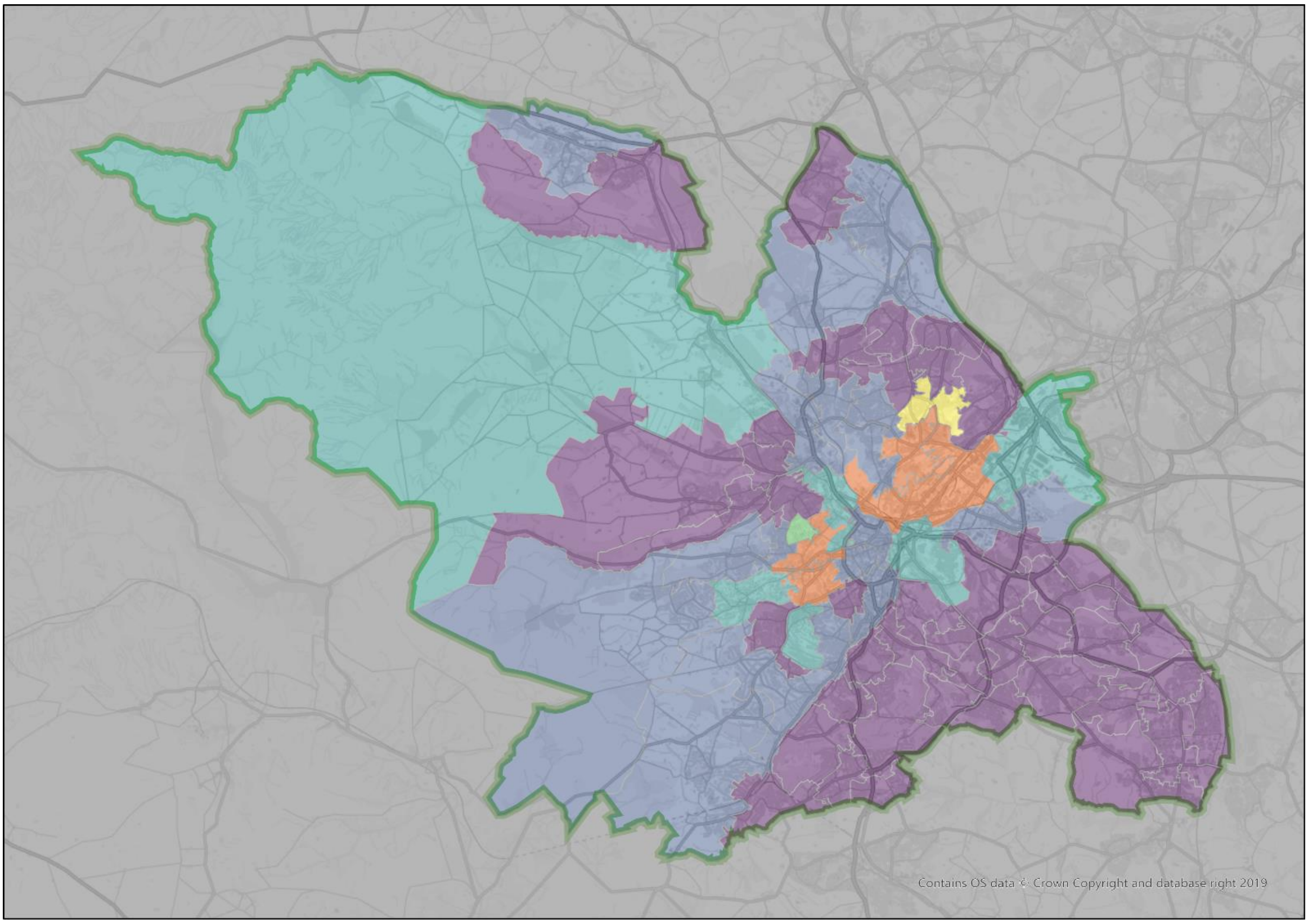

Baseline and Inventory Report – Work Package 1

Report for Sheffield City Council

Customer:

Sheffield City Council

Customer reference:

Zero Carbon Commission: DN461793

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19th June 2020

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Ricardo is certified to ISO9001, ISO14001, ISO27001 and ISO45001

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Glossary

Abbreviation	Definition
GHGI	Greenhouse Gas Inventory
GVA	Gross Value Added
LA CO_2	Local Authority Carbon Dioxide
LULUCF	Land Use, Land-Use Change, and Forestry
MSOA	Middle Super Output Areas
NAEI	National Atmospheric Emissions Inventory
VKM	Vehicle Kilometres

1 Introduction and scope of analysis

Sheffield City Council has set a target for the city to be zero carbon by 2030. In addition, in their report of June 2019, the Tyndall Centre recommended that the city should stay within a cumulative CO_2 emissions budget of 16 Mt CO_2 for the period of 2020 to 2100, which would mean achieving near zero carbon emissions by no later than 2038. The City Council has commissioned ARUP and Ricardo to support them in developing a plan to achieve this net zero goal. The work being carried out falls into 4 work packages:

- WP1 Baseline inventory – developing a detailed understanding of current carbon and GHG emissions;
- WP2 Gap Analysis – projecting this baseline inventory forward under business as usual to assess the scale of the challenge required to meet net zero emissions;
- WP3.1 City level mitigation pathway – developing a set of mitigation options at the city level that can achieve the net zero goal;
- WP3.2 Council estate mitigation pathway – developing a set of detailed mitigation actions for the councils own buildings and fleet;
- WP4 Governance arrangements – will develop the governance approach to support delivery of the net zero pathway.

This report sets out the results of WP1 on the baseline inventory. The work covers an assessment of the current energy use and GHG emissions within Sheffield, along underlying activity.

1.1 Scope of analysis

The baseline inventory has been developed covering the three key Green House Gases (GHG) – CO_2, Methane (CH_4) and nitrous oxide (N_2O). The analysis only considered scope 1 and scope 2 emissions, that is emissions directly generated in the city from combustion or processes and those associated to emissions from electricity use.

The main source of data used is the local and regional carbon dioxide (CO_2) emissions estimates for the UK (LA CO_2) produced by by Ricardo for the Department of Business, Energy & Industrial Strategy (BEIS) in order to provide a nationally consistent evidence base for use in tracking carbon reduction policy. The dataset provides a spatial disaggregation of the CO_2 emissions from the UK Greenhouse Gas Inventory (GHGI), part of the National Atmospheric Emissions Inventory (NAEI), on and end-user basis. CO_2 emissions are estimated, by sector, for each local authority in the UK. The data help identify the key sources of CO_2. By utilising this data, it is possible to disaggregate CO_2 emissions in Sheffield for:

- Industrial and commercial
- Domestic
- Transport
- Agriculture, Waste and Land Use

In addition to the CO_2 data, the main component of GHG emissions, an analysis has been carried out of the key non-CO_2 GHG's, methane (CH_4) and nitrous oxide (N_2O). These data have been extracted from the 1x1km gridded data of the NAEI following the same basic sectoral structure as the CO_2 data. However, these data are calculated on a source basis, i.e. where the emissions are emitted, rather than an end user basis. Therefore, they are not directly consistent with the CO_2 data but give a good estimate of the other GHG's to allow a full picture of GHG's to be presented. The combination of these core datasets is illustrated in Figure 1.

As well as the sectoral breakdown of the data we are also able to provide a spatial disaggregation of the data. The level of spatial disaggregation in the LA CO_2 data is illustrated in Figure 2 below. The spatial detail is different for sector, depending on the key data used for this sector. For the non-CO_2 GHG data from the NAEI the core spatial disaggregation level is the 1x1km grid.

A key element of underlying data that drives the LA CO_2 data is the BEIS regional energy data derived from consumption of gas and electricity at meter points. This data is also reported and analysed in this report, and like the emissions data can be considered spatially.

Figure 1 Core data sources underlying the analysis

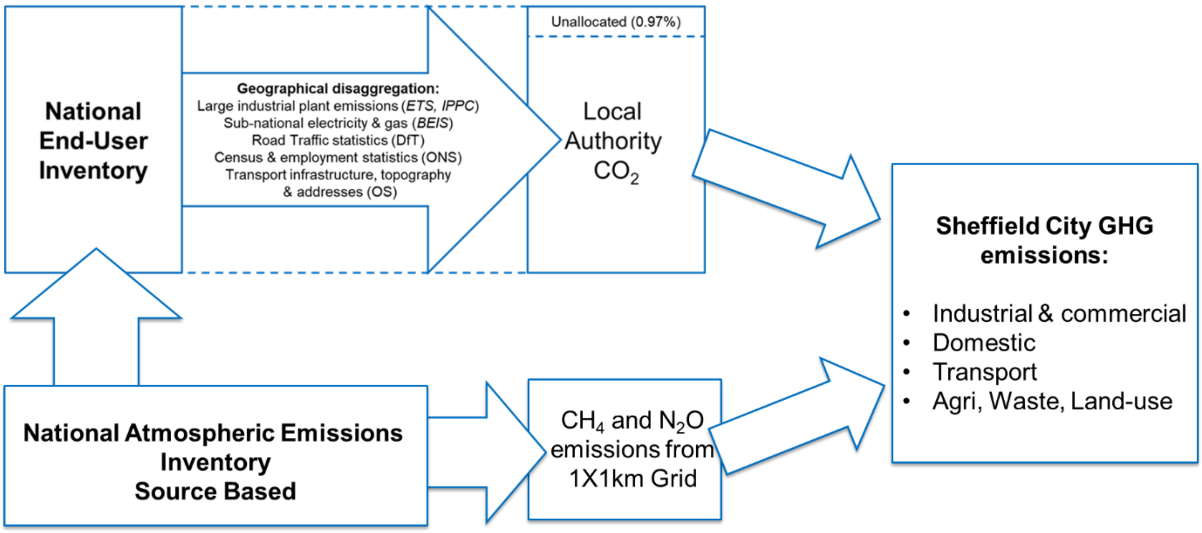
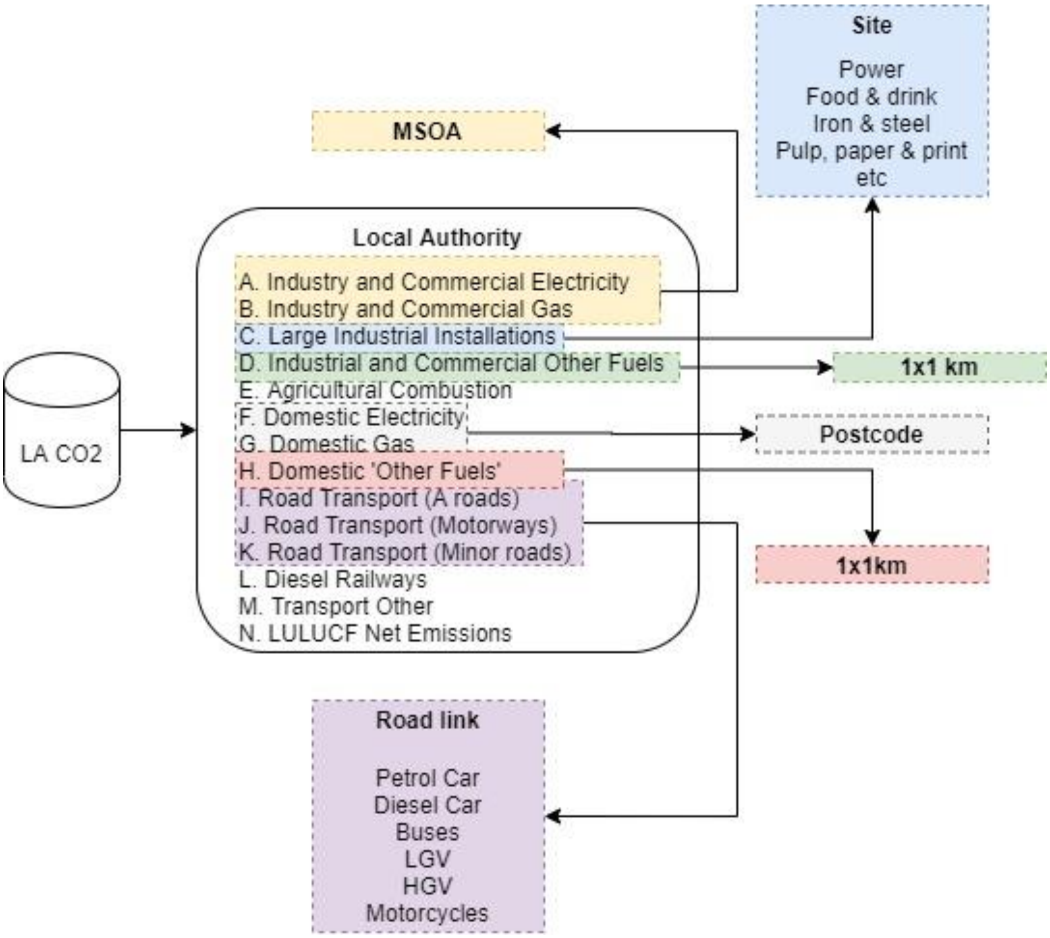


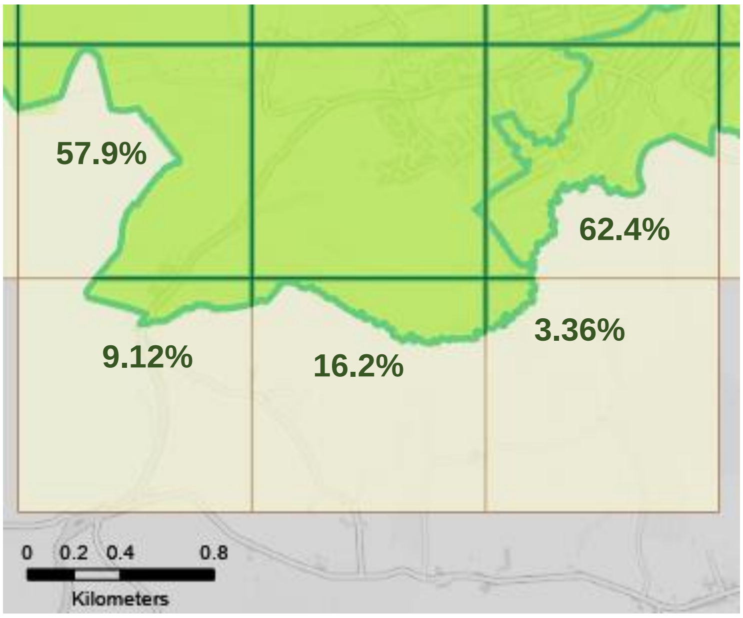
Figure 2 Spatial disaggregation of the local authority CO_2 statistics.



In order to provide a more consistent spatioal analysis of the data from sector to sector we have produced a common spatial mapping of energy consumption and emissions at MSOA level (Middle Layer Super Output Area) – a geospatial unit adopted by the Office for National Statistics to facilitate the reporting of small area statistics. The data utilised for these maps have not always been obtained at MSOA level. The following sequence of applying data to the MSOAs aids the aforementioned.

1. Where MSOA energy consumption data were available the maps used these data
2. Where postcode level data (domestic sector) were provided, emission factors were applied to energy consumption to get emission estimates at MSOA level.
3. Where gridded data (1x1km grids) were utilised, an area weighted approach was adopted to account for the bordering effect. Specifically, for the MSOAs located at the border of Sheffield, the emissions were calculated as a fraction of total emissions per the overlaying 1x1km grid. See Figure 3 for a visualisation.

Figure 3 Percentages of each MSOA section (green) within each 1x1 km grid (yellow).



Further to this approach to overcome the bordering effect, the interpretation of data at MSOA level differs to grid level – when grids were used to present MSOA maps. Specifically, the MSOAs are not consistent in area leading to different interpretations as many grids' data may contribute to one MSOA's data. Following the methods utilised to ensure the appropriate emission estimates are applied to the MSOAs, it is important to clarify that emissions in this report are, therefore, modelled and not obtained directly via in-situ measurements nor via meter readings.

1.2 Structure of the report

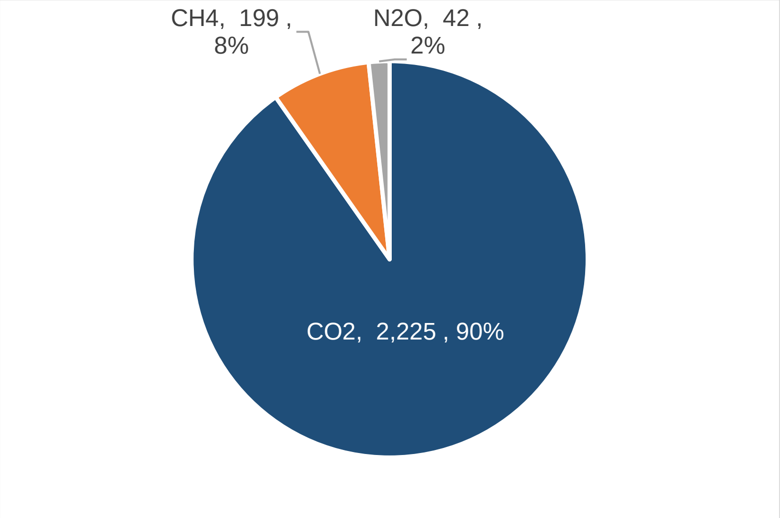
Chapter 2 of this report provides an overview of the key GHG data at the city level. The following chapters then provide a more detailed analysis of each of the 4 key sectors covering energy use data, underlying activity and structure of the sector and resulting CO_2 and GHG emissions. Chapter 8 provides an analysis of current levels of local energy generation and storage and the final chapter pulls together the key points of the analysis and implications for achieve near zero carbon emissions.

The detailed analysis of energy use and CO_2 emissions for each of the sectors in chapters 3 to 6 uses the detailed structural and spatial disaggregation of the local authority CO_2 statistics and NAEI data described above.

2 Overview of CO_2 and GHG emissions from all sectors

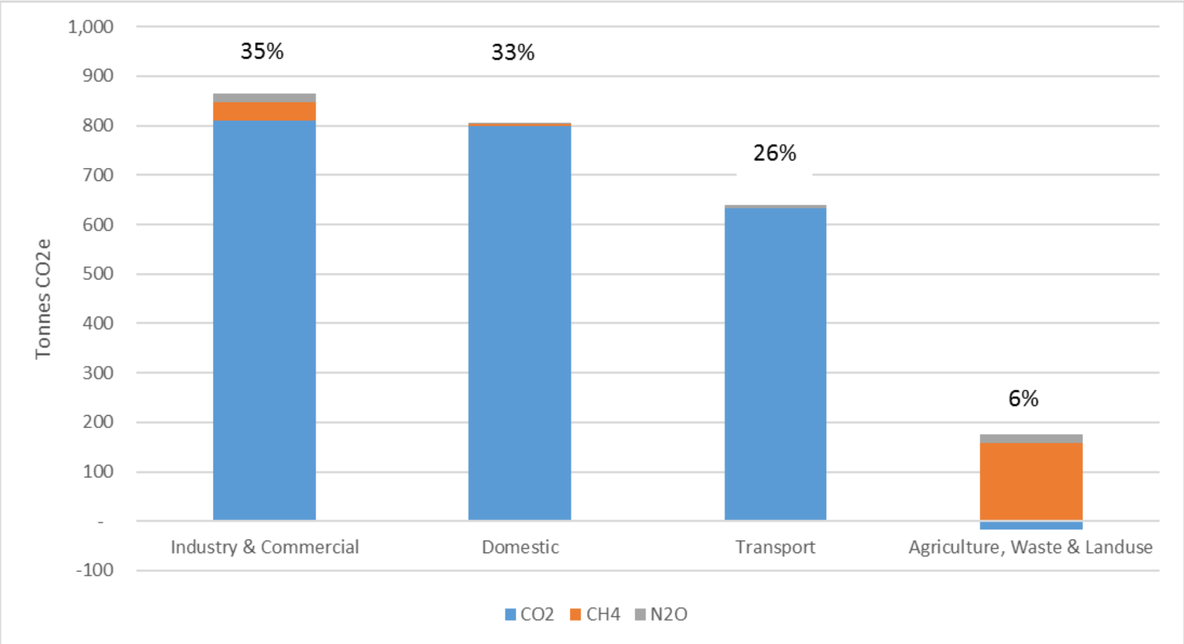
The key GHG at the city level is generally CO_2 driven by combustion of fossil fuels. However, there are other GHG emissions in the form of CH_4 and N_2O which have been included in this analysis. In order to compare these different gases consistently, as they have different global warming potential to CO_2, they have been reported in CO_2 equivalent units (CO_{2e}). The total GHG emissions from the city, in 2017 (the latest year of the data available) is shown in Figure 4 in kt CO_2e. The chart clearly shows that the emissions in kt CO_2e are dominated by carbon dioxide (90%) compared to methane (8%) and nitrous oxide (2%). Hence the focus for action will be to reduce the core CO_2 emissions.

Figure 4 GHG breakdown from all sectors in Sheffield for 2017 (kt CO_2e)



To further understand the GHG emissions and, subsequently, meet the zero-carbon target in Sheffield, it is crucial to understand their sources (i.e. sector). Hence Figure 5 below provides the GHG breakdown by sector and pollutant. Overall the largest emission sources are the industrial & commercial (35%) and domestic sectors (33%), followed relatively closely by road transport (26%). The agricultural, waste & land-use sector contributes to only 6% of all Sheffield's GHG emissions.

Figure 5 GHG by sector in Sheffield for 2017

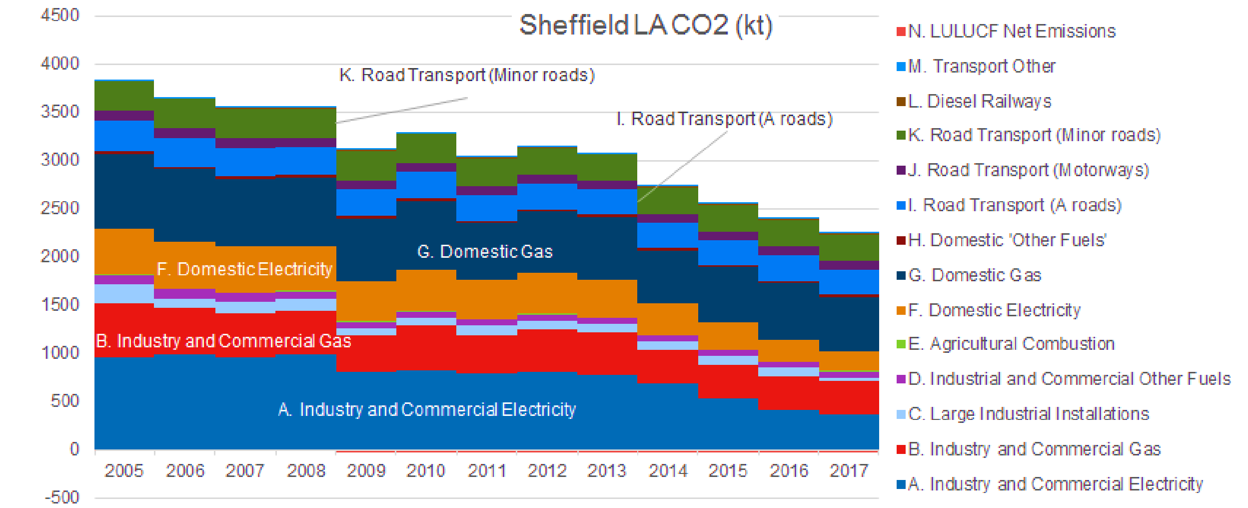


This figure also illustrates that the domestic and transport sectors are nearly all CO_2 emissions, with the industrial and commercial sector being mostly CO_2 emissions. Conversely the agriculture and waste sectors are mostly CH_4 emissions. The land-use sector also shows a small negative value (or sequestration) of CO_2 of some 17 tonnes CO_2e.

2.1 CO_2 timeseries by sector

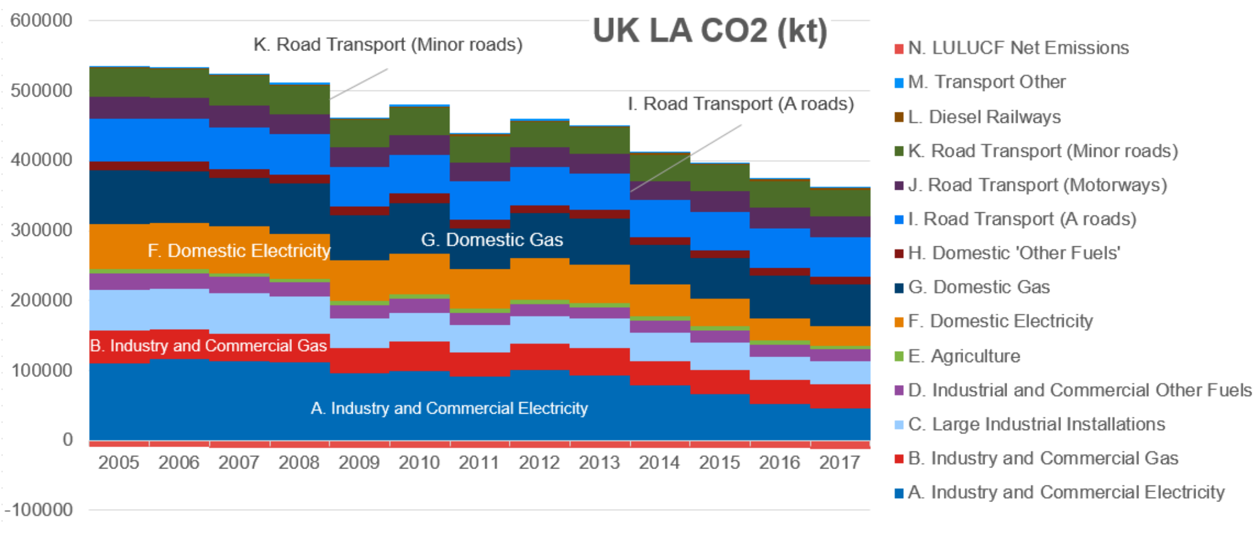
Focusing on the main pollutant of CO_2 a timeseries (Figure 6) is provided showing the emissions' trends between 2005-2017. This provides an illustration of how the different sectors have developed over time. This indicates a significant reduction in emissions in the industrial and commercial sectors, as well as the domestic sector. Conversely the transport sector has little if any reduction in emissions. You can also see the drop in emissions associated with the economic crash in 2008/2009. These trends are explored further in each of the sector focused chapters below.

Figure 6 CO_2 emissions (tonnes) timeseries by sector in Sheffield 2005 to 2017



In order to obtain a more comprehensive understanding and examine the significance of Sheffield's data, Figure 7 was plotted to make comparisons with the UK's LA CO_2 emissions.

Figure 7 CO_2 emissions (tonnes) timeseries by sector in the United Kingdom from 2005 to 2017



A common trend is observed as the CO_2 emissions decrease overall (where from 2014 and onwards the rate of decrease has been greater). Despite this trend, certain sectors contribute to a lesser/greater extent to the total emissions compared to the UK. We can see that Sheffield's emissions from Industrial and Commercial gas consumption are proportionally greater when compared to the total emissions in the UK. On the contrary, Sheffield appears to have a lower contribution to the CO_2 emissions from the traffic on main roads and the Large Industrial Installations compared to the UK as a whole.

Additional comparisons were made with other major cities (Manchester, Leeds, Newcastle, Bristol and Nottingham). Figure 8 shows the total emissions for each city by main sector in 2017. This shows that Sheffield has similar emissions per capita to Manchester, Bristol and Nottingham, but lower than Leeds and Newcastle. Also in general all cities so emissions are split roughly a thord between each of the 3 main sectors, though leads has a somewhat higher contribution from transport at over 40%. The general trend amongst the cities follows the reduction of CO_2 emissions over the years with a noticeable decrease from 2014 and onwards seen in the following charts.

Figure 8 Emissions of CO_2 (kt) for the four sectors from six cities in England (2017).

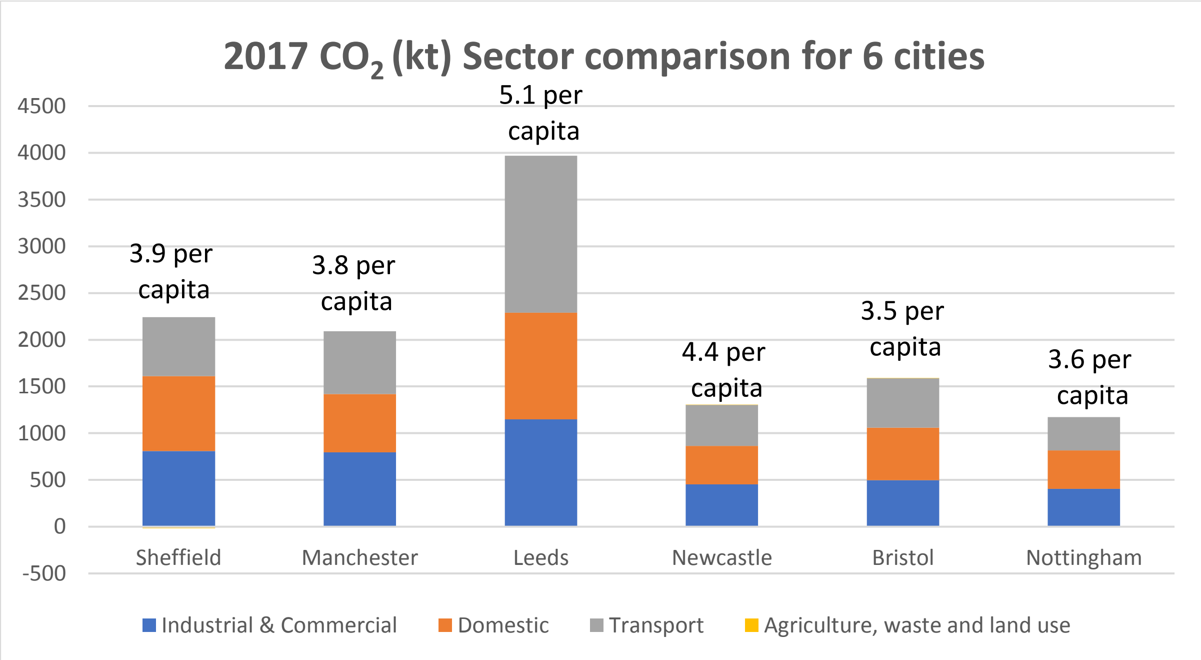
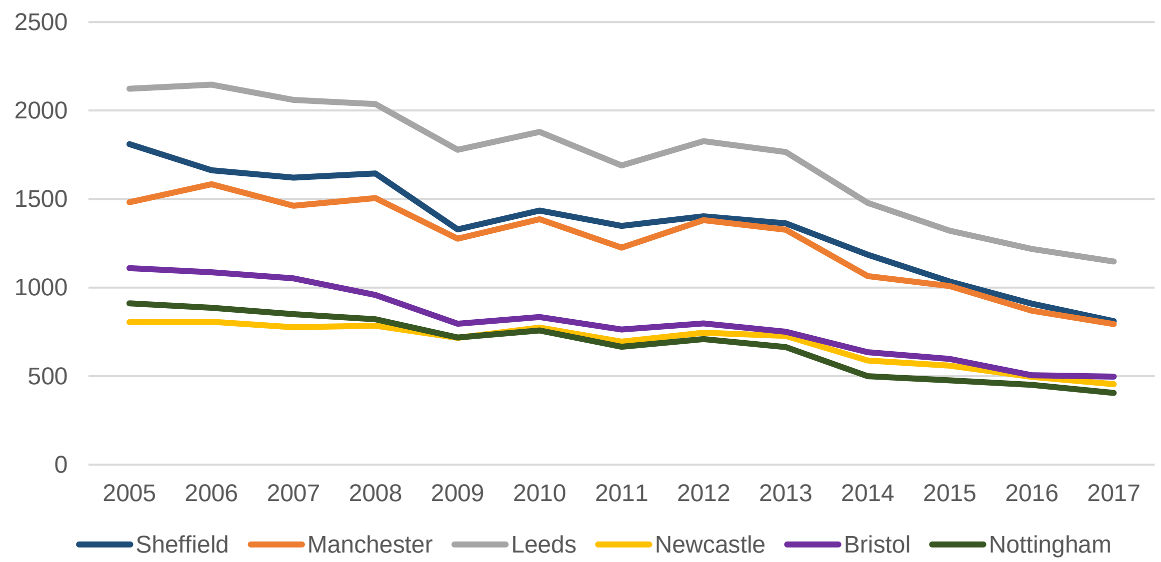
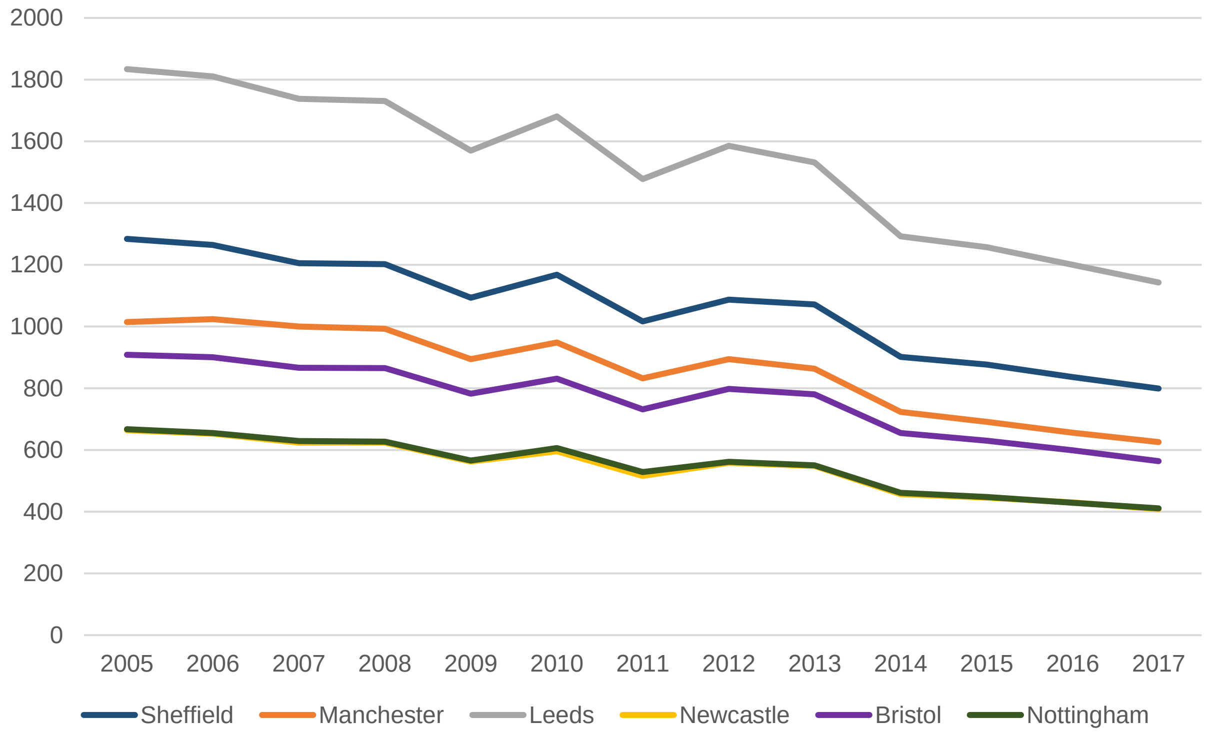


Figure 9 Trend analysis (2005-2017) of Industrial and Commercial CO_2 emissions (kt) in the six cities



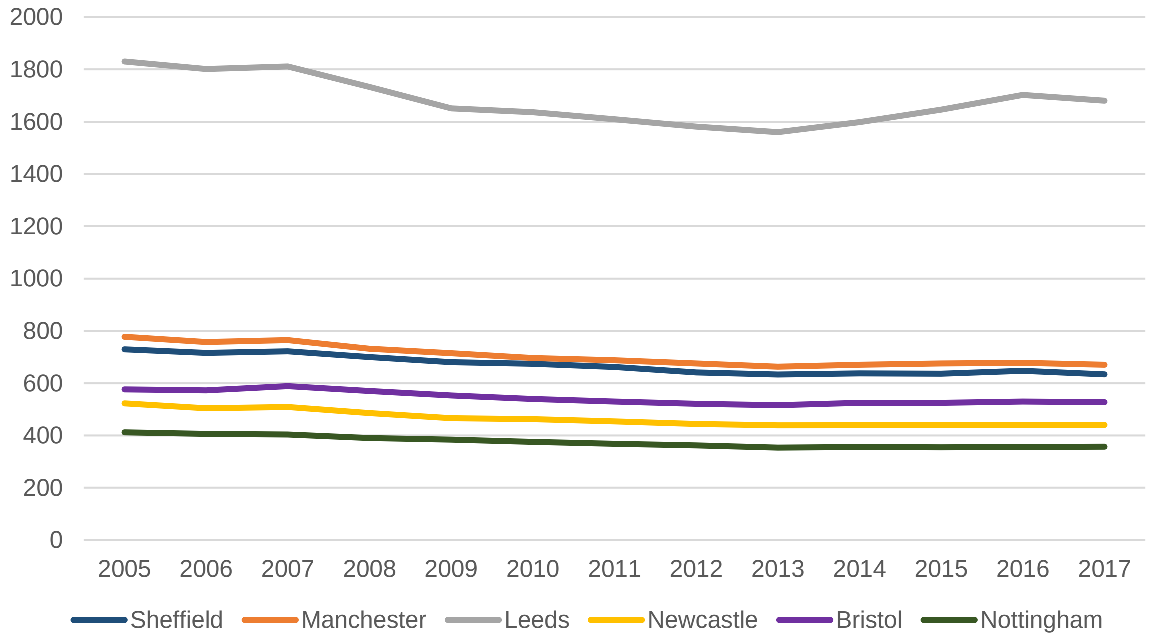
For the Industrial and Commercial sector, the trend indicates a decrease of CO_2 emissions where Leeds is the highest emitter since 2005 and Sheffield still the second highest, despite the decrease in the last three years compared to Manchester.

