SOUTH DUBLIN BASELINE EMISSIONS REPORT

2016

Comhairle Contae Átha Cliath Theas
South Dublin County Council

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

codema Dublin's Energy Agency

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

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Disclaimer

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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 South Dublin 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 Dublin. 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 that affect the local authority area.

The baseline year for this analysis is 2016, with the exception of 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.

Codema found that the total emissions from various sectors in South Dublin total the equivalent of 1,877,900 tonnes of CO_2, which is the equivalent to 6.7 tCO_2eq per capita.. The sectors that produced the most emissions were transport, commercial and residential, producing 39%, 32% and 24% respectively, of total emissions in South Dublin. From this analysis, these three sectors should be the main targets of energy and emission initiatives.

Codema also calculated the total energy use in South Dublin to be 6,783 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 2% to the total fuel mix in South Dublin. Of this renewable energy, 1.5% came from biomass sources.

Residential

- Total residential emissions were 457,300 tonnes of CO_2 in 2016
- Total delivered energy for the residential sector in South Dublin for 2016 was 1,803 GWh
- 49% of the housing stock was rated C3 or better, with D1 the most common rating
- Semi-detached houses made up 55% of the total housing stock, followed by terraced houses (20%), apartments (13%) and detached houses (12%)
- Apartments were the least carbon intensive type of housing, emitting 3.75 tCO_2/apartment
- Detached houses were the most carbon intensive type of housing, emitting 8.78 tCO_2/detached house
- 56% of residential emissions came from natural gas; a further 29% came from electricity

Commercial

- Total emissions in 2016 amounted to 607,700 tonnes of CO_2; of this, 417,900 tonnes came from the services sector and 189,800 tonnes came from the industrial sector
- Total final energy used in 2016 by the commercial sector was 2,023 GWh
- Industrial uses (73%), retail (11%), hospitality (6%) and offices (4%) contributed the most to CO_2 emissions
- Hospitality and retail (warehouses) had the highest emissions per property, at 349 tCO_2 and 203 tCO_2 respectively
- Utility, miscellaneous uses and offices had the lowest emissions per property, at 7.85tCO_2, 8.53tCO_2 and 24.58tCO_2, respectively

Transport

- Total final emissions from transport were 731,000 tonnes of CO_2eq
- Total energy use in transport was 2,799 GWh
- Private and commercial transport made up 51% of South Dublin's modal split; this was followed by public transport at 31%, cycling at 13%, and walking at 5%
- 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 amounted to 29,200 tonnes of CO_2 in South Dublin
- Total delivered energy in 2016 was 117 GWh for social housing in South Dublin
- The majority of social housing units were terraced houses; they accounted for 76% of the total social housing stock, followed by apartments (17%), semi-detached (6%) and detached (1%)
- Terraced houses and apartments were the least carbon intensive type of housing, emitting 3.15 tCO_2 and 3.27 tCO_2 per unit, respectively
- Semi-detached and detached houses were the highest emitters per dwelling, at 3.42 and 4.11 tCO_2/house
- 77% of the social housing stock in South Dublin was rated C3 or better, with C2 being the most common BER type
- 65% of total social housing CO_2 emissions in South Dublin came from natural gas, followed by electricity at 30%

Municipal

- Total final emissions produced by South Dublin County Council in 2016 were 11,900 tonnes of CO_2
- Total final energy used in 2016 in SDCC was 32 GWh
- Buildings and facilities were the largest consumers of energy in the municipality, making up 52% of the total energy consumption
- Public lighting contributed 47% of total emissions in SDCC, followed by buildings/facilities at 45%, and municipal fleet at 8%
- The majority (58%) of SDCC's carbon emissions came from electricity, followed by gas (25%) and diesel (11%)

Agriculture

- Total agriculture-related emissions in South Dublin were 7,000 tonnes of CO_2eq in 2016
- Total energy use in 2016 was 6 GWh
- GHG emissions produced by livestock contributed 74% to total emissions; this was followed by energy-related emissions from livestock, horticulture and crops, at 13%, 10% and 3% respectively
- 75% of emissions produced by livestock came from enteric processes, made up methane and nitrous oxide

Waste

- Total emissions from landfills in South Dublin were estimated at 26,500 tonnes of CO_2eq
- Methane made up 85% of total CO_2eq emissions in landfills

Wastewater

- Total emissions from wastewater in South Dublin were 6,400 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 South Dublin County Council (SDCC), and outlines the methodologies and results of South Dublin'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 South Dublin have on Ireland's overall carbon emissions and energy use. It provides SDCC 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 years 2020 and 2030 (relative to 2005 levels). The significance of Dublin 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 emission reductions, 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. The Luas line in Dublin has recently been extended and is in operation since the end of 2017 (Luas Cross City), accommodating an additional 10 million passenger journeys per year.

All the evidence from national surveys point 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 as follows:

- 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, to which SDCC 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 up by local and regional authorities, which will implement EU targets, namely the 40% GHG reduction target by 2030. All EU states that are signatories to the CoM share the common goal of decarbonising their countries or region 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 South Dublin.

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 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 facilitate the adaptation of this methodology across Ireland. The analysis focused on the current energy demand and fuels that are used to provide energy, and the associated CO_2 emissions and GHG emissions related to activities (agriculture, waste and wastewater) within South Dublin.

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 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 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 1kWh of energy use.

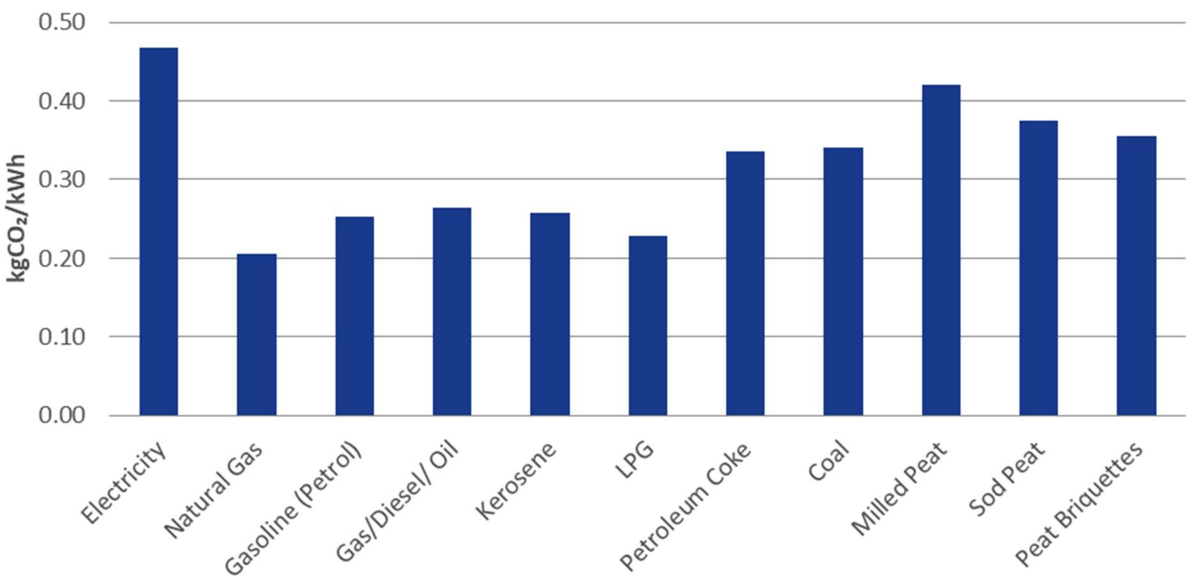

Figure 1 Emission Factors for Different Fuel Types

Residential

This section looks at the emissions arising from the residential sector in South Dublin. It excludes social housing units, as social housing is analysed as a separate section in this report.

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, therefore 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 South Dublin 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 was 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.

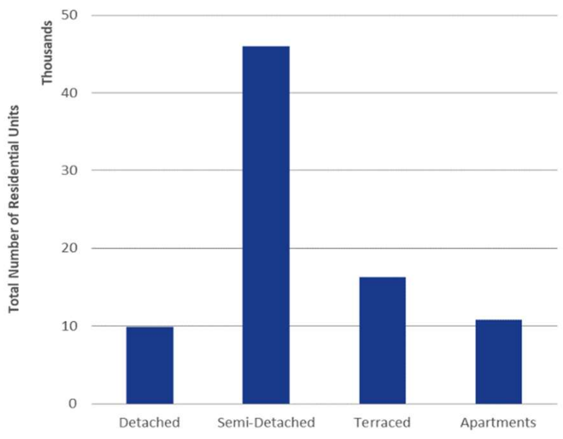

Figure 2 Total Number of Residential Units in South Dublin

The BER Research Tool was developed by SEAI and was 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 is applied. 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 South Dublin. 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 South Dublin. As can be seen from Figure 3, there is a high representation of BERs for each housing type.

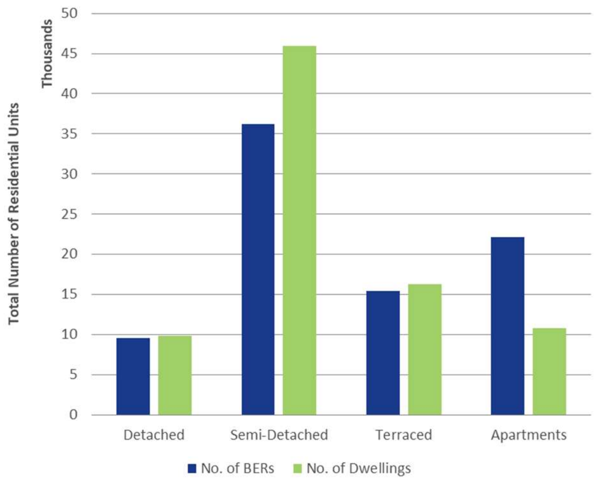

Figure 3 Representation of South Dublin's Residential Households in BER Database

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 South Dublin. 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 South Dublin, Codema analysed a total of 83,321 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 2% of total residential units in South Dublin. 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 areas to be affected.

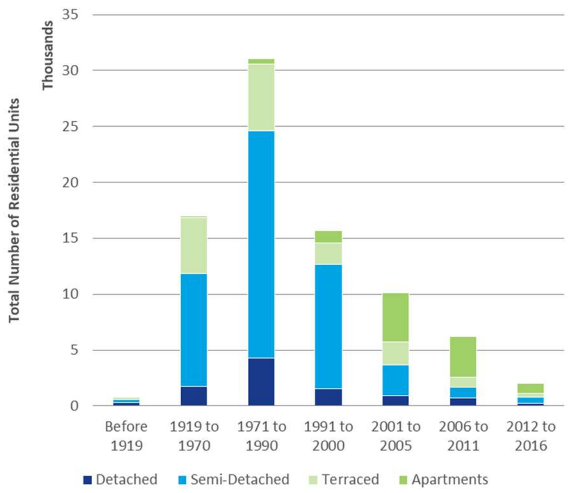

Figure 4 South Dublin's Total Residential Stock by Type and Period Built

As can be seen from Figure 4, 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.

In 2016, the largest share of residential units were semi-detached houses; they made up 55% of the total residential housing stock in South Dublin. This was followed by terraced houses (20%) and apartments (13%), whilst the lowest share of housing were detached houses, comprising of 12% of South Dublin's housing stock.

Total emissions from the residential sector in South Dublin amounted to 457,300 tonnes of CO_2 in 2016. Figure 5 depicts the total emissions by dwelling type. Semi-detached houses had the highest emissions, accounting for 258,700 tonnes of CO_2. This was followed by detached houses, terraced houses and apartments, all of which accounted for 86,600, 71,600 and 40,500 tonnes of CO_2 respectively, of the total emissions in the residential sector in 2016.

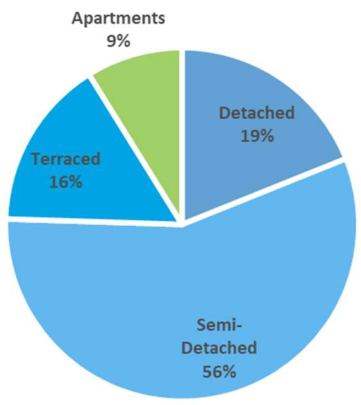

Figure 5 South Dublin's Residential Emissions by Dwelling Type

Figure 6 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 have the least emissions per unit, at 3.75 tCO_2 per apartment. This is followed by terraced, semi-detached and detached houses, emitting 4.4, 5.62 and 8.78 tonnes of CO_2 per dwelling respectively.

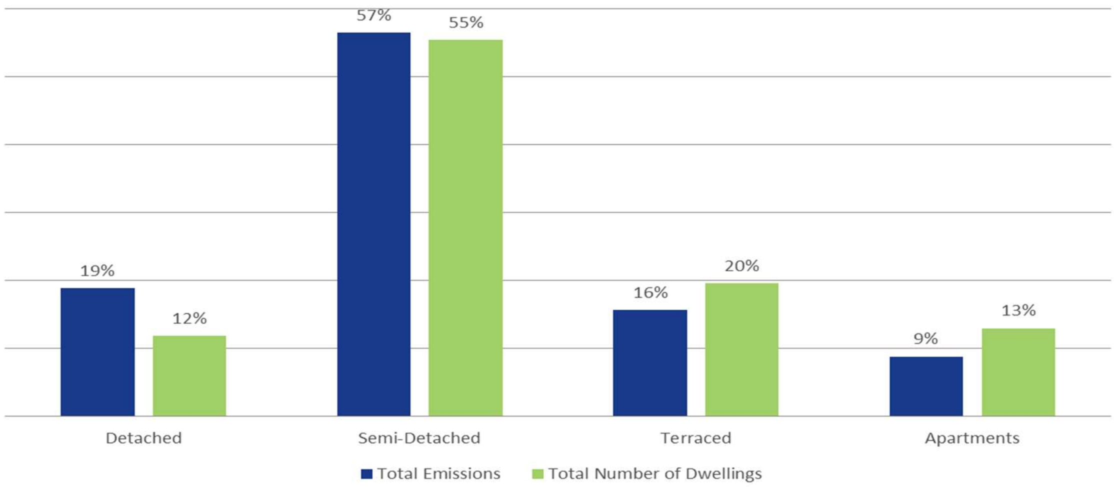

Figure 6 Share of Total Emissions and Number of Residential Units for Each Housing Type

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 South Dublin.

