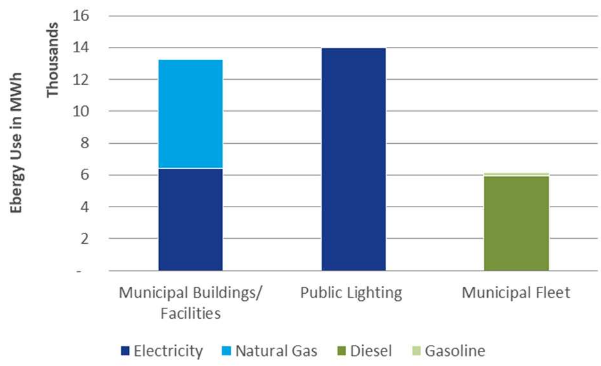

Figure 37 Energy Use in FCC Grouped by Category and Fuel Use

The highest share of fuel used by the council in 2016 was electricity (65%), followed by natural gas (20%). Diesel, which makes up most of the energy used for the vehicle fleet, contributed 18% to the total energy mix. Gasoline amounted to 1% of the total energy mix throughout the council.

When energy use was converted into emissions, the council's total emissions amounted to 12,600 tonnes of CO_2. Public lighting was the highest contributor, accounting for 52% of these total emissions. This was followed by buildings/ facilities and the municipal fleet, each contributing 35% and 13% to the council's CO_2 emissions, respectively.

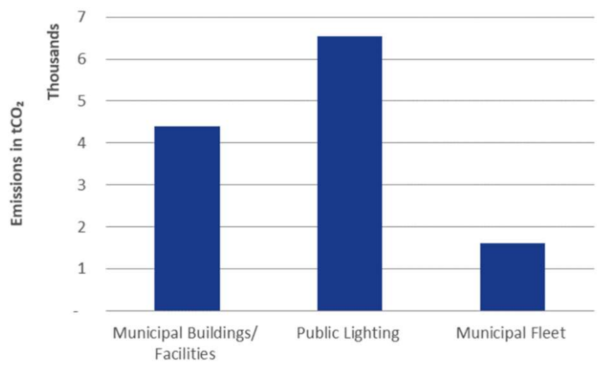

Figure 38 Emissions in tCO_2 by Sector in the Municipality

[3] The emissions from its water supply, mainly pumping water from source to the destination (residential, commercial properties, etc.) are no longer part of the municipality's remit, and have been removed. However, these emissions are still part of the county and have been included with Fingal's total emissions, which may be found in the Conclusions Chapter.

Similarly, if the local authority's energy use is converted into emissions, the highest emissions came from electricity at 76%, followed by diesel and natural gas, each emitting 13% and 11%, respectively.

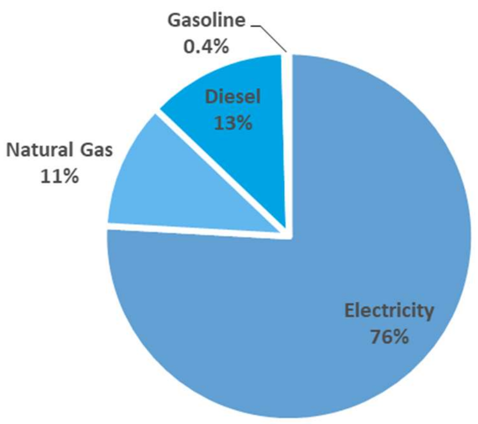

Figure 39 FCC's Emissions by Fuel Type

Key Findings

The key findings from the municipal sector are summarised below:

- Total final emissions produced by FCC in 2016 were 12,600 tonnes of CO_2
- Total final energy used in 2016 by FCC was 33 GWh
- Public lighting was the largest consumer of energy in the municipality, making use of 42% of the total energy consumption
- Public lighting contributed 52% to FCC's total emissions, followed by buildings/ facilities (35%), and municipal fleet (13%)
- FCC's carbon emissions came from electricity (76%), diesel (13%) and natural gas (11%)

Table 6 Fingal's Municipal Inventory, Energy and CO_2 Emissions

Municipal Sector	Electricity	Fossil Fuel							Renewable Energies				Total
		Natural Gas	Liquid Gas	Heating Oil		Diesel	Gasoline	Other Fossil Fuels	Biofuel	Other Biomass	Onsite Generation	Solar Thermal	
				Kerosene	Gasoil								
Municipal Buildings/ Facilities (MWh)	6,392	6,873	-	-	-	-	-	-	-	-	-	-	13,265
Public Lighting (MWh)	13,985	-	-	-	-	-	-	-	-	-	-	-	13,985
Municipal Fleet (MWh)	-	-	-	-	-	5,927	206	-	-	-	-	-	6,134
Total Energy (MWh)	**20,376**	**6,873**	**-**	**-**	**-**	**5,927**	**206**	**-**	**-**	**-**	**-**	**-**	**33,383**
Municipal Buildings/ Facilities (tCO_2)	2,988	1,407	-	-	-	-	-	-	-	-	-	-	4,395
Public Lighting (tCO_2)	6,538	-	-	-	-	-	-	-	-	-	-	-	6,538
Municipal Fleet (tCO_2)	-	-	-	-	-	1,565	52	-	-	-	-	-	1,617
Emissions (tCO_2)	**9,526**	**1,407**	**-**	**-**	**-**	**1,565**	**52**	**-**	**-**	**-**	**-**	**-**	**12,550**

Agriculture

The agricultural sector in Ireland has very little publicly-available data on the energy use and emissions of different agricultural practices.

In the Dublin region, emissions from agriculture are not as high as in other counties in Ireland. This is mainly due to the amount of built up areas in the Dublin region, compared to other counties, which have more farmland available for agricultural practices.

Methodology

Codema obtained the relevant agriculture data from the CSO Census of Agriculture. This data was broken down into the four local authority areas comprising the Dublin region, and into different agricultural activities. The agricultural activities were:

- Livestock
- Crops
- Horticulture

The Census of Agriculture provided data on numbers of livestock units for different types of livestock. The livestock included in this Census and accounted for in this report are:

- Bulls
- Dairy cows
- Beef cattle
- Rams
- Ewes
- Other sheep
- Poultry
- Pigs
- Horses

Meanwhile, crops and horticulture were presented in terms of hectares of area farmed. Crops were broken down into the categories of:

- Cereals
- Silage
- Hay

Horticulture included the following categories:

- Oilseed rape
- Beans and peas
- Maize
- Potato
- Turnip
- Beet
- Vegetables
- Fruit

This Census data was then combined with standard agricultural energy use benchmarks, as developed by An Teagasc, the UK Carbon Trust and the Department of the Environment, Food and Rural Affairs (DEFRA) in Britain. These energy benchmarks were applied to the different agricultural activities, to calculate a total energy use. The total energy use for the three different activities (livestock, crops and horticulture) was broken down into electricity, heat and mobile machinery. The energy benchmarks for livestock were in terms of related energy consumption of different livestock types broken down by energy use – i.e. electricity, heat and mobile machinery, - per livestock unit. Similarly, the crops and horticulture energy benchmarks were in terms of energy use per hectare of area farmed.

The energy use by fuel type was then converted into CO_2 emissions, which were totalled to give the total final energy related emissions from agriculture.

It is widely recognised that agriculture practices, namely the keeping of livestock, produce a large amount of GHG emissions, which may not be quantified by energy-related CO_2 emissions. These GHG emissions commonly arise from animal grazing and waste. Therefore, to quantify these emissions, emission benchmarks were obtained from Cranfield University's 2008 report '*Defra Farm Business Survey Energy Module*'. This report set emission benchmarks for different livestock types in the UK, and the emissions were further broken down into two types of GHG emitting activities:

- Enteric
- Animal Waste Management Systems (AWMS)

Enteric emissions include nitrous oxide (N_2O), as well as true enteric methane (CH_4), from grazing.