Figure 10 Trend analysis (2005-2017) of Domestic CO_2 emissions (kt) in the six cities



The Domestic sectors' CO_2 emissions still follow the same trend as the I&C, however Sheffield is a much higher emitter compared to Manchester (since 2005).

Figure 11 Trend analysis (2005-2017) of Transport CO_2 emissions (kt) in the six cities



As seen in Figure 8 Leeds is the greater emitter of CO_2 compared to the other cities. Contrary to the other sectors, Manchester is the second highest emitter of CO_2. All cities with the exception of Leeds follow a similar and unchanged trend from 2005 to 2017.

For the detailed timeseries graphs of the other major cities (Manchester, Leeds, Newcastle, Bristol and Nottingham) please see Appendix A1.

3 Industrial and commercial emissions

This chapter focuses on emissions in Sheffield from the industrial and commercial sector. The subsections present the historic energy consumption, underlying structure and activity in the sector and CO_2 trends including their corresponding data for 2017 (maps) as well as methane and nitrous oxide (GHG) emissions at MSOA and grid level.

3.1 Energy consumption data

Table 1 Table Industrial and commercial energy consumption in Sheffield[1] [2]

Year	I&C Gas (GWh)	I&C Electricity (GWh)	I&C 'Other fuels*' (ktoe)
2005	3,015	1,845	74
2006	2,648	1,786	58
2007	2,536	1,745	52
2008	2,455	1,776	56
2009	2,060	1,608	59
2010	2,234	1,604	48
2011	2,184	1,616	39
2012	2,184	1,532	44
2013	2,107	1,594	42
2014	2,275	1,663	64
2015	1,877	1,518	45
2016	1,772	1,420	32
2017	1,880	1,437	32

*Where ‘other’ includes petroleum, coal, manufactured solid fuels

The results from Table 1 present noticeable trends. Firstly, the gas consumption in Sheffield from 2005 has been on a bumpy decrease - from 3015 GWh in 2005 to 1880 GWh in 2017 (overall decrease 37.6%). The electricity consumption has also experienced a steady decrease over the years – from 1845 GWh in 2005 to 1437 GWh in 2017 where a slight increase took place from the previous year. The overall decrease in electricity consumption in Sheffield is 22.1% with an average annual decrease of 1.95%. The consumption of other fuels in Sheffield has also decreased over the years – 56.8% reduction from 2005 to 2017 with an average rate of reduction of 4.52% every year.

[1] Source: BEIS sub-national gas, electricity and residual fuel consumption statistics
[2] Excludes fuel consumption from Large Industrial sites

Figure 12 Industrial and commercial gas consumption at MSOA level in Sheffield

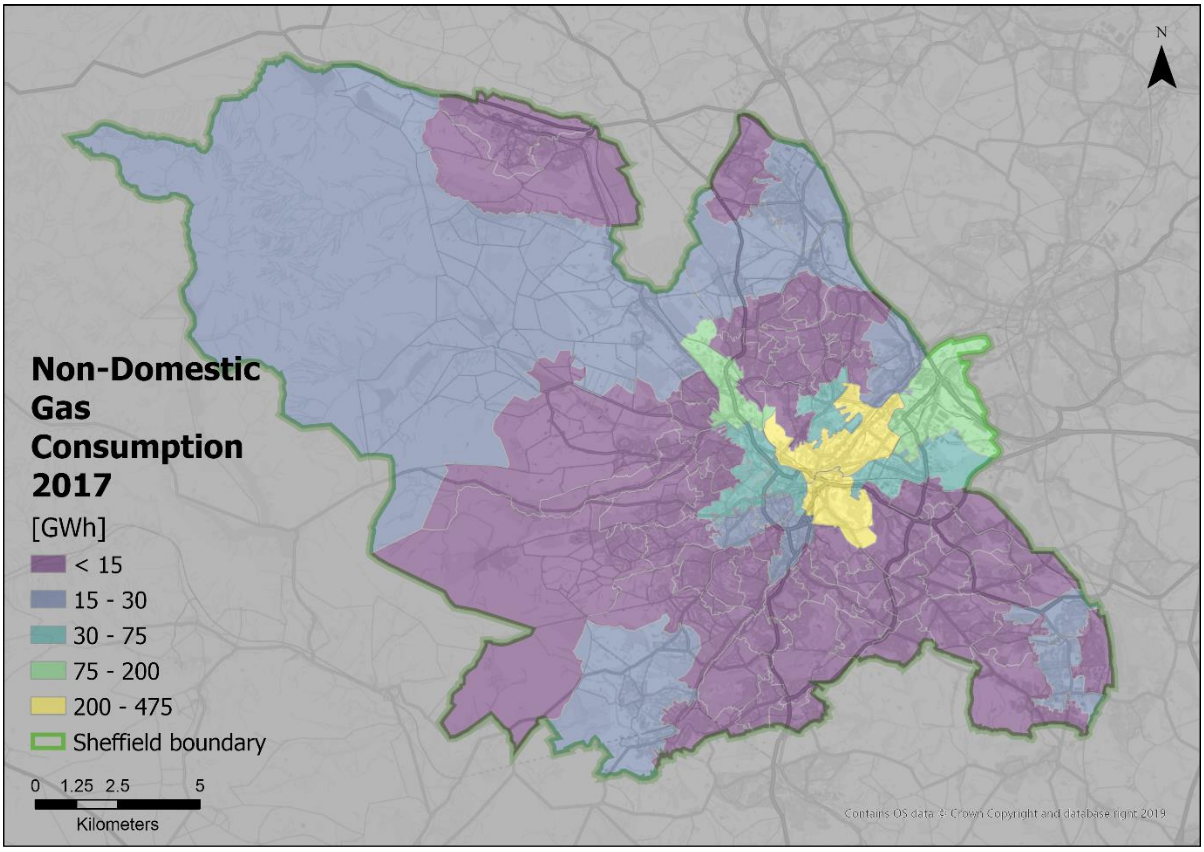
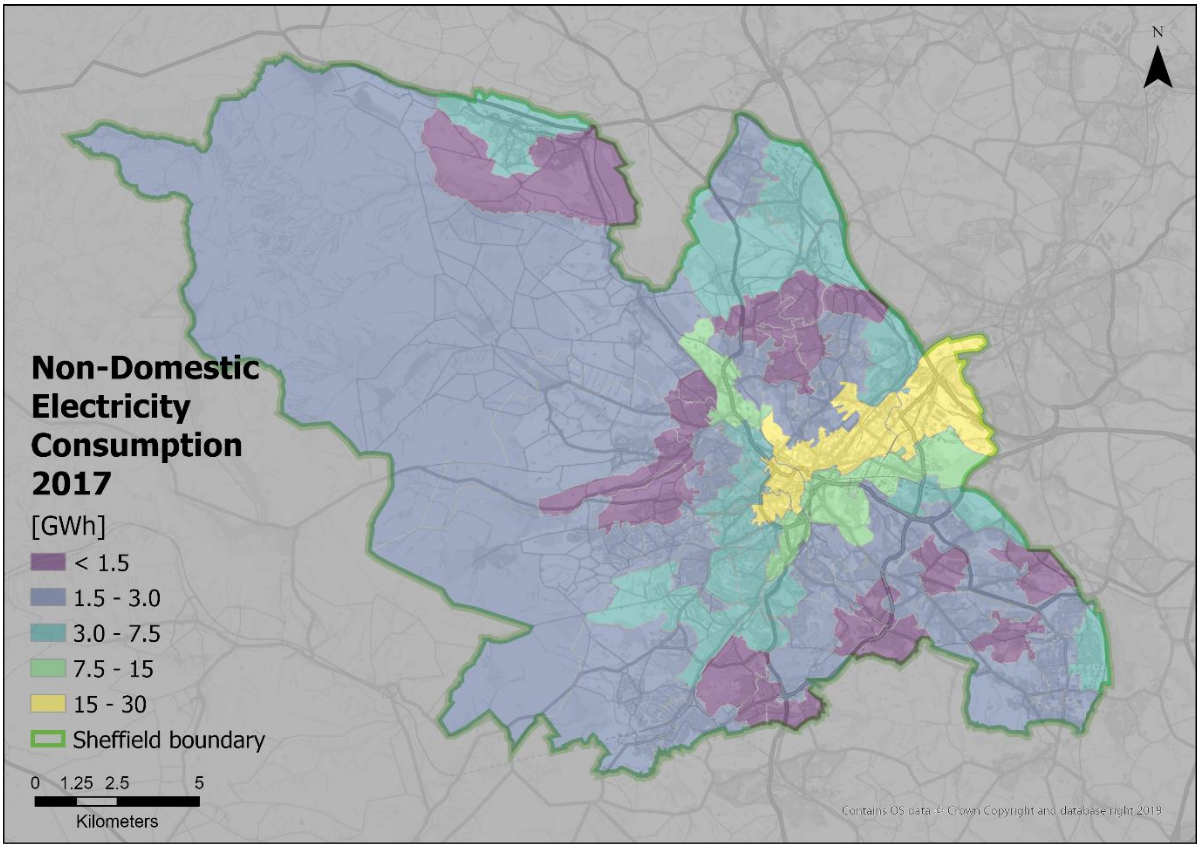


Figure 13 Industrial and commercial electricity consumption in Sheffield



The maps from Figure 12 and Figure 13 highlight important spatial trends. Specifically, the hotspots observed indicate that the city centre and surrounding's MSOAs (in yellow) dominate the energy consumption (for both gas and electricity). Also noticeable is the class range from the maps in Figure 12 and Figure 13 – the upper class (15 – 30 GWh) is an order of magnitude larger than the lower class indicating the big spatial variability in Sheffield.

3.1.1 Energy consumption trend analysis

The following analysis shows the intensity of industrial and commercial energy use with respect to GVA. Figure 14 to Figure 16 show both total consumption and consumption per unit GVA for each of the fuels. Figure 17 shows the intensity of all fuels relative to a 2005 base.

Figure 14 Industrial and commercial gas intensity per GVA compared to 2005 baselines in Sheffield.

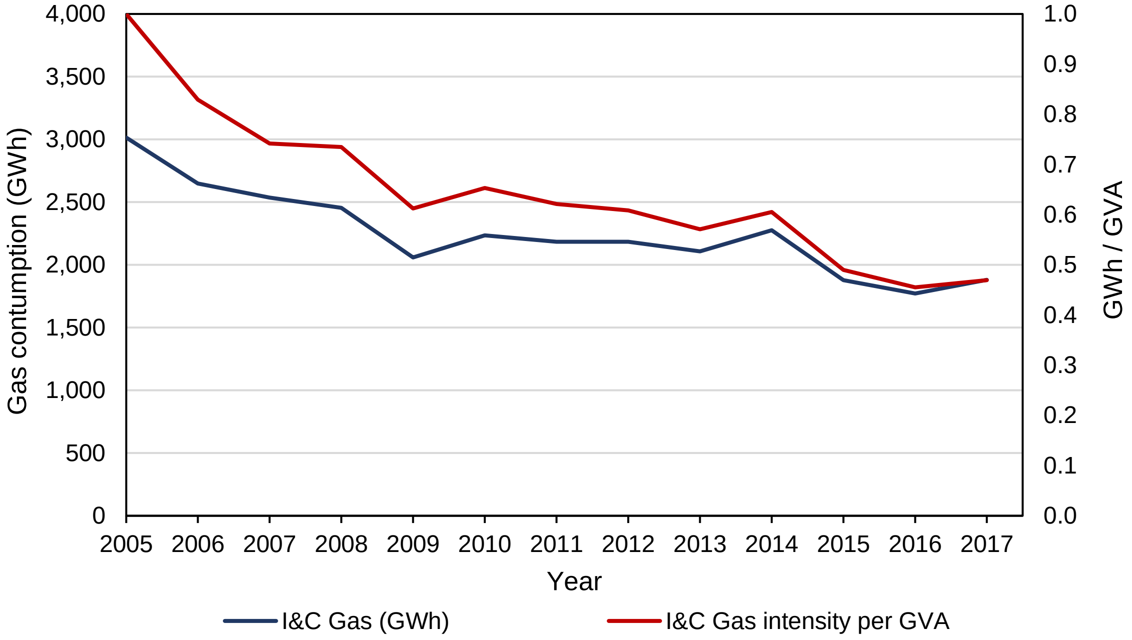
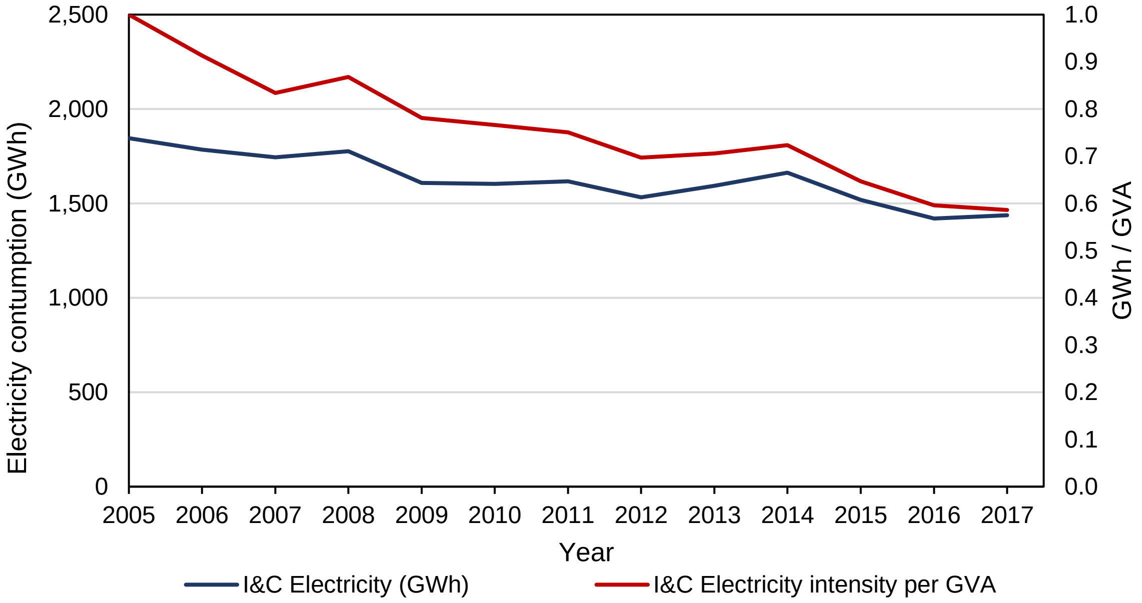


Figure 15 Industrial and commercial electricity intensity per GVA compared to 2005 baselines in Sheffield



The trends observed in Figure 14 and Figure 15 suggest that economic output (using GVA as a proxy) is closely linked to gas and electricity consumption for the first 5 years of the analysis (2005-

2009; coupled but not directly related – constant gap between the two lines). From 2009 and onwards the relationship starts to decouple indicating that the economic output contributes to a lesser extent (intensity line decreased relative to blue line) to the gas and electricity consumption in Sheffield. The same trend is also observed for the 'other fuels' consumption and its influence by the GVA (Figure 16). These results further suggest an increasing efficiency for this sector between 2009-2017 as the red line decreases in relation the consumption (GWh) blue line.

Figure 16 Industrial and commercial 'other fuels' intensity per GVA compared to 2005 baselines in Sheffield

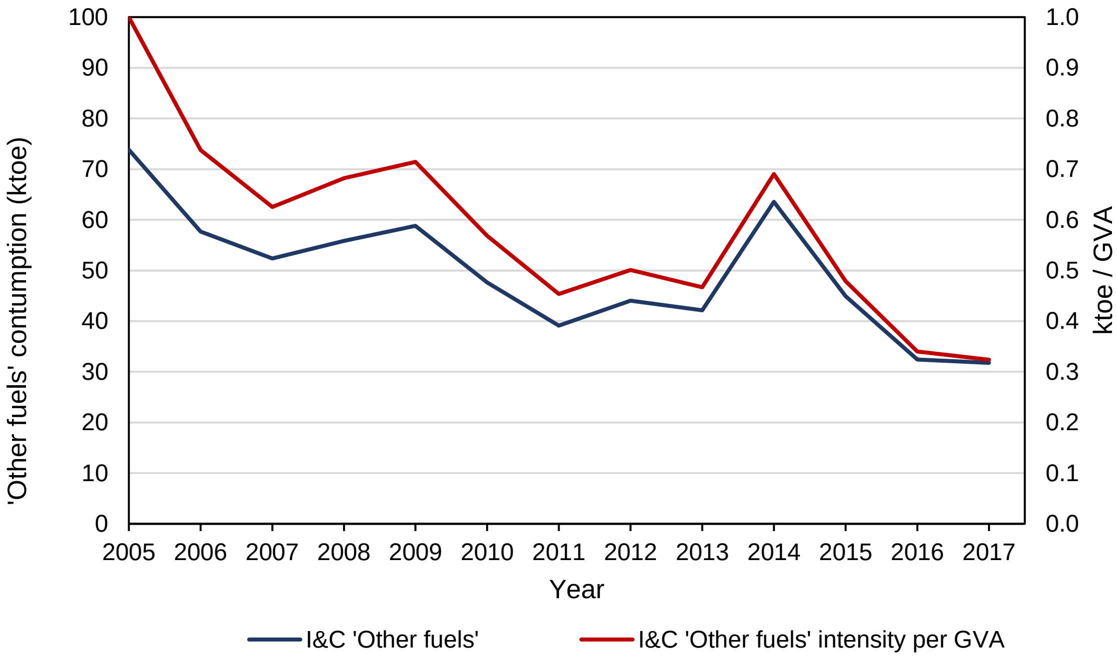
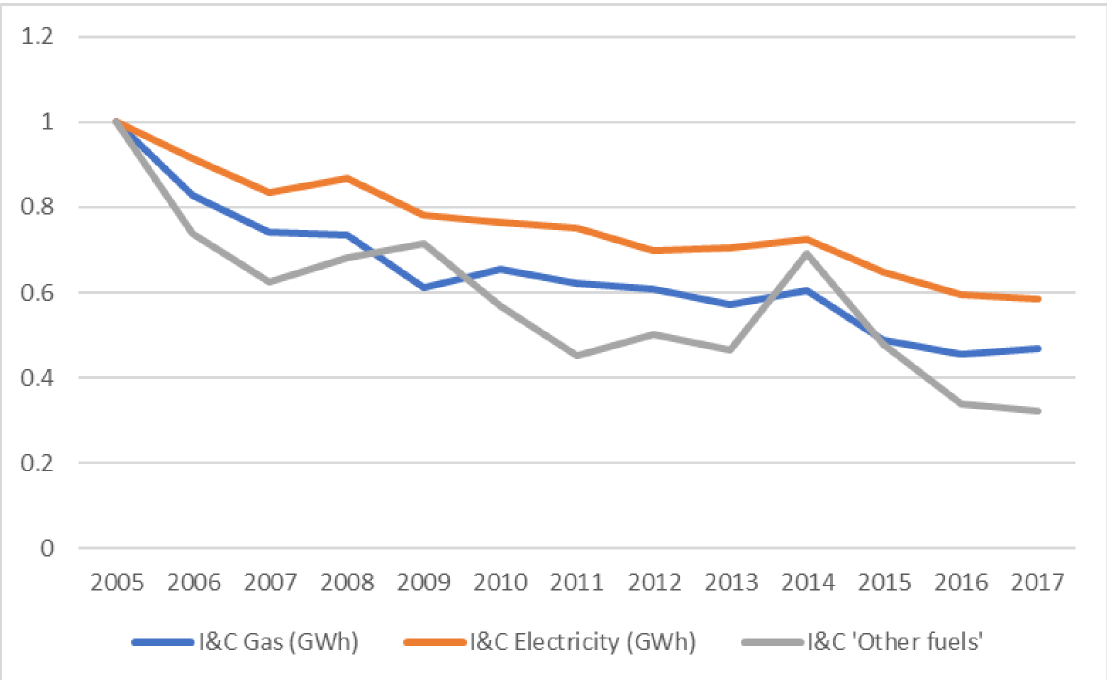


Figure 17 Industrial and commercial energy consumption intensity trend relative to 2005.



Overall the trends present a significant reduction intensity of energy use per GVA dropping by some 40% for electricity use, 50% for gas use and 60% for other fuels. This is likely to be as a result of a mixture of efficiency improvements and some fuel switching.

3.2 Activity data

This subsection summarises the key findings from a review of local data relating to commercial and industrial emissions in Sheffield Local Authority (LA). In 2019, the Office for National Statistics (ONS) reported that there was 15,985 VAT and/or PAYE based enterprises in Sheffield Local Authority. The business rates data provided by Sheffield City Council in March 2020, recorded 18,946 businesses.

Using the ONS date, the enterprises were split into three key sectors. The service sector accounted for the largest number of businesses with 78% of registered businesses in Sheffield LA, followed by the construction sector with 13% and production sector with 9%.

The business rates data provided by Sheffield City Council shows that retail and offices are the largest portion of business in Sheffield.

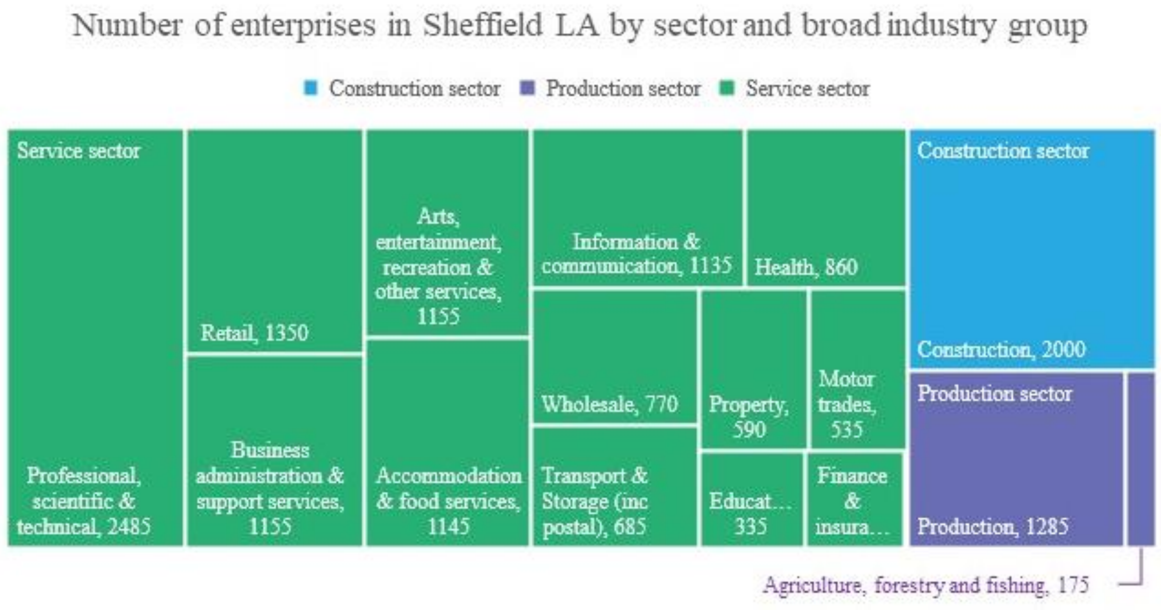
Table 2 Property types in Sheffield based on business rates data provided by Sheffield City Council, March 2020

Property type	Proportion of businesses
Retail	36%
Offices	20%
Warehouse and storage	11%
Industry	15%
Other	18%

3.2.1 Broad industry groups

Using the ONS date, the enterprises were split into 17 broad industrial groups. The professional, scientific and technical industry accounted for the largest number of businesses with 16% of registered businesses in Sheffield LA, followed by the construction industry with 13%.

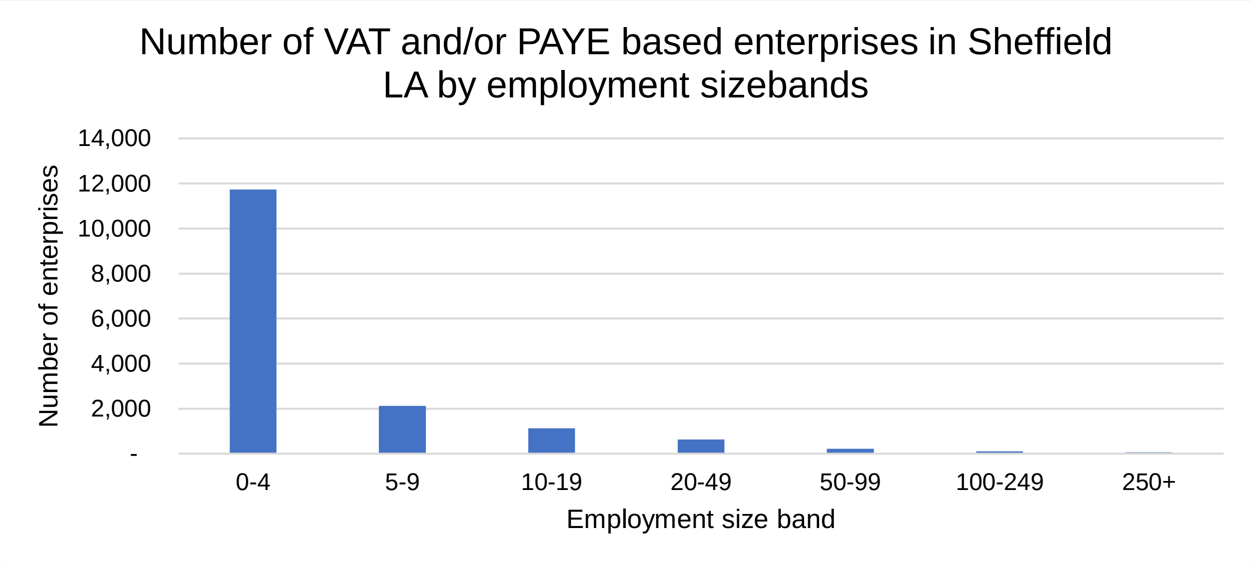
Figure 18 Number of VAT and/or PAYE based enterprises in Sheffield LA by broad industry group, 2019, ONS



3.2.2 Employment size

The enterprises were split into seven employment size bands. An employment size between 0-4 people accounted for the largest number of businesses with 73% of registered businesses in Sheffield Local Authority.

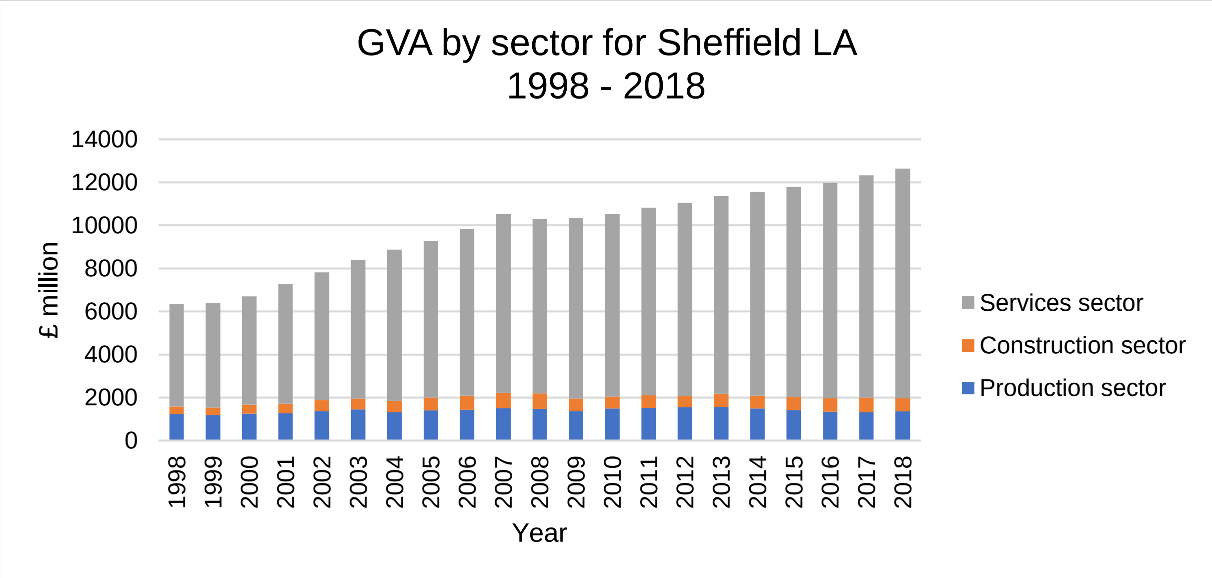
Figure 19 Number of VAT and/or PAYE based enterprises in Sheffield LA by employment size band, 2019, ONS



3.2.3 Gross Value Added

The Office for National Statistics reported that there was £12,639million of gross value added (GVA) in Sheffield Local Authority, for 2018.

Figure 20 GVA (balanced) based on current price for Sheffield LA, ONS



3.2.3.1 Sectors

The enterprises were split into three key sectors. The service sector accounted for the largest proportion of GVA based on current prices with 84%, followed by the production sector with 11% and construction sector with 5%.

3.2.3.2 Broad industry groups

The enterprises were split into 17 broad industrial groups. The wholesale and retail industry accounted for the largest proportion of GVA based on current prices with 13%, followed by the education industry with 12%.

3.2.4 Energy performance

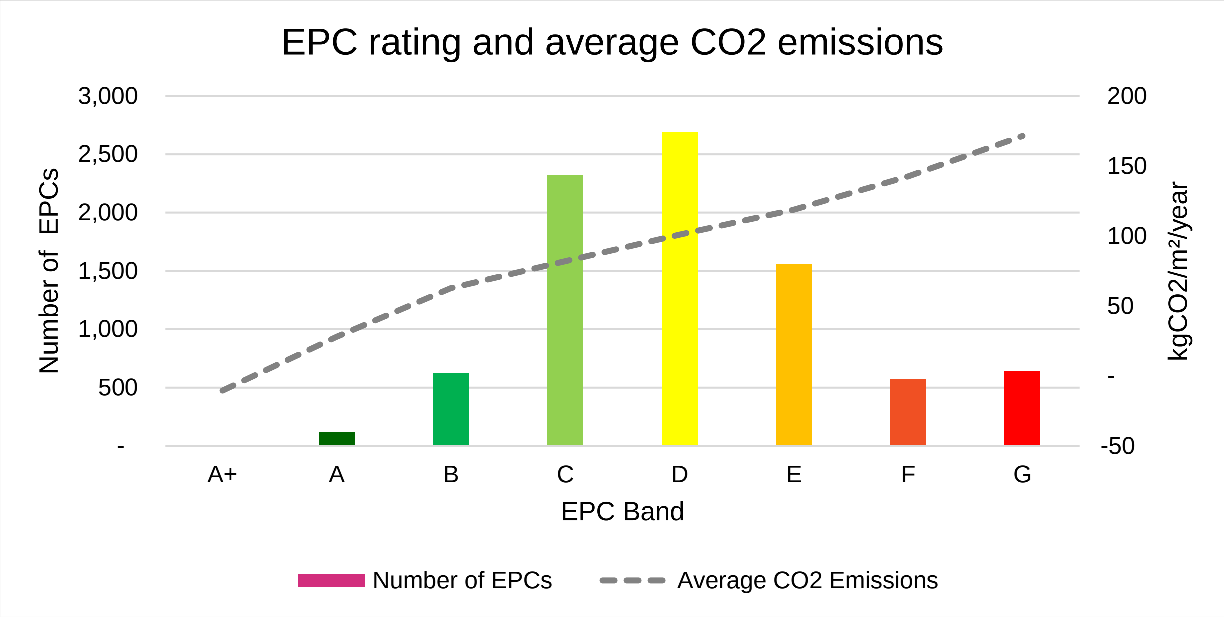
There have been approximately 8,528 energy performance certificates (EPCs) lodged for non-domestic properties in Sheffield from January 2008 to March 2020. The majority of the EPCs lodged for non-domestic properties in Sheffield have an EPC energy rating of D (31%), with the average EPC rating number of 92. Based on the EPC data, the average carbon dioxide emissions for non-domestic properties in Sheffield is 102 $kgCO_2/m^2/year$.

Table 3 Non-domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020

ECP Band	Proportion of EPCs	Average CO_2 Emissions ***($kgCO_2/m^2/year$)***
A+	0%	-10
A 0-25	1%	28
B 26-50	7%	63
C 51-75	27%	82
D 76-100	32%	101
E 101-125	18%	119
F 126-150	7%	143

The data shows the average carbon emissions per floor area reduce as the EPC band improves.

Figure 21 Non-domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020



3.2.5 Archetypes

The proportional data from the EPCs can be used to estimate the types of non-domestic properties, the heating fuel and the systems installed.

3.2.5.1 Property type

Over half of EPCs lodged were for retail units, and a quarter were for offices and workshops. The average CO_2 emissions per floor area are typically higher for retail units.

Table 4 Property types in Sheffield, based on non-domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020

Property type	Proportion of EPCs	Average CO_2 emissions ***(kgCO₂/m²/year)***	Average EPC Band
Retail	52%	128	D
Offices and Workshop	25%	66	E
Warehouse and storage	7%	70	D
Industry	7%	83	D
Other	9%	95	78

3.2.5.2 Main heating fuel

49% of EPCs lodged used grid supply electricity as the main heating fuel, and 46% used natural gas.

Table 5 Main heating fuel in Sheffield, based on non-domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020

Main heating fuel	Proportion of EPCs	Average CO_2 emissions ***(kgCO₂/m²/year)***	Average EPC Band
Grid Supplied Electricity	49%	116	D
Natural Gas	46%	92	D
Other	2%	39	D
District Heating	1%	60	D
Oil	1%	122	F

3.2.5.3 Building environment

Two thirds of EPCs lodged had heating and natural ventilation, and a quarter had air conditioning. Excluding the unconditioned properties, the average CO_2 emissions were lowest for properties that were mixed mode with natural ventilation, however these accounted for 1% of the sample size.

Table 6 Building environment in Sheffield, based on non-domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020

Building environment	Proportion of EPCs	Average CO_2 emissions ***($kgCO_2/m^2/year$)***	Average EPC Band
Heating and Natural Ventilation	67%	108	D
Air Conditioning	25%	98	D
Heating and Mechanical Ventilation	4%	95	D
Unconditioned	2%	40	D
Mixed mode with Natural Ventilation	1%	69	C
Mixed mode with Mechanical Ventilation	<1%	100	D

3.3 CO_2 data

By utilising BEIS' LA CO_2 dataset and Middle Super Output Areas (MSOA) gas and electricity consumption datasets, it is possible to disaggregate LA CO_2 data further into CO_2 emissions per MSOA level within Sheffield. Therefore, emissions estimates for the following sectors have been produced:

- Industrial and Commercial Electricity
- Industrial and Commercial Gas
- Large Industrial Installations
- Industrial and Commercial Other Fuels

Table 7 CO_2 emissions estimates for the industrial and commercial sector in Sheffield 2005-2017 (kt CO_2)[3].