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

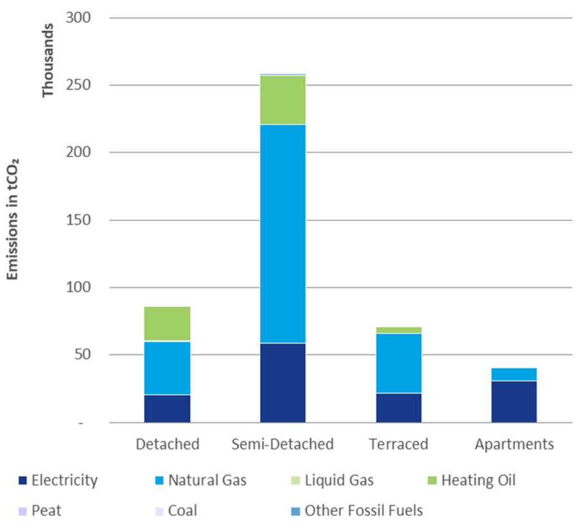

Figure 7 Total Emissions in tCO_2 in the Residential Sector by Fuel Mix and Dwelling Type

The highest emissions in the residential sector come from natural gas, electricity and heating oil, which contribute 56%, 29% and 15% 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.

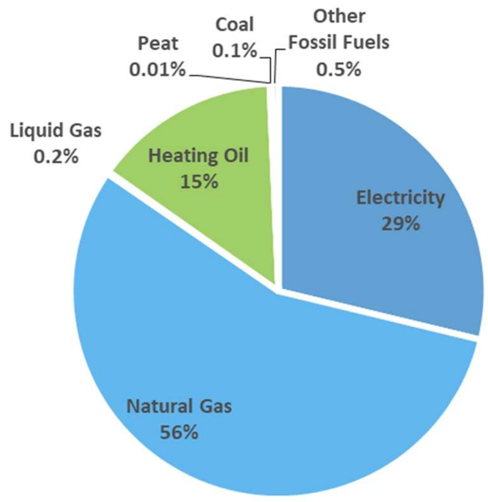

Figure 8 Share of Total Emissions in the Residential Sector by Fuel Type

Total energy use in the residential sector was 1,803 GWh. The residential fuel split mainly comes from natural gas, which makes up 69% of the total energy use in this region, due to the density of the gas grid in Dublin. Electricity is the second highest fuel in demand, making up 16% of the fuel mix, followed by heating oil at 14%.

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

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 67% 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.

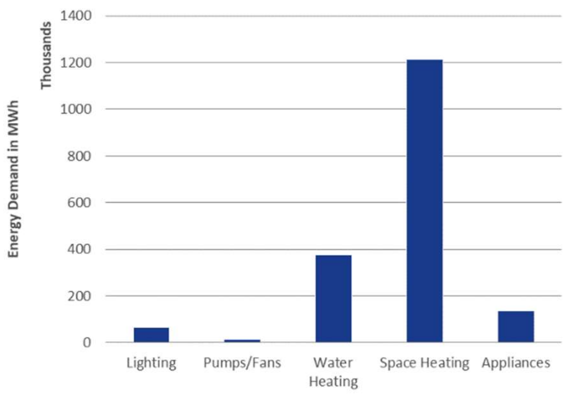

Figure 9 Residential Energy Demand in MWh in South Dublin

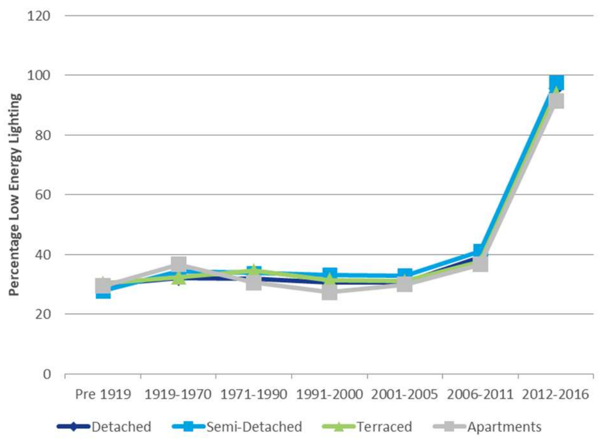

Figure 10 Percentage of Low Energy Lighting by Building Type and Period Built

Figure 10 shows the percentage of low energy lighting, analysed from the BER research tool, and broken down by house type and period built. The overall average percentage of low energy lighting in South Dublin's residential sector was 35%, with newer built dwellings having higher levels. The highest percentage was found in newly built (2012-2016) semi-detached and terraced houses, which had 99% low energy lighting. This shows that there is still room for improvement within the other dwelling types.

Figure 11 and 12 show the total building energy ratings for all residential housing in South Dublin, after the averages for each dwelling type and period built were applied to the entire housing stock.

The most common rating was D1, making up 16% of the residential housing. 49% of residential units in 2016 were rated C3 or better. The majority of better ratings (i.e. A and B ratings) came from newly-built or refurbished apartments.

There were 1,774 A rated residential units in South Dublin, of which 746 units were apartments. Two of these A rated units were A1 rated in 2016.

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

8% of the housing stock was F or G rated, mainly comprising of semi-detached houses that were constructed in the period between 1919 and 1990.

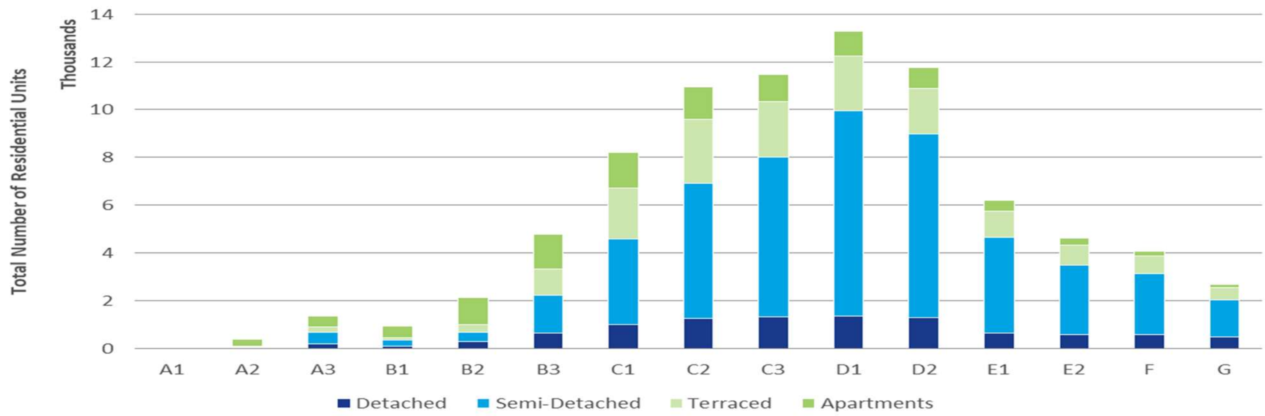

Figure 11 Building Energy Ratings for all the South Dublin's Residential Stock by Dwelling Type

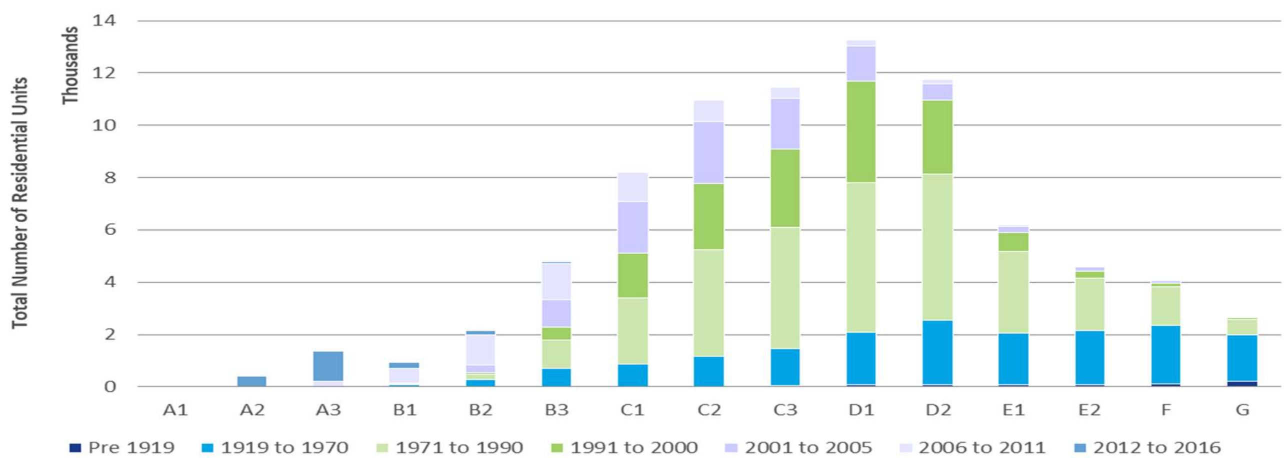

Figure 12 Building Energy Ratings for all South Dublin's Residential Units by Construction Period

Key Findings

- Total residential emissions amounted to 457,300 tonnes of CO_2 in 2016
- Total delivered energy for the residential sector in South Dublin for 2016 was 1,803 GWh
- The majority of residential units were constructed between 1971 and 1990
- Apartments were the least carbon intensive type of housing, emitting 3.75 tCO_2/apartment
- Detached houses were the most carbon intensive type of housing, emitting 8.78 tCO_2/detached house
- Construction of new residential developments for the period between 2012 and 2016 made up 2% of the total housing stock
- 49% of the housing stock was rated C3 or better, with D1 being the most common rating
- Semi-detached houses made up 55% of the total housing stock, followed by terraced houses (20%), apartments (13%) and detached houses (12%)
- Semi-detached houses produced 56% of total residential emissions in South Dublin, followed by detached houses (19%), terraced houses (16%), and apartments (9%)
- 56% of residential emissions came from natural gas, and 29% came from electricity
- At 67%, space heating had the highest energy demand in the residential sector
- The highest percentage of low-energy lighting was for newly built semi-detached and terraced houses, both at 99%
- 69% of the residential fuel mix was made up of natural gas, followed by electricity (16%) and heating oil (14%)

Table 1 South Dublin's Residential Inventory; Energy and CO_2 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)	43,361	193,599	2,153	99,017	42	314	2,275	-	608	**341,369**
Semi-Detached (MWh)	126,073	789,772	1,222	140,581	61	1,184	4,671	-	417	**1,063,981**
Terraced (MWh)	46,752	215,348	134	18,882	29	345	2,356	-	24	**283,870**
Apartments (MWh)	65,192	48,390	40	285	-	1	48	1	2	**113,959**
Total Energy (MWh)	**281,377**	**1,247,109**	**3,548**	**258,765**	**131**	**1,845**	**9,350**	**1**	**1,051**	**1,803,177**
Detached (tCO_2)	20,271	39,630	494	25,447	15	107	600	-	-	**86,564**
Semi-Detached (tCO_2)	58,939	161,666	280	36,129	22	403	1,233	-	-	**258,672**
Terraced (tCO_2)	21,856	44,082	31	4,853	10	118	622	-	-	**71,571**
Apartments (tCO_2)	30,477	9,905	9	73	-	0	13	-	-	**40,478**
Total Emissions (tCO_2)	**131,544**	**255,283**	**814**	**66,503**	**47**	**628**	**2,467**	**-**	**-**	**457,286**

Commercial

The commercial sector includes both the services and industrial sectors. 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.

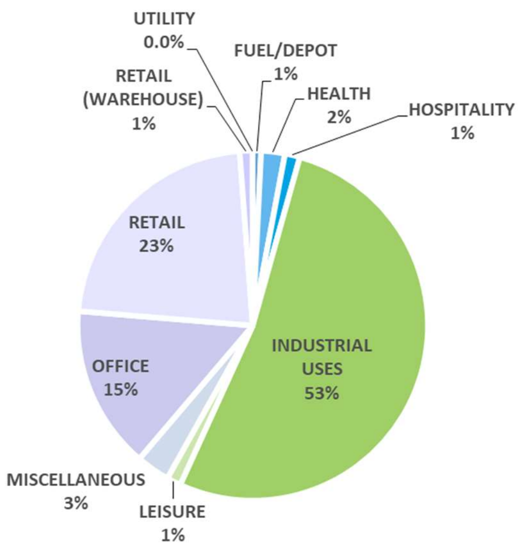

Figure 13 South Dublin's Commercial Properties by Category

The majority of commercial properties can be categorised as industrial uses, retail, and offices, with only 8% accounting for the remaining commercial properties.

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 South Dublin. These properties were also broken down into different categories, type of use, and location.

Currently, there is no energy data available for commercial properties in Dublin, 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, according to their use. There were over 230 different property types listed in South Dublin.

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 County Dublin.

The advantage of using CIBSE energy benchmarks is that they are based on a large sample set, and as Irish building regulations follow 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

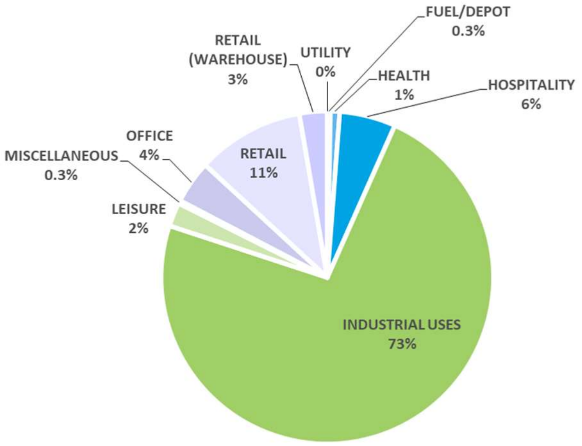

Figure 14 Commercial Emissions by Property Category

Total emissions from the commercial sector in 2016 amounted to 607,700 tonnes of CO_2.

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

- Industrial uses: 445,900 tCO_2
- Retail: 63,500 tCO_2
- Hospitality: 33,200 tCO_2
- Offices: 25,500 tCO_2

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

Industrial uses, retail, hospitality and offices are the main CO_2 emitters, as altogether they made up 93% of the commercial sector's total emissions. From this analysis, these four categories should be the main targets of energy and emission reduction initiatives within this 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, the hospitality and retail (warehouse) categories had the highest shares of emissions at 349 tCO_2 and 203 tCO_2 per building, respectively. On the other hand, utility, miscellaneous uses and offices had the lowest emissions per commercial property at 7.85 tCO_2, 8.53 tCO_2 and 24.58 tCO_2, respectively.