AWMS takes into account emissions from livestock housing and from animal waste management.

The emissions benchmarks were in terms of kg per head per year. Therefore, to find the emissions produced by each livestock unit, an average weight for different farm animals had to be obtained. Average livestock weights were obtained from Environmental Protection Agency (EPA) and Irish Farmers' Association (IFA) publications.

The emission benchmarks were applied to the different livestock types, to calculate the total CO_2 equivalent emissions from livestock in Fingal.

Analysis

The total energy used by Fingal's agriculture sector in 2016 was calculated at 37 GWh. This energy mostly came from diesel, which made up 78% of the sector's total fuel use. This was followed by electricity (16%), and heating oil (6%).

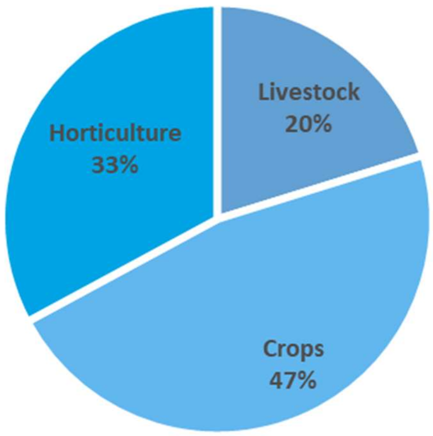

Figure 40 Energy Use by Different Agricultural Sectors

Crops were found to be the most energy intensive activity - 47% of the total energy used was for crops. Horticulture and livestock only made use of 33% and 20%, respectively.

Emissions from Fingal's agriculture sector in 2016 totalled 23,100 tonnes of CO_2eq. As mentioned in the methodology, emissions from livestock had been broken down into energy use related emissions, and emissions related to GHGs. The GHGs were then split into enteric emissions and AWMS emissions.

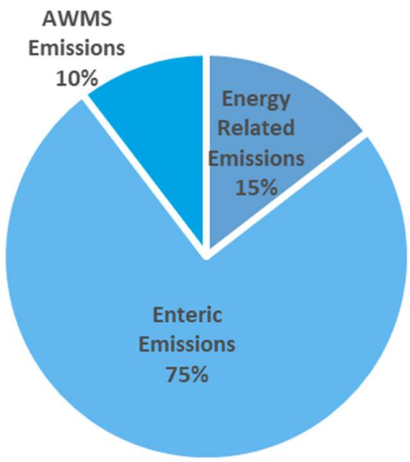

Figure 41 Breakdown of Livestock Emissions in Fingal

Figure 41 shows that 75% of Fingal's livestock emissions came from enteric emissions and were therefore made up of methane and nitrous oxide. It should be noted that only 15% of livestock emissions were energy use related.

As can be seen from Figure 42 below, which depicts the total agriculture emissions in tCO_2 equivalent, over half (53%) of Fingal's agriculture emissions were GHGs produced by livestock. This was followed by emissions from crops (22%), horticulture (16%), and energy use related emissions from livestock (9%).

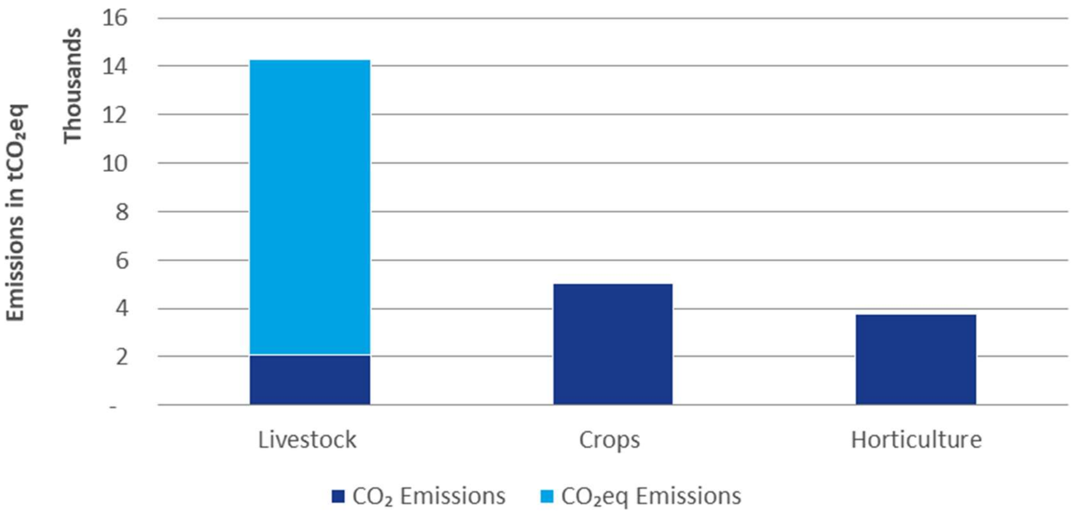

Figure 42 Total Emissions from the Agriculture Sector in Fingal

Key Findings

- Total agriculture related emissions in Fingal were 23,100 tonnes of CO_2eq in 2016
- Total energy use in Fingal's agriculture sector in 2016 was 37 GWh
- GHGs produced directly by livestock contributed 53% to total agriculture emissions, followed by crops, horticulture and energy use related emissions from livestock, 22%, 16% and 9%, respectively
- 75% of emissions produced by livestock came from enteric processes, and are made up of methane and nitrous oxide
- The energy used for agricultural activities mostly came from diesel (78%), followed by electricity (16%) and heating oil (6%)

Table 7 Fingal's Agricultural Inventory; Energy and CO_2 Emissions

Agriculture Sector	Electricity	Fossil Fuel						Renewable Energies		Total
		Natural Gas	Liquid Gas	Heating Oil	Diesel	Gasoline	Other Fossil Fuels	Biofuel	Other Biomass	
Livestock (MWh)	558	-	-	4	6,873	-	-	-	-	7,435
Crops (MWh)	2,438	-	-	2,071	12,760	-	-	-	-	17,269
Horticulture (MWh)	2,868	-	-	162	9,065	-	-	-	-	12,095
Total Energy (MWh)	**5,864**	**-**	**-**	**2,236**	**28,698**	**-**	**-**	**-**	**-**	**36,798**
Livestock (tCO_2)	261	-	-	1	1,815	-	-	-	-	2,076
GHGs from Livestock (tCO_2eq)	-	-	-	-	-	-	-	-	-	12,192
Crops (tCO_2)	1,140	-	-	532	3,369	-	-	-	-	5,040
Horticulture (tCO_2)	1,341	-	-	42	2,393	-	-	-	-	3,775
Total Emissions (tCO_2eq)	**2,741**	**-**	**-**	**575**	**7,576**	**-**	**-**	**-**	**-**	**23,084**

Waste and Wastewater

This section chapter analyses the CO_2 emissions from Fingal's landfill waste and wastewater; namely the emissions from collection, wastewater treatment and disposal.

Waste

Since 2012, government policies have focused on dealing with waste as a resource, as well as reducing or eliminating landfilling (EPA, 2017)[4]. Waste management practices currently promote the recovery of residual waste, rather than disposing of it into landfills.

In 2013, the segregation and separate collection of domestic food waste was legislated and, as a result, municipal waste recycling and composting increased. This has resulted in the reduction of landfill disposal. In the Dublin region, most landfills are inactive, and only six landfills sites are active across Ireland (EPA, 2017). Waste in Ireland consists of domestic, commercial and other waste.