Year	Gas	Electricity	Large Industrial Installations	Other Fuels
2005	554.9	963.0	196.5	96.2
2006	483.1	984.4	100.3	94.4
2007	448.4	963.6	114.2	94.5
2008	464.2	981.6	112.2	86.9
2009	385.4	803.4	70.4	69.1
2010	463.8	822.9	81.1	66.7
2011	394.6	797.1	100.1	57.1
2012	434.3	810.9	92.4	64.9
2013	440.6	779.4	90.7	52.7
2014	347.0	683.5	97.8	56.9
2015	353.8	535.3	81.6	63.4
2016	355.6	409.6	80.4	63.9
2017	348.5	365.7	29.2	67.2

The results from Table 7 indicate an overall reduction in CO_2 emissions in Sheffield, between 2005 and 2017, from electricity and gas consumption as well as large industrial installations and other fuels. Specifically, CO_2 emissions from electricity consumption have experienced an average decrease of 3.11% year-on-year (37.3% overall decrease from 2005 to 2017), from gas consumption an average annual decrease of 7.27% (62.0% overall decrease), from large industrial installations an average decrease of 9.91% year-on-year (85.1% overall decrease) and from other fuels an average annual decrease of 2.33% (30.1% overall decrease).

Table 8 presents the breakdown of CO_2 emissions by source for the Large Industrial Installations. The results indicate a variation in carbon dioxide emissions' increase and decrease by sector. What stands out is the large contribution of CO_2 emissions by the production of iron and steel plants (via combustion processes) despite a 23.5% reduction from 2005. This source accounts for more than 1/3 of the total CO_2 emissions in 2017. For more detailed data for each Large Industrial Installation please refer to Appendix A2.

[3] Source: BEIS LA CO_2 statistics

Table 8 Breakdown of CO_2 emissions for Large Industrial Installations in Sheffield 2010-2017 ($ktCO_2$).

Source Name	2010	2011	2012	2013	2014	2015	2016	2017
Pulp, Paper and Print (combustion)	0.006	0.006	0.006	0.006	0.003	0.003	0.003	0.000
Electric arc furnaces	22.550	26.628	23.892	22.531	24.749	19.283	24.948	26.155
Food & drink, tobacco (combustion)	0.002	0.000	0.000	0.000	0.000	0.000	0.001	0.001
Iron and steel - combustion plant	56.554	72.943	68.194	67.782	72.989	62.087	54.454	1.953
Public sector combustion	0.141	0.102	0.109	0.140	0.038	0.180	0.086	0.229
Other industrial combustion	1.826	0.396	0.166	0.268	0.031	0.083	0.130	0.110
Non-Ferrous Metal (combustion)	0.002	0.002	0.002	0.002	0.000	0.000	0.000	0.000
Industrial urea use	0.000	0.000	0.000	0.000	0.000	0.000	0.811	0.710

The following maps present the CO_2 emissions from gas, electricity and other fuels in Sheffield in 2017.

Figure 22 CO_2 emissions from industrial and commercial gas consumption in Sheffield

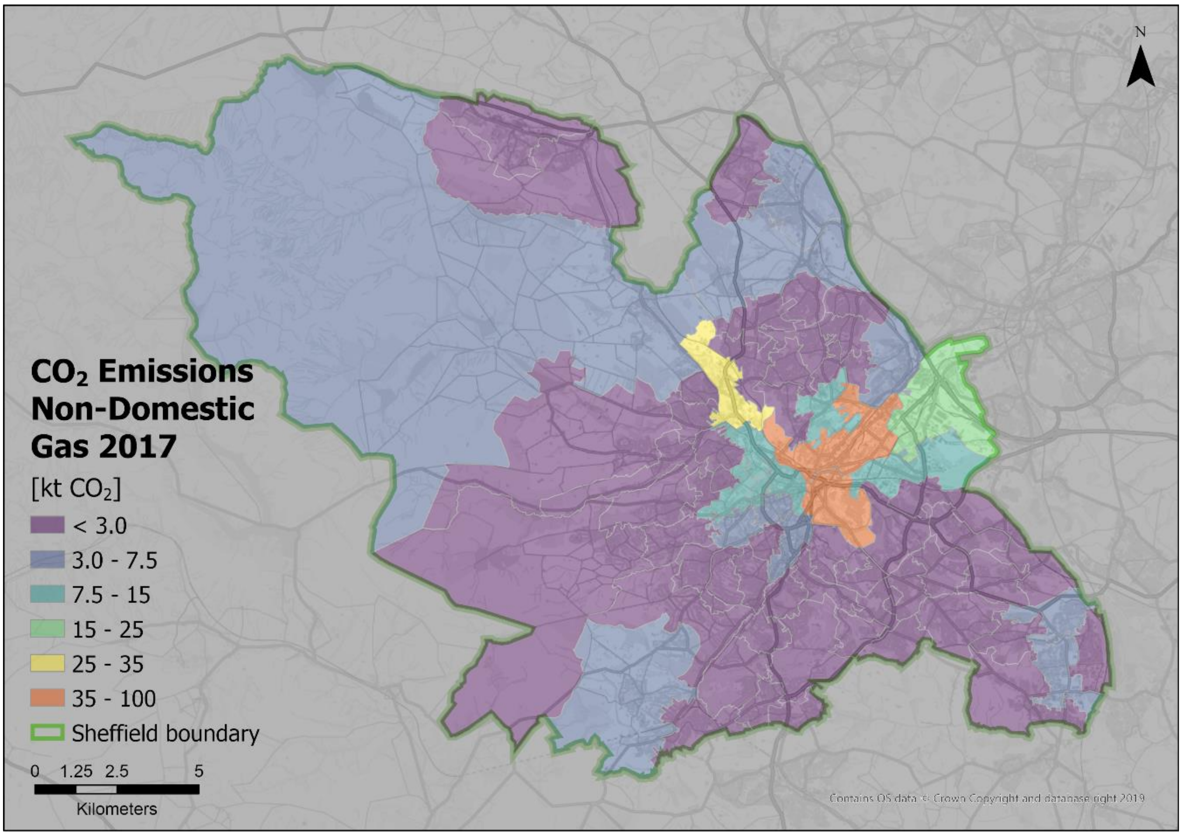


Figure 23 CO_2 emissions from industrial and commercial electricity consumption in Sheffield

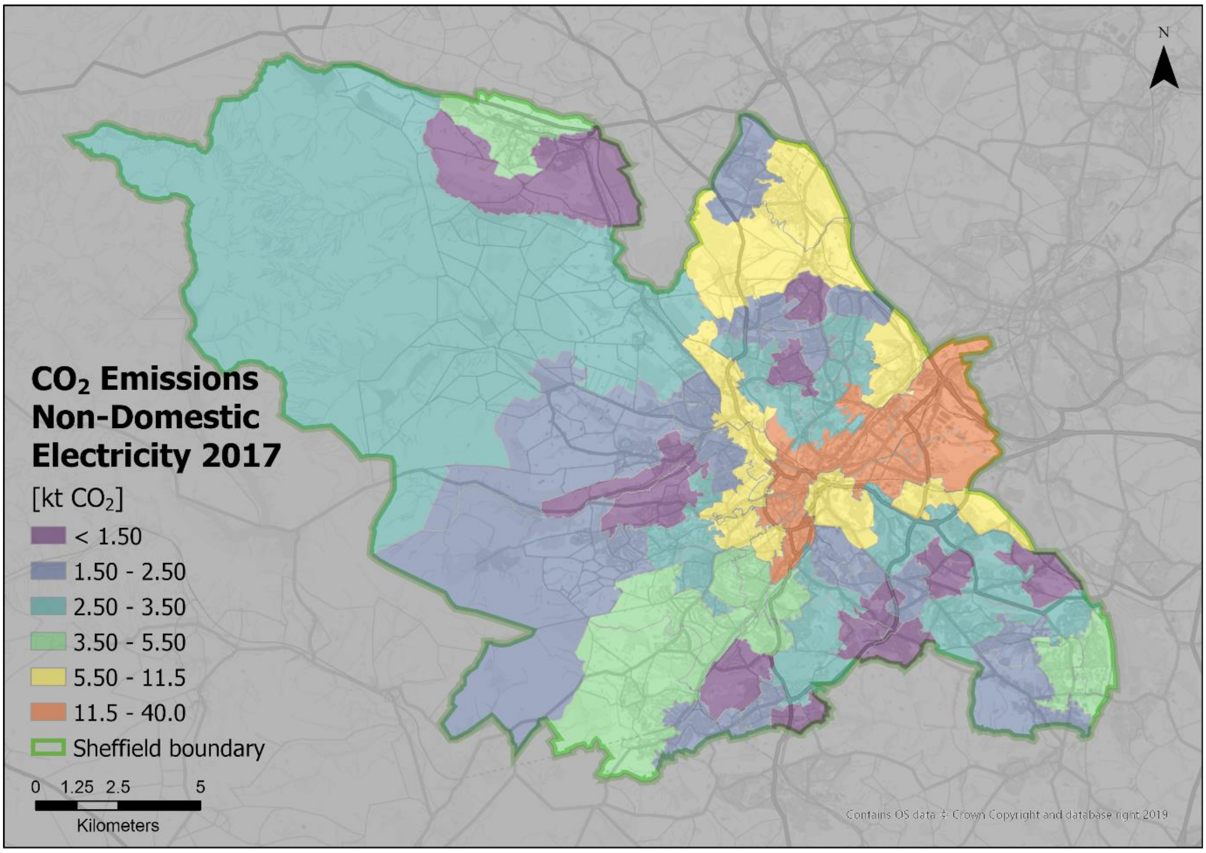


Figure 24 Locations of Large Industrial Installation in Sheffield

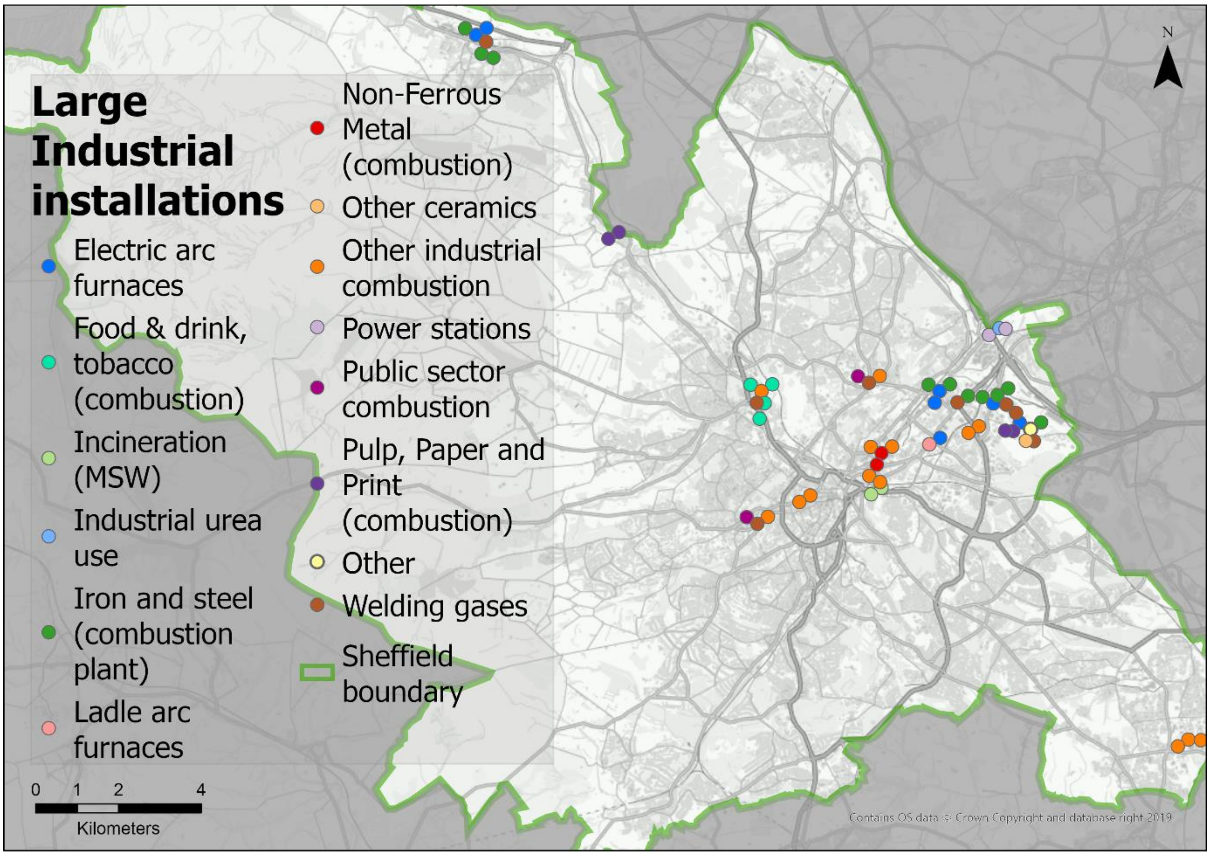


Figure 25 CO_2 estimates from Large Industrial Installations in Sheffield in 2017

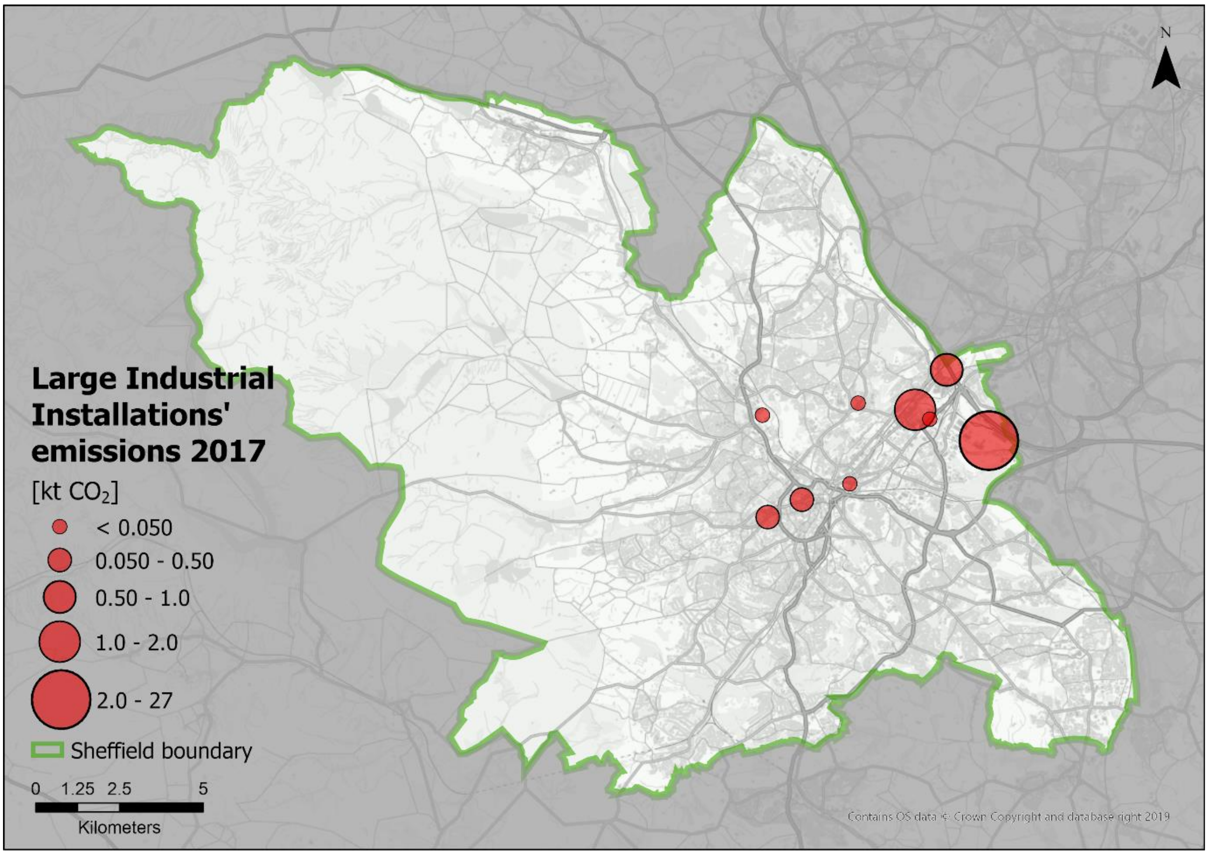
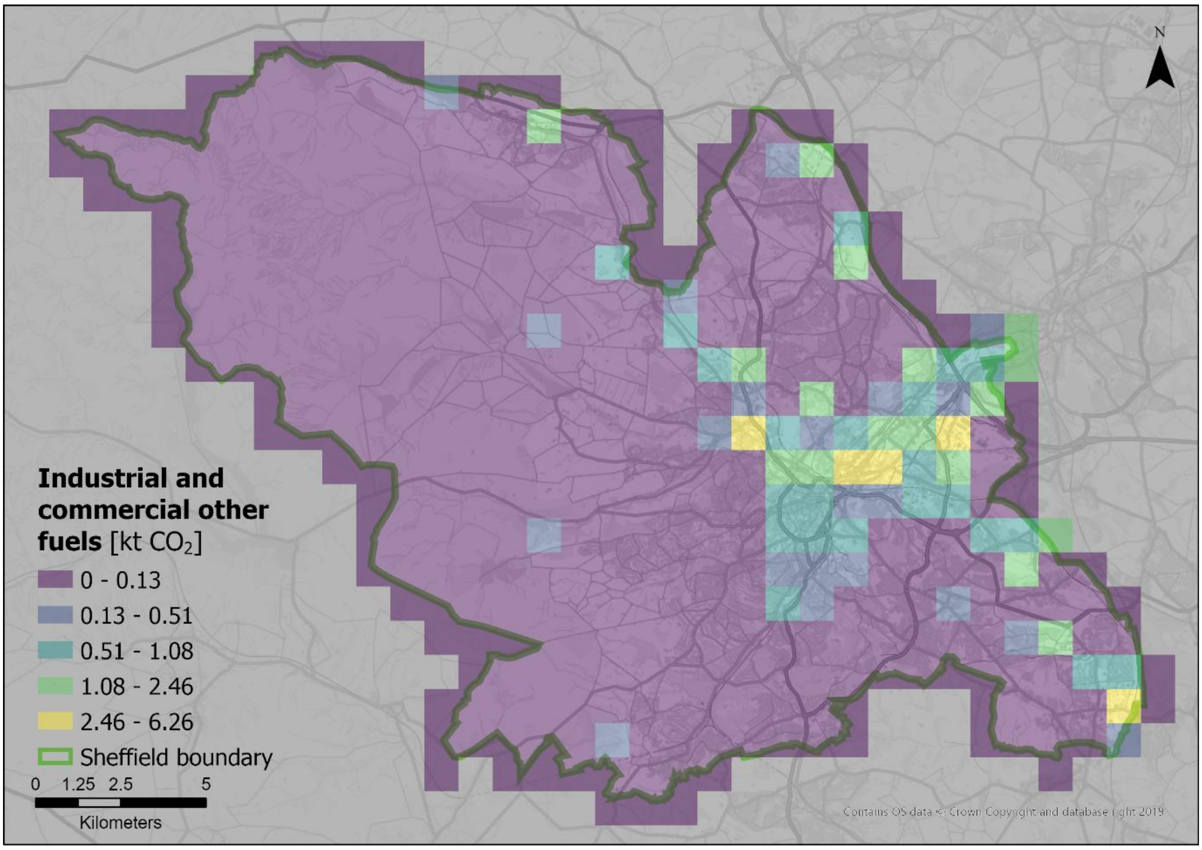
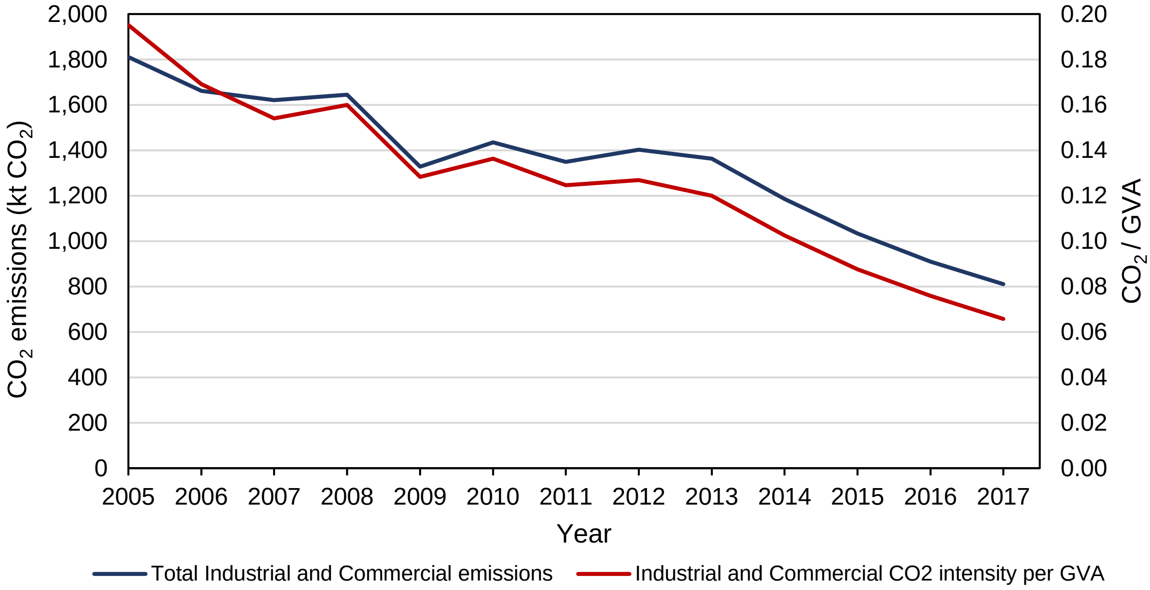


Figure 26 CO_2 emissions from industrial and commercial 'other fuels' in Sheffield at 1x1km level



The maps of CO_2 emissions estimates support the spatial trends from the consumption maps seen in section 3.1 where the city centre of Sheffield dominates such activities – supported by both MSOA and grid-level maps. The CO_2 emission estimates trend analysis (seen in Figure 27 below) also supports the results from section 3.1.1 as the economic output intensity line (red) starts to decouple from the total emissions line (blue) after 2009 – indicating higher efficiency in terms of consumption and, subsequently, lower carbon dioxide emissions.

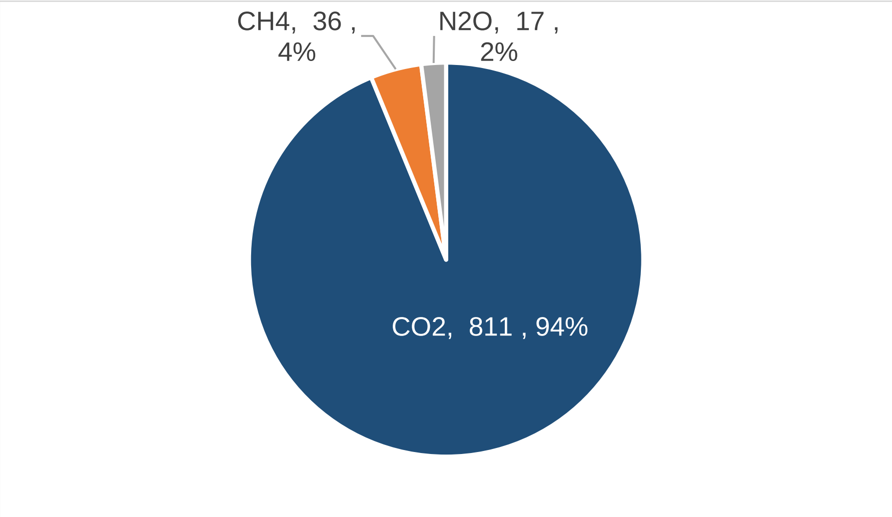
Figure 27 CO_2 emissions and intensity per GVA from the industrial and commercial sectors in Sheffield



CH_4 and N_2O data

In addition to understanding the CO_2 emissions from the sources seen so far in this section, it is also vital to provide insights on methane and nitrous oxide emission estimates from the industrial and commercial sector. Hence, the is subsection of the report focuses on these estimates by providing the GHG breakdown in ktCO_2-equivalent and the relevant maps of GHG emissions at grid level – the MSOA maps can be seen in Appendix A3.

Figure 28 GHG breakdown from industrial and commercial sector (kt CO_2e)



The chart from Figure 28 indicates a 95% dominance in CO_2e by CO_2 emissions and 6% split by methane (4%) and nitrous oxide (2%) indicating the minimal contribution by the later pollutants to CO_2 emissions in Sheffield.

Reinforcing an aforementioned statement on the presence of Large Industrial Installations, the following maps' spatial variability and relatively low emissions show the importance and large contribution of the Large Industrial Installations to the carbon dioxide emissions in Sheffield. Furthermore, the relevant maps indicate that nitrous oxide's largest sources of emissions are found at the west of the city centre and specifically where industrial combustion activities are taking place (Non-ferrous metal (combustion) and other industrial combustion).

Figure 29 Methane emissions from industrial and commercial at 1x1km level in Sheffield

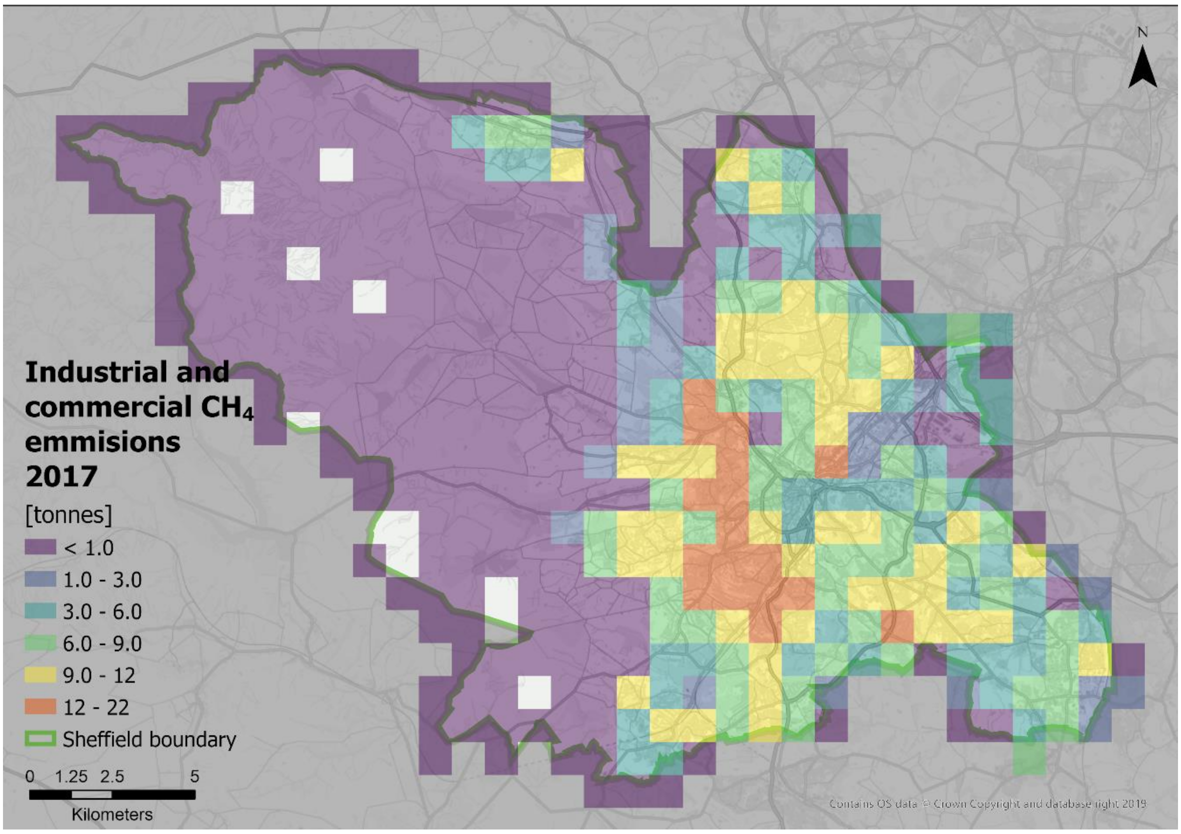
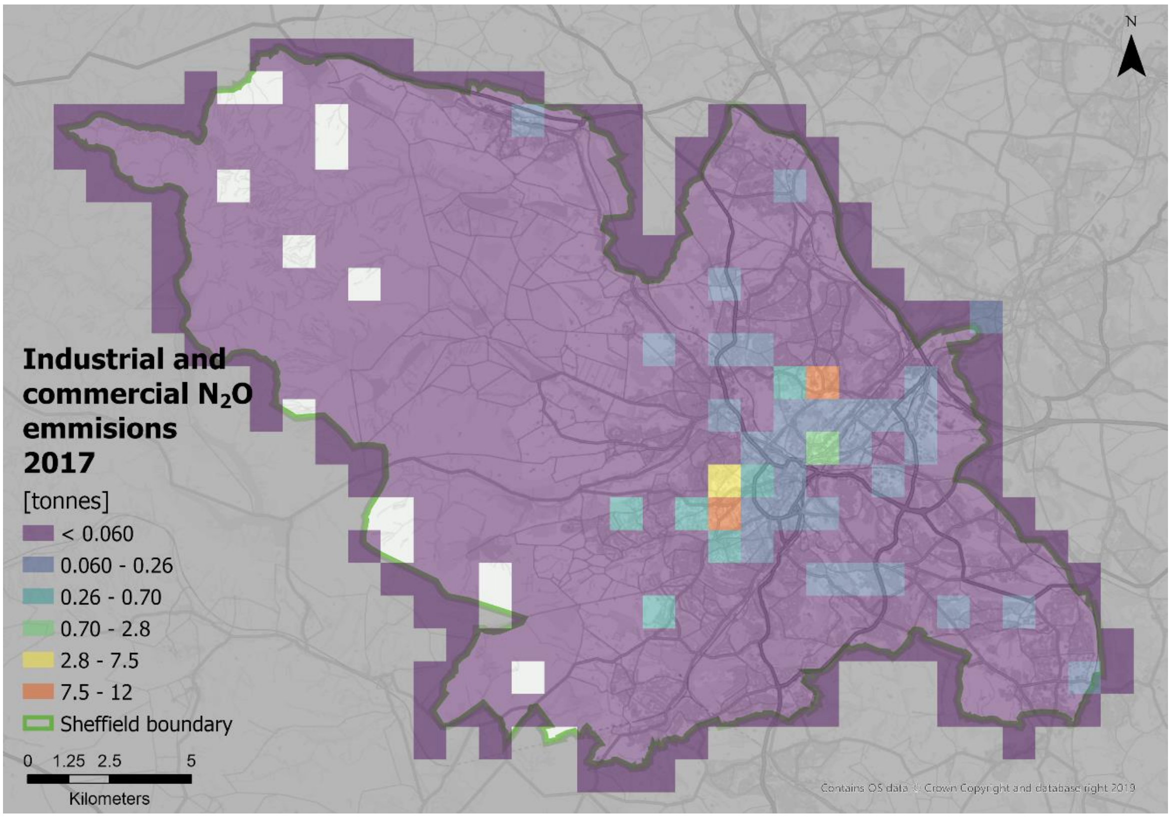


Figure 30 Nitrous oxide emissions from industrial and commercial at 1x1km level in Sheffield



4 Domestic emissions

This chapter concerns emissions in Sheffield from the domestic sector. The subsections that follow present the historic energy consumption, structure and activity in the sector and CO_2 trends including their corresponding data for 2017 (maps) as well as methane and nitrous oxide (GHG) emission maps.

4.1 Energy consumption data

Table 9 Domestic energy consumption in Sheffield[4]

Year	Domestic Gas (GWh)	Domestic Electricity (GWh)	Domestic 'Other Fuels*' (ktoe)
2005	4,248	906	4.2
2006	4,091	893	4.0
2007	3,959	870	4.0
2008	3,782	832	4.3
2009	3,465	840	3.8
2010	3,405	845	4.1
2011	3,204	836	3.8
2012	3,160	822	3.9
2013	3,085	813	3.9
2014	3,065	818	3.6
2015	3,004	804	3.6
2016	2,956	783	3.6
2017	3,053	775	3.6

The domestic gas consumption in Sheffield from 2005 has been on a steady decrease - from 4248 GWh in 2005 to 3053 GWh in 2017 (the only year of a slight increase; overall decrease 28.1%). The domestic electricity consumption has also experienced a steady decrease over the years – from 906 GWh in 2005 to 775 GWh in 2017. The overall decrease in domestic electricity consumption in Sheffield is 14.5% with an average decrease of 1.28% year on year. The domestic energy consumption of other fuels has also decreased over the years and experienced no change in the last 4 years (3.6 kt of oil equivalent).

The 4 maps below present the gas and electricity consumption (GWh) at MSOA and postcode level. The data, for the MSOA maps, have been derived from postcode level.