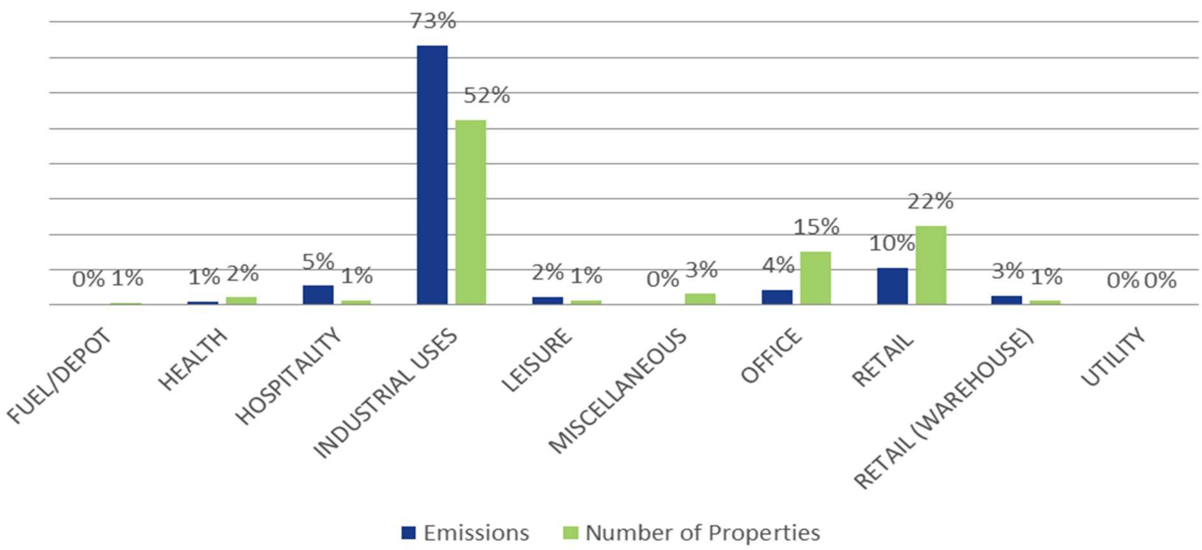

Figure 15 Share of Total Emissions and Number of Commercial Properties in South Dublin

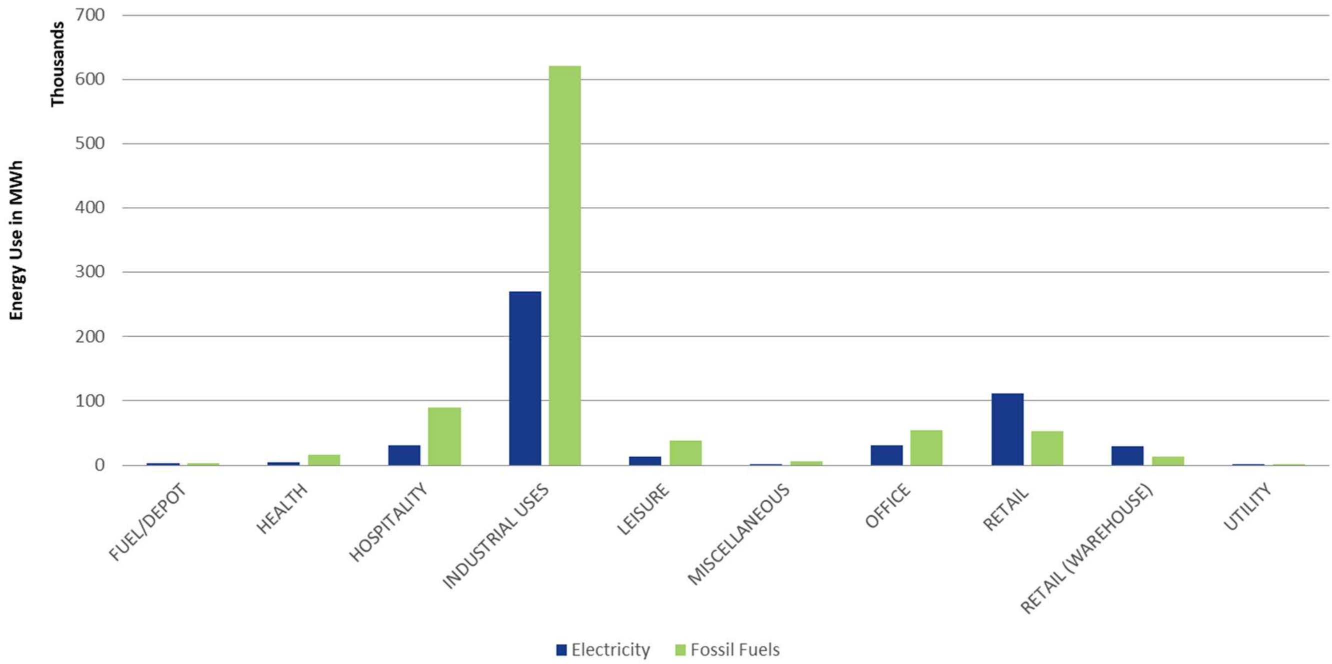

Figure 16 South Dublin's Electricity and Fossil Fuel Use in MWh in the Commercial Sector by Category

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 both fossil fuels (69%) and electricity use (64%).

CIBSE only breaks down fuel use into fossil fuels and electricity. However, for this study, the fuel use was broken down further 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.

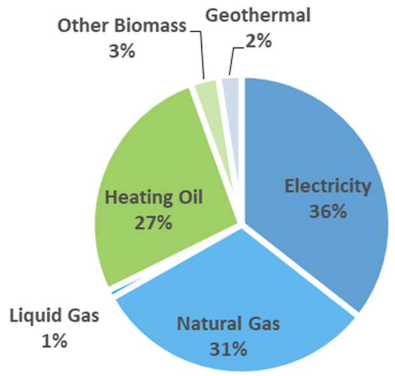

Figure 17 Percentage Energy Use in the Services Sector

The total energy used by the services sector was calculated at 1,388 GWh. This energy mostly comes from electricity at 494 GWh and natural gas at 433 GWh. Heating oil also has a high energy use in the services sector, making up 371 GWh of the total energy mix.

Renewables contribute 77 GWh of the total fuel mix; this is split into 42 GWh of biomass and 35 GWh of geothermal energy.

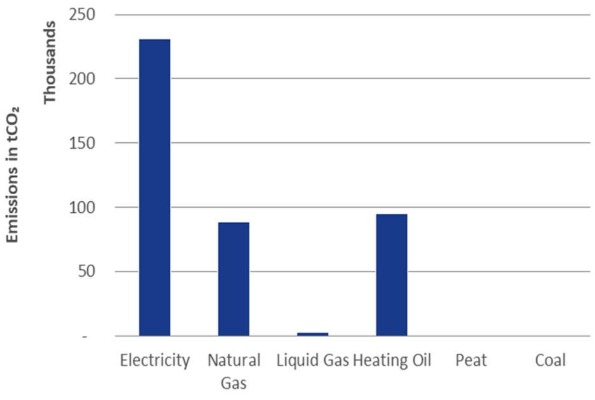

Figure 18 Total Emissions by Fuel Type in the Services Sector in tCO_2

The services sector emitted 417,900 tonnes of CO_2 in 2016. Figure 18 shows that the highest emissions came from electricity (55%), heating oil (23%) and natural gas (21%), within 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 South Dublin are:

- Factories
- Stores
- Workshops
- Warehouses

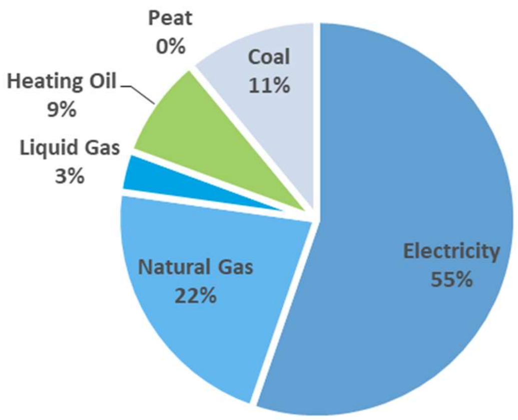

Figure 19 Percentage Energy Use in the Industry Sector

The total energy used in the industrial sector was 635 GWh. Electricity (225 GWh) and natural gas (203 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 56 GWh of the total fuel mix.

Total emissions in the industrial sector were 189,800 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.

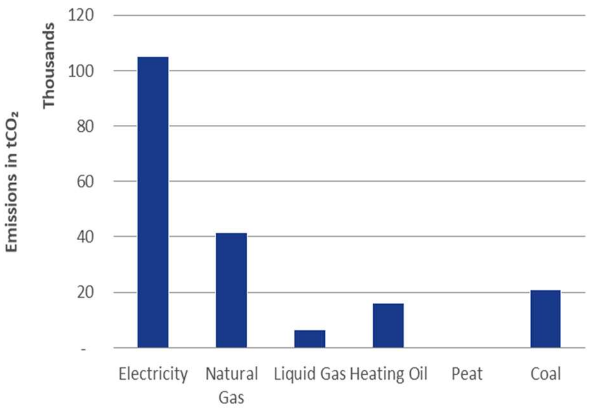

Figure 20 Total Emissions in the Industrial Sector in tCO_2

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 Dublin, 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 607,700 tonnes of CO_2; 417,900 of which came from the services sector, and a further 189,800 came from the industrial sector
- Total final energy used in 2016 by the commercial sector was 2,023 GWh
- The majority of commercial properties were categorised as industrial uses, retail outlets and offices
- Industrial uses (73%), retail (11%), hospitality (6%) and offices (4%) contributed the most to CO_2 emissions
- Hospitality and retail (warehouses) held the highest emissions per property at 349 tCO_2 and 203 tCO_2, respectively
- Utility, miscellaneous uses and offices had the lowest emissions per property at 7.85tCO_2, 8.53tCO_2 and 24.58tCO_2, respectively
- Industrial uses had the highest level of both electricity (64%) and fossil fuel (69%) use within the commercial sector
- Electricity (55%), heating oil (23%), and natural gas (21%) 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 South Dublin'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)	493,798	433,337	12,381	371,432	-	-	-	-	42,096	34,667	**1,387,711**
Industry Sector (MWh)	224,522	203,315	28,098	62,028	265	60,968	-	795	55,136	-	**635,129**
Total Energy (MWh)	**718,320**	**636,653**	**40,479**	**433,460**	**265**	**60,968**	**-**	**795**	**97,232**	**34,667**	**2,022,840**
Services Sector (tCO_2)	230,851	88,704	2,839	95,458	-	-	-	-	-	-	**417,852**
Industry Sector (tCO_2)	104,964	41,619	6,443	15,941	94	20,766	-	-	-	-	**189,827**
Total Emissions (tCO_2)	**335,814**	**130,323**	**9,282**	**111,399**	**94**	**20,766**	**-**	**-**	**-**	**-**	**607,679**

Transport

In 2014, transport 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 shows that commuting has increased nationally 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 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.

Bikes increased to 4.1 million, compared to 1.2 million in 2010 (Department of Transport, 2016). The Cycle-to-Work Scheme also 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 ofCO_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 Dublin 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.

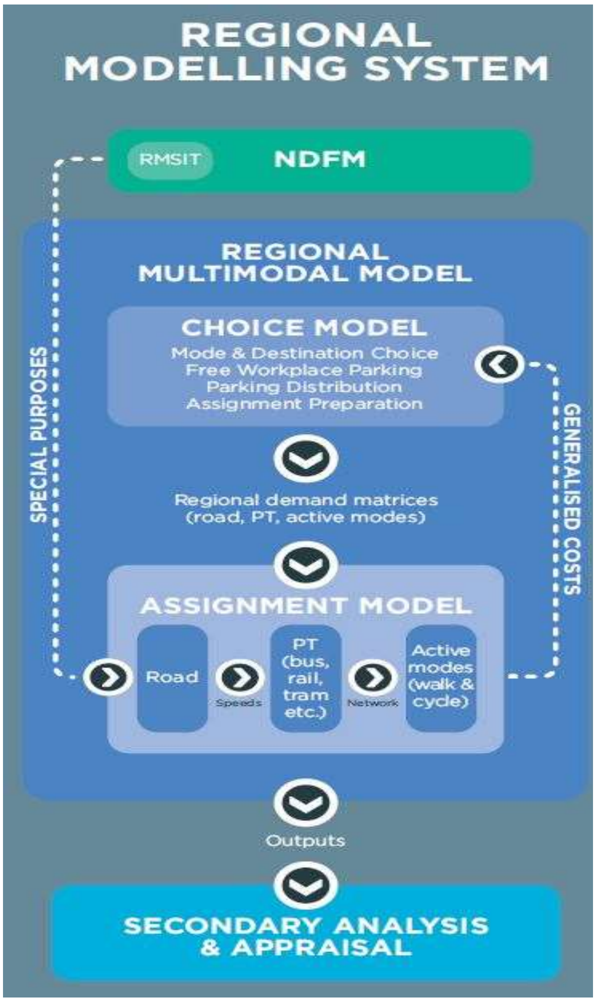

Figure 21 RMM Structure. Source : NTA, 2017

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 GHGs

The emissions that 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).