Methodology

The emissions data from the Dublin region's landfills was obtained from two main data sources: the EPA's 2017 database of waste applications, licences, and environmental information, and the landfills' annual reports. A detailed list of assumptions and limitations may be found in the Appendix section.

The EPA's 2017 waste applications database provided Codema with a list of all licensed landfills in the Dublin region, listed by name and location. From their names and locations, the annual reports for each landfill can be found, which contain a Pollutant Release and Transfer Register (PRTR). The PRTR is a reporting system of emissions and lists more than 350 industrial facilities that are involved in environmentally hazardous activities. Each service or facility listed must provide information regarding the amount of pollutant it releases to air, water and wastewater.

From the PRTR of each landfill licenced in the Dublin region, Codema calculated the total emissions released into the air. The PRTR lists the different GHGs that are released annually, and these were converted into CO_2 equivalent emissions. This allowed the total CO_2 emissions from landfill to be calculated for the Dublin region. However, in order to calculate the landfill emissions for Fingal, the population number for each Dublin area was obtained from the 2016 Census of Population, and the total emissions were divided by population number for each local authority area.

Analysis

Even though most of the landfills in the Dublin region are inactive, they still emit GHG emissions to the atmosphere. Figure 43 depicts the breakdown of landfill emissions in terms of tCO_2eq, this makes them comparable and it is easier to understand their effect on emissions.

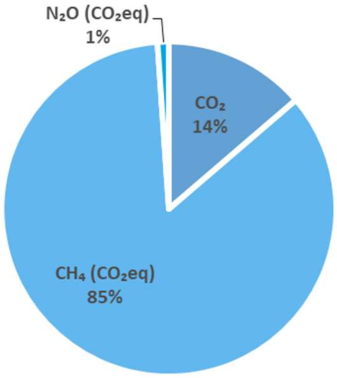

Figure 43 Landfill CO_2eq Breakdown

As can be seen from Figure 43, 85% of the landfills' GHG emissions are made up of methane gas (CH_4), and due to the toxicity of methane, their impact is much larger, even though methane might only be a small proportion of landfill emissions. Therefore, methane gas contributes to more CO_2eq gas than CO_2 does.

Table 8 Landfill Emissions in Fingal

	Total Landfill Emissions in Dublin in tCO_2eq	Total population in Dublin	Population in Fingal	Landfill Emissions in Fingal in tCO_2eq
Calculating Landfill Emissions	128,047	1,345,402	296,214	**28,192**

[4] The Waste to Energy plant began operations in Ringsend in 2017, and may affect future waste analysis.

Wastewater

As the population in the Dublin region keeps growing, the amount of waste generated also increases, as does wastewater. Currently, the wastewater treatment plant in Ringsend serves the population of the Greater Dublin Area (GDA), which includes the Dublin region and commuting towns or from Meath, Kildare and Wicklow. The increase in population and the large area covered by the treatment plant have led authorities to seek a new facility and to develop a National Wastewater Sludge Management Plan, published in 2016, to take some of the pressure off of the Ringsend facility.

Methodology

Ideally, data on emissions from wastewater would have been sourced from Celtic Anglian Water (CAW), who operates the plant at Ringsend. However, CAW was unable to provide the needed wastewater data within the timeframe of this study, and as such, a case study was used to estimate emissions from Ringsend's wastewater collection, treatment and disposal. A detailed list of assumptions and limitations may be found in Appendix A - Assumptions & Limitations.

This case study showed an example of two wastewater treatment plants (WWTPs) in Vienna, Austria, and involved a carbon footprint analysis to calculate the emissions from sewage sludge treatment, anaerobic digestion and sludge dewatering (Parravicini, et al., 2016).

Table 9 shows the emission sources from wastewater that were considered in this case study.

Table 9 Direct and Indirect Emissions from Wastewater

Emissions from Wastewater	
Direct GHG emissions	**Indirect GHG emissions**
Wastewater collection (sewer system)	Electricity supply
Wastewater treatment (WWTP)	Transportation (sewage sludge)
Wastewater discharge in water bodies	Use of chemicals & additives
	Disposal/reuse of residuals

Table 10 Wastewater Emissions in Fingal

	Emissions per capita in $kgCO_2/PE/a$	Population in Fingal	Wastewater Emissions in Fingal in tCO_2eq
Calculating Wastewater Emissions	23	296,214	**6,813**

The emissions that were considered in this study at different treatment stages were methane and nitrous oxide.

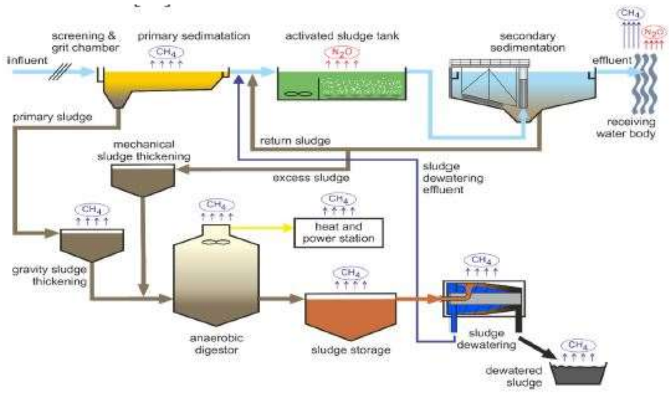

Figure 44 GHG Emissions at WWTP Source : Parravicini et al. (2016)

The carbon footprint analysis of the two WWTPs resulted in GHG emissions per population served, which were then broken down into GHG emissions per capita per annum. In a final step, the GHG emissions were then converted into CO_2 equivalents.

Comparing the findings of this case study with the Ringsend WWTP, which has similar characteristics to the two Austrian sites analysed, allowed Ringsend WWTP's CO_2 emissions to be calculated; these were found to be 23 $kgCO_2eq$ per capita, per annum.

Codema applied the CO_2 equivalent per capita to the population of Fingal, to get the total emissions in Fingal from wastewater. This is shown in Table 10 below.

Analysis

A detailed analysis of wastewater was not conducted, as the data used in this report to calculate wastewater emissions was taken from a case study and not the actual emissions from the Ringsend WWTP. Once the data is made available, a more in-depth analysis will be provided.

Key Findings

Waste

- Total emissions from landfills in Fingal were estimated to be 28,200 tonnes of CO_2eq
- Methane made up 85% of the total CO_2eq emissions from landfills
- CO_2 only contributes to 14% of the total emissions from landfills

Wastewater

- Total emissions from wastewater in Fingal made up 6,800 tonnes of CO_2eq
- Wastewater emissions per person per annum were estimated to be 23 KgCO_2eq

Table 11: Fingal's Waste Emissions Inventory

Waste Emissions in Fingal	Landfill Waste	Wastewater
Total Emissions in tCO_2eq	28,192	6,813

Conclusions

Total Energy Use & Emissions in Fingal

This section examines the energy use and resulting total emissions from the different carbon emitting sectors in Fingal.

The total energy use in Fingal amounted to 7,153 GWh in 2016. At 38%, diesel accounted for the greatest percentage of total energy consumption in Fingal. This was followed by natural gas (27%) and electricity (13%). It should be noted that energy from renewables only contributed 1.6% to the total fuel mix in Fingal. Of this renewable energy, 1.2% came from biomass sources.

The total emissions from the various sectors in Fingal were 1,976,200 tonnes of CO_2eq. Figure 46 below illustrates the total emissions by sector and fuel type; waste and wastewater were not broken down by fuel type, as the data provided was in terms of emissions.