[4] Source: BEIS sub-national gas, electricity and residual fuel consumption statistics

Figure 31 Domestic gas consumption at postcode level in Sheffield

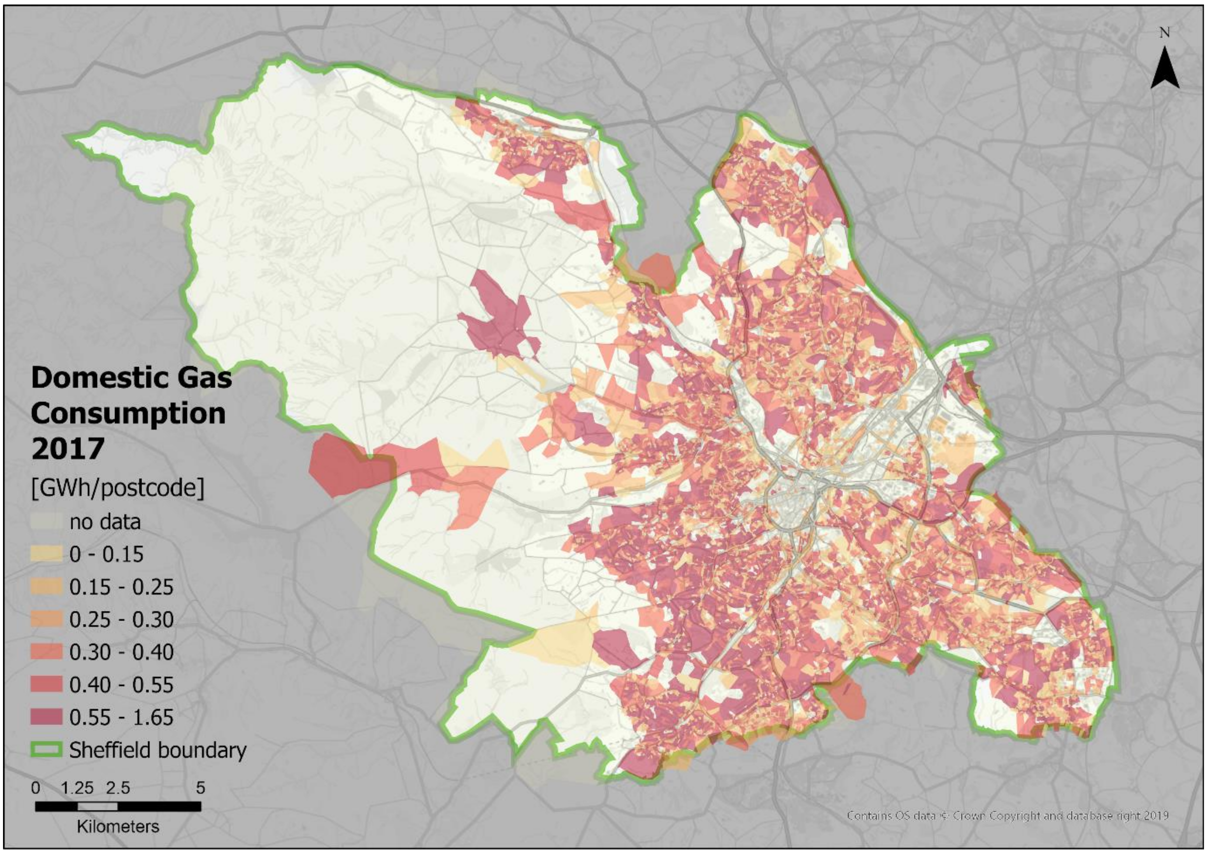


Figure 32 Domestic gas consumption at MSOA level in Sheffield

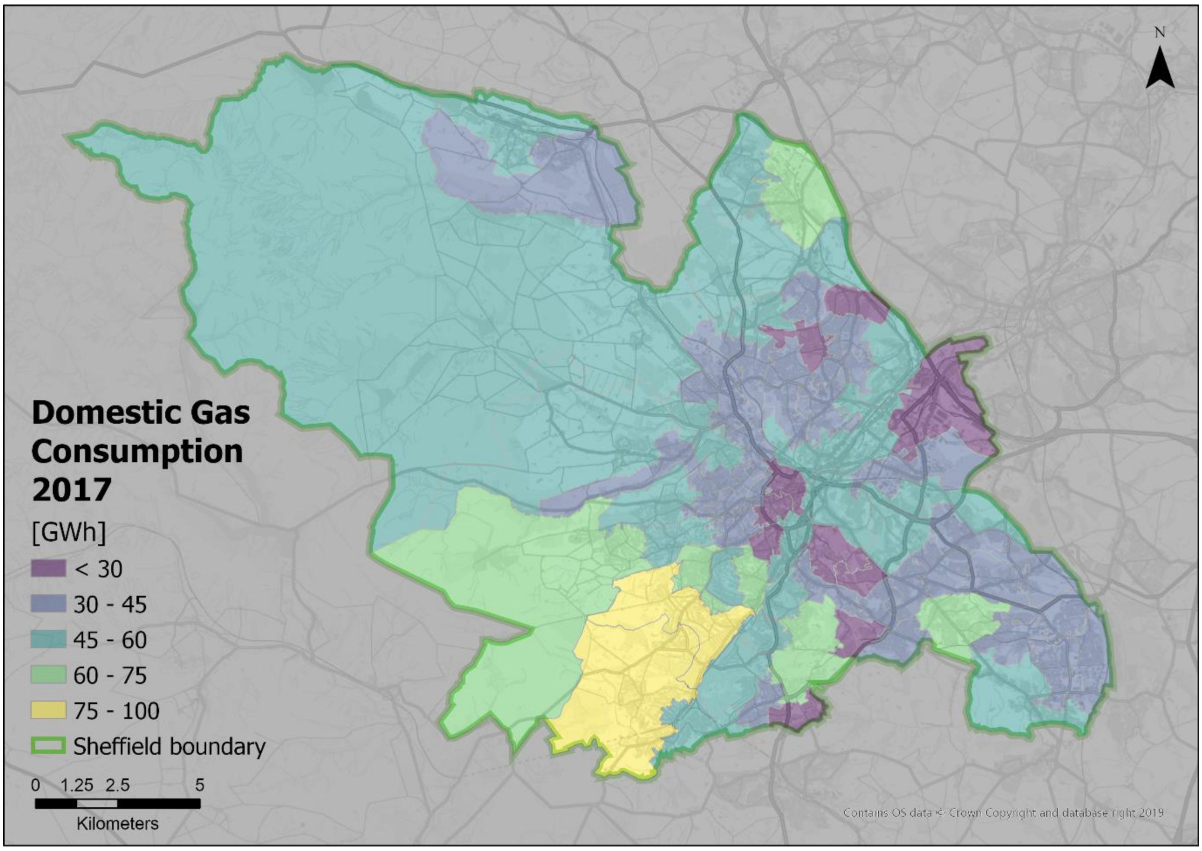


Figure 33 Domestic electricity consumption at postcode level in Sheffield

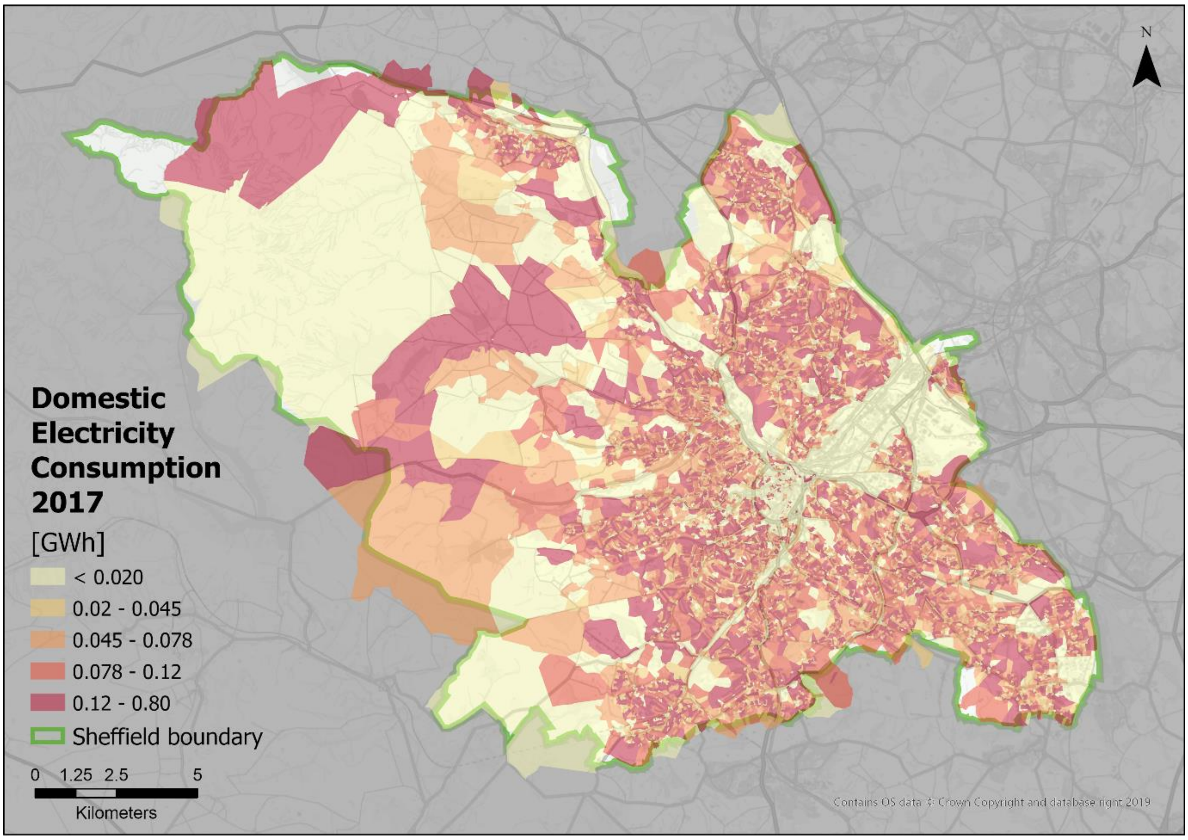
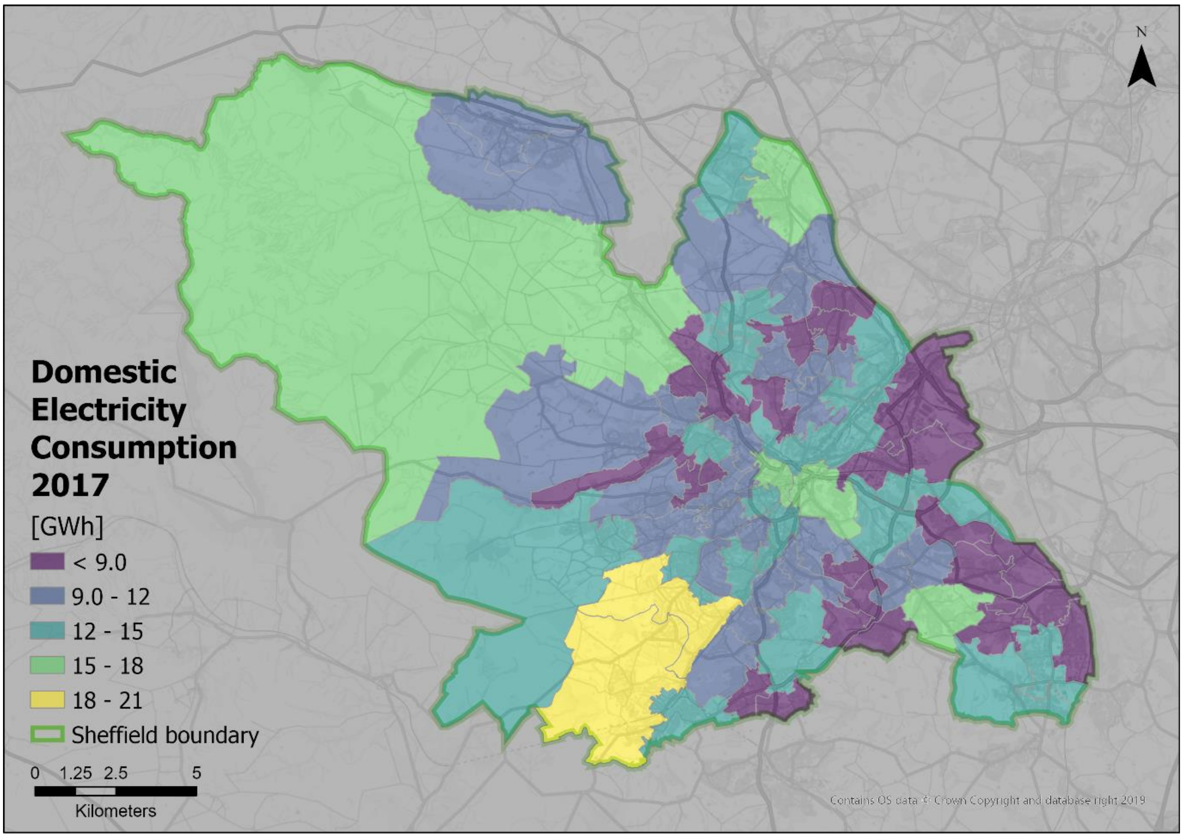


Figure 34 Domestic electricity consumption at MSOA level in Sheffield



Summarising the gas and electricity consumption in Sheffield at MSOA level, presents a more comprehensive and clearer pattern regarding consumption from this sector. The results indicate that the southern MSOAs have the highest consumption of both gas and electricity in 2017 (yellow MSOA from the relevant maps)

4.1.1 Energy consumption trend analysis

The following analysis shows the intensity of domestic energy use with respect to population. Figure 35 to Figure 37 show both total consumption and consumption per unit GVA for each of the fuels. Figure 38 shows the intensity of all fuel relatives to a 2005 base.

Figure 35 Domestic gas intensity per thousand population in Sheffield

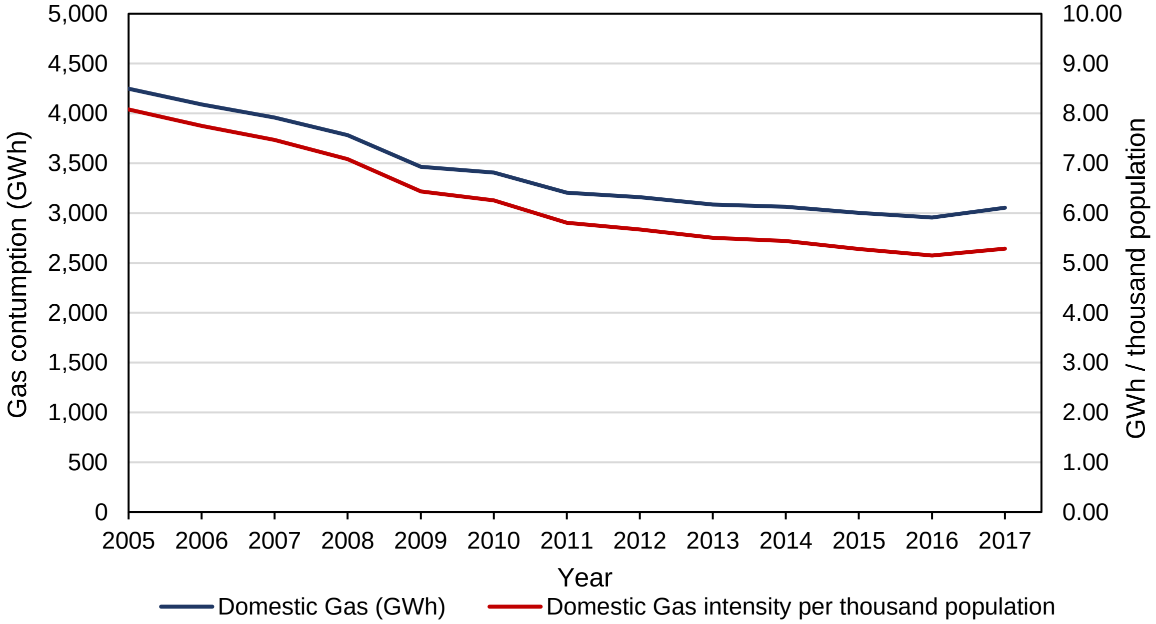


Figure 36 Domestic electricity intensity per thousand population in Sheffield

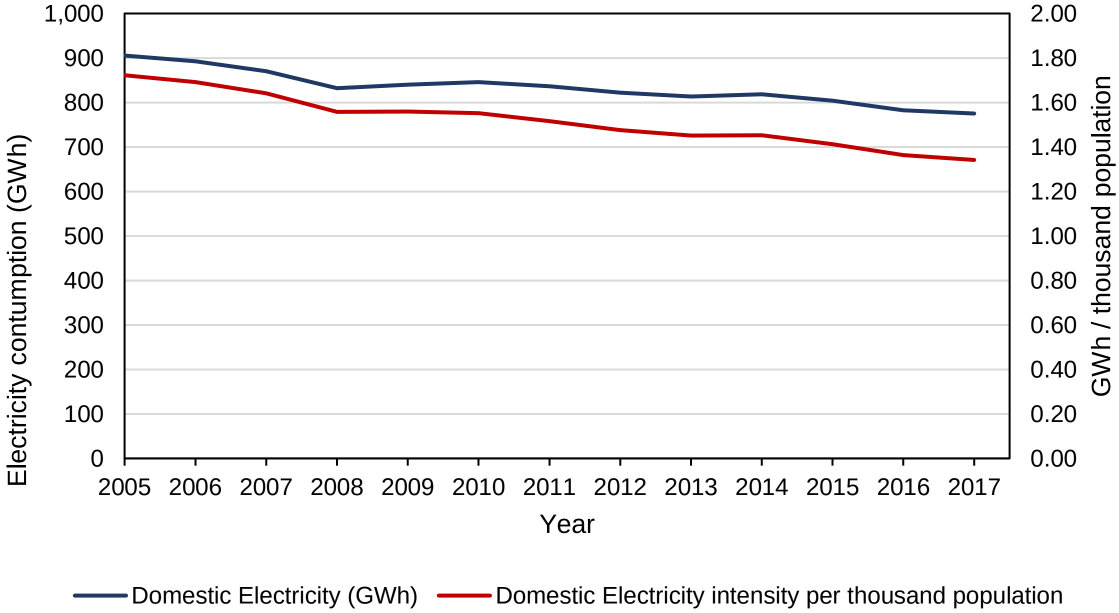
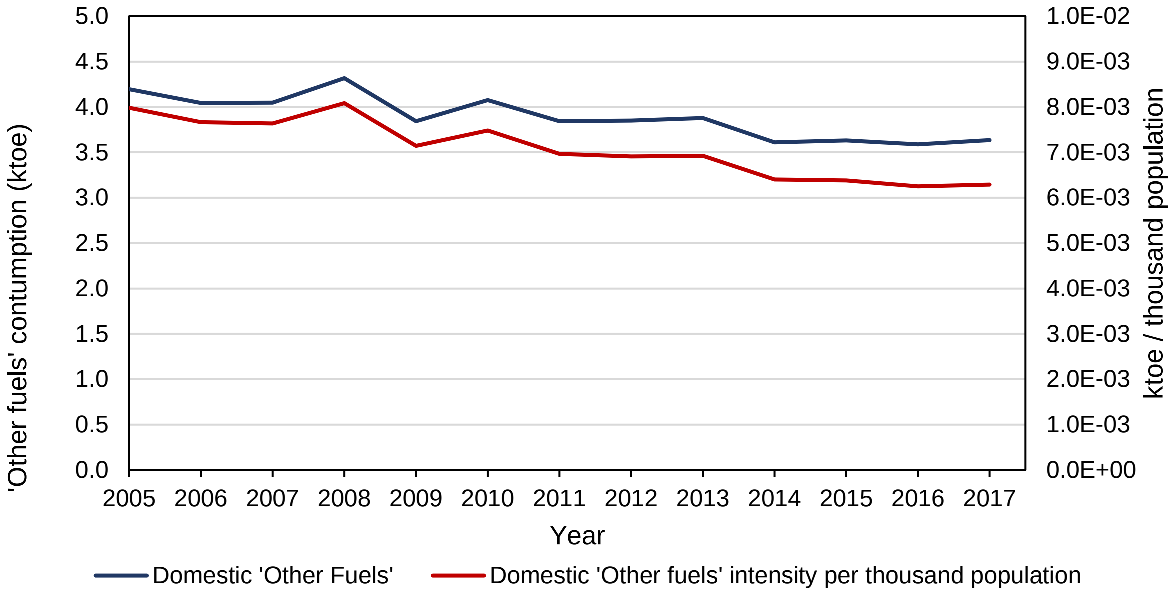
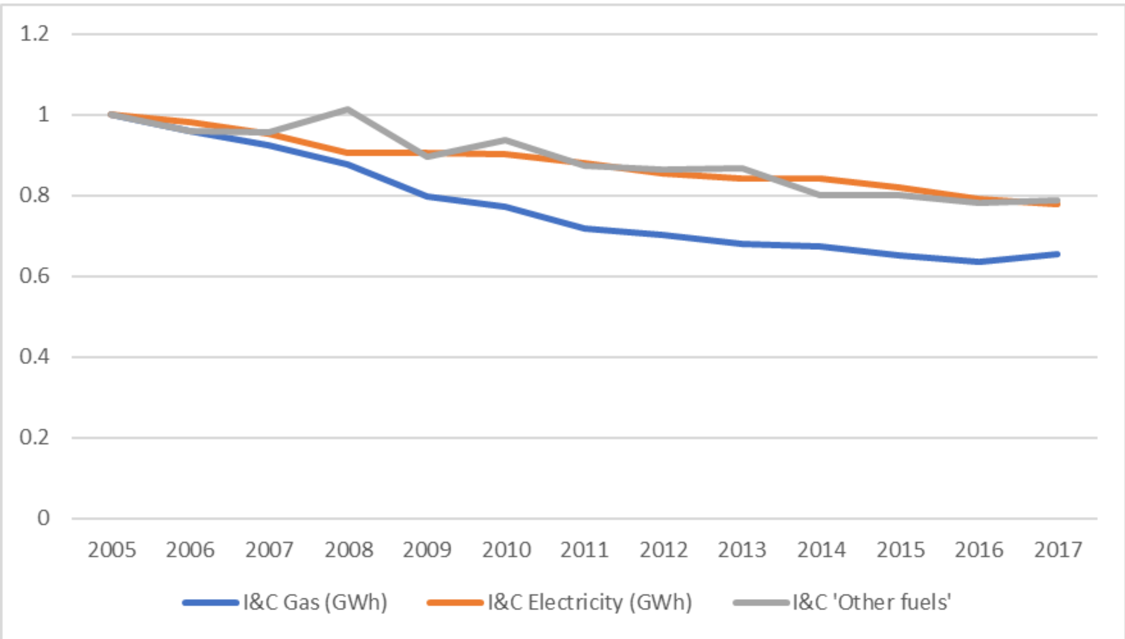


Figure 37 Domestic 'other fuels' intensity per thousand population in Sheffield



The energy consumption trend analysis observed in 4.1.1 (intensity lines /1000 population) are in conjunction with the data from Table 9. The main findings from the trend graphs is that, for the domestic electricity consumption, the effect of population change starts to play a less significant role after 2008 (where the difference between the two lines starts to increase) and for the gas and other fuels consumption this effect of populations starts after 2011.

Figure 38 Domestic energy use intensity relative to 2005



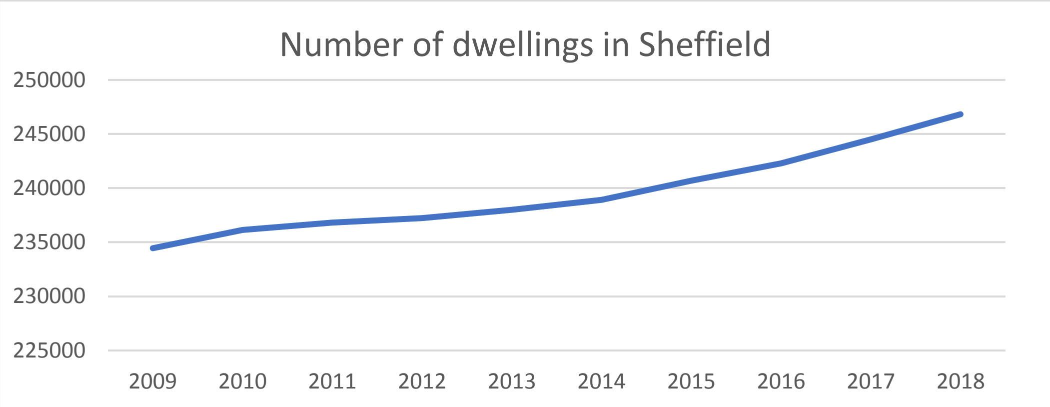
4.2 Activity data

The section summarises the key findings from a review of local data relating to domestic emissions in Sheffield Local Authority (LA).

4.2.1 Number of dwellings

In 2018, there was 247,000 dwellings in Sheffield, accounting for approximately 1% of the 24.2 million dwellings in England. The number of dwellings in Sheffield has increased by over 12,000 since 2009[5].

Figure 39 Number of dwellings in Sheffield between 2009 and 2018, Ministry of Housing, Communities & Local Government



4.2.2 Energy performance

There have been approximately 177,000 energy performance certificates (EPCs) lodged for domestic properties in Sheffield LA from January 2008 to March 2020.

The majority of the EPCs lodged for domestic properties in Sheffield LA have an EPC energy rating of D (39%) and C (30%), with the average EPC rating being 63 falling into the upper portion of band D.

Based on the EPC data, the average annual energy consumption for domestic properties in Sheffield LA is 278 kWh/m²/year and the average carbon dioxide emissions for domestic properties in Sheffield LA is 49 kgCO_2/m²/year or 4 tonnesCO_2/property/year.

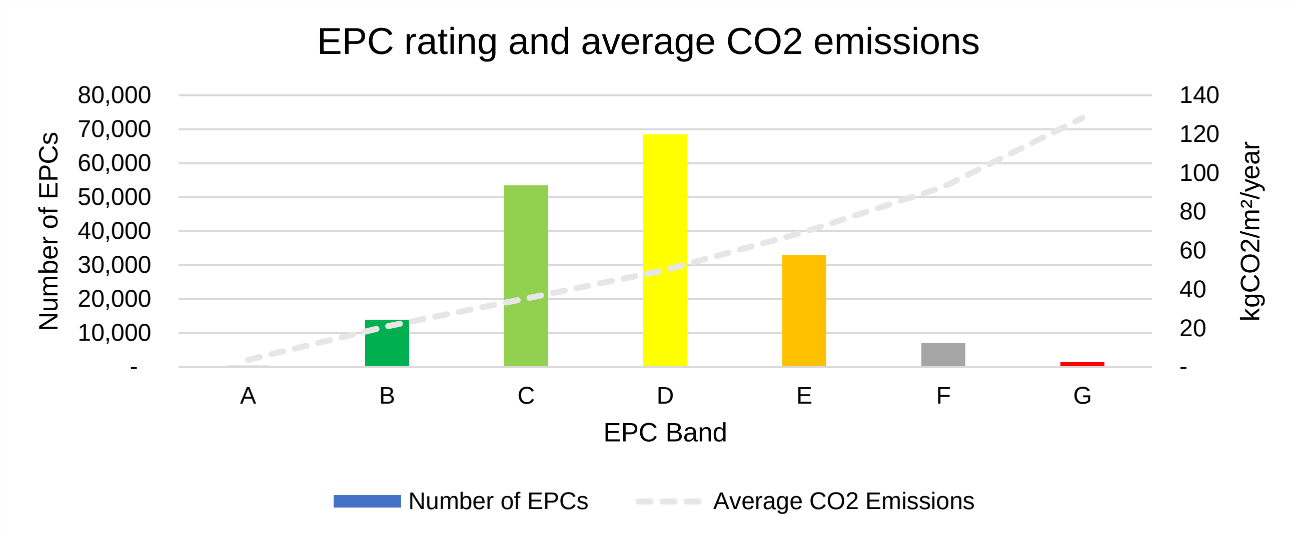
Table 10 Domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020, Ministry of Housing, Communities & Local Government

ECP Band	Proportion	Average Energy Consumption *(kWh//m²/year)*	Average CO_2 Emissions *(kgCO_2/m²/year)*
(92 plus) A	<1%	20	4
(81-91) B	8%	126	21
(69-80) C	30%	205	35
(55-68) D	39%	281	50
(39-54) E	18%	390	70
(21-38) F	4%	522	93
(1-20) G	1%	730	128

The data shows the average carbon emissions per floor area reduce as the EPC band improves.

[5] Number of Dwellings by Tenure and district: Sheffield; 2009 to 2018, Office for National Statistics and the Ministry of Housing, Communities and Local Government

Figure 40 The total number of domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020, Ministry of Housing, Communities & Local Government



4.2.3 Archetypes of dwellings

The proportional data from the EPCs can be used to estimate the types of dwellings, the typical construction, the systems installed and ownership.

4.2.3.1 Property types

66% of EPCs lodged were for houses, 27% were for flats, 4% were for bungalows and 3% were for maisonettes. The average CO_2 emissions per floor area are typically higher for bungalows and houses compared to flats and maisonettes.

Table 11 Property types in Sheffield, based on domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020

Property type	Proportion	Average CO_2 emissions *($kgCO_2/m^2/year$)*	Average EPC Band
Bungalow	4%	52	D
Flat	27%	43	C
House	66%	52	D
Maisonette	3%	40	D

4.2.3.2 Age

A large proportion (43%) of dwellings in Sheffield were constructed before 1950.

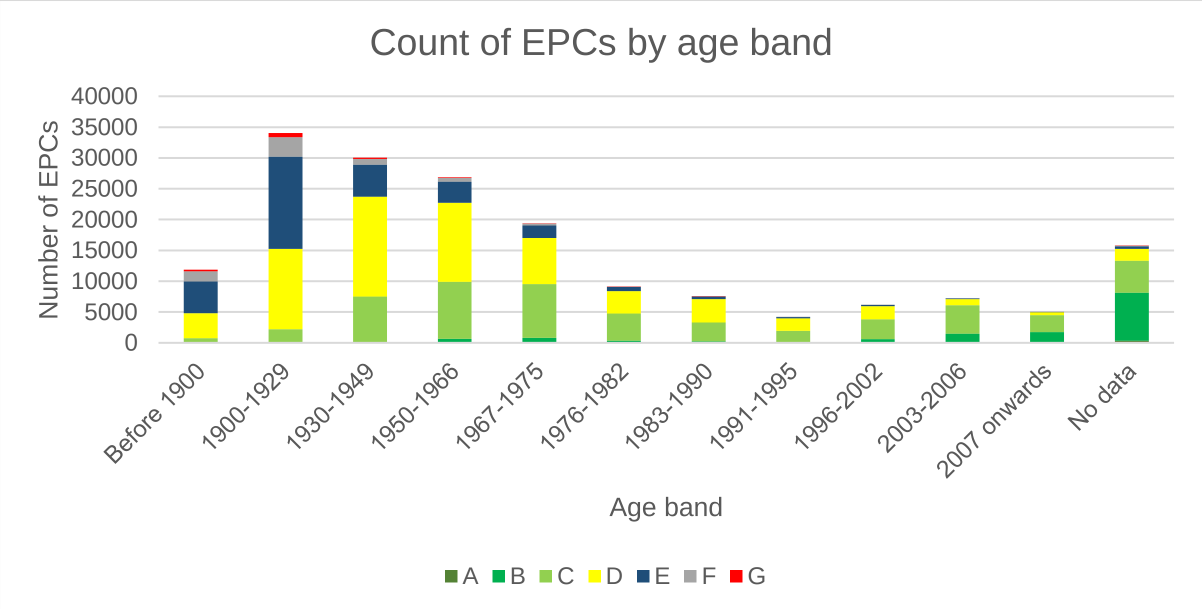
The average EPC rating improves based on the age of the property. The average EPC rating of properties constructed before 1929 is E, the average EPC rating of properties constructed between 1930 and 1995 is D and the average EPC rating of properties constructed after 1995 is C.

The average CO_2 emissions per floor area also decreases based on the age of the property.

Table 12: Age band of properties in Sheffield, based on domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020

Age band	Proportion	Average CO_2 emissions *($kgCO_2/m^2/year$)*	Average EPC Band
Before 1900	7%	67	E
1900-1929	19%	64	E
1930-1949	17%	51	D
1950-1966	15%	48	D
1967-1975	11%	47	D
1976-1982	5%	45	D
1983-1990	4%	45	D
1991-1995	2%	43	D
1996-2002	3%	39	C
2003-2006	4%	34	C
2007 onwards	3%	31	C
Other/unknown	9%	-	-

Figure 41: Age band of properties in Sheffield, based on domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020



4.2.3.3 Glazing

The vast majority (87%) of EPCs lodged had double glazing. Properties with improved glazing performance had a lower average CO_2 emissions and improved average energy rating. It should be noted that the glazing type would not be the only reason for the reduced CO_2 emissions and improved energy rating, as a generally higher standard of construction and system selection would be expected for properties that have triple glazing.

Table 13: Glazing type of properties in Sheffield, based on domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020

Glazing type	Proportion	Average CO_2 emissions *($kgCO_2/m^2/year$)*	Average EPC Band
Single glazing	1%	70	E
Secondary glazing	1%	61	D
Double glazing	87%	51	D
Triple glazing	<1%	37	C
Other/unknown	12%	-	-

4.2.3.4 Walls

The majority (61%) of EPCs lodged had cavity walls, 18% had solid brick walls, 4% had sandstone or limestone walls, 4% had system built, 1% had timber frame walls.

Approximately 50% of buildings were recorded to have insulated wall constructions, compared with 37% that were recorded as having no insulation.

Not surprisingly, properties with insulated wall constructions had a lower average CO_2 emissions and improved average energy rating.

4.2.3.5 Heating system

The main heating system for the vast majority (over 80%) of EPCs lodged was gas boilers and radiators. Properties connected to a community heating scheme typically had better energy efficiency ratings. The average CO_2 emissions are not based on current grid carbon factors.

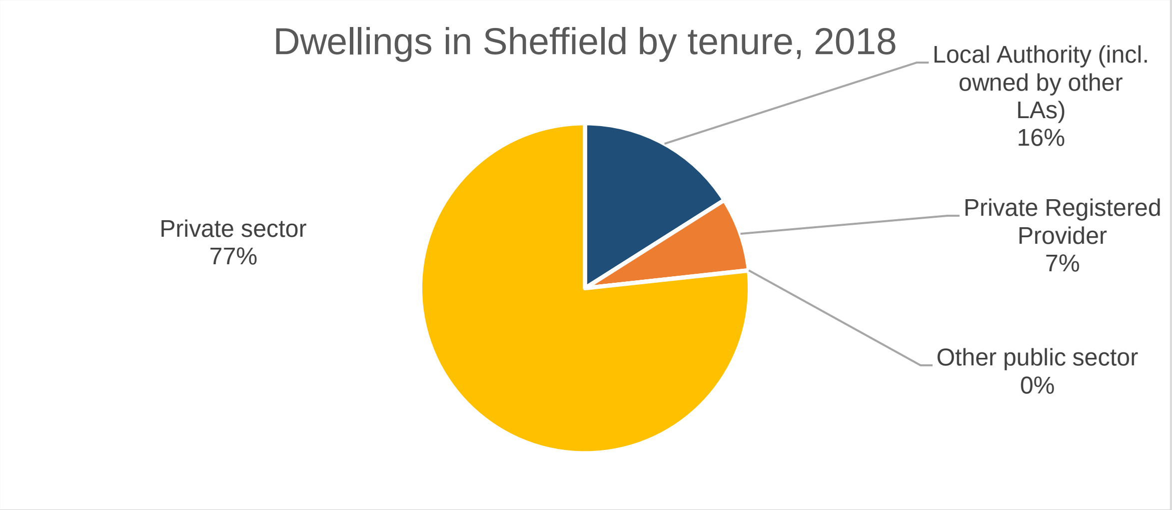
Table 14: Main heating systems of properties in Sheffield, based on domestic EPCs lodged in Sheffield LA region between January 2008 and March 2020

Heating type	Proportion	Average CO_2 emissions *($kgCO_2/m^2/year$)*	Average EPC Band
Boiler and radiators, mains gas	81%	49	D
Room heaters, electric	7%	43	D
Community scheme	5%	38	C
Electric storage heaters	3%	68	D
Other/unknown	4%	-	-

4.2.4 Tenure

In Sheffield in 2018, 189,000 (77%) dwellings were within the private sector (owner-occupied or private rented), 40,000 (16%) dwellings were rented from local authorities and 18,000 (7%) dwellings were rented from private registered providers (social housing).