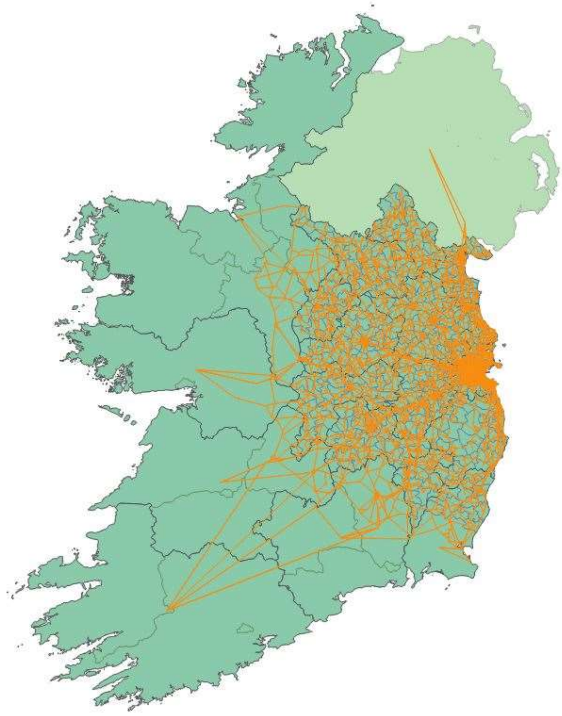

Figure 22 East Regional Model in GIS, Including all the Different Road Links

Analysis

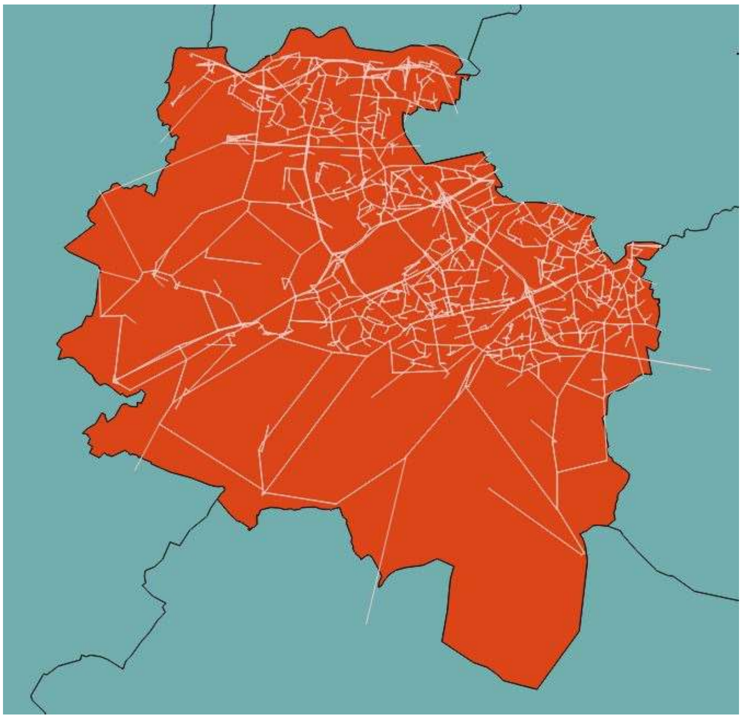

Figure 23 South Dublin Road Links

From the GIS model provided by the NTA, Codema extracted the total GHGs for different road links in South Dublin; these links can be seen in Figure 23 above. Some road links might be located in more than one local authority area; for example, a road link might be in both South Dublin 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 South Dublin 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 for the years 2018 and 2035 were based on 2012 data.

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

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

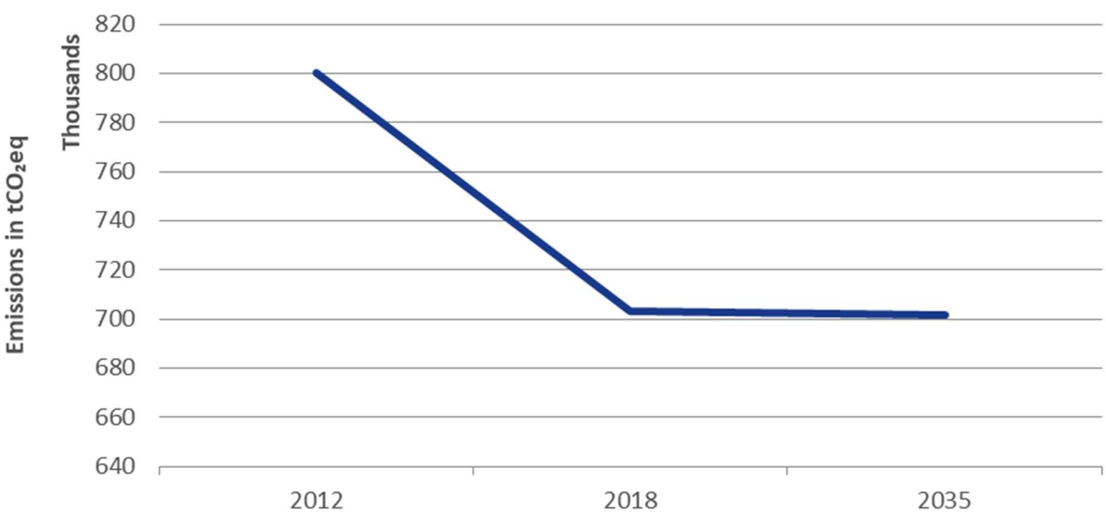

Figure 24 GHG Emission Projections for South Dublin's Transport

Codema then calculated the modal split for South Dublin, based on the 2012 data. Eighteen per cent of total 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.

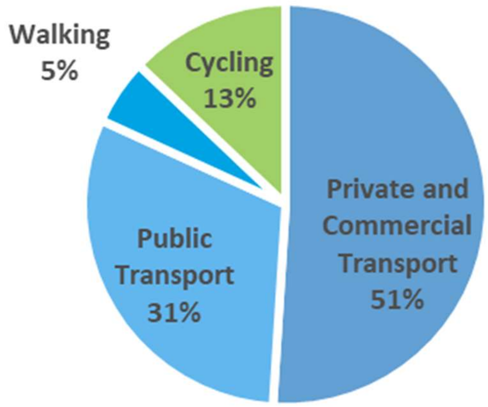

Figure 25 South Dublin's Transport Modal Split in Journeys

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 found the GIS maps were used to find the associated energy use from transportation.

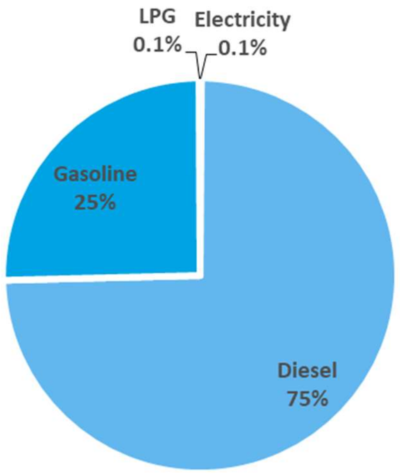

Figure 26 South Dublin's Transport Energy Use

The total energy use from the transport sector in South Dublin amounted to 2,799 GWh. This energy mainly came from diesel (2,086 GWh) and gasoline (709 GWh). Electricity and LPG only made up 0.2% of the total energy use, which is equivalent to 4.9 GWh.

The total emissions from transport in 2016 amounted to 731,000 tonnes of CO_2 equivalent, which were made up of carbon dioxide, methane and nitrous oxide.

Diesel was the main fuel source for both public and private/commercial transport; it made up 75% of total emissions. This was followed by gasoline at 25% and electricity at 0.2% of total emissions.

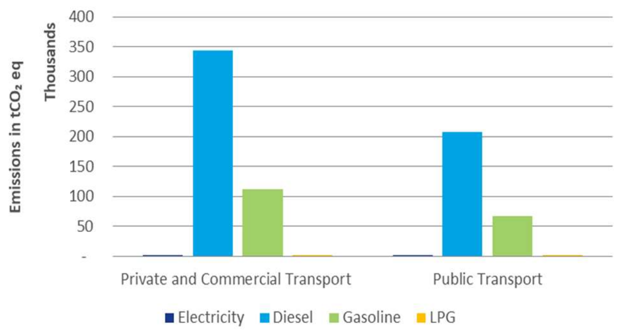

Figure 27 South Dublin's CO_2 Emissions From Transportation

It is good 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 South Dublin.

Key Findings

- Total final emissions from transport were 731,000 tonnes of CO_2eq
- Total energy use in transport was 2,799 GWh
- South Dublin's modal split was broken down as follows: private and commercial transport – 55%, public transport - 31%, cycling - 13% and walking - 5%
- South Dublin's transport emissions mainly came from diesel (75%), followed by gasoline (25%), electricity (0.2%) and LPG (0.1%)

Table 4 South Dublin'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)	1,864	-	1,299,994	441,636	1,158	-	1,744,652
Public Transport (MWh)	1,127	-	785,776	266,945	700	-	1,054,548
Total Energy (MWh)	**2,991**	**-**	**2,085,769**	**708,581**	**1,858**	**-**	**2,799,199**
Private and Commercial Transport (tCO_2eq)	872	-	343,198	111,292	265	-	455,627
Public Transport (tCO_2eq)	527	-	207,445	67,270	160	-	275,402
Total Emissions (tCO_2eq)	**1,398**	**-**	**550,643**	**178,562**	**426**	**-**	**731,029**

Social Housing

South Dublin County Council (SDCC) is responsible for the general maintenance and refurbishment of social housing in the county. This means that much of the energy consumption and emission reductions of South Dublin'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, similar to the residential sector's methodology, is based on two main data sources: SDCC'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 South Dublin housing stock was provided by the 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 four dwelling types, adding up to a total of 28 subsets. Social housing units were broken down into:

- Detached
- Semi-detached
- Terraced
- Apartments

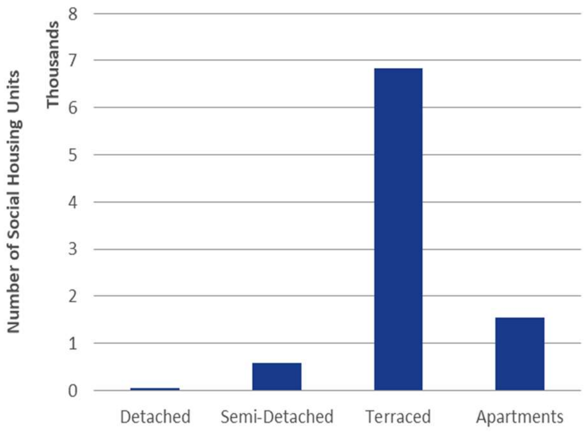

Figure 28 Breakdown of Total Social Housing Units by Construction Type in South Dublin

The BERs analysed in this chapter only represent social housing. The data was filtered by postcode to obtain location-specific data for South Dublin and social housing. The data was then broken down by type of dwelling (detached, semi-detached, terraced 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 South Dublin. As can be seen from Figure 29, there is a high representation of BERs for each type of housing. Codema analysed a total of 5,339 BERs.

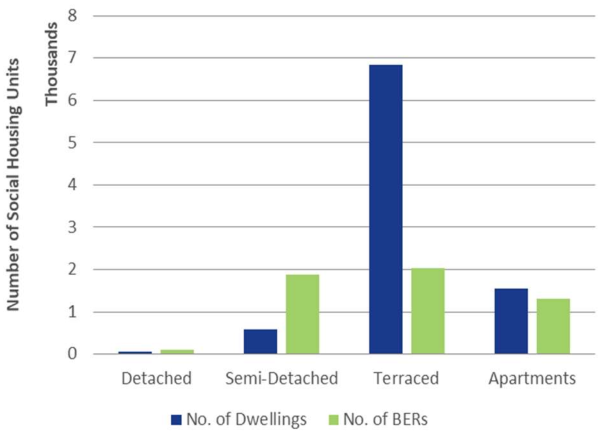

Figure 29 Representation of South Dublin's Social Housing in the BER Database

Analysis

At a regional level, the greatest number of social housing units were built in South Dublin in the period between 1971 and 1990. The period between 2012 and 2016 accounted for less than 1% of the total social housing dwellings. This decrease in social housing units over this period may be related to the economic downturn.

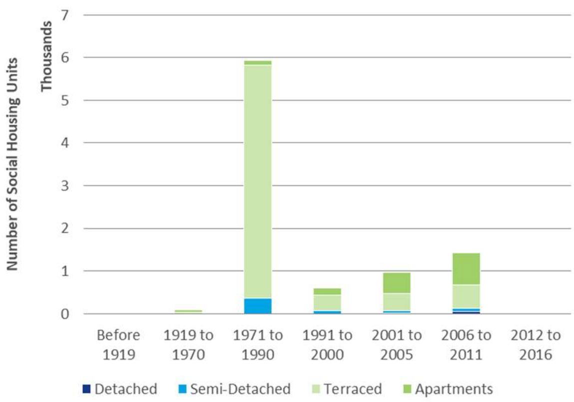

Figure 30 South Dublin's Total Social Housing Stock by Type and Period Built

From 2001 onwards, the main types of housing built were terraced houses and apartments.

In 2016, the majority of social housing dwellings were terraced houses, which made up 76% of the total social housing stock. Apartments amounted to 17% of the total housing stock, followed by semi-detached at 6%. The least dwelling type constructed were detached houses, contributing only 1% to the total social housing stock in South Dublin.

Total emissions from the social housing sector in South Dublin amounted to 29,200 tonnes of CO_2 in 2016. Figure 31 depicts the total social housing emissions by dwelling type. Terraced houses had the highest emissions, at 21,600 tonnes of CO_2, followed by apartments, semi-detached and detached houses, contributing 5,100, 2,400 and 200 tonnes of CO_2, respectively.

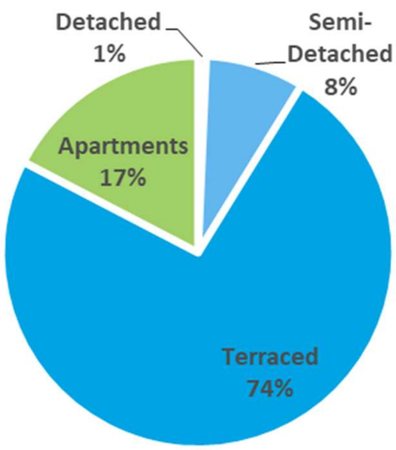

Figure 31 South Dublin's Social Housing Emissions by Dwelling Type

Figure 32 shows the share of emissions produced by the different dwelling types and the corresponding share of social housing units.

Terraced houses and apartments produced the least emissions per unit at 3.15 and 3.27 tonnes of CO_2 per dwelling, respectively. These were followed by semi-detached and detached houses, emitting 3.42 and 4.11 tonnes of CO_2 per dwelling, respectively.

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

Terraced houses and apartments were more efficient as they tend to lose less energy from the building envelope and thus produce fewer emissions. However, semi-detached and detached houses tend to have higher energy losses, as they have more exposed walls.

As explained in the Residential Sector section, many apartments have been recently constructed, resulting in modern building techniques, more efficient materials, and new building regulations.