From this analysis, Codema found that the commercial sector used the most electricity in Fingal, and had the highest emissions from electricity (58%). As explained previously, this may be due to the number of retail and industrial uses in Fingal, which both make use of a large amount of electricity as their main energy source.

The residential sector had the highest CO_2 emissions for natural gas, accounting for 69% of the total gas emissions in Fingal.

Meanwhile, the transport sector accounted for 99% of all diesel emissions in Fingal.

It should be noted that the transport, residential and commercial sectors, had the highest emissions and consumed more fossil fuels than the other sectors.

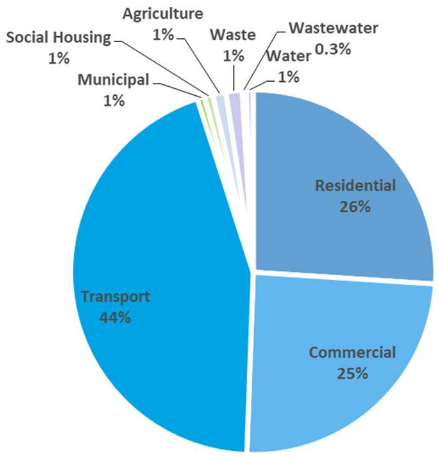

Figure 45 Share of Total Emissions in Fingal

The sectors that produced the most emissions were transport, residential and commercial, producing 44%, 26% and 25%, respectively, of total emissions in Fingal. From this analysis, these three sectors should be the main targets of energy and emission reduction initiatives.

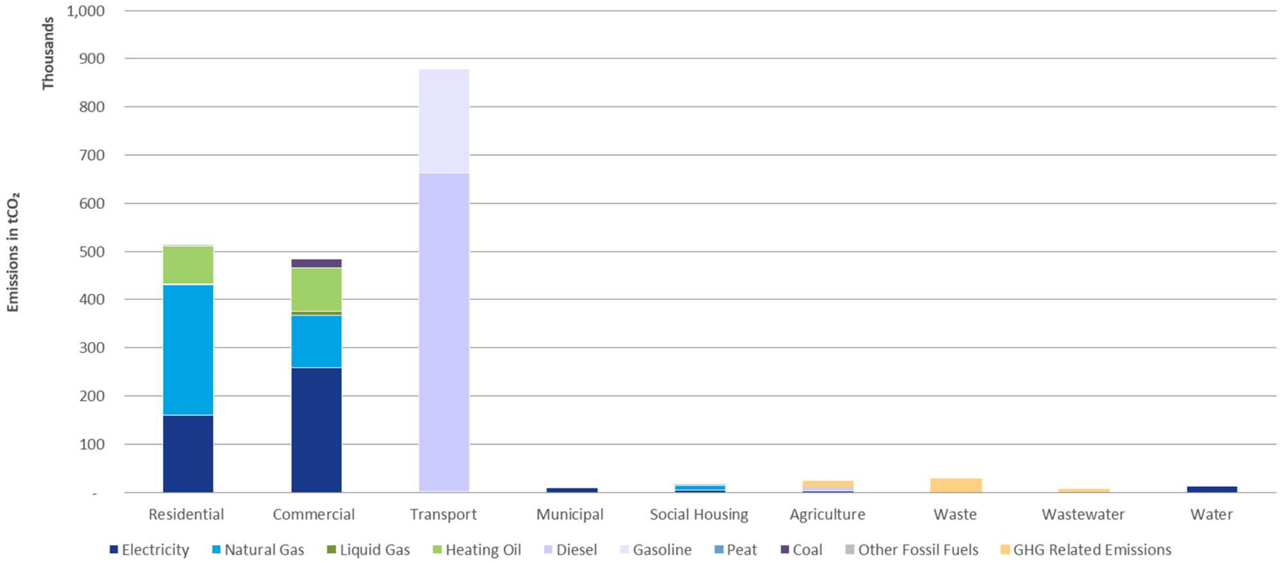

Figure 46 Total Emissions by Fuel Type in Different Sectors

Key Findings

Residential

- Total residential emissions were 514,400 tCO_2 in 2016
- Total delivered energy for the residential sector in Fingal for 2016 was 1,991 GWh
- 60% of the housing stock was C3 rated or better, with C2 being the most common rating
- Semi-detached houses made up 46% of the total housing stock, followed by detached houses (21%), apartments (17%) and terraced houses (16%)
- Apartments were the least carbon intensive type of housing, emitting 3.85 tCO_2/apartment
- Detached houses were the most carbon intensive type of housing, emitting 9.06 tCO_2/detached house
- 53% of residential emissions came from natural gas and 31% from electricity

Commercial

- Total emissions in 2016 were 484,900 tCO_2, 315,000 tCO_2 from the services sector and 169,800 tCO_2 from the industrial sector
- Total final energy used in 2016 by the commercial sector was 1,638 GWh
- Industrial uses (61%), retail (13%), hospitality (9%) and offices (6%) contributed the most to CO_2 emissions
- Hospitality and retail (warehouses) had the highest emissions per property, 303.0 tCO_2 and 203.5 tCO_2, respectively
- Utility, miscellaneous uses and offices had the lowest emissions per property, 5.93 tCO_2, 14.99 tCO_2 and 23.42 tCO_2, respectively

Transport

- Total final emissions from transport were 878,800 tCO_2
- Total energy used in transport was 3,365 GWh
- Fingal's modal split was made up of 51% private and commercial transport, 31% public transport, 13% cycling and 5% walking
- Fingal's transport emissions mainly came from diesel (75%), followed by gasoline (25%), electricity (0.2%), and LPG (0.1%)

Social Housing

- Total final emissions from social housing amounted to 15,100 tCO_2 in Fingal
- Total delivered energy in 2016 amounted to 63 GWh for social housing in Fingal
- 75% of the social housing stock in Fingal were C3 rated or better, with C2 being the most common BER type
- Social housing units in Fingal were apartments and terraced houses, making up 5% and 95% of the total social housing stock, respectively
- Apartments were the least carbon intensive type of housing, emitting 3.1 tCO_2 per apartment
- Houses were the highest emitters per dwelling, with 3.2 tCO_2/house
- 73% of total social housing CO_2 emissions in Fingal came from natural gas, followed by electricity at 24%

Municipal

- Total final emissions produced by FCC in 2016 were 12,600 tCO_2
- Total final energy used in 2016 in FCC was 33 GWh
- Public lighting was the largest consumer of energy in the municipality, amounting to 42% of the total municipal energy consumption
- Public lighting contributed 52% to total emissions in FCC, followed by buildings/facilities (35%), and municipal fleet (13%)
- 76% of FCC's carbon emissions came from electricity, followed by 13% diesel, and 11% natural gas

Agriculture

- Total agriculture related emissions in Fingal were 23,100 tCO_2 in 2016
- Total energy used in 2016 was 37 GWh
- GHGs directly produced by livestock contributed 53% of total agricultural emissions, followed by crops (22%), horticulture (16%) and energy use related emissions from livestock (9%)
- 75% of emissions produced by livestock came from enteric processes, and consisted of methane and nitrous oxide

Waste

- Total emissions from landfills in Fingal in 2016 amounted to 28,200 tCO_2eq
- Methane made up 85% of total CO_2eq emissions from Fingal's landfills

Wastewater

- Total emissions from wastewater in Fingal were 6,800 tCO_2eq
- Wastewater emissions per person per annum were estimated to be 23 $KgCO_2eq$