Figure 42: Proportion of dwellings by tenure in Sheffield, 2018, Office for National Statistics and the Ministry of Housing, Communities and Local Government



4.2.5 Geography

The neighbourhoods with the highest average EPC ranks are neighbourhoods with higher current or ex Council house stock. The neighbourhoods which fall below an average EPC of 55.61 (Category E or F) tend to be on the West of Sheffield, in higher income, owner-occupied or privately rented neighbourhoods. The neighbourhoods with the highest average EPC scores are neighbourhoods with a greater presence of socially rented properties.[6]

[6] Sheffield Energy Extract, Private Sector Condition Survey 2015 filtered by ACORN Income Data 2019

Figure 43: Average SAP based on a Private Sector Condition Survey 2015

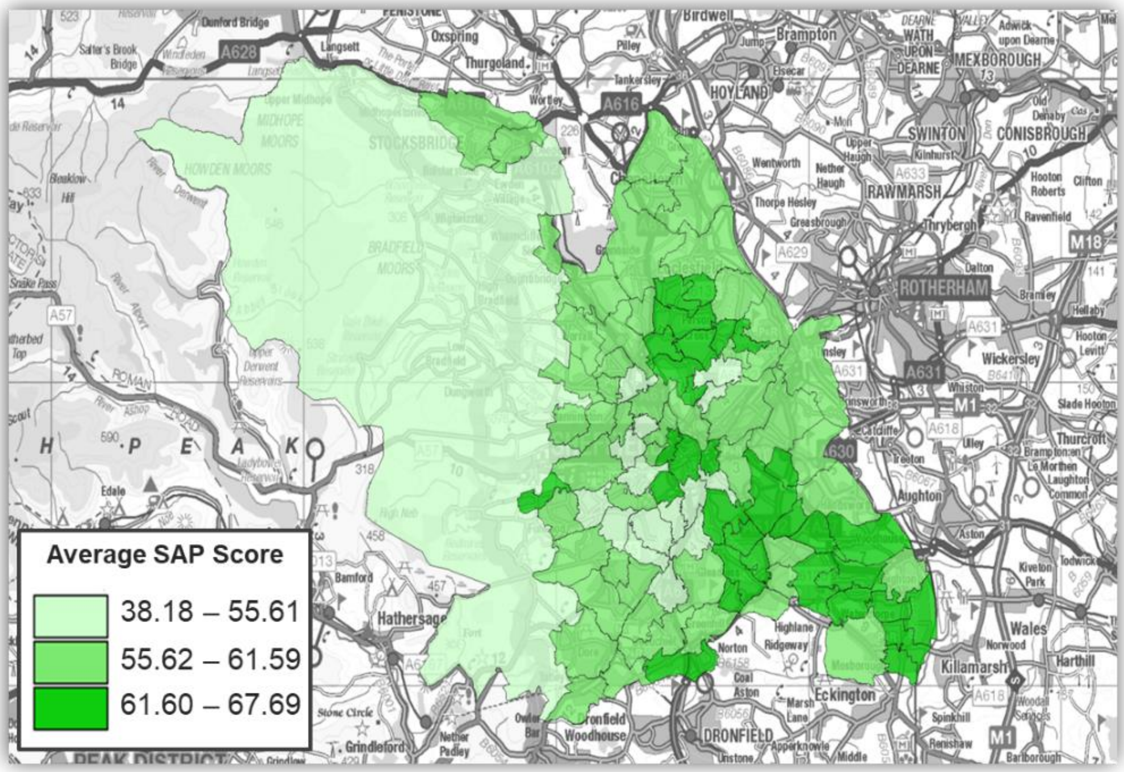
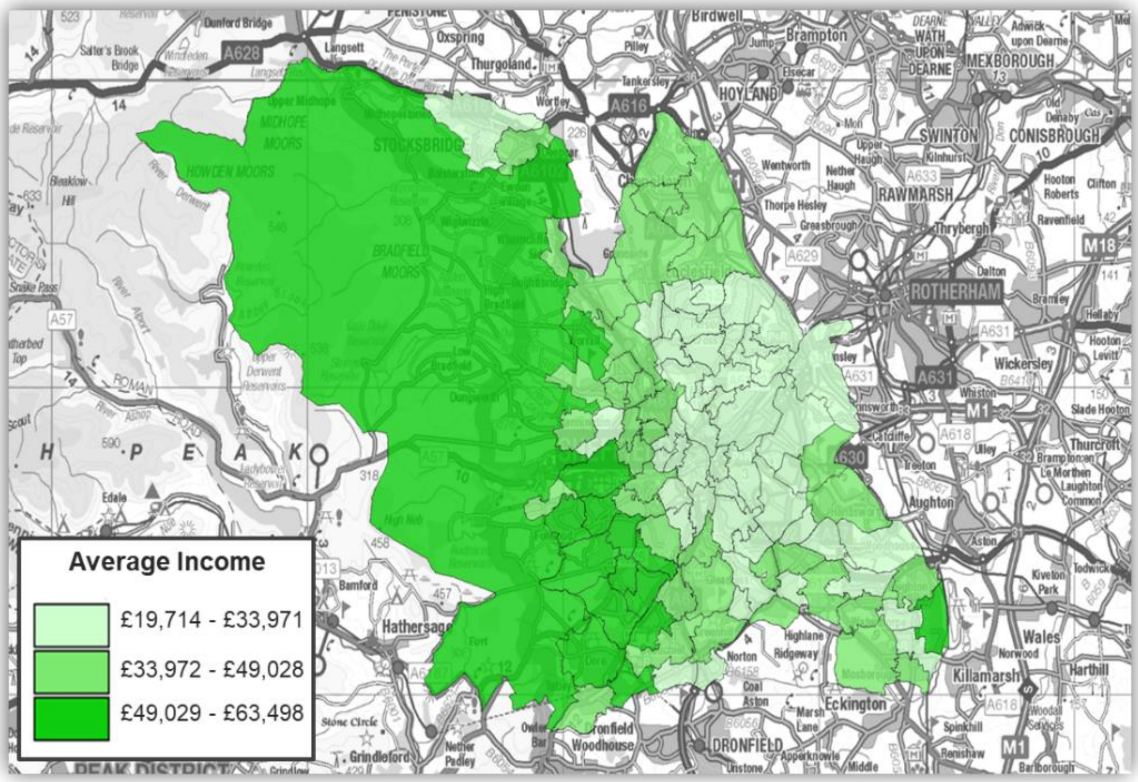


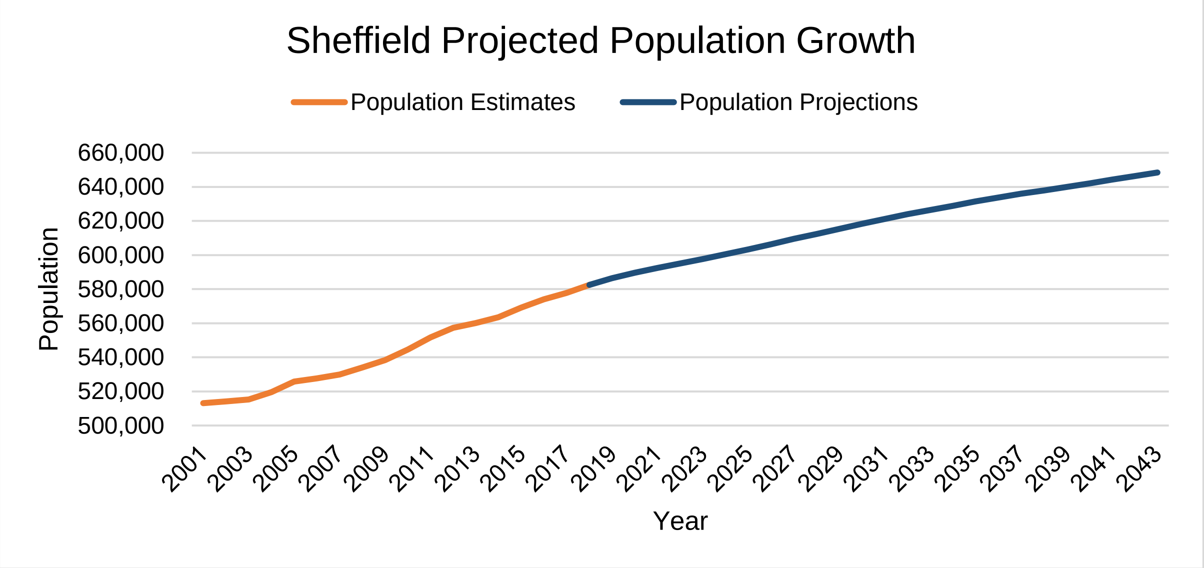
Figure 44: Average Income based on an ACORN Income Data 2019



4.2.6 Population

The population of Sheffield is projected to increase by 29,000 (5%) over the next decade, from an estimated in 590,000 in 2020 to 618,000 by 2030 and to 648,000 by 2043[7].

Figure 45: Sheffield population projected to rise to 618,000 by 2030 and to 648,000 by 2043



4.2.7 New homes

The Sheffield City Council New Homes Delivery Plan, published in 2018, sets out a plan to support the building of over 2,000 new homes, including 725 new affordable homes a year over the next 5 years.

[7] Office for National Statistics Population Estimates and Office for National Statistics Population Projections (2018 based)

4.3 CO_2 data

Table 15 CO_2 emissions estimates from residential in Sheffield 2005-2017 (kt CO_2)[8]

Year	Domestic Gas	Domestic Electricity	Domestic 'Other Fuels'
2005	781.9	472.5	29.5
2006	746.4	492.1	25.8
2007	700.1	480.5	24.3
2008	715.2	460.0	26.8
2009	648.3	419.5	25.8
2010	706.9	433.7	27.2
2011	578.7	412.5	25.7
2012	628.3	435.1	23.7
2013	645.0	397.6	28.4
2014	539.4	336.3	26.1
2015	567.7	283.6	25.8
2016	582.9	228.0	25.1
2017	566.3	197.2	35.5

The results from 4.3 indicate an overall reduction in CO_2 emissions estimates from domestic electricity and gas consumption, between 2005 and 2017. Contrary to these, the CO_2 emissions from other fuels have increased over the years. Specifically, CO_2 emissions estimates from domestic electricity consumption have experienced an annual average decrease of 2.26% (27.6% overall decrease from 2005 to 2017) and from gas consumption an average annual decrease of 6.68% year-on-year (58.3% overall decrease. CO_2 emissions from other fuels have increased by 20.3% from 2005 to 2017 with an average annual increase of 2.47%.

The maps below present the CO_2 emissions from domestic gas, electricity and other fuels' consumption. For the gas and electricity maps data have been derived from postcode-level data and for the other fuels from gridded data – the MSOA-level CO_2 emissions map can be seen in A4.1.

[8] Source: BEIS LA CO_2 statistics

Figure 46 CO_2 emissions from domestic gas consumption at postcode level in Sheffield

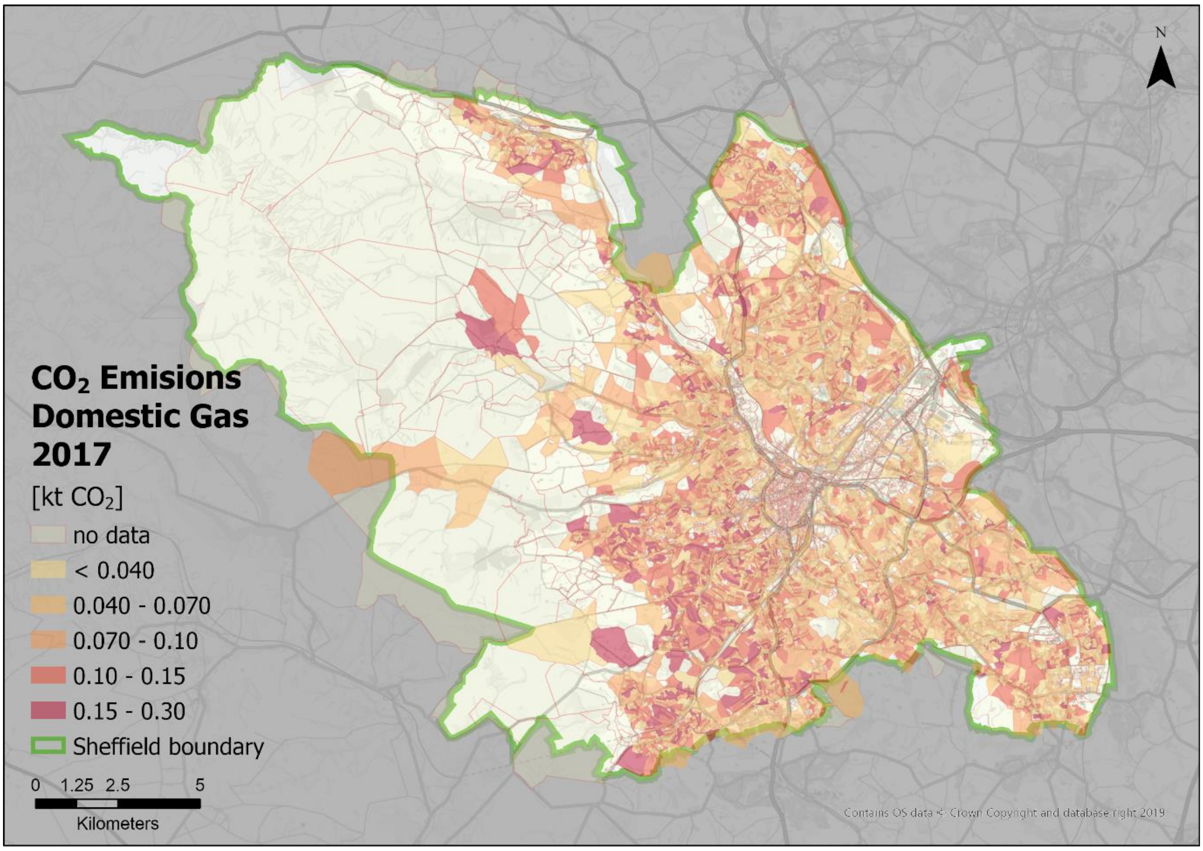


Figure 47 CO_2 emissions from domestic gas consumption at MSOA level in Sheffield

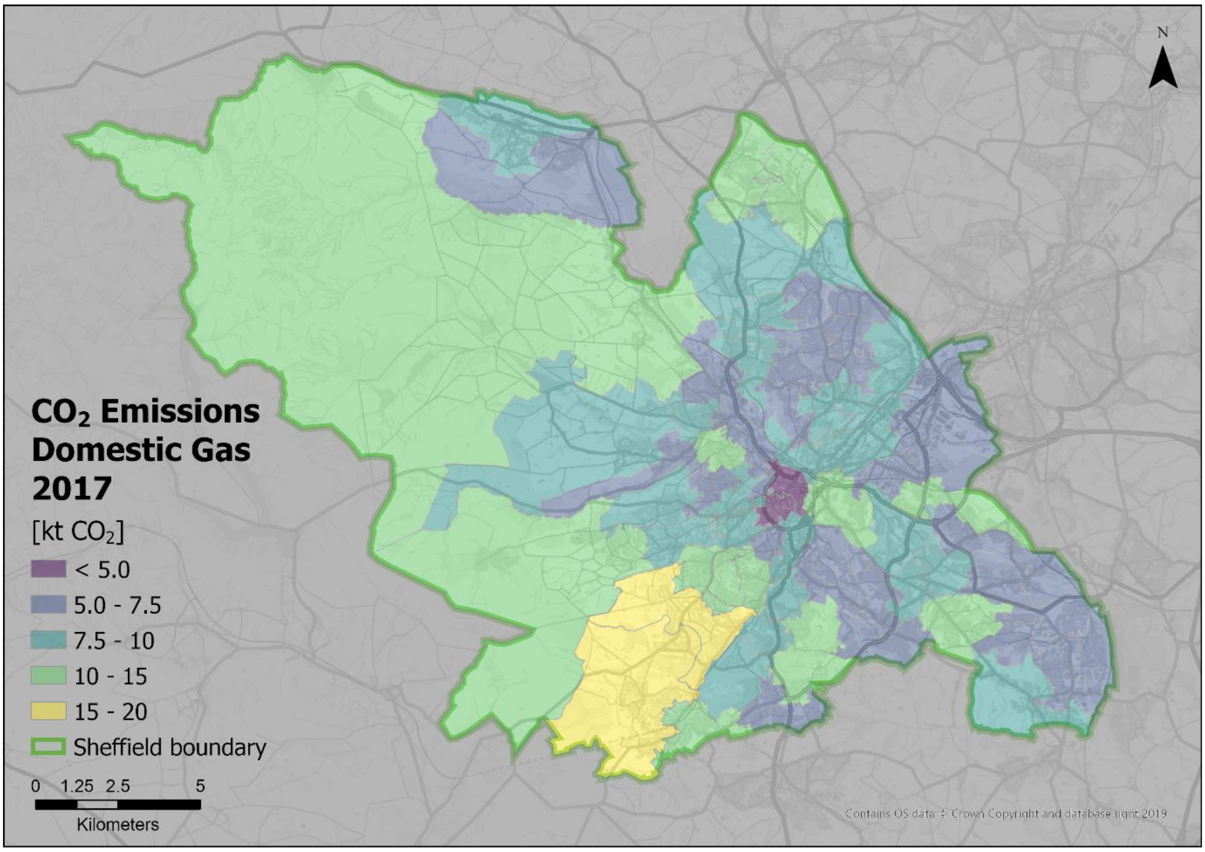


Figure 48 CO_2 emissions from domestic electricity consumption at postcode level in Sheffield

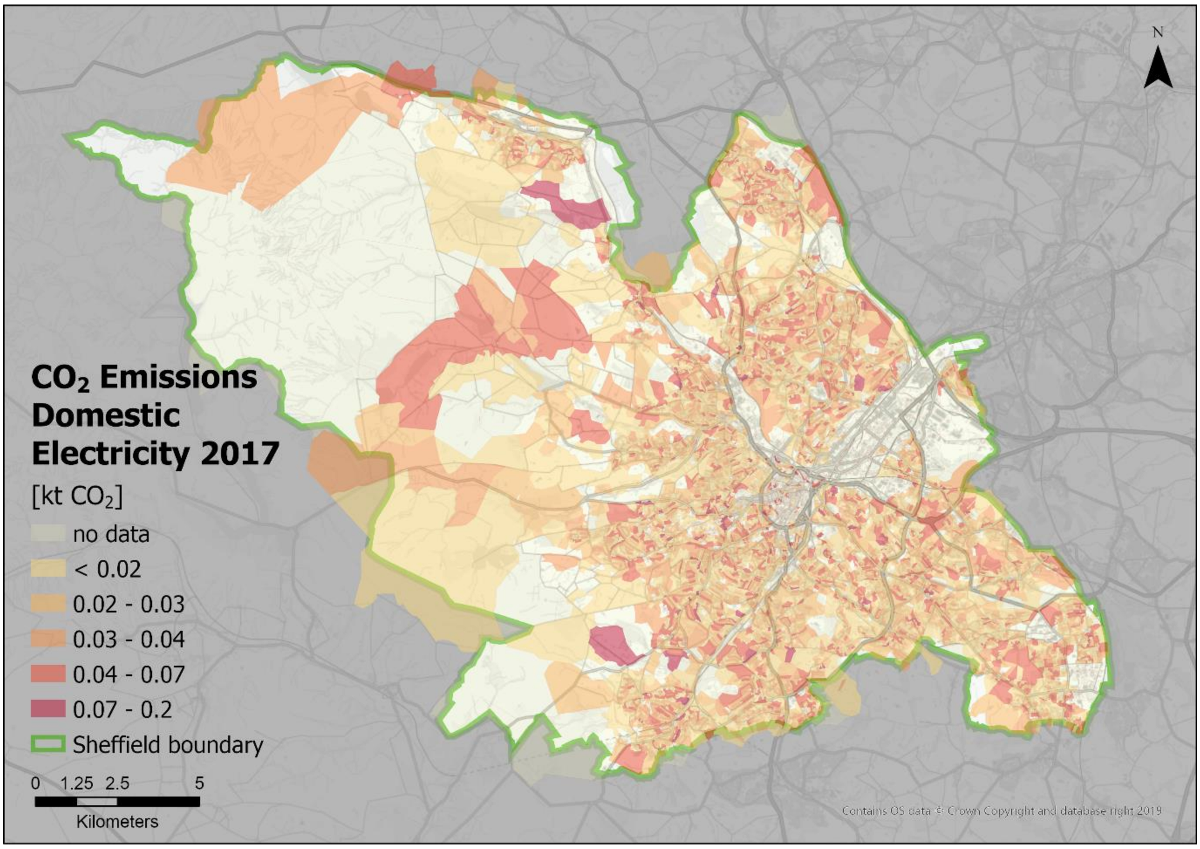


Figure 49 CO_2 emissions from domestic electricity consumption at MSOA level in Sheffield

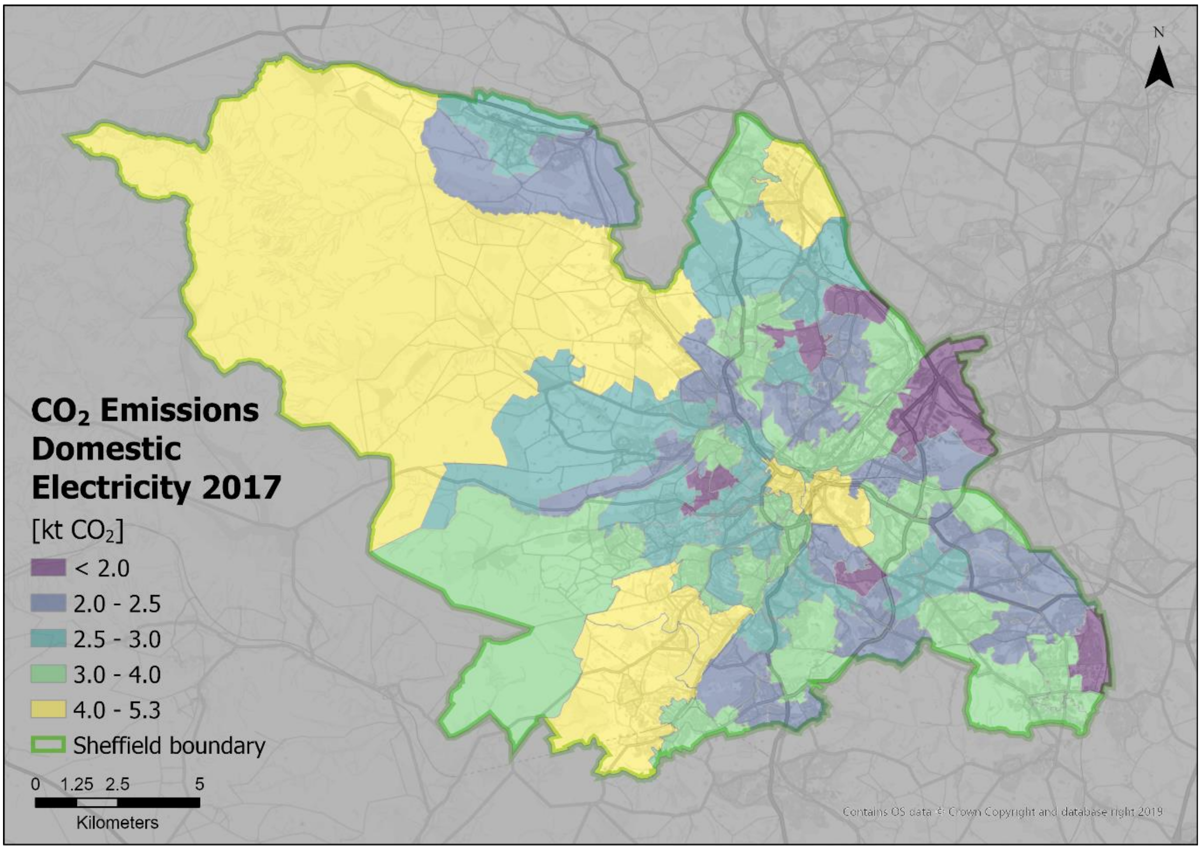
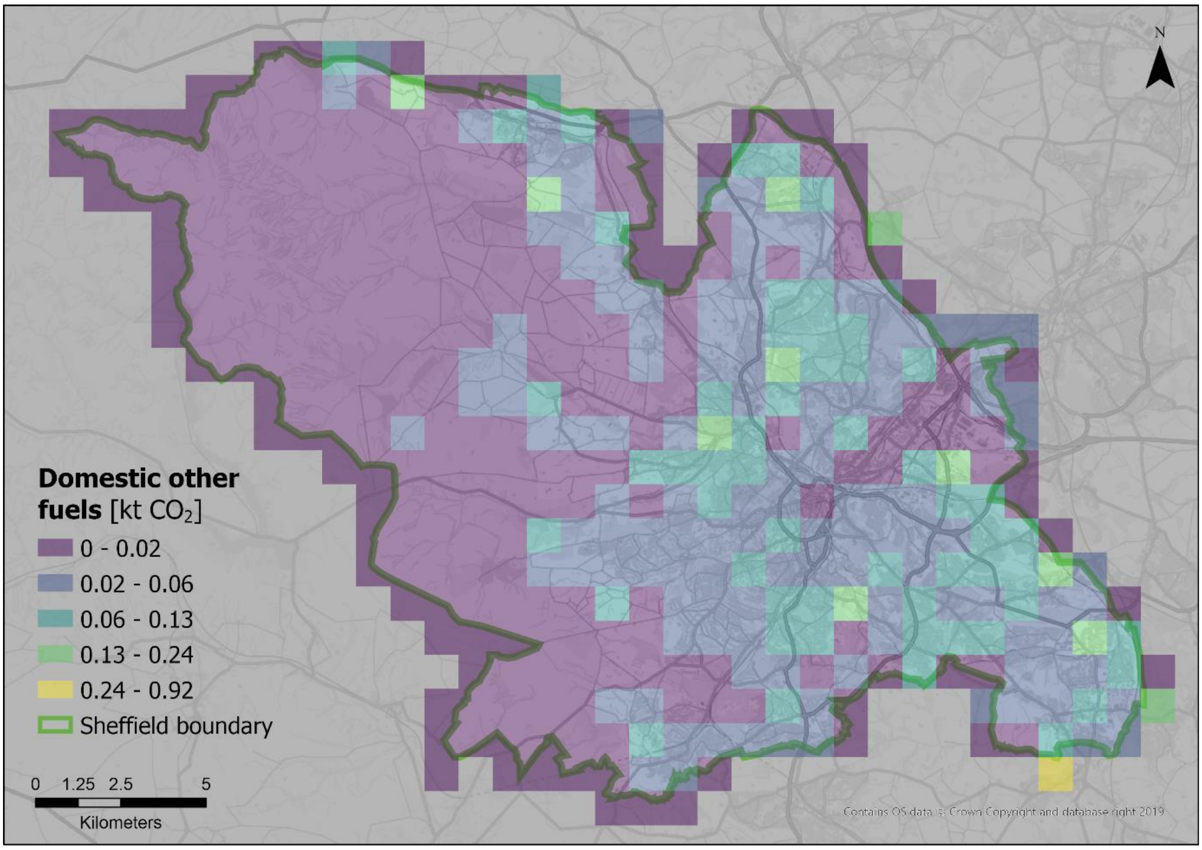


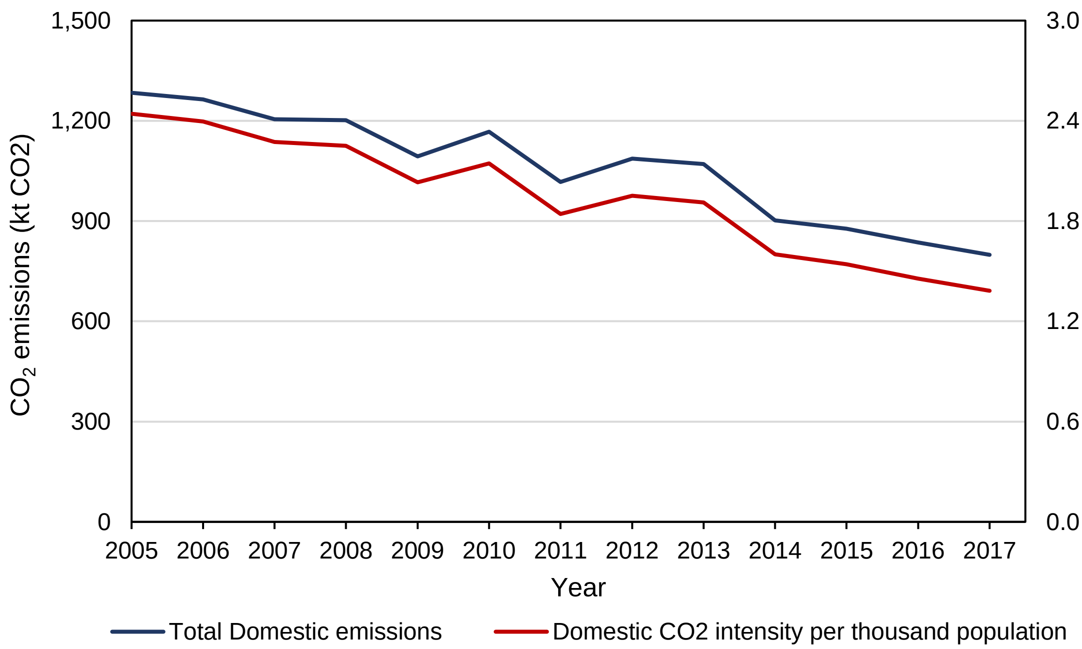
Figure 50 CO_2 emissions from domestic 'other fuels' at 1x1km level in Sheffield



The maps of CO_2 emissions from gas consumption indicate that southern MSOAs (in yellow) are the highest emitters whereas for CO_2 emissions from electricity consumption present the rural area, city centre, southern area and the north-eastern MSOAs as the highest emitters indicating a higher spatial variability in Sheffield for this sector. The map of Figure 50 present the highest CO_2 emissions from other fuels' consumption to be the south-eastern region of the border (near the town of Eckington).

4.3.1 CO_2 trend analysis

Figure 51 CO_2 emissions and intensity per population from the domestic sector in Sheffield

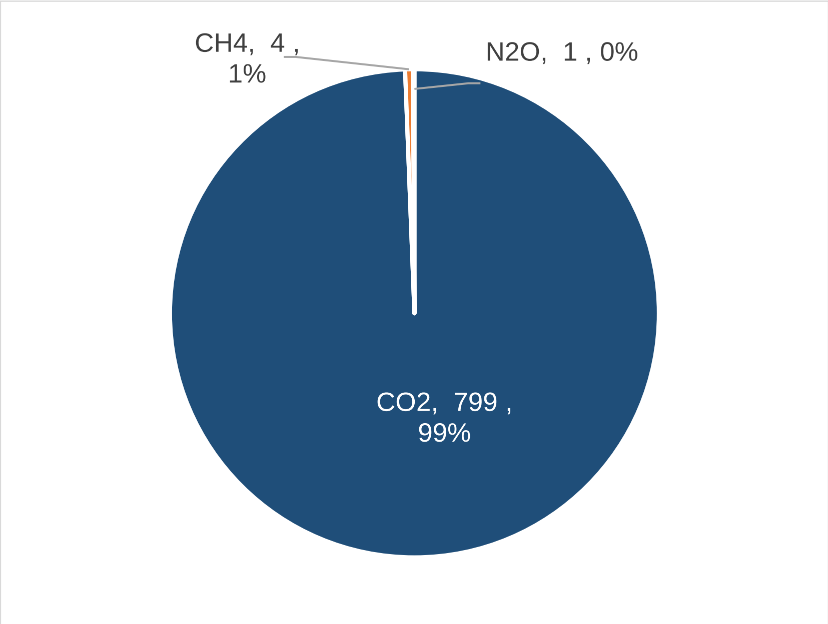


The trend from the line graph indicates that carbon dioxide emissions in Sheffield decrease over time and that population's intensity line (red) starts to decouple from the total domestic emissions indicating an increased efficiency of CO_2 emissions with regards to population change over the years.

4.4 CH_4 and N_2O data

Further to previous trends of the CO_2 emissions from the sources, it is also important to provide insights on methane and nitrous oxide emission estimates from the domestic sector. This subsection of the report focuses on these estimates by providing the GHG breakdown in ktCO_2-equivalent and the relevant maps of GHG emissions at grid level – the MSOA maps can be seen in Appendix A4.

Figure 52 GHG breakdown from residential (kt CO_2e)



The chart from Figure 52 indicates that CO_2 dominates the emissions (99%) in CO_2e where methane contributes to ~1% and nitrous oxide to <1%. The maps, in Figure 53 and Figure 54, present the methane and nitrous oxide emissions at grid level. The spatial distribution of these GHG indicates the same patterns for the two gases. Specifically, the highest emissions are located at areas surrounding the city centre – where the low emissions are located at the rural region of Sheffield (west).

Figure 53 Methane emissions from residential at 1x1km level in Sheffield

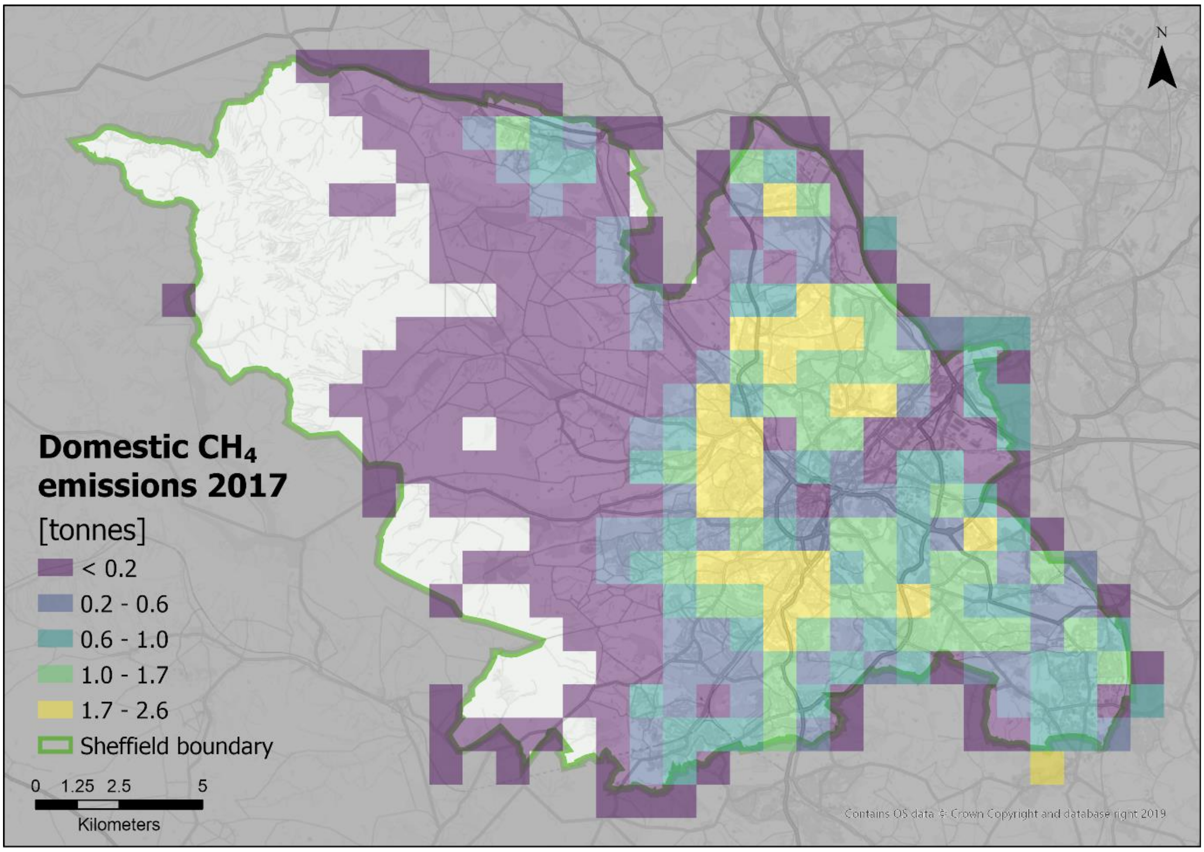
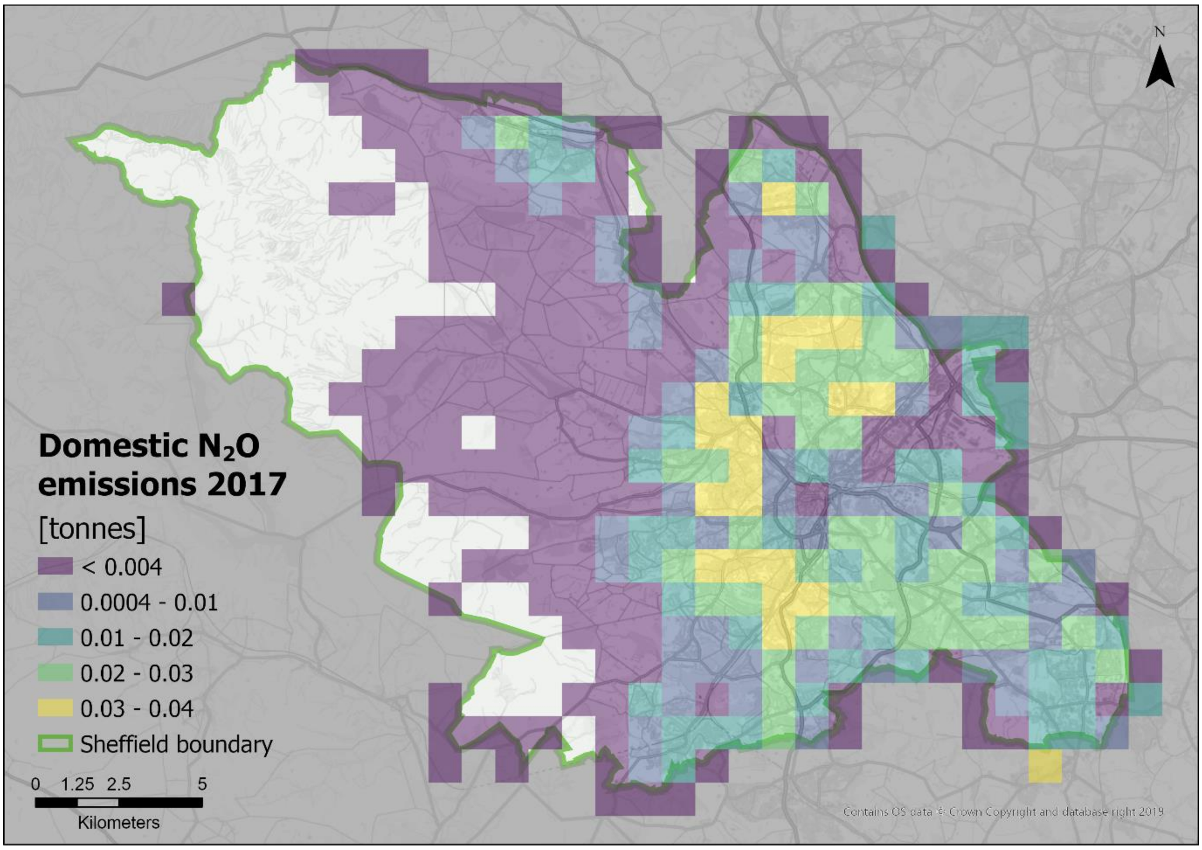


Figure 54 Nitrous oxide emissions from residential at 1x1km level in Sheffield



5 Road Transport emissions

This section concerns emissions in Sheffield from the Road Transport sector and relates only to traffic within the city boundary. It does not account for travel related to the city but beyond its administrative boundary as this is considered scope 3 emissions and has been excluded from the analysis. The subsections present the historic energy consumption and CO_2 trends including their corresponding data for 2017 (maps) as well as methane and nitrous oxide (GHG) emissions at grid level.