It is also important to note that in social housing, detached houses are also fairly recent, as they have mainly been constructed between 2006 and 2011. This is the main reason why detached houses performed better than semi-detached, as the majority of semi-detached houses were built in an earlier period. The age of the housing stock would result in less efficient buildings, unless they are being continuously upgraded

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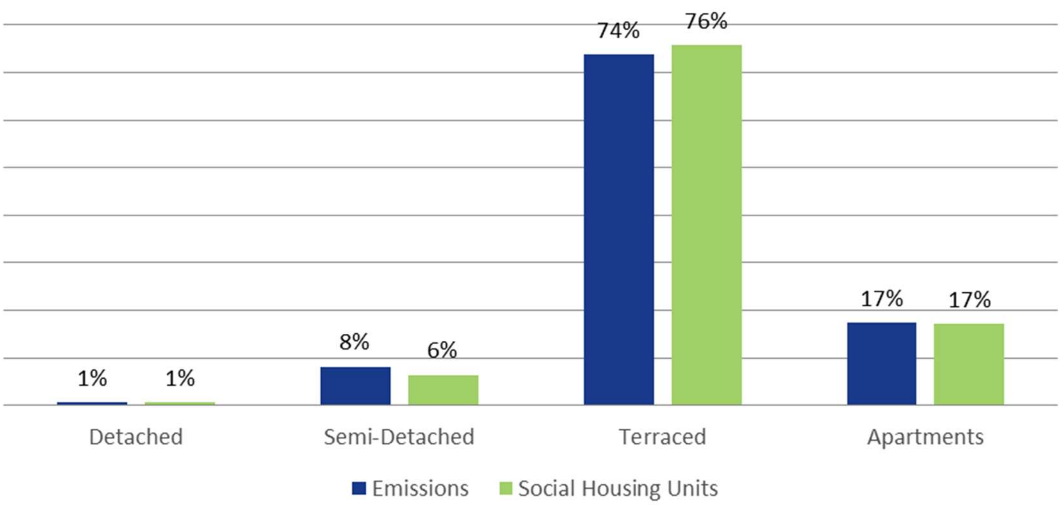

Figure 32 Share of Total Emissions and Number of Units for Each Social Housing Type in South Dublin

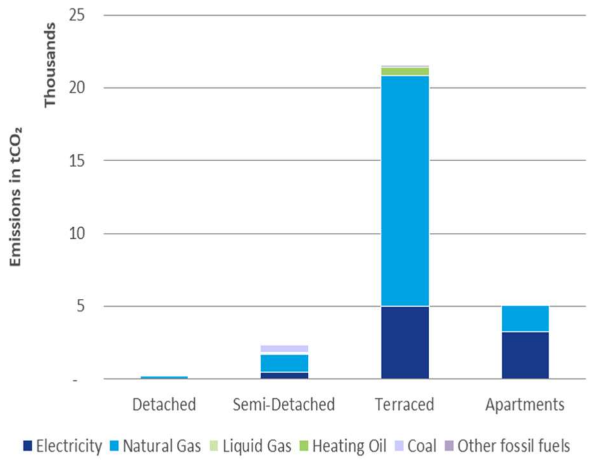

Figure 33 Total Emissions in tCO_2 in the Social Housing Sector by Fuel Mix and Dwelling Type

Figure 33 shows the total emissions for the social housing sector in South Dublin, grouped by fuel and dwelling type.

The highest percentage of emissions came from natural gas and electricity, which accounted for 65% and 30% of the total, respectively. Coal, heating oil, other fossil fuels and liquid gas contributed 5.1% to total emissions. Other fossil fuels include multi-fuel stoves that have no particular fuel specified, and account for only 1% of the fuel mix.

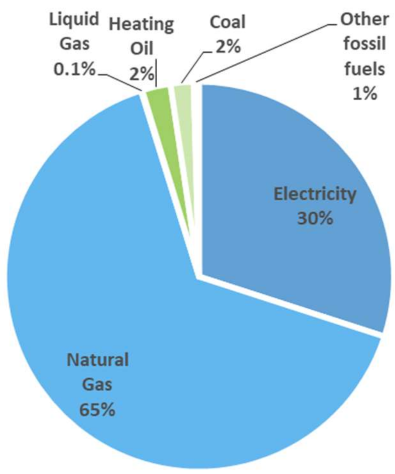

Figure 34 Share of Total Emissions from Social Housing by Fuel Type

South Dublin's social housing sector consumed a total of 117 GWh of energy in 2016. The majority of this energy use came from natural gas, accounting for 80% of the total. This may be due to the density of the gas grid in Dublin. Electricity contributed 16% to the fuel mix, which made it the second highest type of energy used.

Heating oil, other fossil fuel, coal and liquid gas made up 4.1% of the energy use.

From this analysis renewables, namely biomass, contributed 0.1% to the fuel mix.

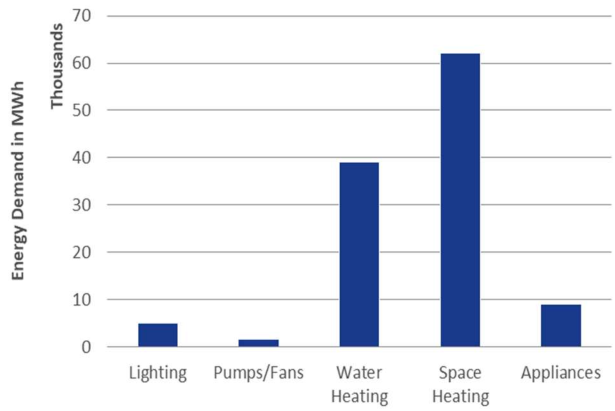

Figure 35 Social Housing Energy Demand in MWh in South Dublin

Figure 35 shows space heating had the highest energy demand (53%), followed by water heating at (34%). This shows that most of the total energy use is for heating generally (i.e. both space and water heating).

Lighting and pumps/ fans are the least energy intensive, making up only 4% and 1%, respectively, of the total energy demand.

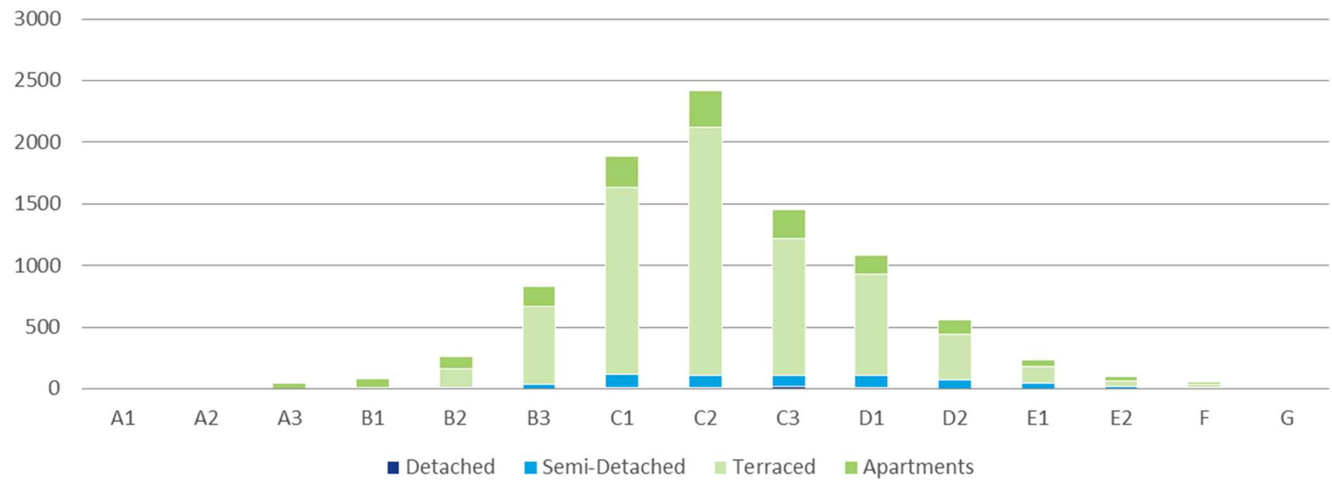

Figure 36 Building Energy Ratings for all the South Dublin's Social Housing Stock by Dwelling Type

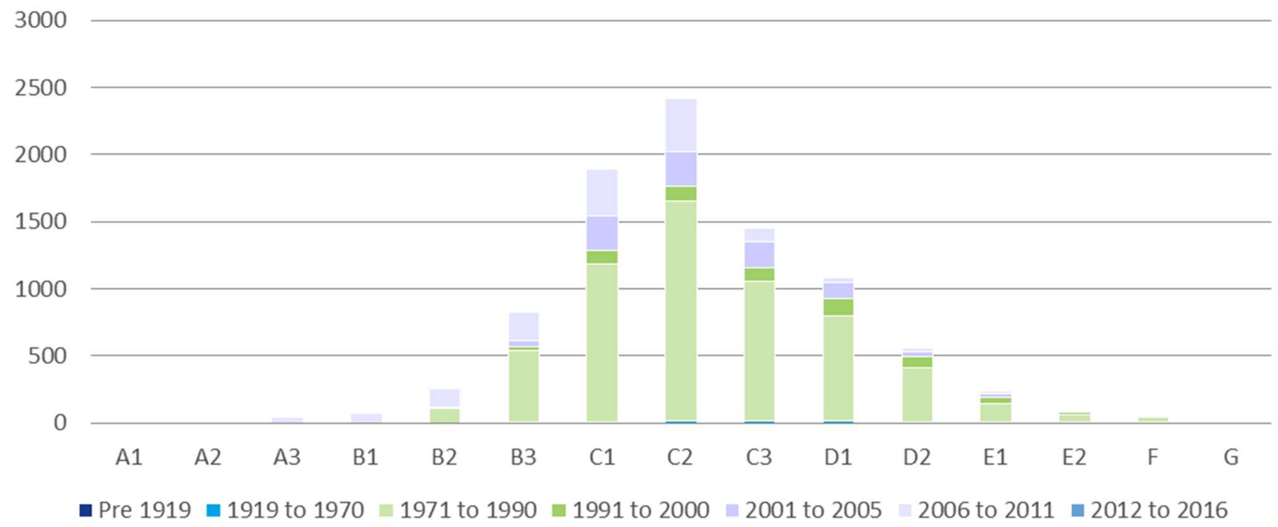

Figure 37 Building Energy Ratings for all South Dublin's Social Housing Units by Construction Period

Figure 36 and 37 show the total building energy ratings for all social housing in South Dublin, for each dwelling type and period built.[1]

It can be seen that the most common rating was C2, which makes up 27% of the total social housing stock in South Dublin.

The majority of buildings that had a C2 rating were terraced houses. From this analysis, Codema found that 77% of South Dublin's total social housing stock had a C3 rating or better. Of these, 47 houses had an A3 rating; however, no A1 or A2 dwellings could be found in South Dublin for 2016.

There were very few F and G rated houses; they made up just 1% of the total social housing stock in South Dublin.

[1] It may be noted that should the actual BERs for the total social housing stock in South Dublin 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 South Dublin's social housing amounted to 29,200 tonnes of CO_2
- Total delivered energy in 2016 amounted to 117 GWh for social housing in South Dublin
- Construction of social housing in South Dublin was the highest between 1971 and 1990
- Terraced houses and apartments were the least carbon intensive type of housing, emitting 3.15 tCO_2 and 3.27 tCO_2 per unit, respectively
- Semi-detached and detached houses were the highest emitters per dwelling, at 3.42 and 4.11 tCO_2/house
- 77% of the social housing stock in South Dublin was rated C3 or better, with C2 being the most common BER type
- The majority of social housing units were terraced houses, making up 76% of the total, followed by apartments (17%) semi-detached, (6%) and detached (1%)
- Terraced houses had the highest emissions, accounting for 74% of total emissions, followed by apartments, semi-detached and detached houses, contributing 17%, 8% and 1% to total emissions, respectively
- 65% of total social housing CO_2 emissions in South Dublin came from natural gas, followed by electricity at 30%
- Space heating and water heating had the highest energy demand, accounting for 53% and 34% of the total energy demand, respectively
- Natural gas accounted for 80% of the total energy consumption, followed by electricity at 16%

Table 5 South Dublin'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	
Detached (MWh)	88	688	-	50	-	-	-	-	-	827
Semi-Detached (MWh)	1,037	6,031	116	254	-	1,635	17	-	5	9,096
Terraced (MWh)	10,688	77,264	-	2,384	-	-	474	-	58	90,867
Apartments (MWh)	6,898	8,987	-	3	-	-	3	-	-	15,891
Total Energy (MWh)	18,712	92,971	116	2,691	-	1,635	494	-	63	116,681
Detached (tCO_2)	41	141	-	13	-	-	-	-	-	195
Semi-Detached (tCO_2)	485	1,235	27	65	-	557	5	-	-	2,373
Terraced (tCO_2)	4,997	15,816	-	613	-	-	125	-	-	21,550
Apartments (tCO_2)	3,225	1,840	-	1	-	-	1	-	-	5,066
Total Emissions (tCO_2)	8,748	19,031	27	692	-	557	130	-	-	29,184

Municipal

South Dublin County Council (SDCC) is responsible for the energy use and emissions[2] from its buildings and facilities, its public lighting, and also 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' 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 total energy consumption for SDCC, and broke this down by type of energy use - electricity, thermal (LPG, natural gas, kerosene, gas oil and wood) and transport (diesel, petrol and biofuels). This 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, SDCC's total energy use in 2016 was 32 GWh. The council's buildings and facilities were the highest energy consumers, accounting for 52% of the council's overall consumption. This is mainly due to the large number of council-owned buildings. Public lighting was the second highest energy consumer, accounting for 37% of the total energy consumption, and the council's fleet, accounted for 11%.

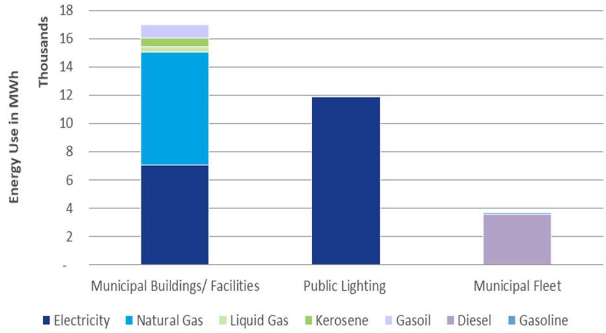

Figure 38 Energy Use in SDCC Grouped by Category and Fuel Use

The highest share of fuel used by the council in 2016 was electricity (58%), followed by natural gas (25%). Diesel, which makes up part of the energy used for the vehicle fleet, contributed 11% to the total fuel mix.

When energy use was converted into emissions, the council's total emissions amounted to 11,900 tonnes of CO_2. Public lighting was the highest contributor, accounting for 47% of these total emissions. This was followed by buildings/facilities and the municipal fleet, each contributing 45% and 8% to the council's CO_2 emissions, respectively.