Table 12 Fingal's Emissions Inventory; Energy and CO_2 Emissions

Fingal		Fossil Fuels									Renewable Energies				Total
	Electricity	Natural Gas	Liquid Gas	Heating Oil	Diesel	Gasoline	LPG	Peat	Coal	Other Fossil Fuels	Biofuel	Other Biomass	Onsite Generation	Geothermal	
Residential (MWh)	343,407	1,323,058	5,768	304,985	-	-	-	151	1,597	10,222	3	1,565	-	-	**1,990,756**
Commercial (MWh)	554,518	528,853	35,052	352,881	-	-	-	237	54,548	-	711	83,034	-	27,756	**1,637,590**
Transport (MWh)	3,596	-	-	-	2,507,510	851,855	2,234	-	-	-	-	-	-	-	**3,365,195**
Municipal (MWh)	20,376	6,873	-	-	5,927	206	-	-	-	-	-	-	-	-	**33,383**
Social Housing (MWh)	7,821	53,625	-	1,436	-	-	-	-	16	222	-	26	-	-	**63,144**
Agriculture (MWh)	5,864	-	-	2,236	28,698	-	-	-	-	-	-	-	-	-	**36,798**
Waste (MWh)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Wastewater (MWh)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Water (MWh)	26,551	-	-	-	-	-	-	-	-	-	-	-	-	-	**26,551**
Total Energy (MWh)	**962,133**	**1,912,409**	**40,821**	**661,538**	**2,542,135**	**852,061**	**2,234**	**388**	**56,160**	**10,444**	**714**	**84,625**	**-**	**27,756**	**7,153,418**
Residential (tCO_2)	160,543	270,830	1,323	78,381	-	-	-	54	544	2,698	-	-	-	-	**514,372**
Commercial (tCO_2)	259,237	108,256	8,037	90,690	-	-	-	84	18,579	-	-	-	-	-	**484,885**
Transport (tCO_2eq)	1,681	-	-	-	661,983	214,667	512	-	-	-	-	-	-	-	**878,843**
Municipal (tCO_2)	9,526	1,407	-	-	1,565	52	-	-	-	-	-	-	-	-	**12,550**
Social Housing (tCO_2)	3,656	10,977	-	369	-	-	-	-	5	58	-	-	-	-	**15,066**
Agriculture (tCO_2eq)	2,741	-	-	575	7,576	-	-	-	-	-	-	-	-	-	**23,084**
Waste (tCO_2eq)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**28,192**
Wastewater (tCO_2eq)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**6,813**
Water (tCO_2)	12,426	-	-	-	-	-	-	-	-	-	-	-	-	-	**12,426**
Total Emissions (tCO_2/tCO_2eq)	**449,810**	**391,470**	**9,360**	**170,015**	**671,124**	**214,719**	**512**	**138**	**19,128**	**2,756**	**-**	**-**	**-**	**-**	**1,976,229**

Appendices

Acknowledgements

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Appendix A - Assumptions & Limitations

Residential & Social Housing

- Locations 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, meaning that the postcode might be the same for more than one local authority area. This might result in certain dwellings, that are in other local authority regions to be placed in the county Fingal area as they share a common postcode
- BER certificates are only required if a house is being sold or rented. 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

Commercial

- There are no energy benchmarks available in Ireland for commercial properties. Therefore, the UK CIBSE Guide was used, which is based on numerous surveys in the UK for different commercial property types
- Most of the benchmarks used by CIBSE are outdated, with some surveys dating back to 1992. This may not reflect the energy usage of the baseline year
- All energy figures used are 'Typical Practice' figures as described by CIBSE
- The energy use in retail is based on floor area used for sales. Therefore, no energy was allocated for storage or back of house uses
- All offices are assumed as 'naturally ventilated open plan', as described in CIBSE
- Hairdressing/salons are assumed as 'high street agencies' due to their higher energy use when compared to 'general retail'
- Any properties without a specific property use were considered as 'general retail'
- 80% space efficiency was assumed for conversion from net internal area to gross internal area
- All internal 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 entered manually, which gives rise to errors

Transport

- The NTA model is based on the Census publications. When this report was produced, Census 2016 was not available to the NTA. Therefore, the main data used for this research was 2012 data provided by the NTA
- Fleet type 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
- Emissions were not adjusted to take into account the gradient links
- Projections for 2016 modal split assume that the modal split will remain the same as 2011, with the only changes being the fuel mix for the different types of transport
- Projections for 2016 GHG emissions are based on 2011 projections for 2018 and 2035
- Breakdown of emissions for the Dublin region were assumed to be the same as SEAI's 2016 Energy in Ireland 1990 – 2016, Share of Emissions in Transport

Municipal

- Data for the municipality was gathered from the Monitoring & Reporting System, which is updated manually, which may give rise to errors

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
- There are very few energy benchmarks available in Ireland. So, energy use benchmarks, developed by Teagasc, the UK Carbon Trust and the Department of the Environment, Food and Rural Affairs (DEFRA) in Britain, were used as a representation of Irish agriculture
- Throughout this sector, it has been assumed that all mobile machinery makes use of green diesel as their energy fuel, and all heating is supplied by heating oil
- Emission benchmarks used for livestock were obtained from Cranfield University's 2008 report. Thus, it has been assumed that emissions from livestock in the UK are representative of livestock in Ireland

Waste & Wastewater

- Landfill emissions were the only type of waste considered
- Wastewater emissions were gathered from a case study in Austria for a WWTP with similar properties. However, this is not the measured figure of wastewater emissions in the Dublin region, which might be slightly higher or lower than the quoted figures

Appendix B - Emissions

ETS and Non-ETS

The Emissions Trading System (ETS) was set in place by the European Union (EU) to reduce greenhouse gas emissions cost-effectively. A cap is set on the total GHG emissions that can be emitted by a company. Companies in the EU receive a set of emission allowances, or they may buy them and trade with other companies as needed. The cap is reduced over time so that the total emissions are reduced over time.

Emissions from ETS that are measured, reported and verified are carbon dioxide (CO_2), nitrous oxide (N_2O) and perfluorocarbons (PFCs). ETS sectors include:

- Power and heat generation
- Energy-intensive industry sectors, which include oil refineries, steel works and production of iron, cement, lime, glass, ceramics, etc.
- Aviation
- Shipping
- Plants above a certain size

Non-ETS sectors include:

- Agriculture
- Buildings
- Energy
- Transport
- Services
- Small industries
- Waste

GHGs Considered

The emissions considered in this study follow the Environmental Protection Agency's (EPA) report entitled *Ireland's National Inventory Report 2015*. The EPA set up an inventory of total CO_2 and GHG emissions from different sectors, as well as following the Intergovernmental Panel on Climate Change.

Table 13 GHG Emissions Considered for Each Sector

IPCC Level 2 Source Category		GHG
1.A.1	Energy Industries	CO_2
1.A.3	Transport	CO_2
3.A	Enteric Fermentation	CH_4
1.A.4	Other Sectors (Commercial/ Residential/ Agriculture)	CO_2
3.D	Agricultural Soils	N_2O
1.A.2	Manufacturing Industries and Construction	CO_2
3.B	Manure Management	CH_4
2.F.1	Refrigeration and air-con	HFC
2.A.1	Cement Production	CO_2
5.A	Solid Waste Disposal	CH_4

Emission Factors

As explained at the start of this report, emission factors are used to convert energy use to CO_2 emissions; these are dependent on the type of fuel used, so therefore different fuels have different emission factors. Unlike fossil fuels, which have different emission factors depending on the fuel type, renewable energy sources have an emissions factor of zero; this means that no emissions are attributed to energy sourced from renewables.

The national emission factors produced by SEAI were used throughout this study and may be found in Table 14 below.