5.1 Fuel consumption data

Table 16 Road transport energy consumption in Sheffield.

Year	Buses	Diesel Cars	Petrol Cars	Motorcycles	HGV	Diesel LGV	Petrol LGV
2005	14,108	33,281	104,948	1,173	25,635	25,831	3,111
2006	14,028	36,764	102,169	1,085	25,972	26,377	3,094
2007	14,258	40,497	100,259	1,169	25,032	28,042	2,866
2008	13,282	44,777	95,207	1,076	26,414	28,171	2,568
2009	13,014	45,832	93,862	1,092	24,065	27,703	2,325
2010	13,222	46,624	88,923	989	24,166	28,757	2,193
2011	12,151	49,261	85,789	1,009	21,583	30,299	2,104
2012	11,038	50,744	81,029	1,017	20,467	29,333	1,880
2013	11,089	52,654	76,490	955	21,078	29,656	1,719
2014	11,002	53,200	75,074	960	22,149	31,508	1,639
2015	10,348	53,460	73,349	932	21,122	31,602	1,481
2016	9,166	55,205	71,366	885	21,477	33,265	1,380
2017	9,038	55,703	67,793	919	21,373	32,050	1,214

The results from the Road Transport's energy consumption data (Table 16) indicate a decrease in consumption for most the vehicular classes – with Diesel Cars and Diesel LGVs the two exceptions. Specifically, buses' consumption decreased by 35.9% from the first year of record (3.54% average annual reduction), diesel cars' increased by 67.4% (4.45% average annual increase), petrol cars' consumption decreased by 35.4% from the first year of record (3.56% average annual reduction), motorcycles' decreased by 21.7% from 2005 to 2017 (1.87% average annual reduction), HGVs' decreased by 16.6% (1.37% average annual reduction), diesel LGVs' increased by 24.1% with an average annual increase of 1.84% and, lastly, petrol LGV's consumption decreased by more than half (60.1%) from 2005 to 2017 with a year-on-year annual average decrease of 7.48%.

The maps below present the Road Transport emissions at MSOA and link-by-link level for diesel and petrol vehicles. The highest level of emissions is found at the north of the city and dominated by the M1. More generally as you would expect the emissions are highest along the main road network.

Figure 55 Road transport fuel consumption from diesel vehicles in Sheffield at MSOA level.

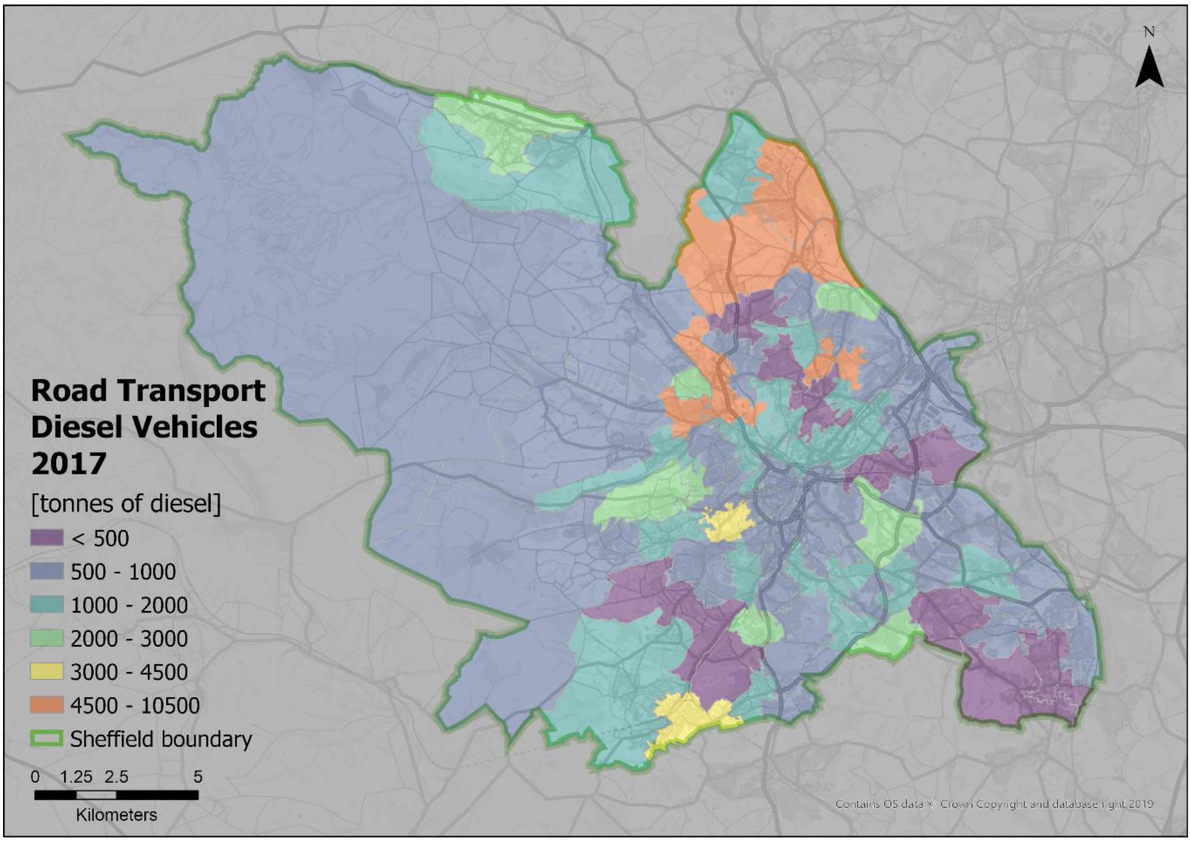


Figure 56 Road transport fuel consumption from diesel vehicles in Sheffield at road-link level (major roads).

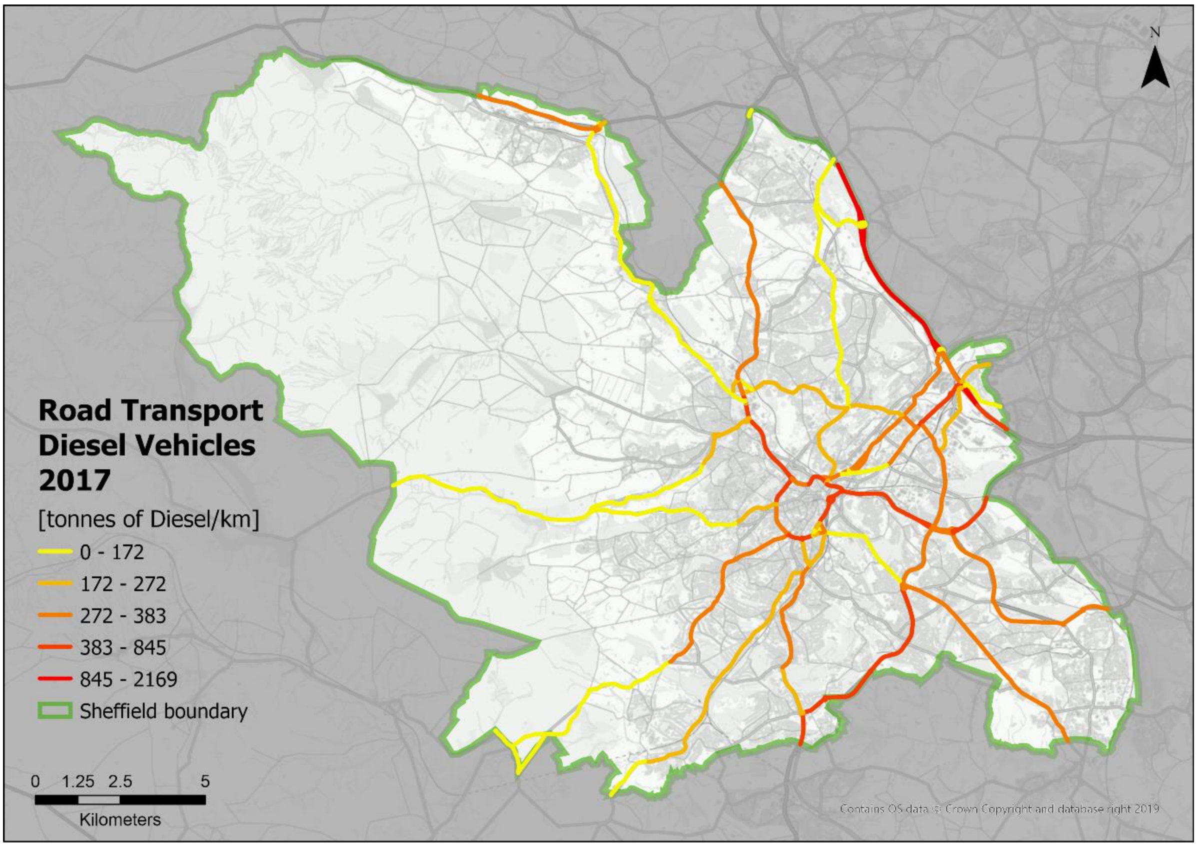


Figure 57 Road transport fuel consumption from petrol vehicles in Sheffield at MSOA level.

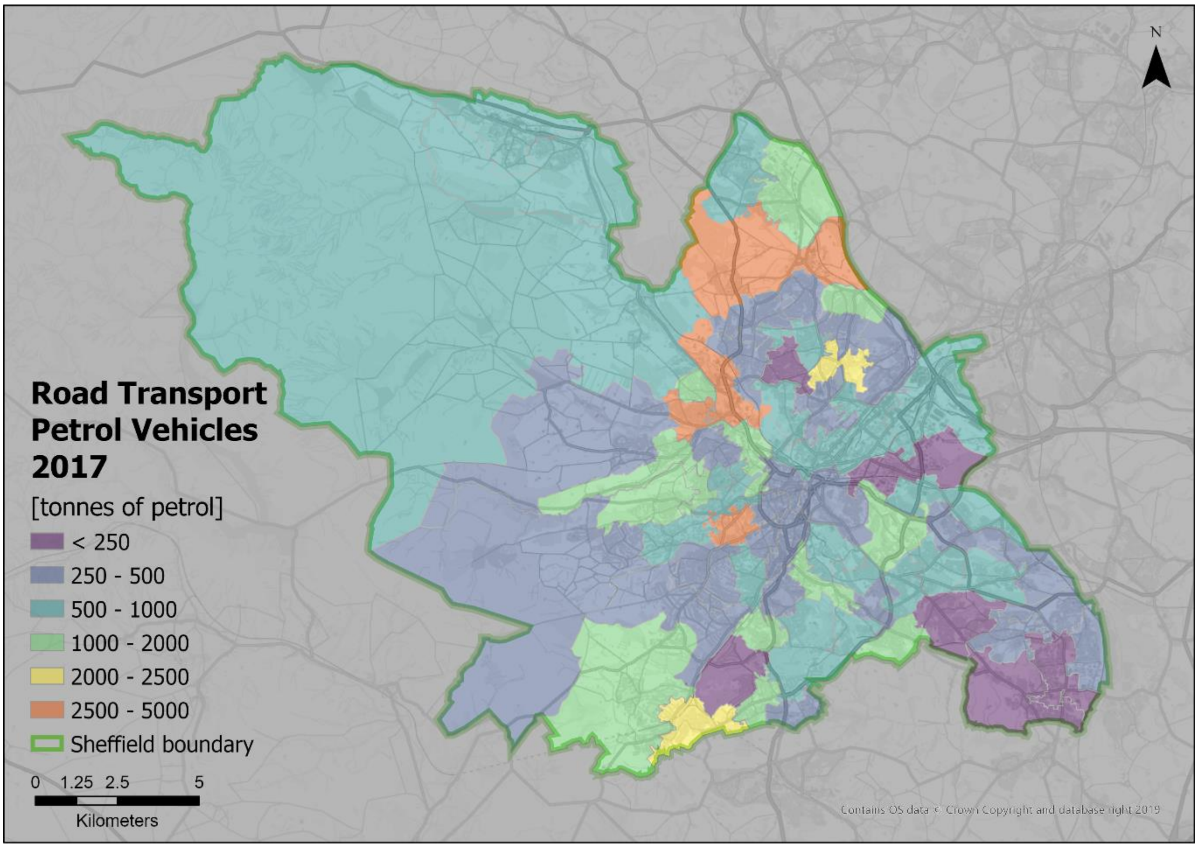
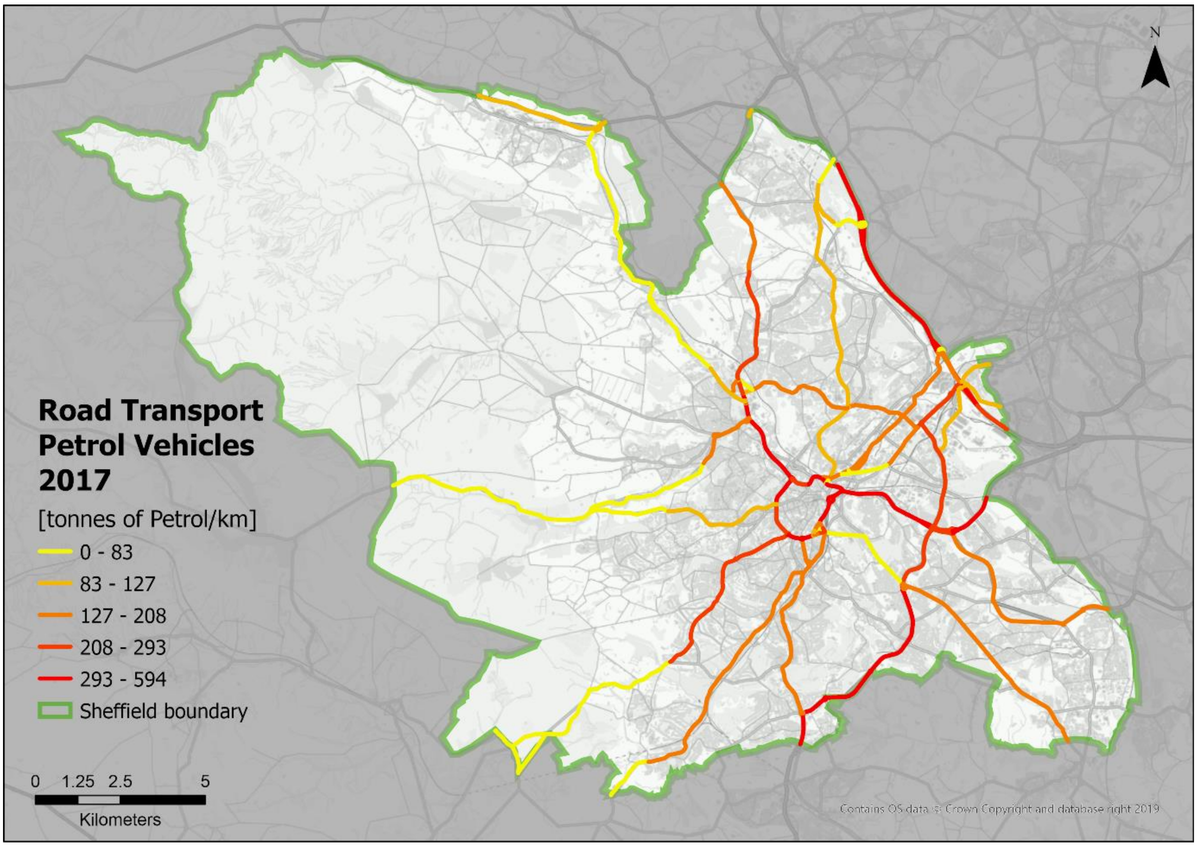


Figure 58 Road transport fuel consumption from petrol vehicles in Sheffield at road-link level (major roads).

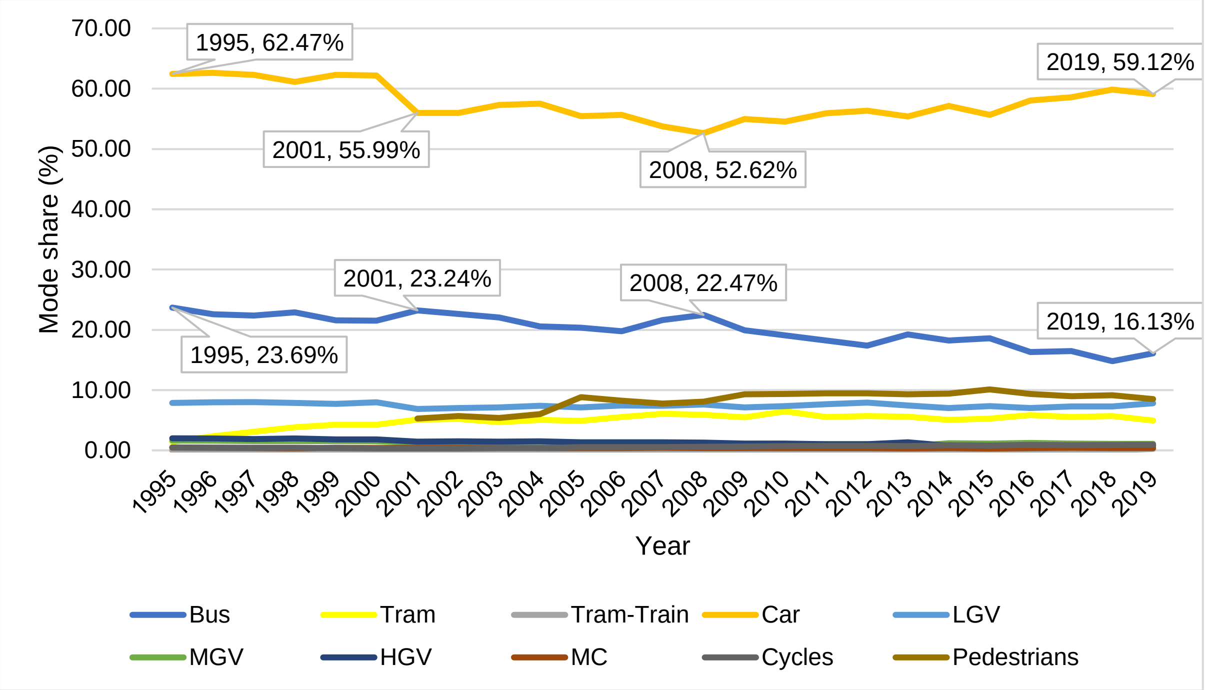


5.2 Activity data

5.2.1 Mode share

The daily proportion of people trips crossing the outer and inner Sheffield cordon by mode over the last 25 years[9].

Figure 59 Mode Share of People Trips



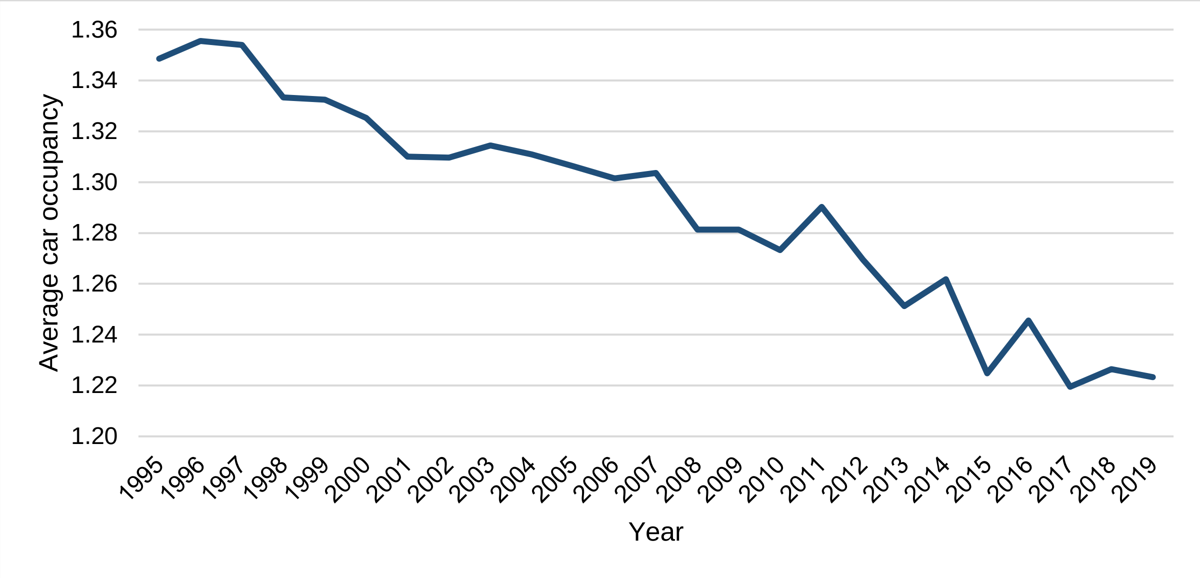
The data shows that since 1995, cars have accounted for approximately 60% of the mode share of person trips in Sheffield. In 2019, the combined share of bus, tram and tram-train was 21% of all trips. Cyclists and pedestrians accounted for 9% of the total mode share, and the remaining 10% constitutes goods vehicles and motorcycles.

5.2.2 Vehicle Occupancy

The average car occupancy in Sheffield has remained below 1.40 since the 1980s. Figure 60 shows the trend in average car occupancy recorded over the past 25 years. Occupancy has seen a continuous decline over the years, with current average car occupancy of 1.21

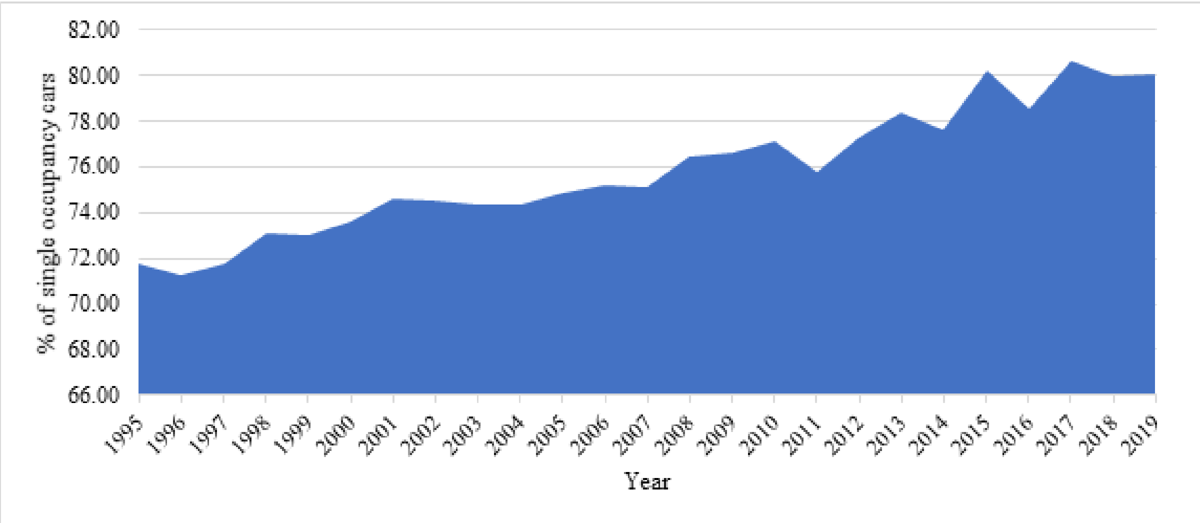
[9] Sheffield Cordon Data provided by SCC dated 2020-01-16

Figure 60 Average Car Occupancy in Sheffield



Historic trends indicate that the number of single occupancy cars have remained significantly high in Sheffield, with the percentage share rising each year[10]. Figure 61 shows the trend in percentage of single occupancy cars, over the years. In 2019 80% of cars had a single occupant.

Figure 61 Percentage of Single Occupancy Cars in Sheffield



5.2.3 Vehicle kilometres

Data from the Sheffield City Region Transport Model (SCRTM) showed that cars accounted for nearly 84% of the daily average vehicle kilometres in Sheffield District in 2016 (see Figure 61)[11]. Light Goods Vehicles (LGVs) and Heavy Goods Vehicles (HGVs) accounted for 12% and 3% of all vehicle kilometres respectively, with buses taking up less than 2% of all vehicle kilometres. Total daily average vehicle kilometres by vehicle type is provided in Table 17.

[10] Ibid
[11] Based on Annual Average Daily Flow

Figure 62 Proportion of Vehicle Kilometres in Sheffield District by Vehicle Type (2016)

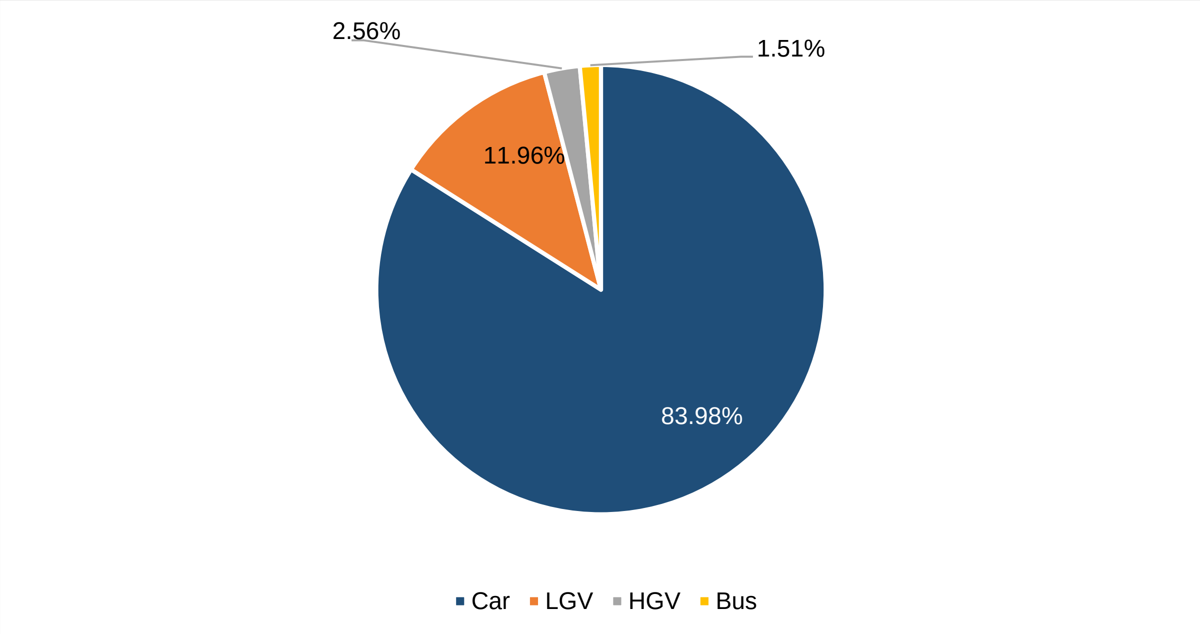


Table 17 Total Daily Average Vehicle Kilometres in Sheffield District by Vehicle Type (2016)

Vehicle Type	Total Vehicle Kilometres
Car	3,809,900
LGV	542,380
HGV	116,080
Bus	68,348

5.2.4 Fuel split

Automatic Number Plate Recognition (ANPR) data from 2019 showed that among all the unique vehicles recorded in Sheffield City Centre, 54.3% were diesel-engine, 43.5% petrol and 1.9% hybrid-electric vehicles. The total proportion of full electric vehicles was less than 2.2%. Figure 62 shows the proportion of different vehicle classes by fuel type and Table 18 shows the number of unique vehicles corresponding to each fuel type for an average day.

It can be noted that diesel is the predominant fuel type of most classes of vehicles in Sheffield City Centre, except for private cars which have around 4% more petrol-engine vehicles than diesel-engine vehicles.

Figure 63 Fuel Split by Vehicle Type

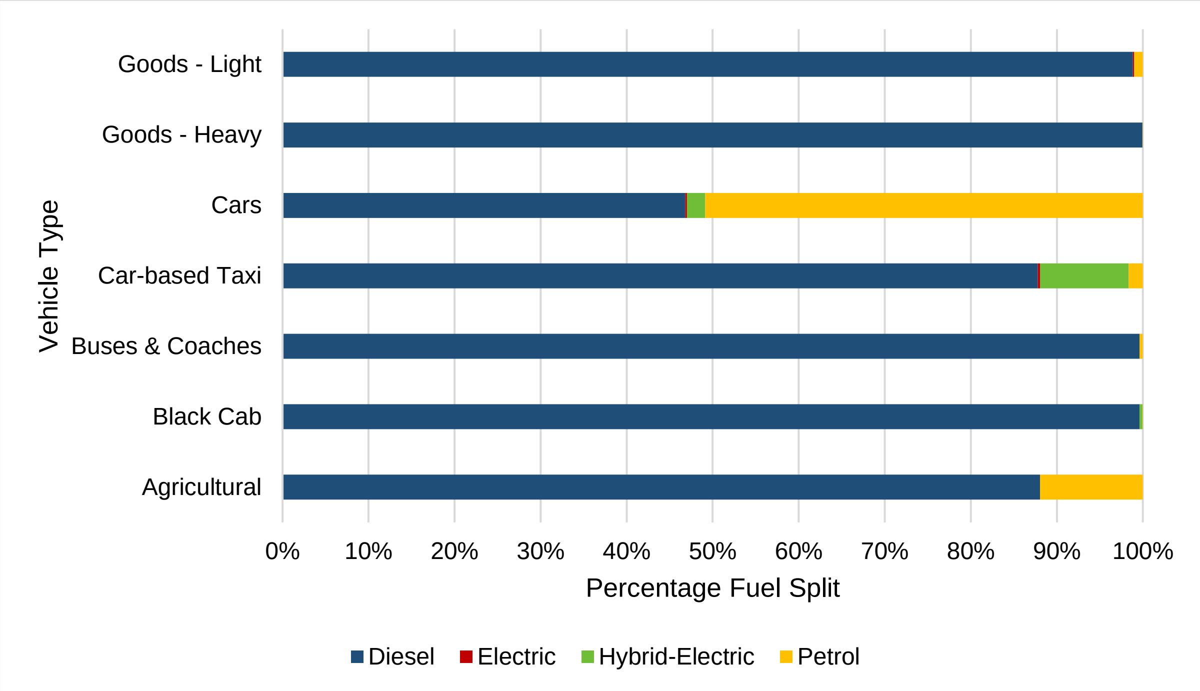


Table 18 Fuel Split by Number of Vehicles (daily average)

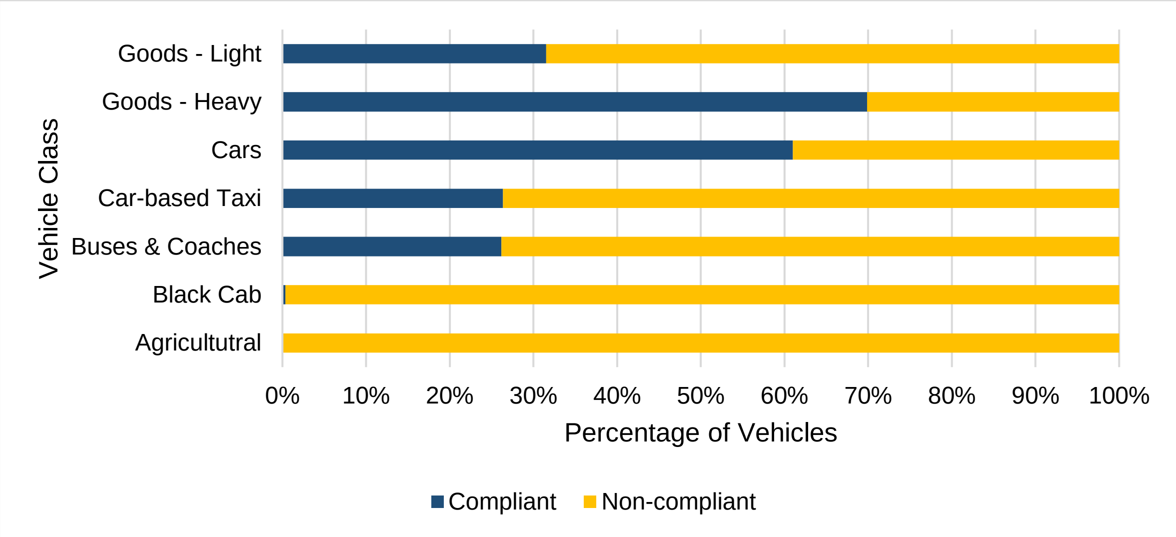
Fuel	Number of Vehicles
Diesel	393,276
Petrol	314,868
Hybrid-Electric	13,715
Electricity	1,454
Gas/Bi-Fuel	383
Hybrid DE	292
Petrol/Gas	59
Gas	32
Steam	5
Other	5

5.2.5 Euro standards

Euro emission standards define the permissible levels of exhaust emissions, mainly nitrogen oxides (NOx), hydrocarbons (HC), carbon monoxide (CO) and particulate matter (PM) produced by vehicles[12]. Analysis of ANPR data from Sheffield City Centre in 2019 showed that 44.7% of all vehicles recorded were not compliant with the respective Euro standards. Figure 63 shows the compliance split by vehicle type. 99.6% of black cabs, 73.8% of buses and coaches and 73.6% of car-based taxis were noted to fall below the permitted Euro standards. This shows that a significant proportion of vehicles were producing carbon monoxide, hydrocarbons, oxides of nitrogen and particulate matter beyond the permissible levels.

[12] https://ec.europa.eu/growth/sectors/automotive/environment-protection/emissions_en

Figure 64 Compliance to Euro Standards by Vehicle Type



5.2.6 Electric Vehicle Charging

Currently, there are electric vehicle charging points at around 20 locations within Sheffield, with around 26 slow chargers, 16 fast chargers and 9 rapid chargers in total[13]. Sheffield City Council (SCC) has received Early Measures Fund (EMF) funding from the Government's Joint Air Quality Unit (JAQU) and Ultra Low Emission Taxi Infrastructure Scheme funding from the Office of Low Emission Vehicles (OLEV) in order to provide 22 more rapid chargers (50kw) for electric vehicles[14]. Of the 22 chargers to be installed in 2020, 10 chargers will be for the exclusive use of hackney carriage taxis and private hire vehicles. The remaining 12 chargers will be available for use by the general public as well as taxi and private hire drivers.

[13] Next Green Car / Zap Map (2020) accessed at https://www.zap-map.com/live/
[14] Communication from SCC via email

5.3 CO_2 data

Table 19 CO_2 emissions estimates for transport in Sheffield 2005-2017 (kt CO_2)[15]

Year	Road Transport (A roads)	Road Transport (Motorways)	Road Transport (Minor roads)	Diesel Railways	Transport Other
2005	305.4	107.7	303.5	9.0	3.8
2006	298.8	107.3	296.7	8.8	3.9
2007	292.4	103.6	312.0	9.4	3.9
2008	280.2	95.0	311.6	9.1	4.1
2009	272.8	93.5	300.8	9.0	3.8
2010	272.2	95.2	294.4	9.1	3.8
2011	271.2	92.7	284.8	9.0	3.7
2012	260.2	91.5	276.7	9.5	3.6
2013	254.3	92.0	273.9	9.4	3.6
2014	255.0	89.3	280.5	9.4	3.6
2015	257.7	91.9	274.3	9.3	3.5
2016	261.5	94.0	279.7	9.1	3.4
2017	257.8	93.2	270.0	8.9	3.4

The results from Table 19 indicate an overall reduction in CO_2 emissions estimates for all sections of the Road Transport sector between 2005 and 2017. Specifically, A roads have experienced an average annual decrease of 1.4% and a 15.6% decrease from 2005 to the latest year, Motorways a 1.15% average annual decrease and 13.5% amongst all years, Minor roads a 0.9% average annual decrease and 11.0% decrease from 2005 to 2017, diesel railways a minimal decrease of 1.11% throughout this period and carbon dioxide emissions-decrease by 10.5% for Transport other.

The following maps present the carbon dioxide emissions at MSOA level and link-by link (tonnes of CO_2/km).

[15] Source: BEIS LA CO_2 statistics

Figure 65 Road transport emissions (kt CO_2) from diesel vehicles in Sheffield at MSOA level.