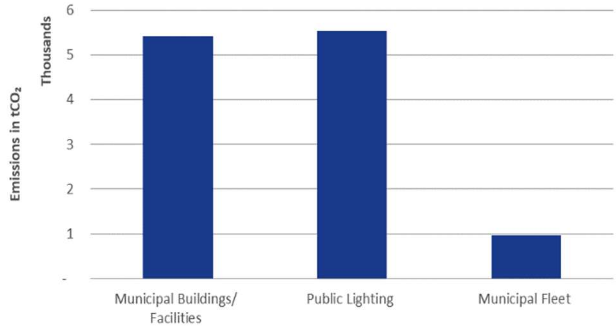

Figure 39 Emissions in tCO_2 by Sector in the Municipality

[2] Emissions from 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 South Dublin'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 74%, followed by natural gas and diesel, each emitting 14% and 8%, respectively.

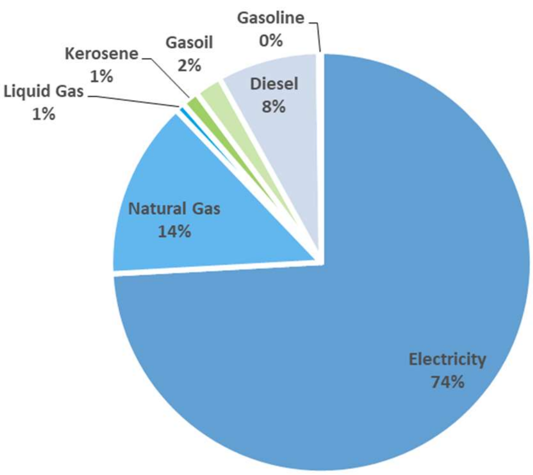

Figure 40 SDCC's Emissions by Fuel Type

Key Findings

The key findings from the municipal sector are summarised below.

- Total final emissions produced by SDCC in 2016 amounted to 11,900 tonnes of CO_2
- Total final energy used in 2016 in SDCC was 32 GWh
- Buildings and facilities were the largest consumers of energy in the municipality. They made up 52% of the total energy consumption
- Public lighting contributed to 47% of total emissions in SDCC, followed by buildings/facilities at 45%, and municipal fleet at 8%
- Electricity accounted for 58% of SDCC's total carbon emissions, followed by gas at 25% and diesel at 11%

Table 6 South Dublin County Council's Municipal Inventory, Energy and CO_2 Emissions

Municipal Sector	Electricity	Fossil Fuel							Renewable Energies				Total
		Natural Gas	Liquid Gas	Heating Oil: Kerosene	Heating Oil: Gasoil	Diesel	Gasoline	Other Fossil Fuels	Biofuel	Other Biomass	Onsite Generation	Solar Thermal	
Municipal Buildings/ Facilities (MWh)	7,056	8,007	370	599	935	-	-	-	-	-	-	-	16,966
Public Lighting (MWh)	11,861	-	-	-	-	-	-	-	-	-	-	-	11,861
Municipal Fleet (MWh)	-	-	-	-	-	3,542	105	-	-	-	-	-	3,647
Total Energy (MWh)	**18,916**	**8,007**	**370**	**599**	**935**	**3,542**	**105**	**-**	**-**	**-**	**-**	**-**	**32,474**
Municipal Buildings/ Facilities (tCO_2)	3,299	1,639	85	154	247	-	-	-	-	-	-	-	5,423
Public Lighting (tCO_2)	5,545	-	-	-	-	-	-	-	-	-	-	-	5,545
Municipal Fleet (tCO_2)	-	-	-	-	-	935	26	-	-	-	-	-	962
Total Emissions (tCO_2)	**8,843**	**1,639**	**85**	**154**	**247**	**935**	**26**	**-**	**-**	**-**	**-**	**-**	**11,929**

Agriculture

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

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

Methodology

The CSO Census of Agriculture is the main source of data used for this chapter. This data was broken down into the different local authority areas and agricultural activities/sectors in Dublin. The agricultural activities were split into:

- Livestock
- Crops
- Horticulture

The Census of agriculture provided data on the number of units for different types of livestock. The livestock included in the census and were 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:

- Cereals
- Silage
- Hay

Horticulture included:

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

Codema then combined the Census data 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. Codema applied these energy benchmarks to the different agricultural activities (livestock, crops and horticulture), to calculate the 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, crops and horticulture energy benchmarks were based on energy use per hectare of area farmed.

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

It is widely recognised that agriculture practices, namely livestock, produce a large amount of GHG emissions, which may not be quantified by energy-related CO_2 emissions. These GHG emissions commonly rise from animal grazing and waste. Therefore, to quantify these emissions, Codema used benchmarks from Cranfield University's 2008 report '*Defra Farm Business Survey Energy Module*'. This report set emission benchmarks for different livestock 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 sourced from Environmental Protection Agency (EPA) and Irish Farmers' Association (IFA) publications.

Codema then applied the emission benchmarks to the different animals, in order to calculate the total CO_2 equivalent emissions from livestock.

Analysis

The total energy use by the agriculture sector in South Dublin amounted to 6 GWh. This energy mostly came from diesel, which makes up 89% of the fuel use. This was followed by electricity at 9% and heating oil at 2%.

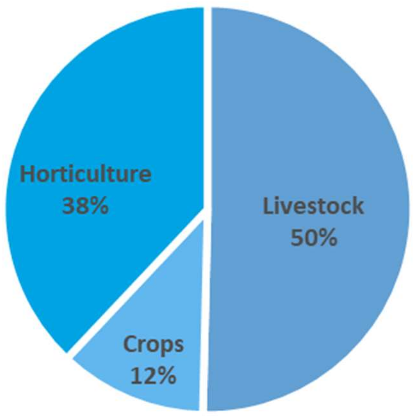

Figure 41 Energy Use by Different Agricultural Sectors

Codema found that livestock was the most energy-intensive activity, accounting for 50% of total energy use. Horticulture and crops accounted for 38% and 12% of the total, respectively.

Emissions in South Dublin from the agriculture sector total 7,000 tonnes of CO_2eq. As mentioned in the methodology, emissions from livestock have been broken down into energy-related emissions and emissions related to GHGs. The GHGs were split into enteric emissions and AWMS emissions.

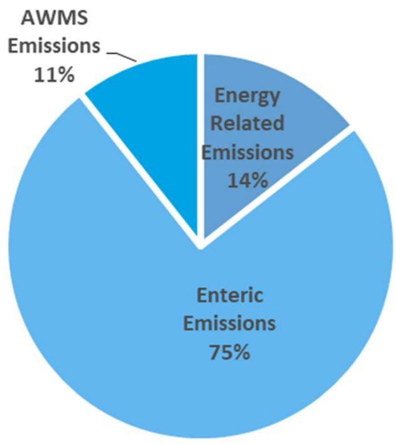

Figure 42 Breakdown of Livestock Emissions in South Dublin

Figure 42 shows that livestock emissions mostly come from enteric emissions, as they make up 75% of the total. Therefore, 75% of total emissions were made up of methane and nitrous oxide. It may be noted that only 14% of total livestock emissions came from energy-related emissions.

Figure 43 below depicts the total emissions in tCO_2 equivalent and shows that livestock produce most of the GHG emissions. Overall, GHG emissions accounted for 74% of total agricultural emissions in South Dublin. This was followed by energy-related emissions from livestock (13%), horticulture (10%), and crops (3%).

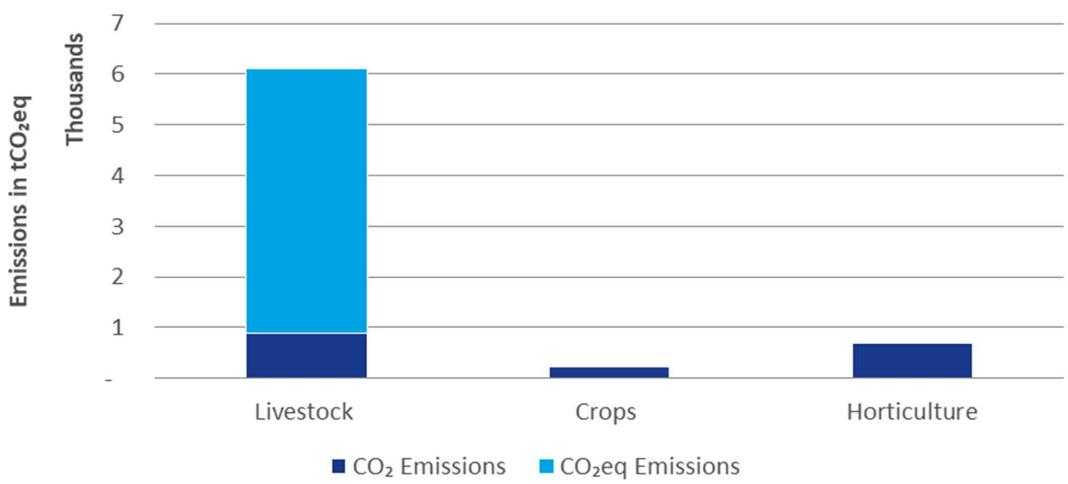

Figure 43 Total Emissions from the Agriculture Sector in South Dublin

Key Findings

- Total agricultural-related emissions in South Dublin were 7,000 tonnes of CO_2eq in 2016
- Total energy use in 2016 was 6 GWh
- GHG emissions produced by livestock contributed 74% to total emissions; this was followed by energy-related emissions from livestock, horticulture and crops (13%, 10% and 3%, respectively)
- 75% of emissions produced by livestock came from enteric process, made up methane and nitrous oxide
- The energy for agricultural activities was mainly fuelled by diesel (89%), followed by electricity (9%), and heating oil (2%)

Table 7 South Dublin'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)	177	-	-	2	3,024	-	-	-	-	3,202
Crops (MWh)	99	-	-	84	558	-	-	-	-	742
Horticulture (MWh)	301	-	-	21	2,092	-	-	-	-	2,414
Total Energy (MWh)	**577**	**-**	**-**	**107**	**5,674**	**-**	**-**	**-**	**-**	**6,358**
Livestock (tCO_2)	83	-	-	1	798	-	-	-	-	881
GHGs from Livestock (tCO_2eq)	-	-	-	-	-	-	-	-	-	5,228
Crops (tCO_2)	46	-	-	22	147	-	-	-	-	215
Horticulture (tCO_2)	141	-	-	5	552	-	-	-	-	698
Total Emissions (tCO_2eq)	**270**	**-**	**-**	**28**	**1,498**	**-**	**-**	**-**	**-**	**7,023**

Waste and Wastewater

This section analyses the CO_2 emissions from landfill waste and wastewater; namely 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)[3]. Waste management practices currently promote the recovery of residual waste, rather than disposing into landfills.

In 2013, 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 the whole of Ireland, (EPA, 2017). Waste in Ireland consists of domestic, commercial and other waste.

Methodology

Codema obtained the emissions data from landfills from two main data sources: the EPA 2017 Waste Applications, Licences, Environmental Information, and landfill annual reports. A detailed list of assumptions and limitations may be found in the Appendix section.

The EPA 2017 Waste Applications provided Codema with a list of all licensed landfills in the Dublin region. The licensed landfills are listed by name and location. From the names and location, 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 on the amount of pollutant releases to air, water and wastewater.

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

Analysis

Even though most of the landfills in Dublin are inactive, they still emit GHG emissions to the atmosphere. Figure 44 depicts the breakdown of landfill emissions in terms of tCO_2eq, as this makes them comparable and it is easier to understand their effect on emissions.

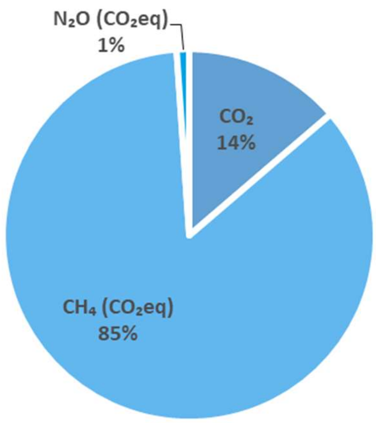

Figure 44 Landfill CO_2eq Breakdown

As may be seen from Figure 44, most of the GHG emissions are made up of methane gas (CH_4), which, due to its toxicity, has a much larger impact even though it might only represent a small proportion of landfill emissions. Therefore, methane gas contributes to more CO_2eq gas than CO_2 does.

Table 8 Landfill Emissions in South Dublin

	Total Landfill Emissions in Dublin in tCO_2eq	Total population in Dublin	Population in South Dublin	Landfill Emissions in South Dublin in tCO_2eq
Calculating Landfill Emissions	128,047	1,345,402	278,749	**26,530**

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[3] 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 increases, so does 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 commuter belts such as 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 develop a National Wastewater Sludge Management Plan, published in 2016, to take some of the pressure off the Ringsend facility.

Methodology

Ideally, emissions from wastewater are collected from Celtic Anglian Water (CAW), which operates the plant at Ringsend. However, CAW was unable to provide 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 the Appendix section.

This case study showed an example of two wastewater treatment plants (WWTP) in Vienna, Austria, which 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

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

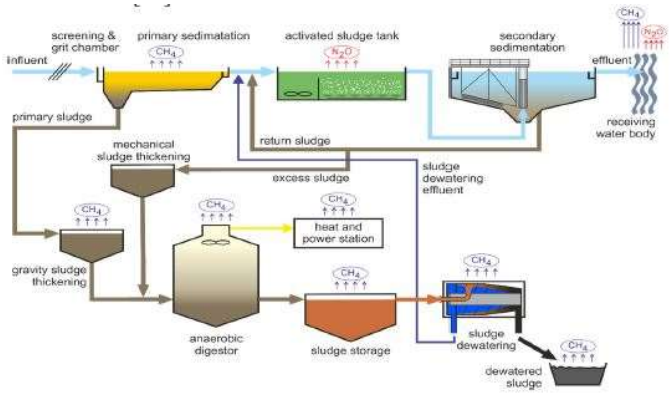

Figure 45 GHG Emissions at WWTP, Source : Parravicini et al. (2016)

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

Codema compared the findings of this case study with the Ringsend WWTP (which has similar characteristics to the two Austrian sites analysed) and was able to calculate the CO_2 emissions to be 23kgCO_2eq per capita, per annum.

Codema then applied the CO_2 equivalent per capita to the population of South Dublin, to get the total emissions in South Dublin from wastewater. This has been 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 were 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.

Table 10 Wastewater Emissions in South Dublin

	Emissions per capita in kgCO_2/PE/a	Population in South Dublin	Wastewater Emissions in South Dublin in tCO_2eq
Calculating Wastewater Emissions	23	278,749	6,411

Key Findings

Waste

- Total emissions from landfills in South Dublin amounted to 26,500 tonnes of CO_2eq
- Methane makes up 85% of total CO_2eq emissions in landfills
- CO_2 only contributes to 14% of total emissions in landfills

Wastewater

- Total emissions from wastewater in South Dublin were 6,400 tonnes of CO_2eq
- Wastewater emissions per person per annum were estimated to be 23 KgCO_2eq

Table 11: South Dublin's Waste Emissions Inventory.