Table 14 Emission Factors

Emission Factors	Electricity	Gas	Liquid Fuels					Solid Fuels and Derivatives				Renewable Energies				
		Natural Gas	Gasoline (Petrol)	Gas/Diesel/ Oil	Kerosene	LPG	Petroleum Coke	Coal	Milled Peat	Sod Peat	Peat Briquettes	Onsite Generation	Biogas	Solar Thermal	Biodiesel	Bioethanol
$kgCO_2/kWh$	0.468	0.205	0.252	0.264	0.257	0.229	0.335	0.341	0.420	0.374	0.356	0.000	0.000	0.000	0.000	0.000

CO_2 factors are used to convert GHG emissions to CO_2 equivalent. The CO_2 equivalents used were from international approximations (Climate Change Connection, 2017), and may be found in the table below.

Table 15 CO_2 Equivalents

Greenhouse Gas	Symbol	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	$c\text{-}C_4F_8$	10,300
Perfluoropentane	C_5F_{12}	13,300
Perfluorohexane	C_6F_{14}	9,300

Appendix C - Comparing Residential Housing to Social Housing

This section analyses and compares the energy use and emissions arising from both the residential and social housing sector. For the purpose of comparison, different types of residential houses (detached, semi-detached and terraced) were grouped into houses, so as to match social housing dwelling types[5].

In 2016, Fingal's housing (including both residential and social housing) accounted for 529,400 tonnes of CO_2, which is 27% of total emissions in Fingal.

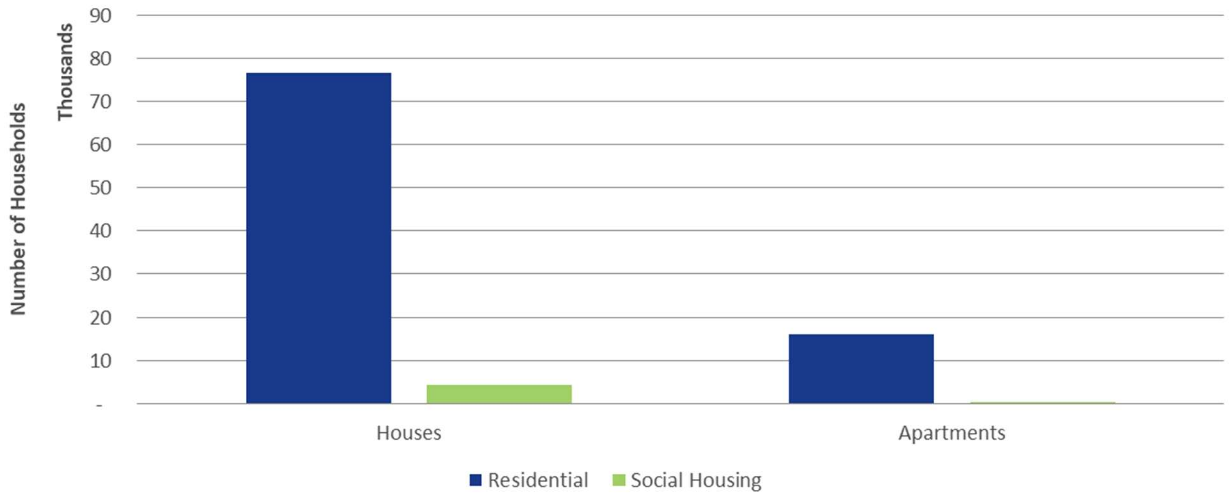

Figure 47 Total Number of Households by Type in Fingal

As can be seen from Figure 47 and 48, social housing is a small percentage of the total households and floor area in Fingal. Social housing accounts for 5% of total housing units and 3% of the total Fingal housing floor area.

The most common type of dwelling in residential households was houses, making up 83% of the total residential units in 2016. Houses also had the largest floor area, at 88%. Furthermore, for social housing, the most common type of dwelling was also houses, making up 95% of FCC's total social housing units, and 96% of the total social housing floor area.

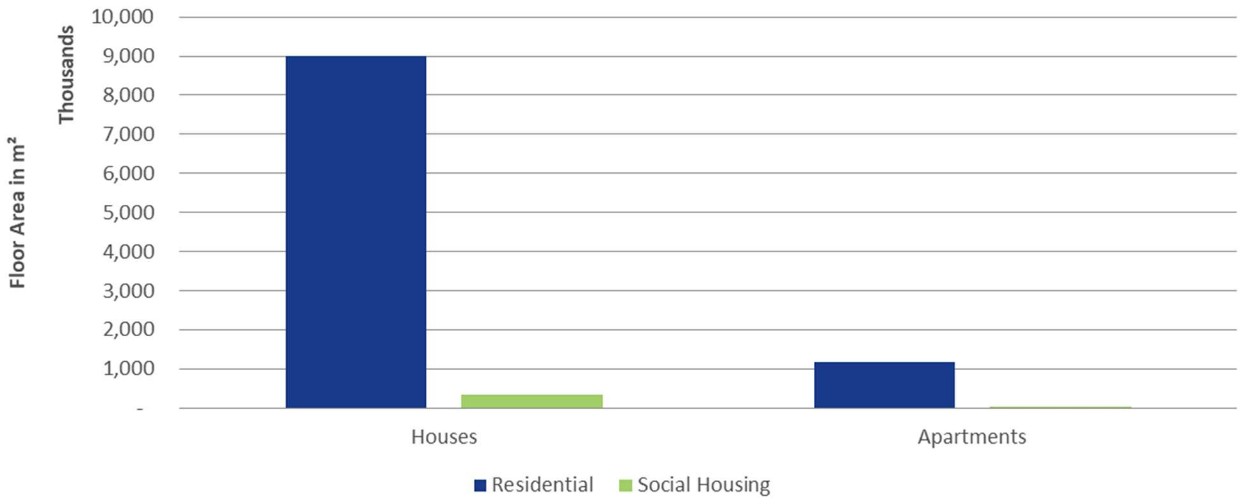

Figure 48 Total Household Floor Areas by Type of Dwelling in Fingal

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[5] The term houses in social housing were used to represent: detached, semi-detached and terraced houses. 'Houses' were used as the data was not broken down further into the different house types.

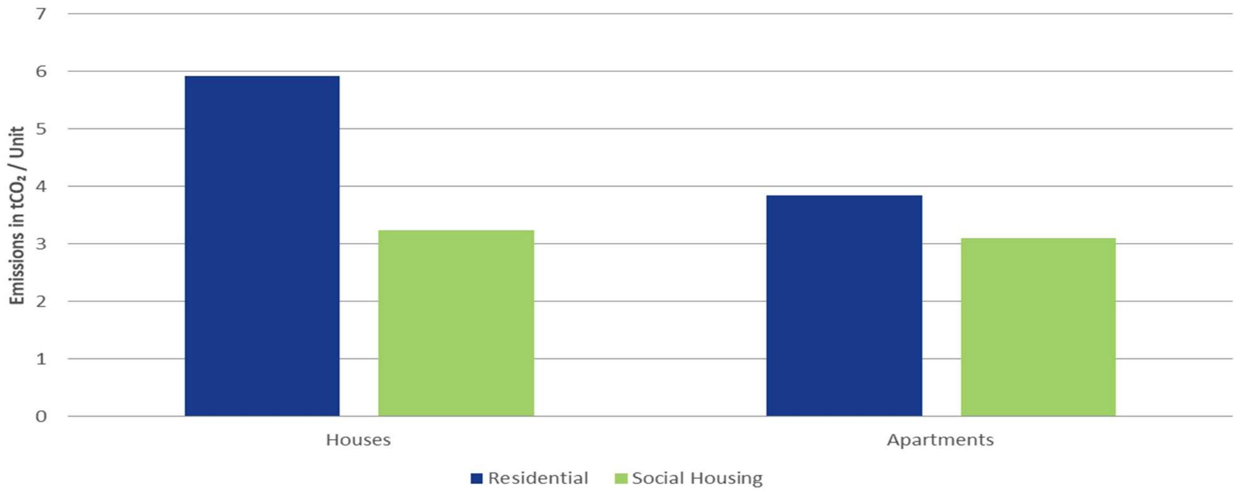

Figure 49 Emissions in tCO_2/unit for Residential and Social Housing

When comparing emissions per unit, between social housing and residential, social housing units (3.23tCO_2/dwelling) were found to emit fewer emissions than residential units (5.55tCO_2/dwelling). Overall, social housing units produced 42% less emissions per unit than residential developments.