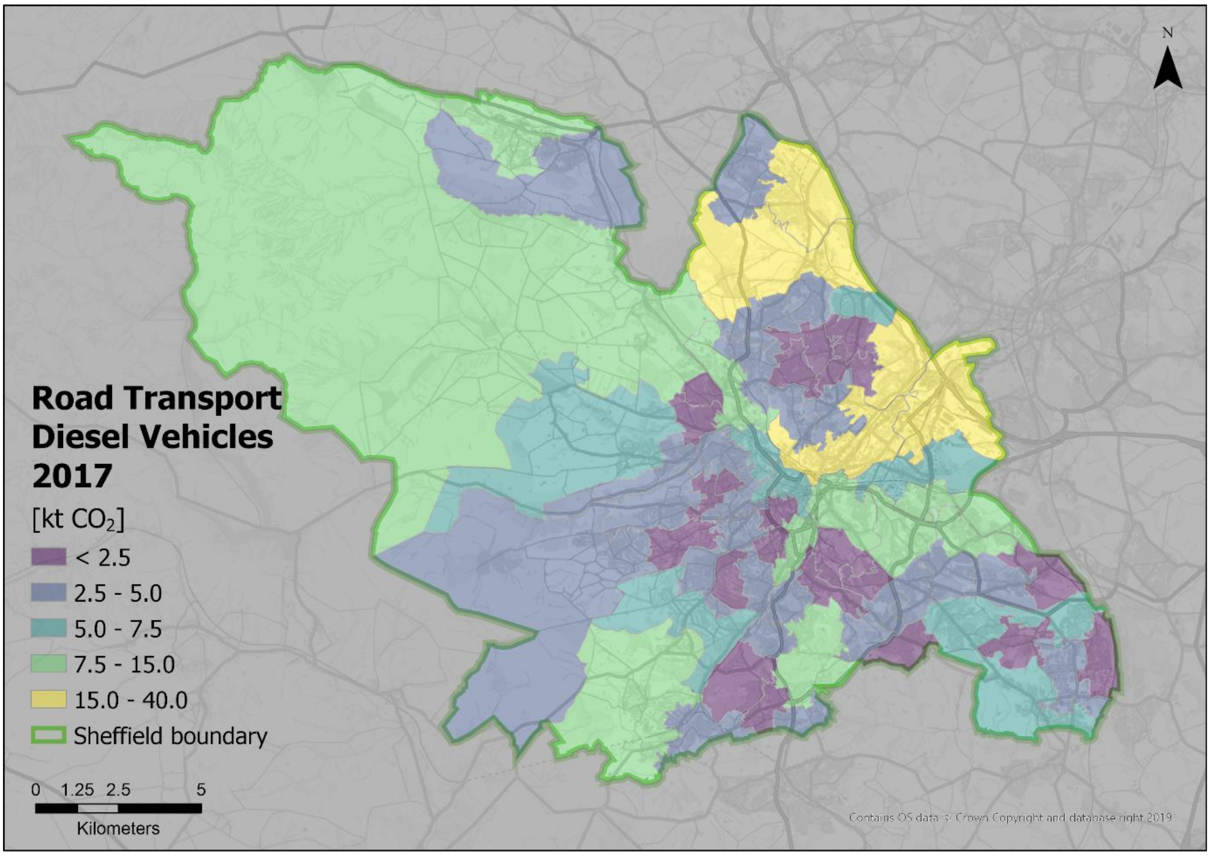


Figure 66 CO_2 emissions from diesel vehicles at road-link level (major roads) in Sheffield.

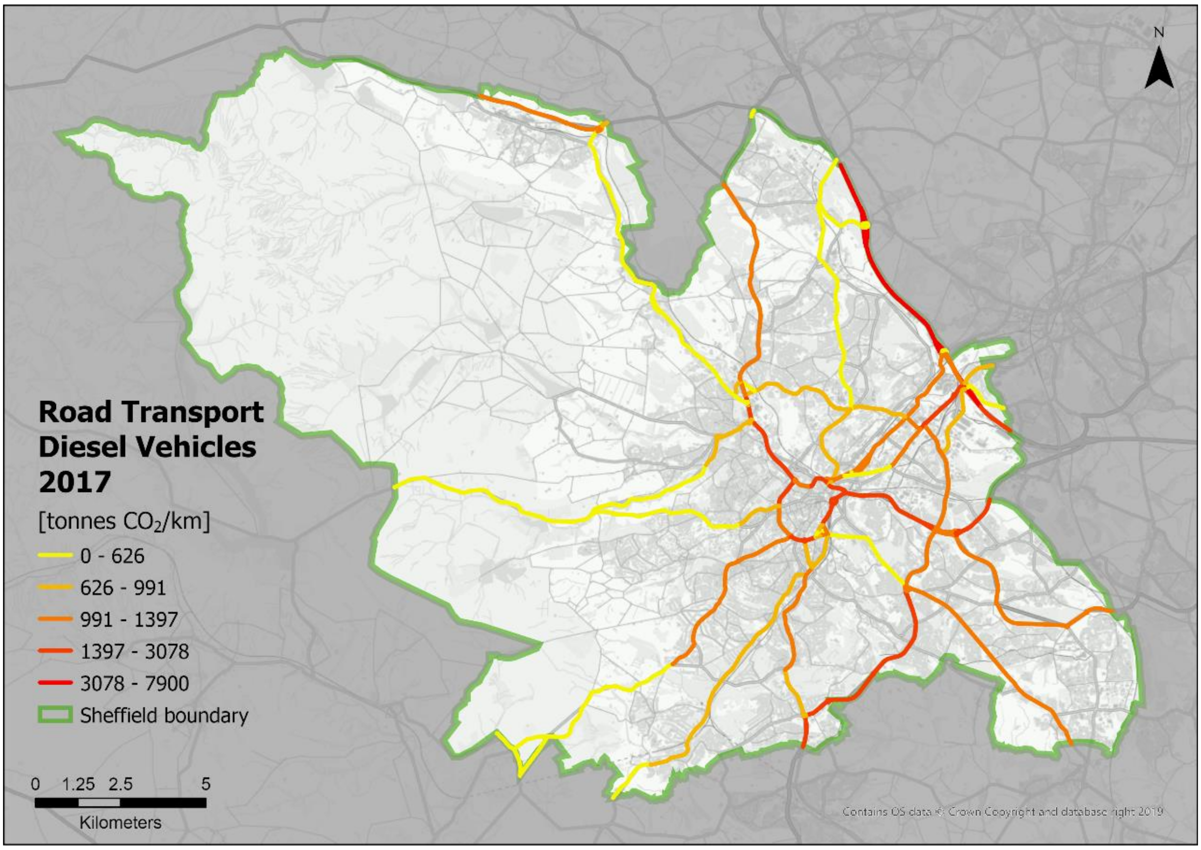


Figure 67 Road transport emissions (kt CO_2) from petrol vehicles in Sheffield at MSOA level.

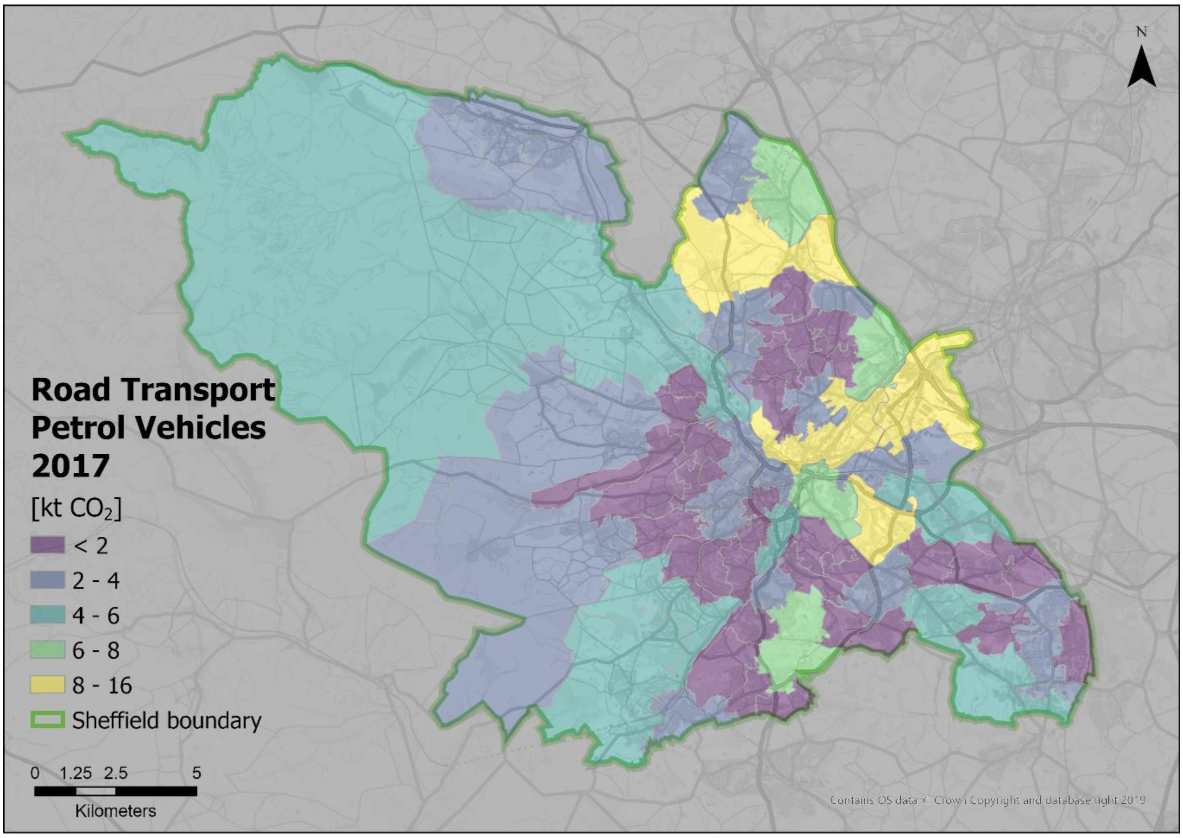
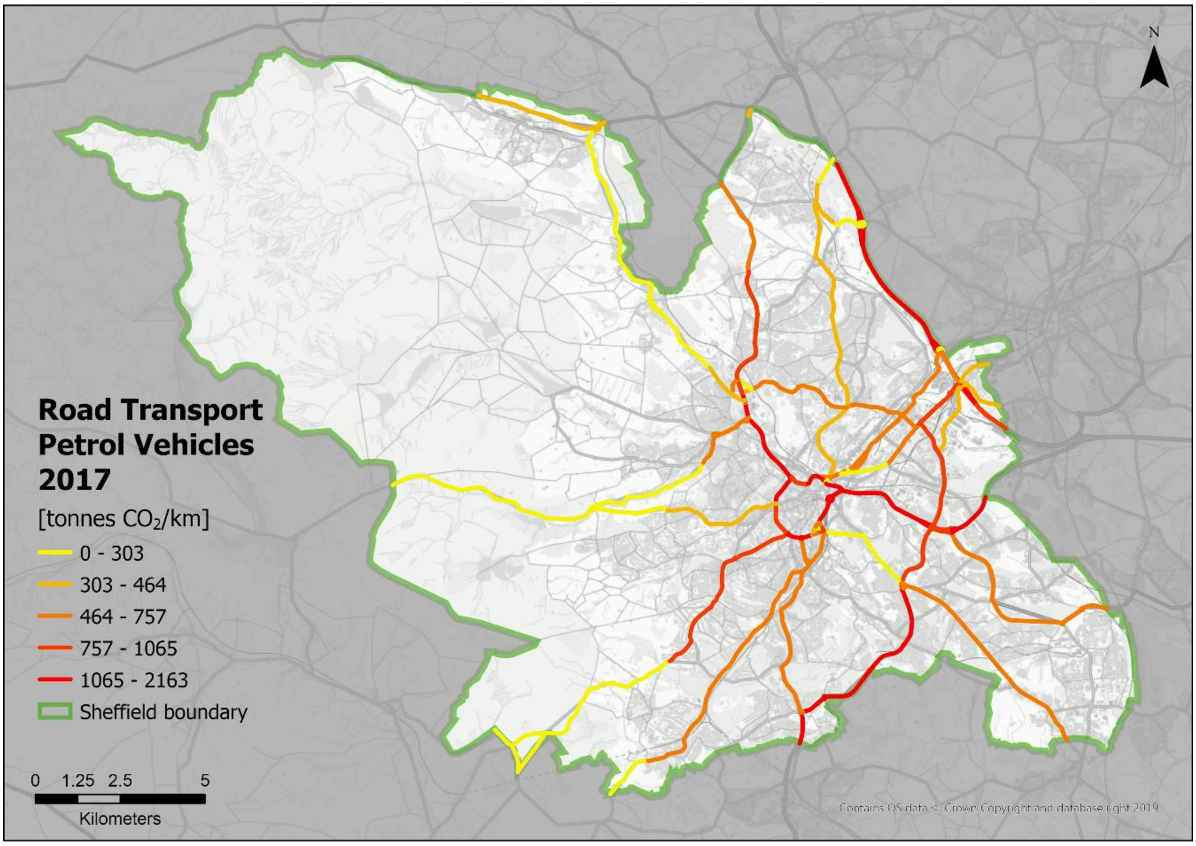


Figure 68 CO_2 emissions from petrol vehicles at road-link level (major roads) in Sheffield.

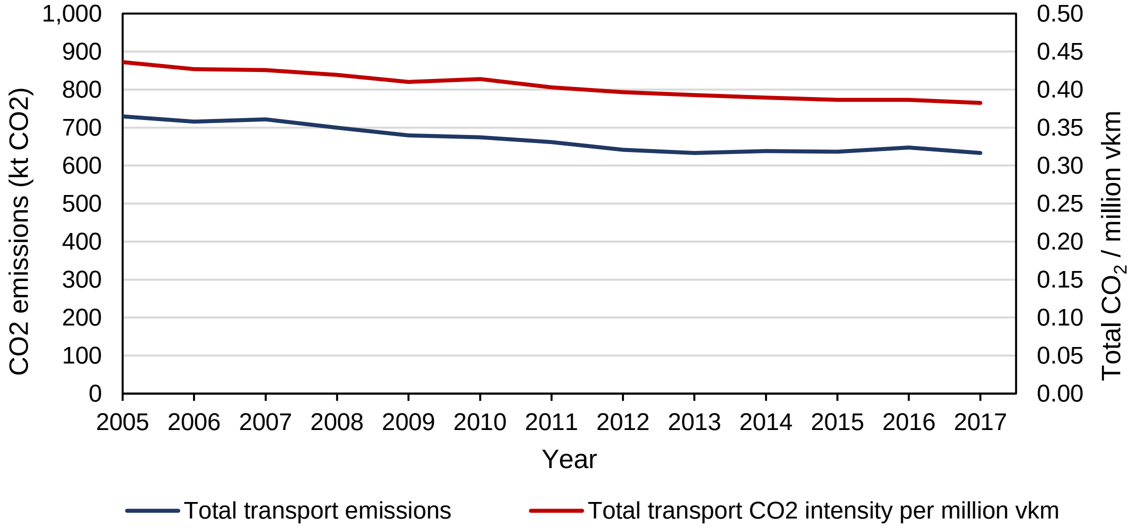


The results present the same patterns for CO_2 emissions from both diesel and petrol vehicles. Specifically, the CO_2 emissions are higher for the MSOAs located near the M1 motorway and between the city centre. Furthermore, the emissions of from diesel vehicles are almost double the equivalent from petrol vehicles at the higher emitting MSOAs.

The link-by-link results present higher emissions for roads leading to/starting from the city centre as well as the M1 motorway. In addition, the higher emitting road links for diesel vehicles are on average three times higher in tonnes of CO_2 compared to petrol vehicles. In this level of spatial analysis, road gradient has not been taken into consideration as research has shown that this factor doesn't impact the emissions.

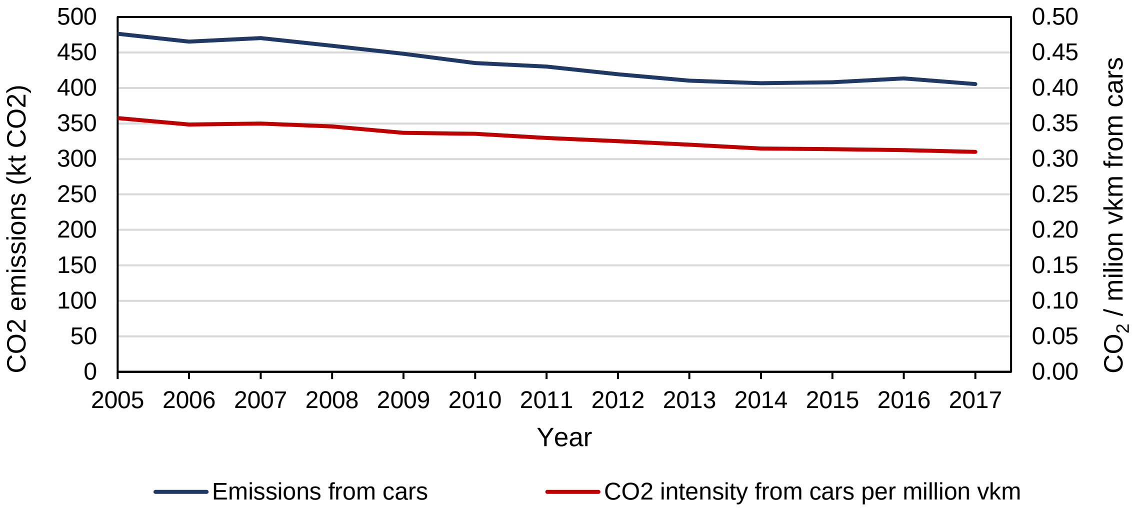
5.3.1 CO_2 Trend Analysis

Figure 69 CO_2 emissions (kt CO_2) from transport against total vehicle traffic (million vkm) in Sheffield[16]



[16] Source: BEIS LA CO_2 statistics and DfT Local authority traffic statistics

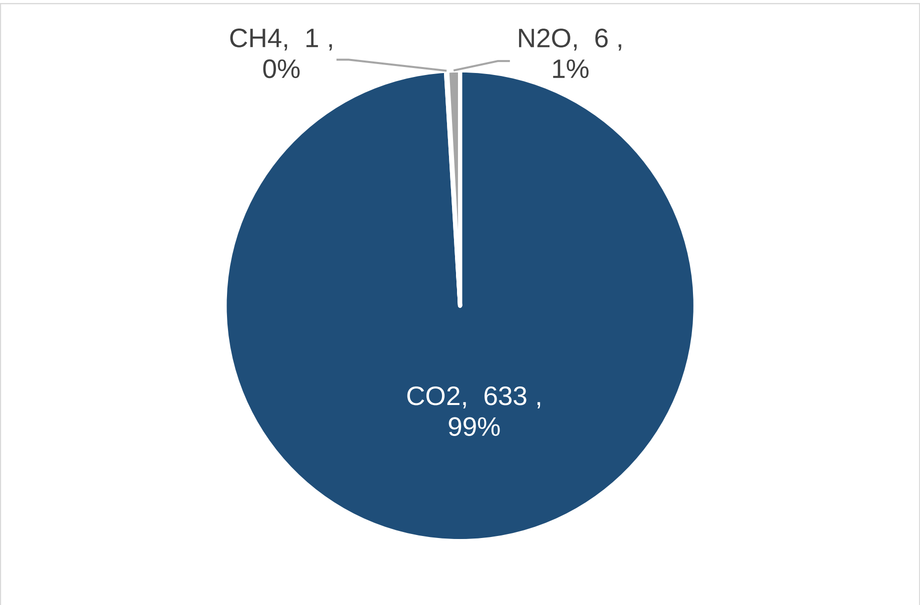
Figure 70 CO_2 emissions (kt CO_2) from cars against vehicle traffic from cars (million vkm) in Sheffield[16]



The trends from Figure 69 and Figure 70 provide more insights on the effect of vehicle kilometres to the total emissions of carbon dioxide from all transport emissions and emissions from cars. Figure 69's trend suggests that total emissions' changes per year and annual emissions per one million vkm follow the same trend. However, in the last two years these two lines start to couple indicating a decreasing vkm is responsible for lower emissions. The trend of Figure 70 presents that the vkm effect on car CO_2 emissions is fairly constant throughout the years despite an overall decrease of car CO_2 emissions. This suggests that for the most recent years that the traffic flow has slightly decreased.

5.4 CH_4 and N_2O data

Figure 71 GHG breakdown from transport (ktCO2e)



The Road Transport's GHG breakdown indicates a 99% dominance by CO_2 (633 of total 640 ktCO2e). The maps below present the emissions from methane and nitrous oxide from the Road

Transport sector at grid level – the MSOA maps can be found in Appendix A5. The results at grid level present eastern Sheffield boundary and, more specifically, the M1 motorway as the highest region of GHG emissions. Also noticeable is the class range between the 2 GHG – nitrous oxide emissions are one order of magnitude greater than methane.

Figure 72 Methane emissions from transport at 1x1 km grid level in Sheffield

Figure 73 Nitrous oxide emissions from transport at 1x1 km grid level in Sheffield

6 Agriculture, waste and land use

This section concerns emissions in Sheffield from the agricultural, waste and land use sector. The subsections present the historic energy consumption and CO_2 trends including their corresponding data for 2017 (maps) as well as methane and nitrous oxide (GHG) emissions at grid level.

6.1 CO_2 data

Table 20 CO_2 emissions estimates for agriculture, waste and land use in Sheffield 2005-2017 ($ktCO_2$)[17]

Year	Agriculture	Net LULUCF
2005	4.3	-15.3
2006	4.1	-16.6
2007	3.8	-17.2
2008	3.8	-18.0
2009	3.8	-18.2
2010	3.8	-18.8
2011	3.9	-19.4
2012	3.9	-19.4
2013	3.7	-20.4
2014	3.9	-20.4
2015	4.0	-21.1
2016	4.0	-20.9
2017	4.0	-21.4

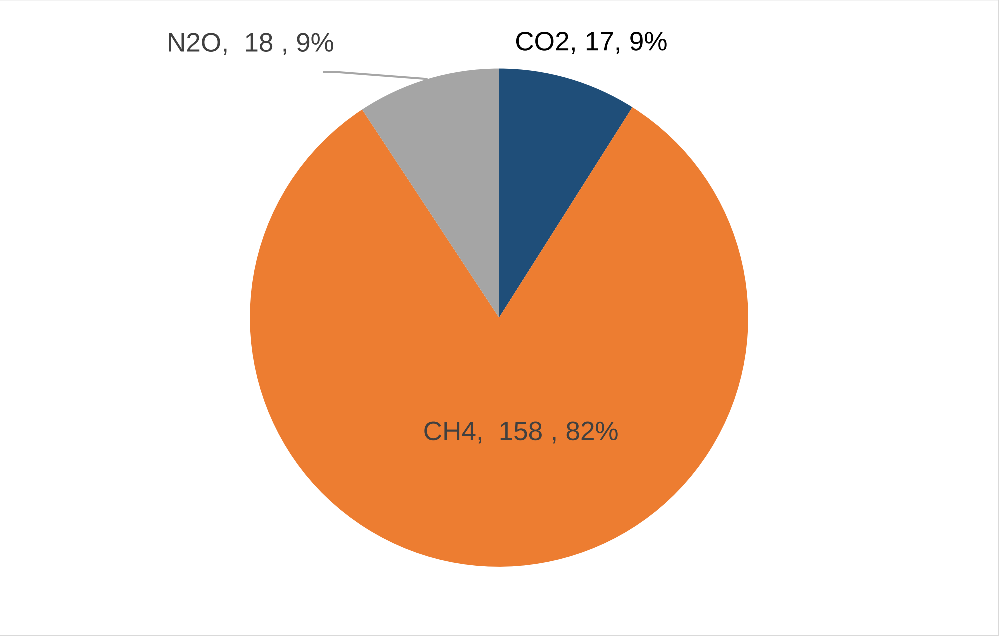
The carbon dioxide emission data and associated trends from Table 20 indicate an overall slight decrease in CO_2 emissions from the agricultural sector in Sheffield over the years (7%) where in the last three years' emissions show no change. In addition, CO_2 emissions attributed to LULUCF, show an increasing net decrease (40%) with an average annual decrease of 2.9%.

The negative figures for land use represent carbon sequestration from natural habitats. The level of sequestration will relate to the type and quality of this habitat. Some local information on the habitats on South Yorkshire is provided by the South Yorkshire Local Nature Partnership website.

[17] Source: BEIS LA CO_2 statistics

6.2 CH_4 and N_2O data

Figure 74 GHG breakdown from agriculture, waste and land use (ktCO2e)



The GHG breakdown from the Agricultural, waste and land use sector indicate an even split between methane (9%) and carbon dioxide (9%) whereas methane emissions dominate the split by contributing to 82% (158 kt CO2e) of the total GHG emissions in Sheffield.

The maps below present the nitrous oxide and methane emissions of this sector at grid level – as with the previous chapters the MSOA maps can be found in the relevant appendix – see Appendix A6. The maps results indicate very high emissions of methane (in accordance to Figure 74) near the M1 motorway, south-east of the city centre and closer to the rural area (near the Peak District National Park) at the west (orange grids from Figure 75). On the contrary the nitrous oxide emissions are relatively low and seem to be higher just west of the city centre. The methane emissions are approximately 3 orders of magnitude higher than nitrous oxides emissions for the highest emitting grids.

Figure 75 Methane emissions from agriculture, waste and land use at 1x1 km grid level in Sheffield

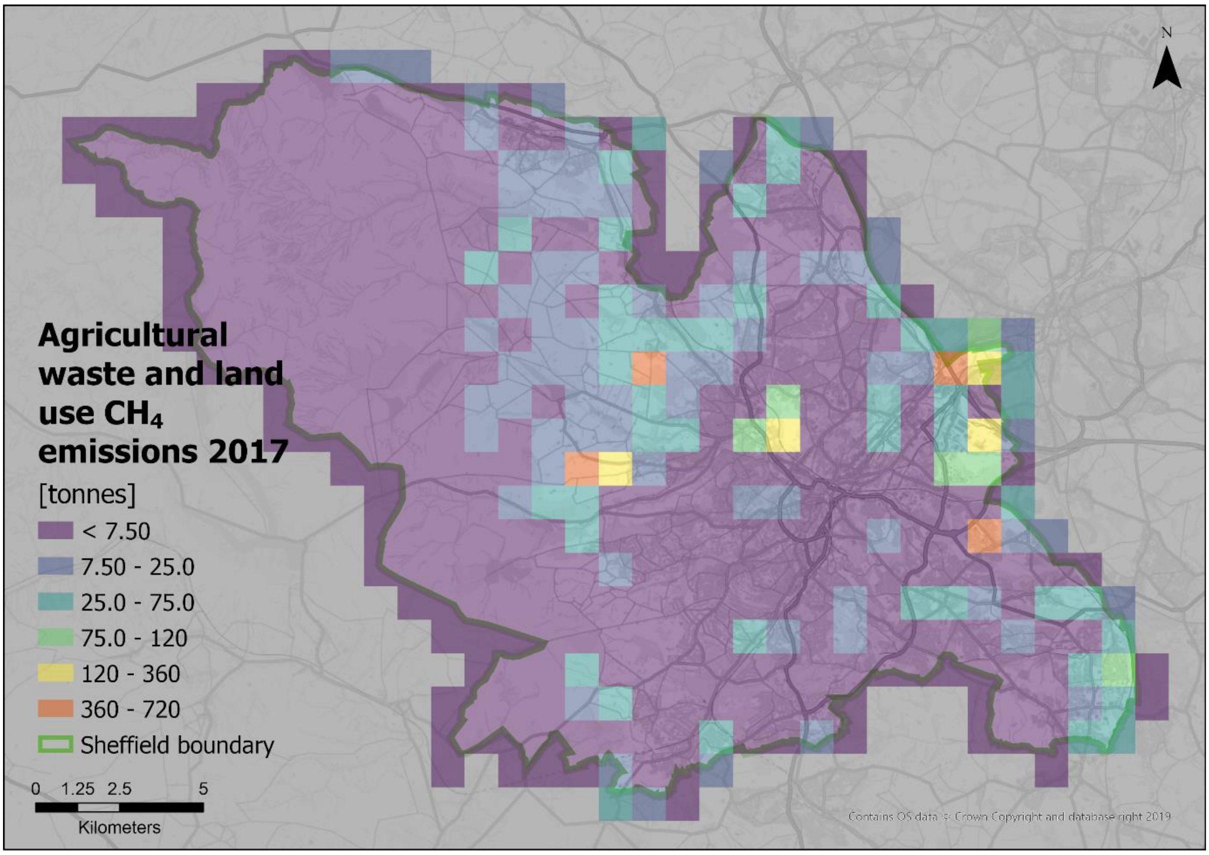
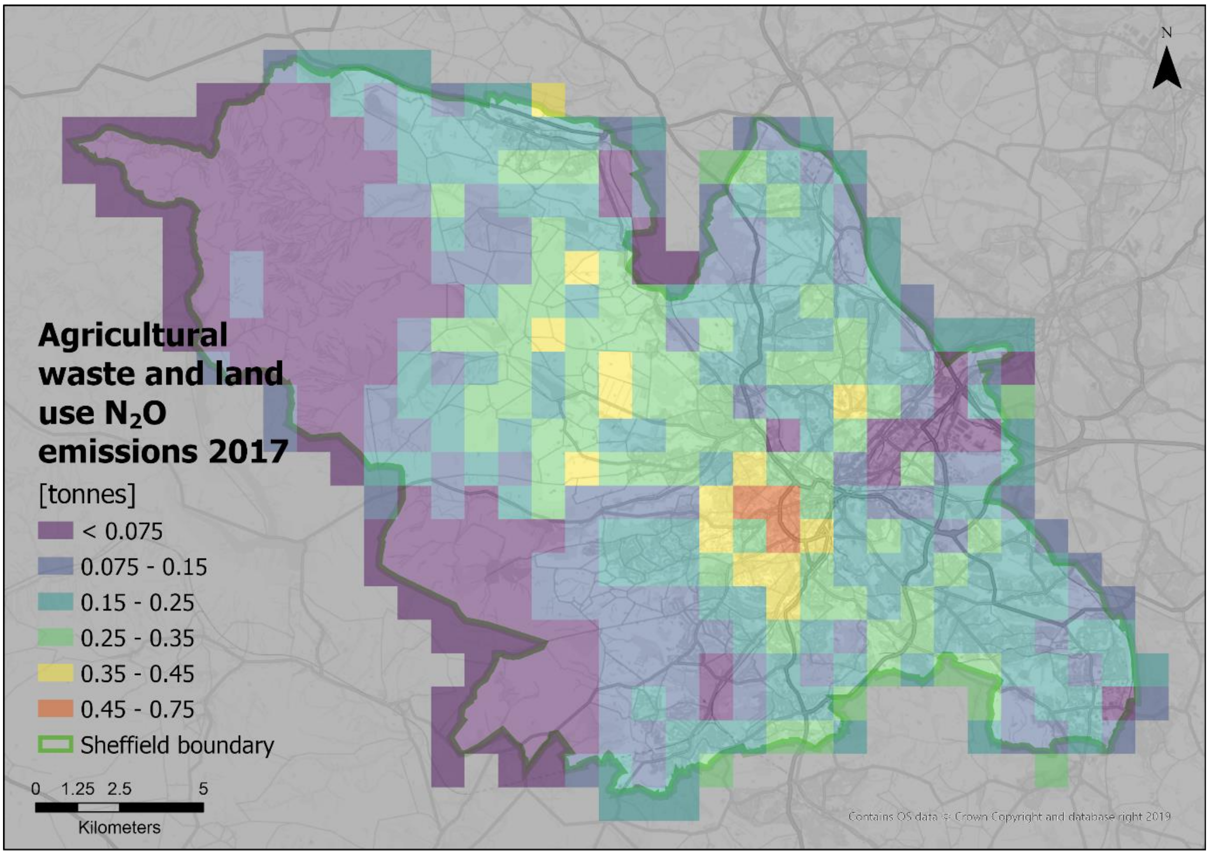


Figure 76 Nitrous oxide emissions from agriculture, waste and land use at 1x1 km grid level in Sheffield



7 Local energy generation and storage

The purpose of this note is to summarise the indigenous energy generation (heat and electricity) in the Sheffield local authority area. This information will form part of the baseline developed within Work Package 1 for Sheffield City Council net zero pathways project.

7.1 Heat

7.1.1 Scope

This assessment focussed on the heat generation in the Sheffield local authority area for heat generated by all sources other than natural gas.

We have used readily available information to estimate:

- Total number of installations
- Total installed capacity (MW)
- Total heat exported from each site (GWh/year)
- Emissions associated with the heat (tCO_2e/year)

There is limited information in the public domain about the generation of heat. Given the highly distributed nature of heating systems, it is difficult to get a full picture without in depth research. We particularly highlight the following exclusions and limitations of this analysis:

- We have not considered any gas-fired boilers or CHP plants. We understand that gas usage is considered elsewhere in the study.
- We have not considered any renewable heating installations which aren't registered under the RHI scheme. We know there are several SCC biomass heating systems which supply community heating systems and pre-dated RHI but these are relatively small in the context of the whole city.
- We have not included domestic wood burning stoves.
- We have not included coal and oil-fired heating systems.

7.1.2 Data sources

The data sources used for this analysis are summarised in the table below.

Data Source	Description	Link
RHI Monthly Deployment Data published by BEIS	UK RHI data from November 2011-March 2020	RHI
Veolia Environmental Services	Information provided direct to the project team in relation to the Sheffield Energy Recovery Facility (ERF) which generates heat and electricity from Sheffield's waste.	

7.1.3 Data summary

The table below summarises the installed capacity and exported heat from sites in Sheffield.

Technology	No of installations	Capacity MW_{th}	Generation GWh/year
Domestic RHI installations	252	3.2[18]	15.1[19]
Non-domestic RHI installations	63	11.0[18]	140.6[19]
Sheffield ERF which supplies heat to the Sheffield District Energy Network	1	Up to 45MW available. Typical peak load is 40-42MW.	97.4[20]
Blackburn Meadows Biomass CHP which supplies heat to a district heating network in the Don Valley area	1	Up to 25MW available. Typical peak load is currently unknown	Currently unknown
Total	**317**	**54.2**	**253.1**

7.2 Electricity

7.2.1 Scope

This assessment focussed on the electricity generation in the Sheffield local authority area for electricity generated by all sources other than natural gas.

We have used publicly available information to estimate:

- Total number of installations
- Total installed capacity (MW)
- Total electricity exported from each site (GWh/year)
- Emissions associated with the electricity (tCO_2e/year)

We have not considered any gas-fired electricity generation or CHP plants. We understand that gas usage is considered elsewhere in the study.

7.2.2 Data sources

The data sources used for this analysis are summarised in the table below.

[18]This was calculated by multiplying the number of institutions by the average capacity and design SPF values for new and legacy installations
[19] This was calculated by applying the proportional representation of technologies in Sheffield to the heat generated and paid for in the UK
[20] Annual average based on total heat consumed during the period 2012-2019

Data Source	Description	Link
BEIS data on renewable electricity generation by local authority	Data covering number of installations, capacity, annual generation and emissions between 2014 and 2018 (latest available dataset)	Renewable electricity by local authority
UK Government GHG Conversion Factors 2019	GHG conversion factors for different fuel types	GHG Factors
Veolia Environmental Services	Annual performance report 2019	Annual Performance Report 2019
E.ON Blackburn Meadows – Renewable Energy Plant Design and Access Statement	A description of the processes used to determine the GHG factor for Blackburn Meadows	Design and Access Statement

7.2.3 Data summary

The table below summarises the installed capacity and electricity generation from sites in Sheffield.

Technology	No of installations	Capacity MW	Generation GWh/year	Emissions tCO_2e/year
Photovoltaics	5,451	22.1	20.8	0
Onshore Wind	9	0.1	0.1	0
Hydro	3	0.6	2.2	0
Sewage Gas	1	2.0	11.1	2.32
Landfill Gas	3	4.9	17.8	3.55
Municipal Solid Waste[21]	1	19.0	105.9[22]	4,335
Plant Biomass[23]	8	62.3	315.9	4,938
Total	**5,476**	**111.0**	**473.8**	**9,279**

There is no electricity generation recorded in Sheffield from anaerobic digestion, offshore wind, wave/tidal, animal biomass or cofiring.