Waste Emissions in South Dublin		
	Landfill Waste	Wastewater
Total Emissions in tCO_2eq	26,530	6,411

Conclusions

Total Energy Use & Emissions in South Dublin

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

The total energy use in South Dublin amounted to 6,783 GWh in 2016. At 31%, diesel accounted for the greatest percentage of this energy use. This was followed by natural gas (29%) and electricity (15%). It should be noted that energy from renewables only contributed 2% to the total fuel mix in South Dublin. Of this renewable energy, 1.5% came from biomass sources.

The total emissions from the various sectors in South Dublin total 1,877,900 tonnes of CO_2eq. Figure 47 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 uses the most electricity in South Dublin, and also had the highest emissions from electricity (69%). As explained in the previous chapter (Emission Sectors, Commercial), this may be due to the number of industrial uses in South Dublin with a high electricity demand.

Natural gas had the highest CO_2 emissions in the residential sector, accounting for 63% of total gas emissions in South Dublin.

Meanwhile, the transport sector accounted for 99.6% of all diesel emissions in South Dublin.

It should be noted that the transport, commercial and residential sectors had the highest emissions and consume more fossil fuels than other sectors, producing 39%, 32% and 24% respectively, of total emissions in South Dublin. From this analysis, these three sectors should be the main targets of energy and emission reduction initiatives.

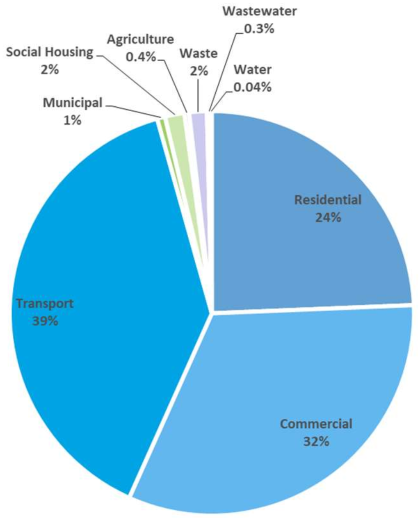

Figure 46 Share of Total Emissions in South Dublin

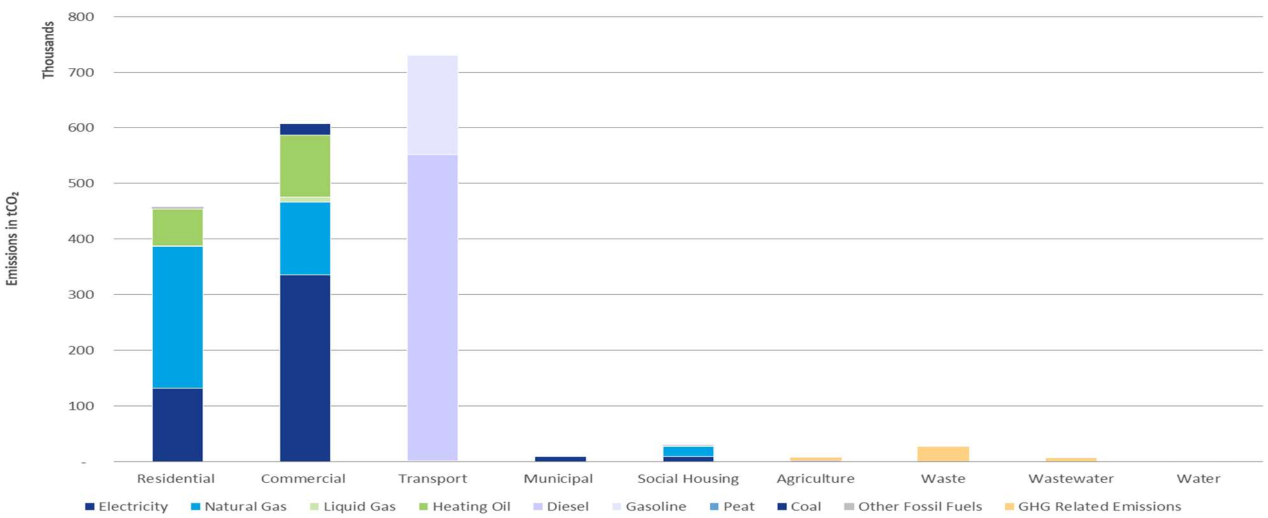

Figure 47 Total Emissions by Fuel Type in Different Sectors

Key Findings

Residential

- Total residential emissions were 457,300 tCO_2 in 2016
- Total delivered energy for the residential sector in South Dublin for 2016 was 1,803 GWh
- 49% of the housing stock was rated C3 or better, with D1 being the most common rating
- Semi-detached houses made up 55% of the total housing stock, followed by terraced houses (20%), apartments (13%) and detached houses (12%)
- Apartments were the least carbon-intensive type of housing, emitting 3.75 tCO_2/apartment
- Detached houses were the most carbon-intensive type of housing, emitting 8.78 tCO_2/detached house
- 56% of residential emissions came from natural gas and 29% from electricity

Commercial

- Total emissions in 2016 were 607,700 tCO_2; of this total, 417,900 tCO_2 came from the services sector and 189,800 tCO_2 came from the industrial sector
- Total final energy used in 2016 by the commercial sector was 2,023 GWh
- Industrial uses (73%), retail (11%), hospitality (6%) and offices (4%) contributed the most to CO_2 emissions
- Hospitality and retail (warehouses) had the highest emissions per property, at 349 tCO_2 and 203 tCO_2, respectively
- Utility, miscellaneous uses and offices had the lowest emissions per property, at 7.85 tCO_2, 8.53 tCO_2 and 24.58 tCO_2, respectively

Transport

- Total final emissions from transport were 731,000 tCO_2eq
- Total energy use in transport was 2,799 GWh
- South Dublin's modal split was made up of 51% private and commercial transport, public transport, 31%, cycling, 13% and walking, 5%
- 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 29,200 tCO_2 in South Dublin
- Total delivered energy for social housing in South Dublin was 117 GWh in 2016
- The majority of social housing units were terraced houses, making up 76% of the total stock; this was followed by apartments (17%), semi-detached houses (6%), and detached houses (1%)
- Terraced houses and apartments were the least carbon-intensive type of housing, emitting 3.15 tCO_2 and 3.27 tCO_2 per unit, respectively
- Semi-detached and detached houses were the highest emitters per dwelling, at 3.42 and 4.11 tCO_2/house
- 77% of the social housing stock in South Dublin was rated C3 or better, with C2 being the most common BER type
- 65% of total CO_2 emissions from social housing in South Dublin came from natural gas, followed by electricity at 30%

Municipal

- Total final emissions produced by SDCC in 2016 were 11,900 tCO_2
- Total final energy used in 2016 in SDCC was 32 GWh
- Buildings and facilities were the largest consumers of energy in the municipality. They made up 52% of the total energy consumption
- Public lighting contributed to 47% of total emissions in SDCC, followed by buildings/facilities at 45%, and municipal fleet at 8%
- 58% of SDCC's carbon emissions came from electricity, followed by gas (25%) and diesel (11%)

Agriculture

- Total agricultural-related emissions in South Dublin amounted to 7,000 tCO_2 in 2016
- Total energy use in 2016 was 6 GWh
- GHG emissions produced by livestock contributed 74% to total emissions; this was followed by energy related emissions from livestock (13%), horticulture (10%), and crops, (3%)
- 75% of emissions produced by livestock came from enteric processes, made up methane and nitrous oxide
- Only 14% of livestock emissions were energy-related

Waste

- Total emissions from landfills in South Dublin amounted to 26,500 tCO_2eq
- Methane makes up 85% of total CO_2eq emissions in landfills

Wastewater

- Total emissions from wastewater in South Dublin were estimated to be 6,400 tCO_2eq
- Wastewater emissions per person per annum were estimated to be 23 $KgCO_2eq$

Table 12 South Dublin's Emissions Inventory; Energy and CO_2 Emissions

South Dublin	Electricity	Fossil Fuels									Renewable Energies				Total
		Natural Gas	Liquid Gas	Heating Oil	Diesel	Gasoline	LPG	Peat	Coal	Other Fossil Fuels	Biofuel	Other Biomass	Onsite Generation	Geothermal	
Residential (MWh)	281,377	1,247,109	3,548	258,765	-	-	-	131	1,845	9,350	1	1,051	-	-	1,803,177
Commercial (MWh)	718,320	636,653	40,479	433,460	-	-	-	265	60,968	-	795	97,232	-	34,667	2,022,840
Transport (MWh)	2,991	-	-	-	2,085,769	708,581	1,858	-	-	-	-	-	-	-	2,799,199
Municipal (MWh)	18,916	8,007	370	1,534	3,542	105	-	-	-	-	-	-	-	-	32,474
Social Housing (MWh)	18,712	92,971	116	2,691	-	-	-	-	1,635	494	-	63	-	-	116,681
Agriculture (MWh)	577	-	-	107	5,674	-	-	-	-	-	-	-	-	-	6,358
Waste (MWh)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wastewater (MWh)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water (MWh)	1,803	-	-	-	-	-	-	-	-	-	-	-	-	-	1,803
Total Energy (MWh)	**1,042,695**	**1,984,739**	**44,514**	**696,557**	**2,094,985**	**708,686**	**1,858**	**397**	**64,448**	**9,844**	**797**	**98,346**	**-**	**34,667**	**6,782,532**
Residential (tCO_2)	131,544	255,283	814	66,503	-	-	-	47	628	2,467	-	-	-	-	457,286
Commercial (tCO_2)	335,814	130,323	9,282	111,399	-	-	-	94	20,766	-	-	-	-	-	607,679
Transport (tCO_2eq)	1,398	-	-	-	550,643	178,562	426	-	-	-	-	-	-	-	731,029
Municipal (tCO_2)	8,843	1,639	85	401	935	26	-	-	-	-	-	-	-	-	11,929
Social Housing (tCO_2)	8,748	19,031	27	692	-	-	-	-	557	130	-	-	-	-	29,184
Agriculture (tCO_2eq)	270	-	-	28	1,498	-	-	-	-	-	-	-	-	-	7,023
Waste (tCO_2eq)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26,530
Wastewater (tCO_2eq)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,411
Water (tCO_2)	844	-	-	-	-	-	-	-	-	-	-	-	-	-	844
Total Emissions (tCO_2/tCO_2eq)	**487,461**	**406,276**	**10,207**	**179,022**	**553,076**	**178,589**	**426**	**141**	**21,951**	**2,598**	**-**	**-**	**-**	**-**	**1,877,914**

Appendices

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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 home owners. 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 South Dublin 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 inputted 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 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 Dublin was 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 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 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 the 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 emissions arising from both the residential and social housing sector. In 2016, South Dublin's housing (including both residential and social housing) accounted for 486,500 tonnes of CO_2, which is 26% of total emissions in South Dublin.

Figure 48 Total Number of Households by Type in South Dublin

As can be seen from Figure 48 and Figure 49, social housing accounts for just 10% of total housing in South Dublin, and 7% of the total housing floor area in the county.

The most common type of dwelling in residential households was semi-detached houses, making up 55% of the total residential units in 2016. Semi-detached houses also had the largest residential floor area in South Dublin, at 57%. For social housing, the most common dwelling type was terraced houses, making up 76% of SDCC's total social housing units. Furthermore, terraced houses also had the greatest floor area, accounting for 80% of the total social housing floor area in South Dublin.

Figure 49 Total Household Floor Areas by Type of Dwelling in South Dublin

When comparing emissions per unit between social housing units and residential units, social housing units (3.24 tCO_2/dwelling) were found to emit fewer emissions per unit than residential unit (5.52 tCO_2/dwelling). Apartments for the residential sector produced the least emissions (3.75 tCO_2/apartment) from all the different dwelling types Meanwhile, in social housing, terraced houses were the least emitters per dwelling, at 3.15tCO_2/ house.

In the residential sector, detached houses were the highest polluters at 8.78 tCO_2 per house, whilst in the social housing sector, semi-detached houses produced the most emissions, at 4.11 tCO_2 per house.

Detached and semi-detached houses in both the residential and social housing sector are the least efficient due to the way these dwellings are built; that is, they have a larger floor area than other dwelling types, have more exposed area, and no neighbouring houses to shelter them. All these factors contribute to a higher energy use and thus higher emissions (unless renewables are used as a source of energy). Houses usually have a larger floor area than apartments, which in turn, leads to an increase in energy demand (space heating, for example). Semi-detached and terraced houses, similar to detached houses, would have a larger building envelope than apartments, leading to higher energy losses and an increased energy demand.

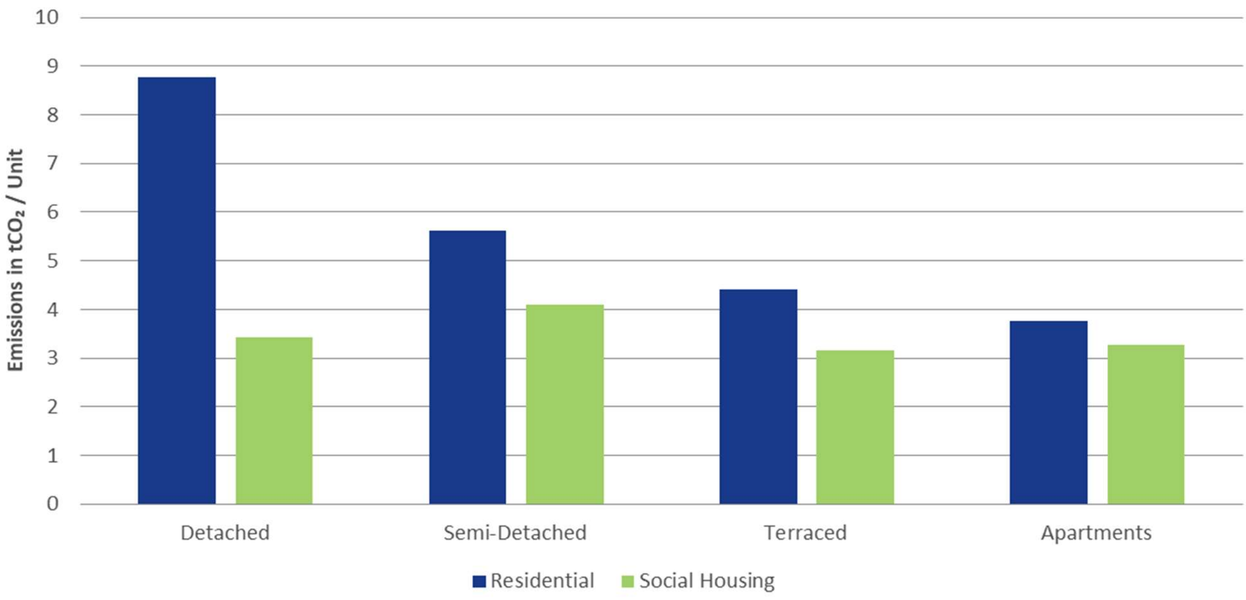

Figure 50 Emissions in tCO_2/unit for Residential and Social Housing

As for social housing, terraced houses were found to be the least carbon-intensive. This might be due to the fact that terraced houses are the most common type of social housing with a higher likelihood of being refurbished most recently by the local authority, resulting in a more efficient type of housing.