Apartments, for both social housing and residential households, were found to produce the least emissions from all the different dwelling types (houses and apartments). Apartments in the social housing sector emitted 3.10tCO_2 per apartment, while in the residential sector, apartments contributed 3.85tCO_2 per apartment.

In the residential sector, houses were the highest polluters, at 5.91tCO_2 per unit, while in the social housing sector, houses produced 3.24tCO_2 per unit.

Houses in both the residential and social housing sector were the least efficient type of dwelling, due to the way these dwellings are built, i.e. they have a larger floor area than other dwelling types, more exposed areas and no neighbouring houses to shelter them, and all these factors contribute to a higher energy use and thus higher emissions (unless renewables are used as a source of energy).

Figure 50 Building Energy Ratings for Residential and Social Housing

Figure 50 represents the average BERs for both social housing and residential units, which were applied to the total housing stock in Fingal. It can be seen that the most common BER in social housing was a C2 rating, making up 28% of the total social housing stock. Meanwhile, in the residential sector, the most common rating was also a C2; however, they only made up 15% of the total residential sector.

In the residential sector, 60% of the BERs were found to be C3 or better, while in the social housing sector, 75% of the BERs were C3 rated or better. It may also be noted that in the residential sector, 6% of energy ratings were an F or G rating, as opposed to the social housing sector, which only had 1% F or G ratings.

It can be seen that overall energy use and emissions in the social housing sector were much less than for the residential sector. These results reflect the ongoing retrofitting work that is being carried out by Fingal County Council to upgrade their less efficient social housing stock.

Appendix D - Municipal Emissions

Current Situation

Figure 51 shows the total CO_2 emissions from 2006 (baseline year) up to 2016. The baseline year is chosen by each local authority; this is dependent on the year in which FCC started reporting its energy use and emissions on the M&R system.

The greatest emission reductions were between 2006 and 2014. From 2014 up to 2016, the emission reductions then started to even out. This might be the effect of the economic downturn on the activity levels of the local authority, or it might be due to the higher emission reduction actions, which would have been carried out in earlier years. These might be the easier emission reductions to achieve and yield a more drastic emission change. However, over the years these actions become harder to achieve, and therefore Fingal County Council must keep on striving to reach its targets and become a leader in emission reductions.

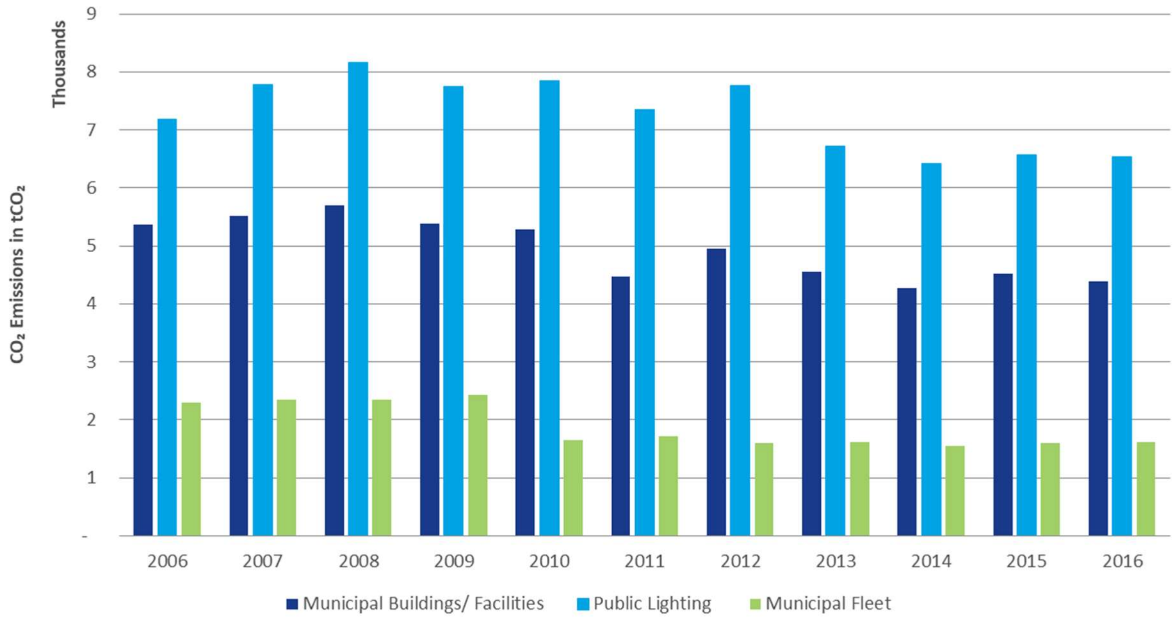

Figure 51 2006 – 2016 Emissions for FCC

Key Findings

- Buildings and Facilities have reduced their total emissions by 18%; however, between the period 2014 and 2016 emissions increased on an annual basis
- Public Lighting emissions reduced by 9% from 2006 to 2016, but have increased from 2014 to 2016
- Municipal fleet emissions decreased by 29% in 2016, however an increase in emissions was recorded from 2014 to 2016

2030 Emission Reduction Targets

The 2030 Emission Reduction Targets were set by the Covenant of Mayors for Climate and Energy, of which FCC is a signatory. The 2030 target is a 40% reduction in emissions from the baseline year (2006).

The graph below illustrates the total emissions in FCC and the target glidepath (emission target). It was found that in 2016, FCC was 25% away from meeting the 2030 target (40% emission reduction).