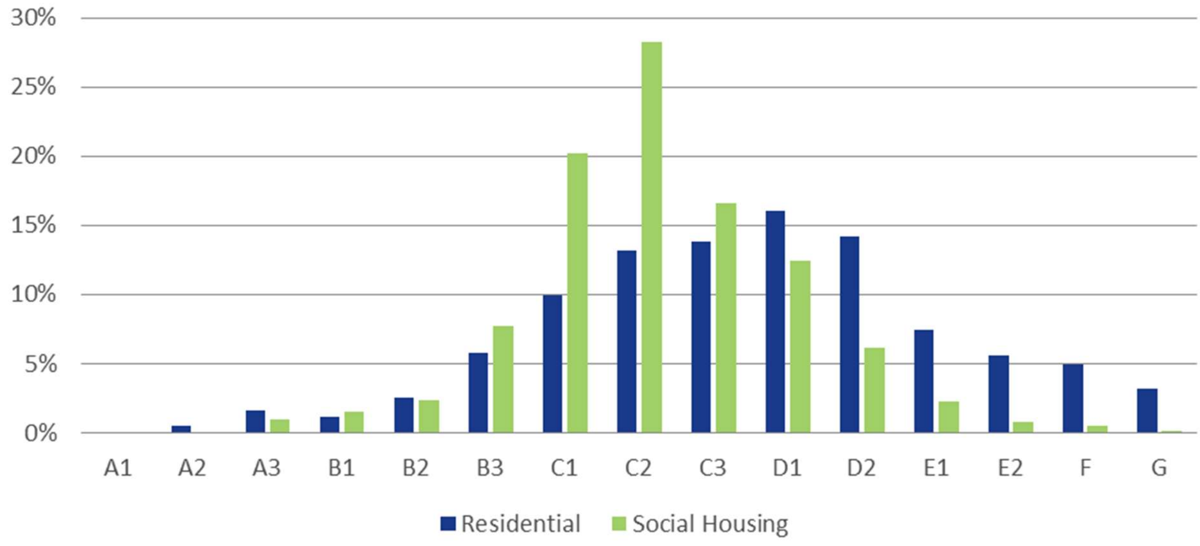

Figure 51 Building Energy Ratings for Residential and Social Housing

Figure 51 represents the average BERs for both social housing and residential units, which were applied to the total housing stock in South Dublin. It can be seen that the most common BER in social housing was a C2 rating, which made up 28% of the total social housing stock. Meanwhile, in the residential sector, the most common BER was a D1, making up 16% of the total residential sector.

In the residential sector, 49% of the BERs were rated C3 or better, compared to 78% of social housing units. Similarly, in the residential sector, 8% of dwellings had an F or G rating, compared 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 lower than the residential sector. These results reflect the ongoing retrofitting work that is being carried out by South Dublin County Council to upgrade the less efficient social housing stock.

Appendix D - Municipal Emissions

Current Situation

Figure 52 shows the total CO_2 emissions from 2009 (baseline year) up to 2016. The baseline year is chosen by each local authority; this is dependent on the year that SDCC started reporting their energy use and emissions on the M&R system.

As can be seen from the figure below, the greatest emission reductions were between 2009 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 higher emission reduction actions 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 South Dublin County Council must keep on striving to reach its targets and become a leader in emission reductions.

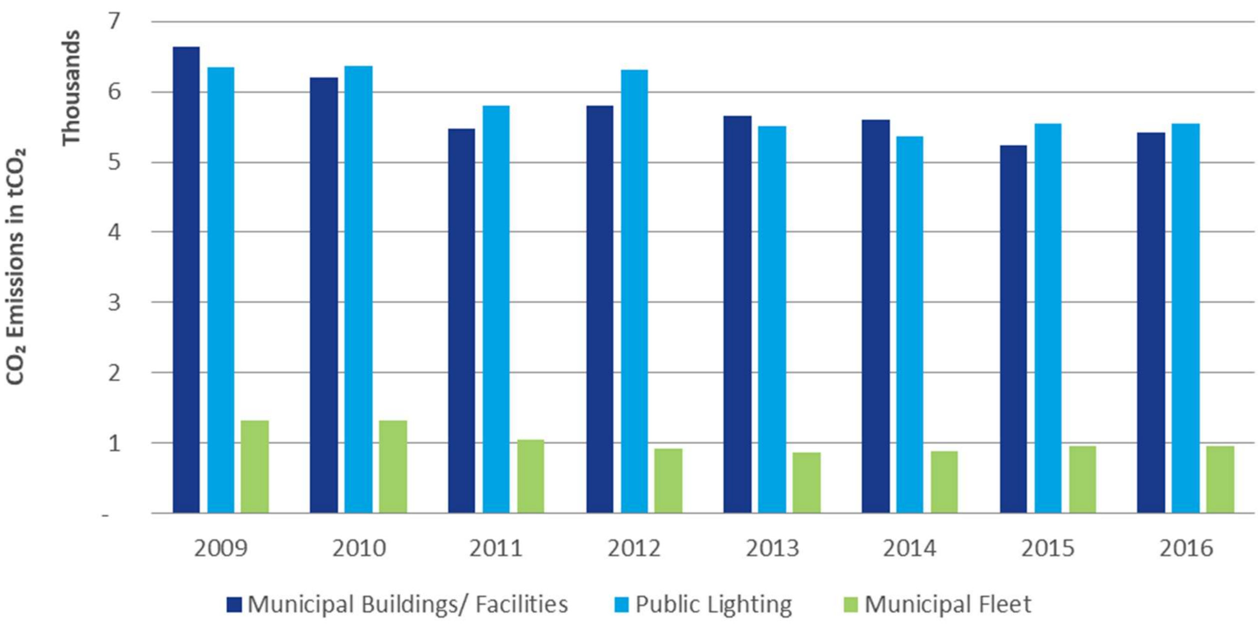

Figure 52 2009 – 2016 Emissions for SDCC

Key Findings

- Buildings and Facilities have reduced their total emissions by 18% over the eight year period
- Public Lighting emissions reduced by 13% from 2009 to 2016, but emissions have increased annually from 2014 to 2016
- Municipal fleet emissions decreased by 28% in 2016, however an increase was recorded for the period of 2014 to 2016

2030 Emission Reduction Targets

The 2030 Emission Reduction Targets were set by the Covenant of Mayors for Climate and Energy, to which SDCC is a signatory. The 2030 target is a 40% reduction in emissions from the baseline year (2009).

The graph below illustrates the total emissions in SDCC and the target glidepath (emission target). It was found that in 2016, SDCC was 23% away from meeting the 2030 target (40% emission reduction).

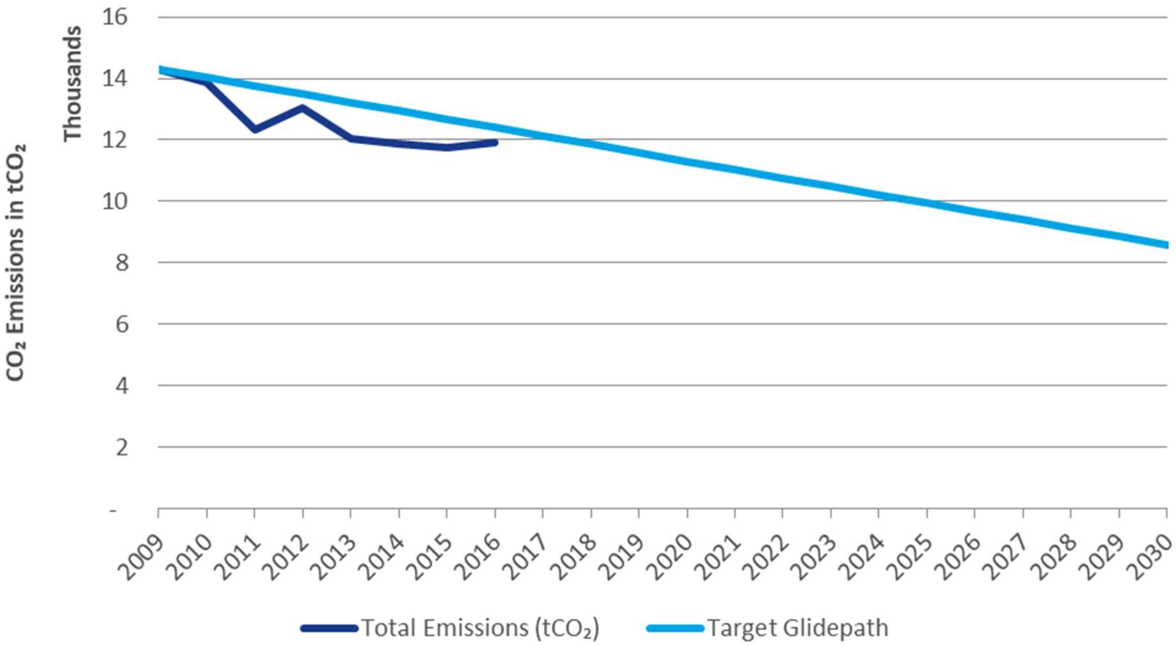

Figure 53 2030 Emissions Target for SDCC

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

Sector		FINAL ENERGY CONSUMPTION [MWh]															
		Electricity	Heat/cold	Fossil fuels								Renewable energies					Total
				Natural gas	Liquid gas	Heating oil	Diesel/Gas oil	Gasoline	Lignite	Coal	Other fossil fuels	Plant oil	Biofuel	Other biomass	Solar thermal	Geothermal	
BUILDINGS, EQUIPMENT/FACILITIES AND INDUSTRIES																	
Municipal buildings, equipment/facilities		7,056	-	8,007	370	1,534	-	-	-	-	-	-	-	-	-	-	16,966
Tertiary (non municipal) buildings, equipment/facilities		493,798	-	433,337	12,381	371,432	-	-	-	-	-	-	-	42,096	-	34,667	1,387,711
Residential buildings		300,089	-	1,340,079	3,665	261,456	-	-	131	3,480	9,844	-	1	1,114	-	-	1,919,859
Public lighting		11,861	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,861
Industry	Non-ETS	226,324	-	203,315	28,098	62,028	-	-	265	60,968	-	-	795	55,136	-	-	**636,931**
	ETS (not recommended)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Subtotal		1,039,127	-	1,984,739	44,514	696,451	-	-	397	64,448	9,844	-	797	98,346	-	34,667	3,973,328
TRANSPORT																	
Municipal fleet		-	-	-	-	-	3,542	105	-	-	-	-	-	-	-	-	**3,647**
Public transport		1,127	-	-	700	-	785,776	266,945	-	-	-	-	-	-	-	-	**1,054,548**
Private and commercial transport		1,864	-	-	1,158	-	1,299,994	441,636	-	-	-	-	-	-	-	-	**1,744,652**
Subtotal		2,991	-	-	1,858	-	2,089,311	708,686	-	-	-	-	-	-	-	-	2,802,847
OTHER																	
Agriculture, Forestry, Fisheries		577	-	-	-	107	5,674	-	-	-	-	-	-	-	-	-	**6,358**
TOTAL		1,042,695	-	1,984,739	46,372	696,558	2,094,985	708,686	397	64,448	9,844	-	797	98,346	-	34,667	6,782,532

Sector		CO_2 emissions [t] / CO_2 eq. emissions [t]															
		Electricity	Heat/cold	Fossil fuels								Renewable energies					Total
				Natural gas	Liquid gas	Heating Oil	Diesel/Gas oil	Gasoline	Lignite	Coal	Other fossil fuels	Plant oil	Biofuel	Other biomass	Solar thermal	Geothermal	
BUILDINGS, EQUIPMENT/FACILITIES AND INDUSTRIES																	
Municipal buildings, equipment/facilities		3,299	-	1,639	85	401	-	-	-	-	-	-	-	-	-	-	5,423
Tertiary (non municipal) buildings, equipment/facilities		230,851	-	88,704	2,839	95,458	-	-	-	-	-	-	-	-	-	-	417,852
Residential buildings		140,292	-	274,314	839	67,194	-	-	47	1,187	2,598	-	-	-	-	-	486,470
Public lighting		5,545	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,545
Industry	Non-ETS	105,807	-	41,619	6,443	15,941	-	-	94	20,766	-	-	-	-	-	-	**190,670**
	ETS (not recommended)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Subtotal		485,792	-	406,276	10,194	178,988	-	-	-	21,977	2,598	-	-	-	-	-	1,105,959
TRANSPORT																	
Municipal fleet		-	-	-	-	-	935	26	-	-	-	-	-	-	-	-	**962**
Public transport		527	-	-	160	-	207,445	67,270	-	-	-	-	-	-	-	-	**275,402**
Private and commercial transport		872	-	-	265	-	343,198	111,292	-	-	-	-	-	-	-	-	**455,627**
Subtotal		1,398	-	-	426	-	551,578	178,589	-	-	-	-	-	-	-	-	731,991
OTHER																	
Agriculture, Forestry, Fisheries		270	-	-	-	28	1,498	-	-	-	-	-	-	-	-	-	**1,795**
OTHER NON-ENERGY RELATED																	
Waste management																	**26,530**
Waste water management																	**6,411**
Other non-energy related (Agriculture GHG emissions)																	**5,228**
TOTAL		487,460	-	406,276	10,619	179,015	553,076	178,589	-	21,977	2,598	-	-	-	-	-	1,877,914

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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

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

SDCC – South Dublin County Council

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
Átha Cliath Theas
South Dublin County Council

SUSTAINABLE
ENERGY AUTHORITY
OF IRELAND

Dublin's Energy Agency

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