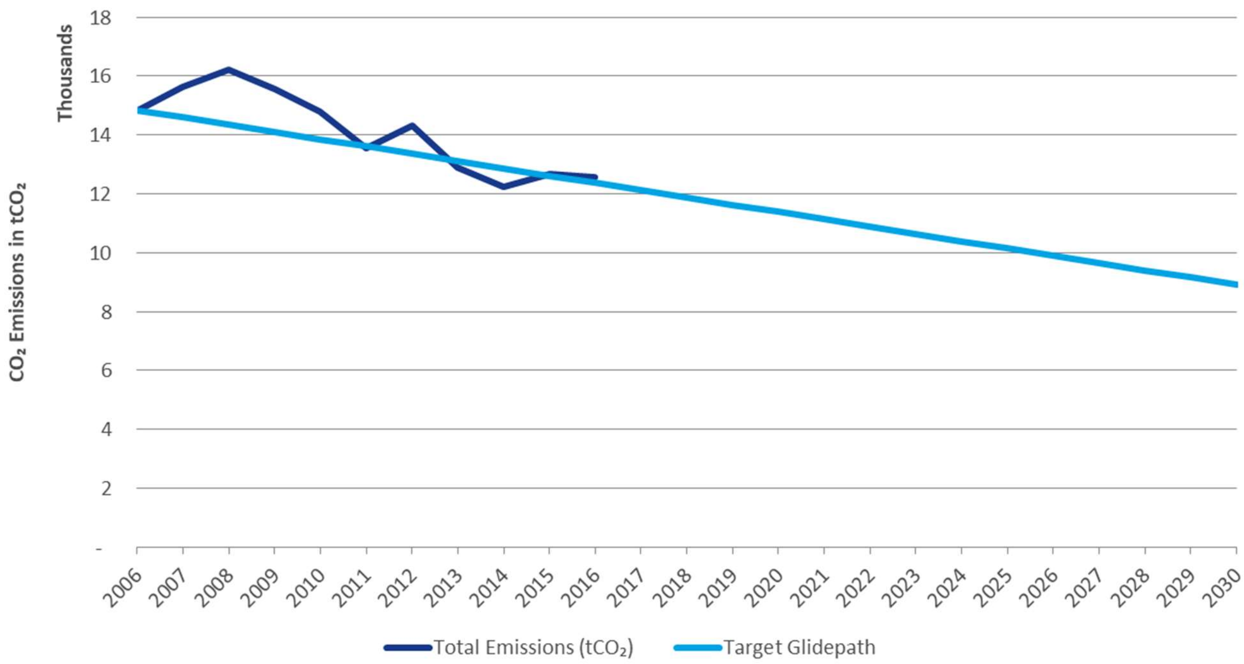

Figure 52 2030 Emissions Target for FCC

Appendix E - Fingal's Energy and Emission Inventory in the Covenant of Mayors for Climate & Energy

Sector		FINAL ENERGY CONSUMPTION [MWh]															
				Fossil fuels								Renewable energies					
		Electricity	Heat/cold	Natural gas	Liquid gas	Heating oil	Diesel/Gas oil	Gasoline	Lignite	Coal	Other fossil fuels	Plant oil	Biofuel	Other biomass	Solar thermal	Geothermal	Total
BUILDINGS, EQUIPMENT/FACILITIES AND INDUSTRIES																	
Municipal buildings, equipment/facilities		6,392	-	6,873	-	-	-	-	-	-	-	-	-	-	-	-	13,265
Tertiary (non municipal) buildings, equipment/facilities		353,641	-	346,949	9,913	297,384	-	-	-	-	-	-	-	33,704	-	27,756	1,069,346
Residential buildings		351,228	-	1,376,683	5,768	306,421	-	-	151	1,613	10,444	-	3	1,591	-	-	2,053,901
Public lighting		13,985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13,985
Industry	Non-ETS	227,429	-	181,905	25,139	55,496	-	-	237	54,548	-	-	711	49,330	-	-	594,795
	ETS (not recommended)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal		952,673	-	1,912,409	40,821	659,301	-	-	388	56,160	10,444	-	714	84,625	-	27,756	3,745,291
TRANSPORT																	
Municipal fleet		-	-	-	-	-	5,927	206	-	-	-	-	-	-	-	-	6,134
Public transport		1,355	-	-	842	-	944,659	320,921	-	-	-	-	-	-	-	-	1,267,776
Private and commercial transport		2,241	-	-	1,393	-	1,562,851	530,934	-	-	-	-	-	-	-	-	2,097,419
Subtotal		3,596	-	-	2,234	-	2,513,437	852,061	-	-	-	-	-	-	-	-	3,371,328
OTHER																	
Agriculture, Forestry, Fisheries		5,864	-	-	-	2,236	28,698	-	-	-	-	-	-	-	-	-	36,798
TOTAL		962,133	-	1,912,409	43,055	661,538	2,542,135	852,061	388	56,160	10,444	-	714	84,625	-	27,756	7,153,418

Sector		CO_2 emissions [t] / CO_2 eq. emissions [t]															
				Fossil fuels								Renewable energies					
		Electricity	Heat/cold	Natural gas	Liquid gas	Heating Oil	Diesel/Gas oil	Gasoline	Lignite	Coal	Other fossil fuels	Plant oil	Biofuel	Other biomass	Solar thermal	Geothermal	Total
BUILDINGS, EQUIPMENT/FACILITIES AND INDUSTRIES																	
Municipal buildings, equipment/facilities		2,988	-	1,407	-	-	-	-	-	-	-	-	-	-	-	-	4,395
Tertiary (non municipal) buildings, equipment/facilities		165,327	-	71,020	2,273	76,428	-	-	-	-	-	-	-	-	-	-	315,048
Residential buildings		164,199	-	281,807	1,323	78,750	-	-	54	549	2,756	-	-	-	-	-	529,438
Public lighting		6,538	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,538
Industry	Non-ETS	106,336	-	37,236	5,764	14,263	-	-	84	18,579	-	-	-	-	-	-	182,262
	ETS (not recommended)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal		445,388	-	391,470	9,360	169,440	-	-	138	19,128	2,756	-	-	-	-	-	1,037,681
TRANSPORT																	
Municipal fleet		-	-	-	-	-	1,565	52	-	-	-	-	-	-	-	-	1,617
Public transport		633	-	-	193	-	249,390	80,872	-	-	-	-	-	-	-	-	331,088
Private and commercial transport		1,048	-	-	319	-	412,593	133,795	-	-	-	-	-	-	-	-	547,755
Subtotal		1,681	-	-	512	-	663,547	214,719	-	-	-	-	-	-	-	-	880,459
OTHER																	
Agriculture, Forestry, Fisheries		2,741	-	-	-	575	7,576	-	-	-	-	-	-	-	-	-	10,892
OTHER NON-ENERGY RELATED																	
Waste management																	28,192
Waste water management																	6,813
Other non-energy related (Agriculture GHG emissions)																	12,192
TOTAL		449,810	-	391,470	9,872	170,015	671,124	214,719	138	19,128	2,756	-	-	-	-	-	1,976,229

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Table of Figures

Table of Tables

Abbreviations

AWMS – Animal Waste Management Systems

BER – Building Energy Rating

CAW – Celtic Anglian Water

CIBSE – Chartered Institution of Building Energy Services Engineers

CO_2 – Carbon Dioxide

CO_2eq – Carbon Dioxide Equivalent

CoM – Covenant of Mayors for Climate Change and Energy

CSO – Central Statistics Office

DAFM – Department of Agriculture, Food and Marine

DEFRA - Department of the Environment, Food and Rural Affairs

EPA – Environmental Protection Agency

ETS – Emissions Trading Scheme

FCC - Fingal County Council

GDA – Greater Dublin Area

GDP – Gross Domestic Product

GHG – Greenhouse Gas

GIS – Graphical Information Science

HGV – Heavy Goods Vehicle

IFA – Irish Farmer's Association

IPCC – Intergovernmental Panel on Climate Change

kWh – Kilowatt-hour

ktCO_2 – Kilo tonnes of Carbon Dioxide emissions

LPIS – Land Parcel Information System

LUAS – Dublin's Light Rail System

MWh –Megawatt-hour

MtCO_2 – Mega tonnes of Carbon Dioxide emissions

NDFM – National Demand Forecasting Model

NHTS – National Household Travel Survey

NTA – National Transport Authority

PRTR – Pollutant Release and Transfer Register

RD&D – Research, Development and Demonstration

RMM – Regional Multi-modal Modes

RMS – Regional Modelling System

SEAI – Sustainable Energy Authority Ireland

SIMI – The Society of the Irish Motor Industry

tCO_2 – 1 tonne of Carbon Dioxide emissions

UCC – University College Cork

WWTP – Wastewater Treatment Plant

Comhairle Contae Fhine Gall
Fingal County Council

SEAI SUSTAINABLE ENERGY AUTHORITY OF IRELAND

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