[21] This is the Sheffield Energy Recovery Facility operated by Veolia Environmental Services
[22] From Veolia Annual Performance Report 2019
[23] This includes the Blackburn Meadows biomass-fuelled CHP plant

8 Summary and conclusions

This report provides the baseline data to help Sheffield City Council to work towards achieving zero carbon emissions. The report presents the results of the spatial disaggregation of the CO_2 emissions from the UK Greenhouse Gas Inventory (GHGI) along with the associated energy use data and the structural and activity data for each main sector as follows:

- Industrial and commercial
- Domestic
- Transport
- Agriculture, Waste and Land Use

Top level messages

- **90% of total GHG emissions are CO_2 hence the focus for further analysis should be on this pollutant;**
- **Methane is the dominant non-CO_2 GHG and is largely related to agriculture and waste disposal.**
- **Industry and commercial emissions (35%) and domestic emissions (33%) and the largest sectors and nearly entirely CO_2.**
- **Transport is the 3rd largest sector at 26% of emissions**
- **The remainder are from agricultural, waste and land-use, which form most of the non-CO2 GHG emissions.**
- **All sectors have seen declining emissions with the industrial and commercial sector reducing the most followed by the domestic sector. The transport sector has seen the lest reduction at only about 17% since 2005.**

8.1 Industrial and commercial sector

The industrial and commercial sector is the largest source of GHG emissions in the city at 35% of the total, of which nearly all are CO_2 emissions. Some of the key features of this sector are as follows:

- Energy consumption has dropped by some 33% since 2005, with the largest drop being in solid fuels and then gas.
- Overall energy Intensity has drop by between 40 and 65%, dependant on fuel this will reflect a range of factors from structural change with an increasing service sector, efficiency improvements and some fuel switching.
- Most of the CO_2 emissions related to commercial and light industrial activity, with only about 4% related to large industrial sources
- Overall some 85% of commercial and industrial premises are retail, offices and warehouses - so the focus on mitigation in this sector should be really on energy efficiency and low carbon energy sources for these types of premises, with industry being less significant and harder to change
- The largest industrial sources are the iron and steel sector followed by incineration.
- The geographical focus of the industrial and commercial emissions is the industrial area to the North East of the city along the Don Valley

8.2 Domestic sector

Domestic emissions are the second largest sector of emissions and are almost entirely CO_2 emissions. Key aspects of this sector are:

- Energy use dropped by 25% overall with a 30% reduction for gas, indicating both boiler and fabrics efficiency improvements) and a15% reduction for electricity indicating improvements in appliance efficiency.

- Energy intensity per capita matches the overall patter for energy use fuel use - so indicates all the reduction relates to efficiency rather than structural change.
- Geographically the emissions distribution mirrors that of industrial and commercial sector, with energy use being in the South West of the city (larger, detached housing).
- The EPC data shows a normal distribution around a D rating, so there is significant scope for improvement. A shift from D to B would reduce emissions by about 40%, and a shift to A by about 90%.
- As might expected older houses have worse EPC ratings, however, but even more modern properties built since 2000 have an average rating of C so can be improved.
- In terms of main heating source 81% are gas boilers, 10% are electric and 5% some form of district heating. This indicates a need for a major shift away from gas boilers to zero carbon heating sources.

8.3 Road transport sector

Transport is the 3rd largest sector but only just behind industrial commercial and domestic emissions at some 26% of the total. These emissions are nearly entirely related to road transport, with 84% related to car traffic, and are virtually all CO_2. The key features of this sector are:

- Total emissions dropped by about 17%, which is the smallest reduction of all sectors.
- There is been a significant growth in diesel cars and vans, while petrol cars declined, similar to elsewhere in the country.
- Also, HGVs emissions have remained relatively constant.
- Car mode share has remained around 60% for the last 15 years, but the bus share has declined 24% to 16%.

Overall decarbonising transport will be a significant challenge with a key focus being on mode shift to low carbon modes and generating a rapid uptake of zero emission vehicles.

8.4 Agriculture, waste and land use

The agricultural, waste and land-use sector is the smallest sector at some 6% of GHG emissions. This is also the only sector where methane dominates the GHG emissions (82%; 158 kt CO2e). The results from the Agricultural, waste and land use sector have indicated that CO_2 emissions have slightly decreased between 2005 and 2017 (7% decrease). The CO_2 emissions attributed to LULUCF, show an increasing net decrease (40%) with an average annual decrease of 2.9%. Continuing or enhancing this trend will help the net carbon emissions balance. The spatial analysis has shown that the hotspots of methane emissions are much higher in emissions than the 'colder' spots and are located near the eastern region of the Peak District National Park and near the motorway.

8.5 Energy generation and storage

There is a growing amount of locally generated renewable heat and electricity in the city. The current annual heat generation is some 253 GWh per year and electricity is higher at 474 GWh per year. Putting this in context the total gas demand in the city (assumed to be largely heat) is some 5,000 GWh, so the current local heat supply is about 7% of this. Total electric demand is some 2,212 GWh per local generation equates to about 21% of this so significantly higher than for heat.

9 References

Tsagatakis, I., Ruddy, M., Richardson, J., Otto, A., Pearson, B., & Passant, N. (2019). *UK Emission Mapping Methodology*. Retrieved from National Atmospheric Emissions Inventory: https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1910040848_Mapping_Methodology_for_NAEI_2017_v1.pdf

Appendices

This last chapter of the report contains additional information that supplements the main chapters. It consists of the detailed emissions (tonnes of CO_2) from the Large Industrial Installations in 2017 and the maps at MSOA level – where these have been derived from gridded data (1x1km^2 grids).

A1 LA CO_2 emissions from other major cities

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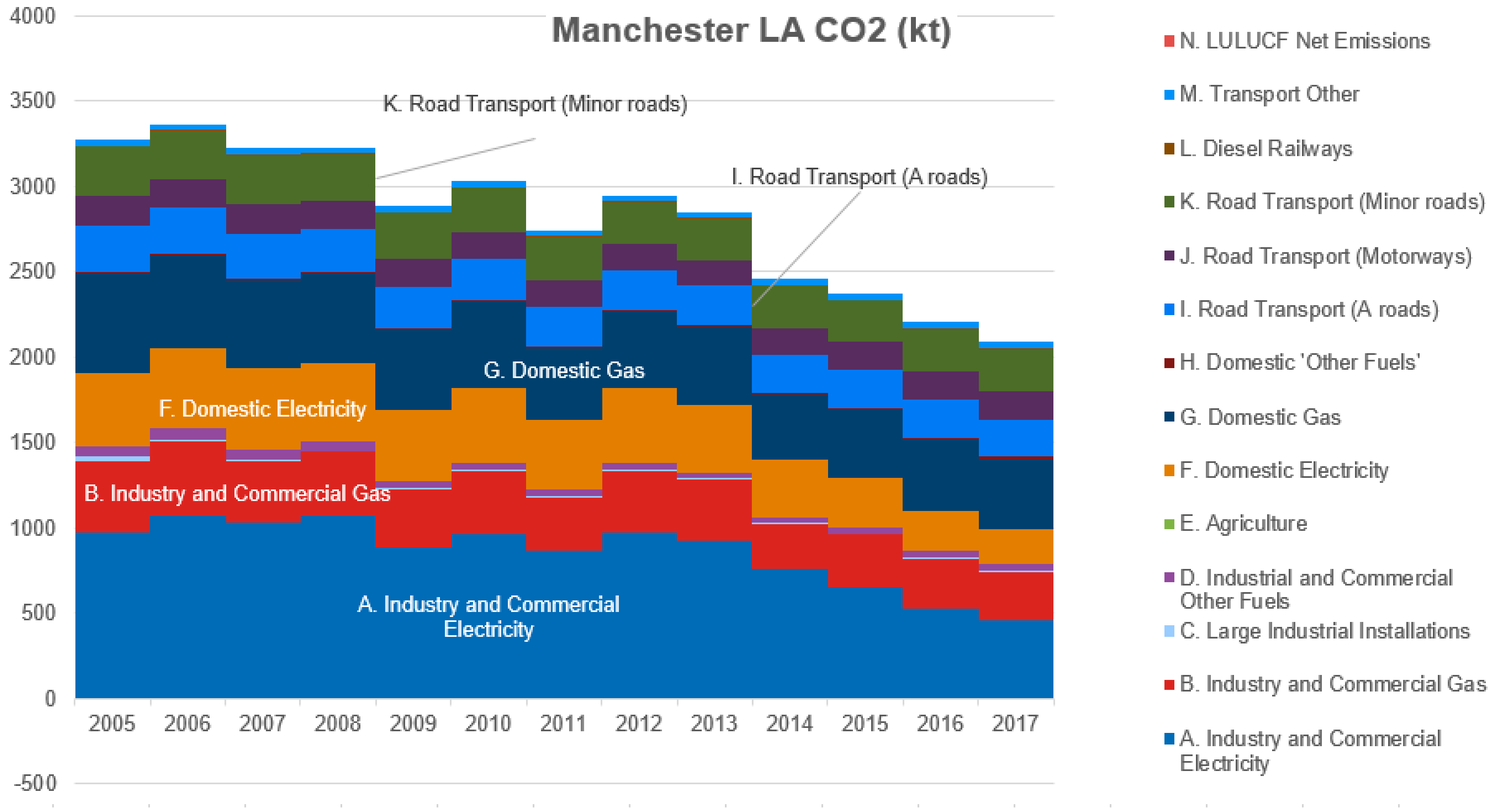
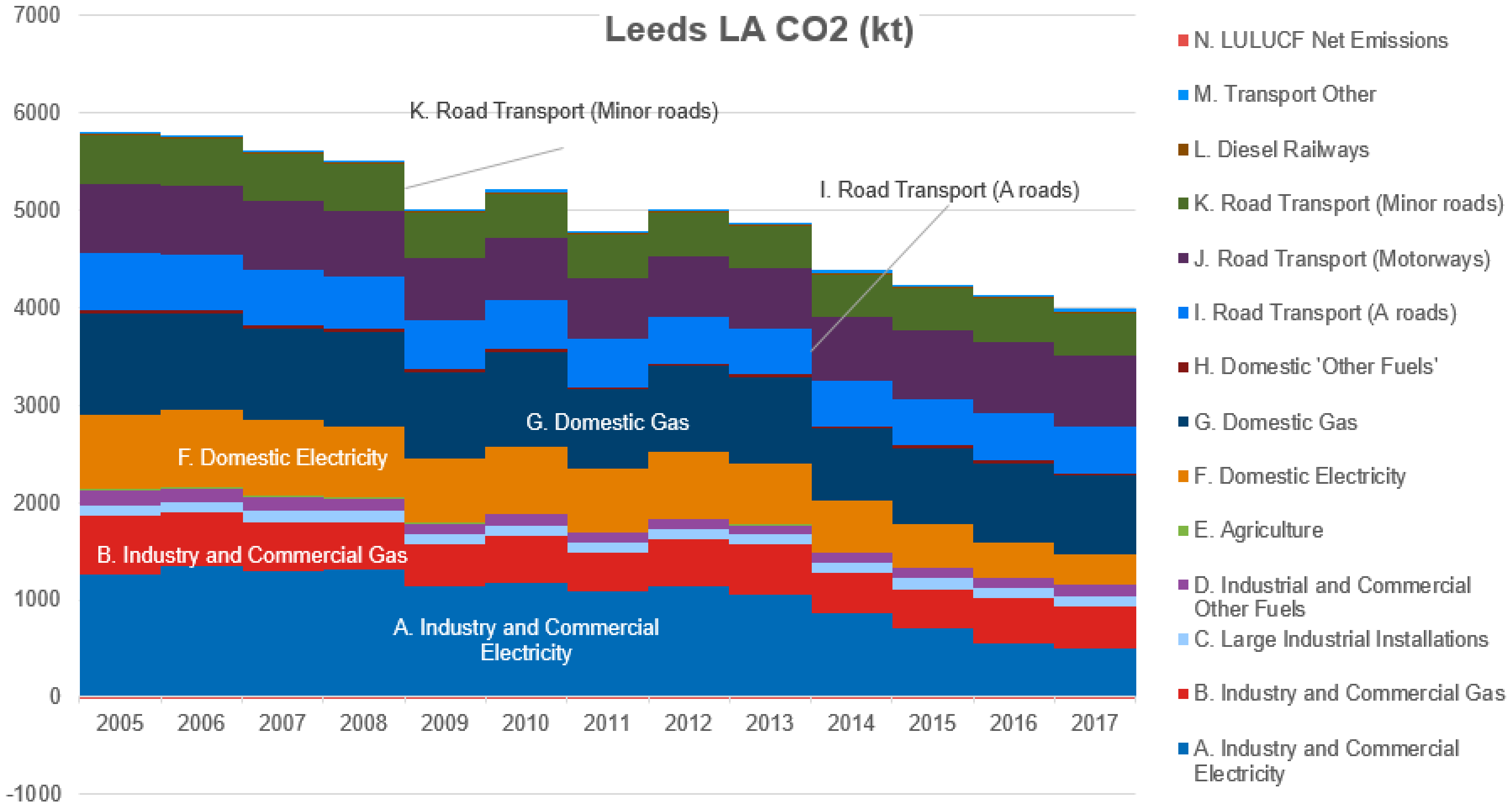
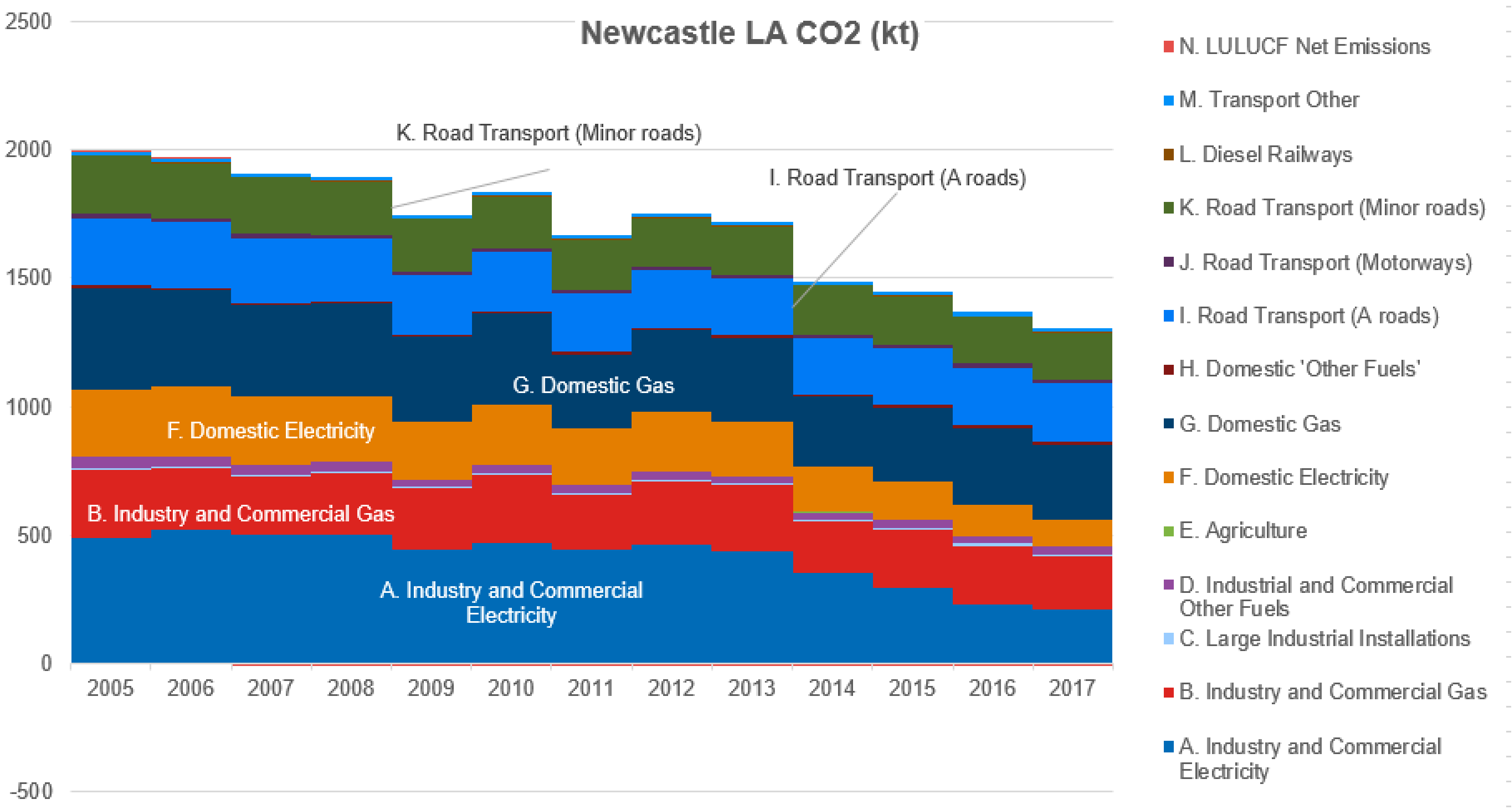
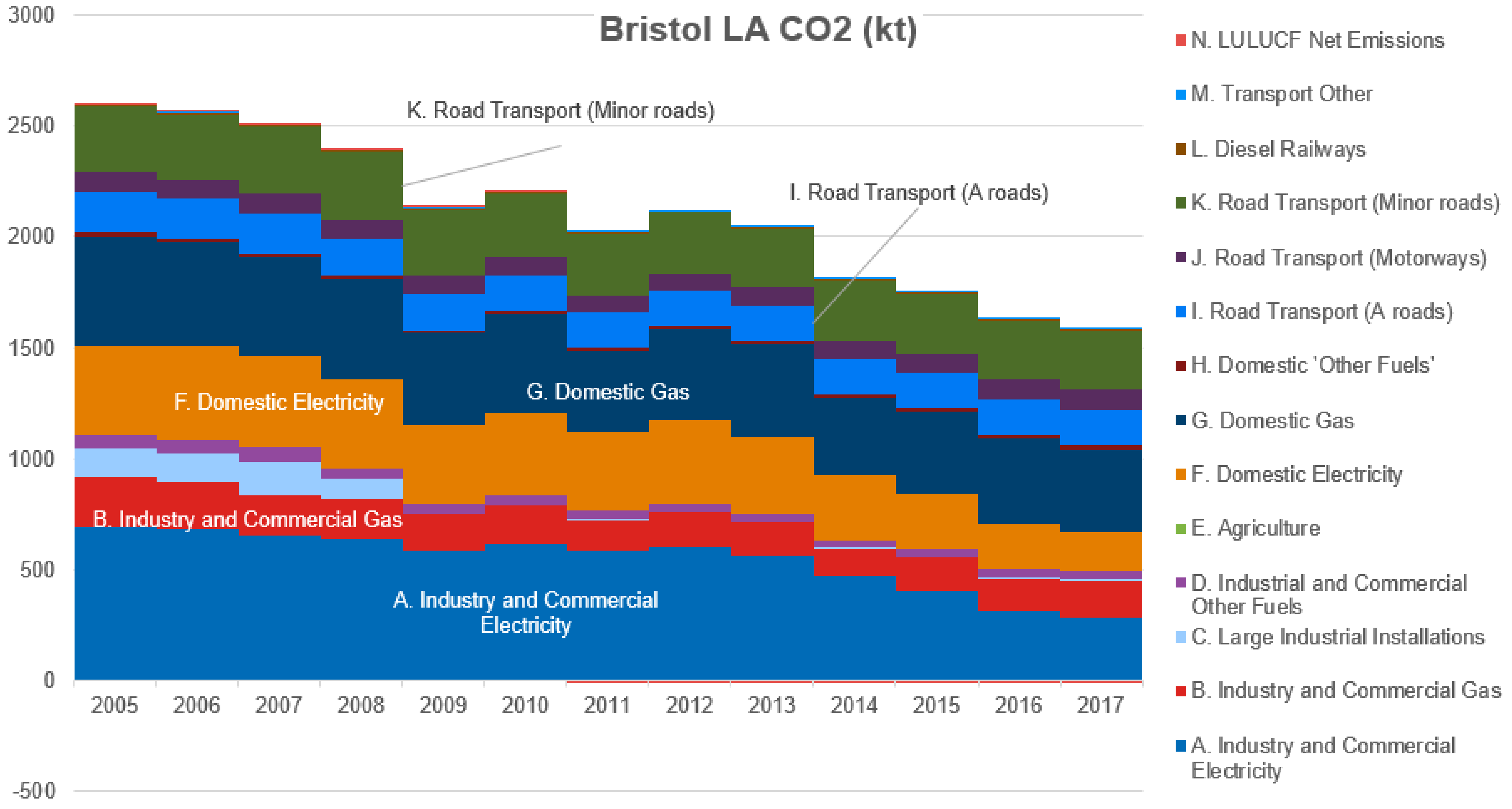



Leeds LA CO2 (kt)
7000
6000
5000
4000
3000
2000
1000
0
-1000
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
K. Road Transport (Minor roads)
I. Road Transport (A roads)
G. Domestic Gas
F. Domestic Electricity
B. Industry and Commercial Gas
A. Industry and Commercial Electricity
N. LULUCF Net Emissions
M. Transport Other
L. Diesel Railways
K. Road Transport (Minor roads)
J. Road Transport (Motorways)
I. Road Transport (A roads)
H. Domestic 'Other Fuels'
G. Domestic Gas
F. Domestic Electricity
E. Agriculture
D. Industrial and Commercial Other Fuels
C. Large Industrial Installations
B. Industry and Commercial Gas
A. Industry and Commercial Electricity


Newcastle LA CO2 (kt)
2500
2000
1500
1000
500
0
-500
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
K. Road Transport (Minor roads)
I. Road Transport (A roads)
G. Domestic Gas
F. Domestic Electricity
B. Industry and Commercial Gas
A. Industry and Commercial Electricity
N. LULUCF Net Emissions
M. Transport Other
L. Diesel Railways
K. Road Transport (Minor roads)
J. Road Transport (Motorways)
I. Road Transport (A roads)
H. Domestic 'Other Fuels'
G. Domestic Gas
F. Domestic Electricity
E. Agriculture
D. Industrial and Commercial Other Fuels
C. Large Industrial Installations
B. Industry and Commercial Gas
A. Industry and Commercial Electricity


Bristol LA CO2 (kt)
3000
2500
2000
1500
1000
500
0
-500
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
K. Road Transport (Minor roads)
I. Road Transport (A roads)
F. Domestic Electricity
G. Domestic Gas
B. Industry and Commercial Gas
A. Industry and Commercial Electricity
N. LULUCF Net Emissions
M. Transport Other
L. Diesel Railways
K. Road Transport (Minor roads)
J. Road Transport (Motorways)
I. Road Transport (A roads)
H. Domestic 'Other Fuels'
G. Domestic Gas
F. Domestic Electricity
E. Agriculture
D. Industrial and Commercial Other Fuels
C. Large Industrial Installations
B. Industry and Commercial Gas
A. Industry and Commercial Electricity

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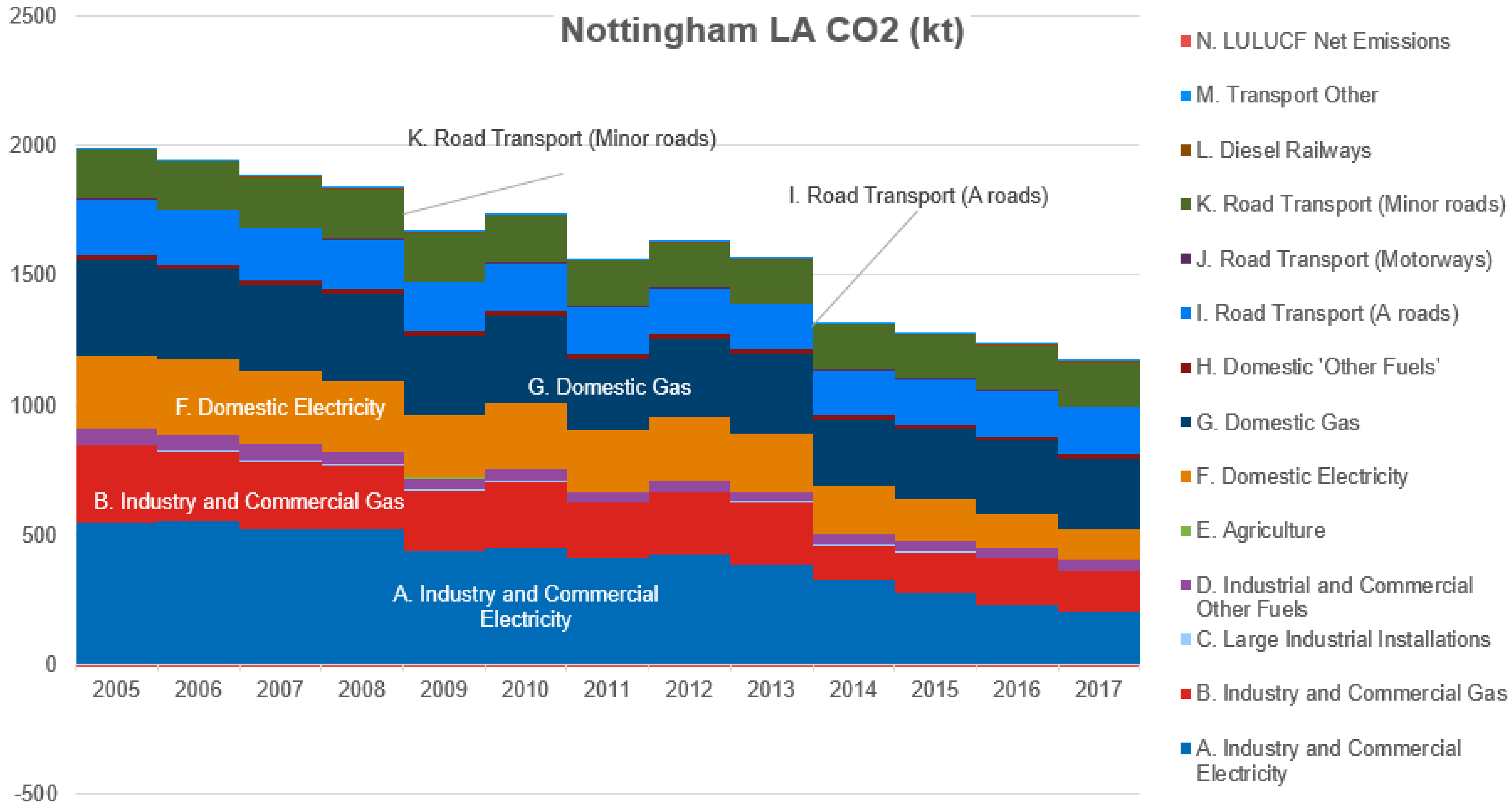
Nottingham LA CO2 (kt)
2500
2000
1500
1000
500
0
-500
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
K. Road Transport (Minor roads)
I. Road Transport (A roads)
G. Domestic Gas
F. Domestic Electricity
B. Industry and Commercial Gas
A. Industry and Commercial Electricity
N. LULUCF Net Emissions
M. Transport Other
L. Diesel Railways
K. Road Transport (Minor roads)
J. Road Transport (Motorways)
I. Road Transport (A roads)
H. Domestic 'Other Fuels'
G. Domestic Gas
F. Domestic Electricity
E. Agriculture
D. Industrial and Commercial Other Fuels
C. Large Industrial Installations
B. Industry and Commercial Gas
A. Industry and Commercial Electricity

A2 Detailed Large Industrial Installations' CO_2 emissions in 2017

PlantID	Operator	Kt CO_2	OS_GRE	OS_GRN
4384	Georgia Pacific GB Ltd		430200	394050
4390	Outokumpu Stainless Ltd		439500	389800
4408	Sheffield Forgemasters Engineering Ltd		437960	388810
8147	Cadbury Trebor Bassett		433900	390100
8420	Sheffield Forgemasters Engineering Ltd	1.916124	438200	390100
8610	Corus UK Ltd		427000	398700
8714	Outokumpu Stainless Ltd	26.15547	440400	389180
8762	Sheffield Teaching Hospitals NHS Trust	0.035166	436500	390300
8763	Sheffield Teaching Hospitals NHS Trust	0.193482	433800	386900
9627	Veolia ES Sheffield Ltd	0.103752	434820	387420
9628	Veolia ES Sheffield Ltd	0.006292	436770	387900
11963	Cadbury UK Ltd		433855	389434
13070	Kraft Foods UK Ltd	0.000622	433900	390100
13691	ATI Allvac Ltd		436800	388600
13699	Sheffield Forgemasters Engineering Ltd	0.03671	438634	389821
13708	Polestar UK Print Ltd		439900	389700
13756	Tata Steel UK Ltd		427246	398529
14199	Eon Climate and Renewables UK Biomass Ltd	0.710239	439551	391549
8610	Corus UK Ltd		427000	398700
13756	Tata Steel UK Ltd		427246	398529
763	Corus UK Ltd		427240	398510

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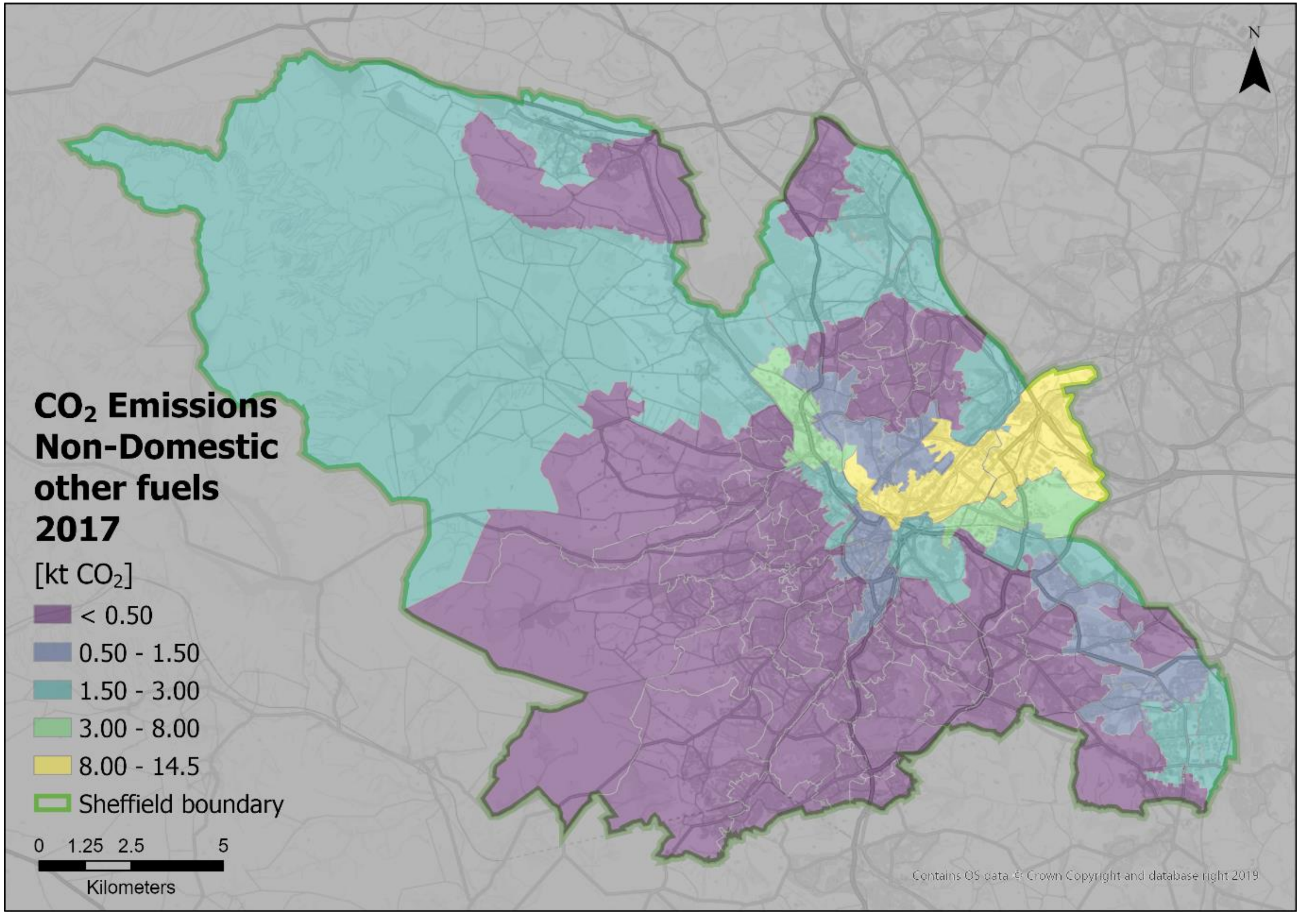
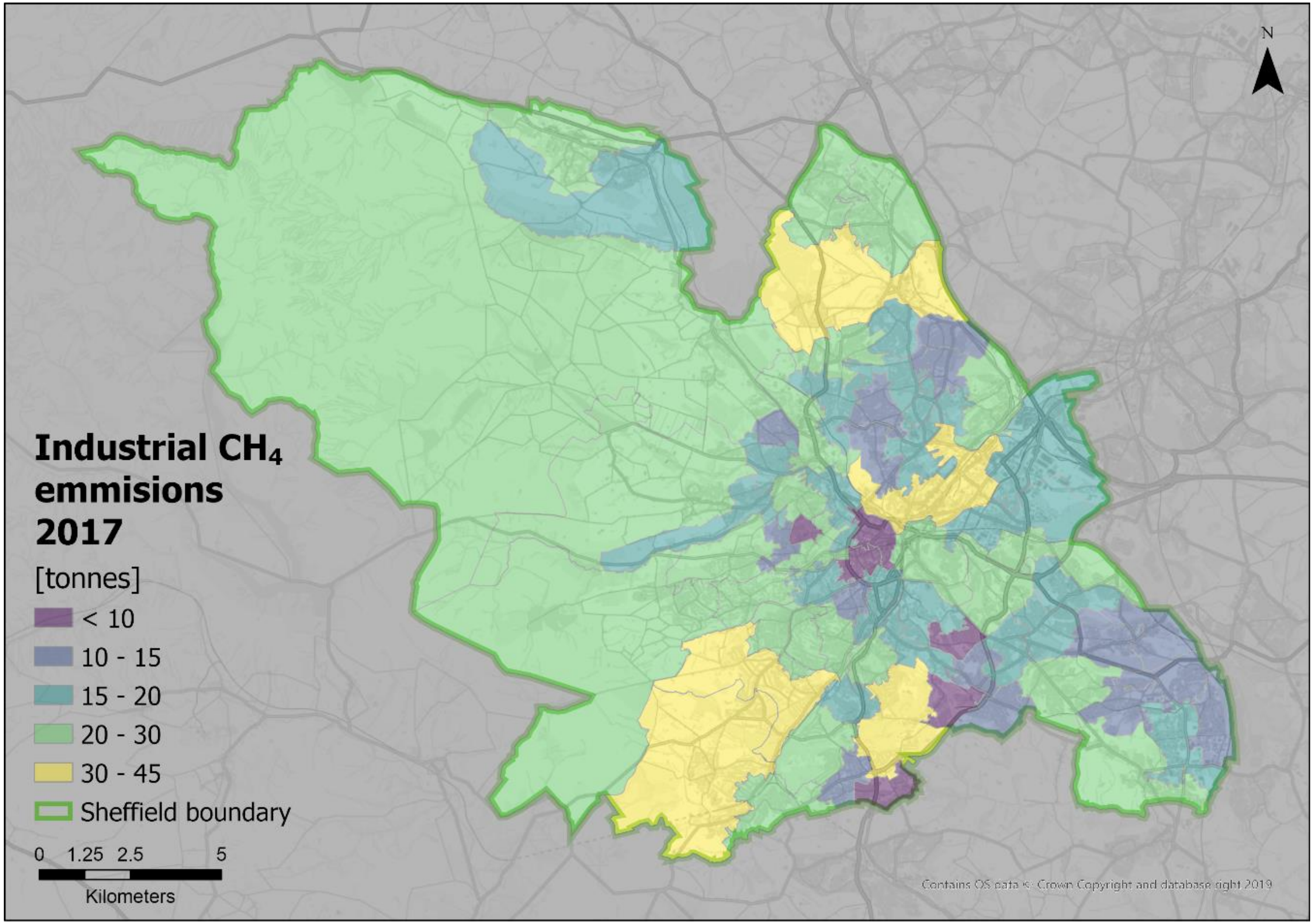
A3 Industrial and commercial – MSOA maps

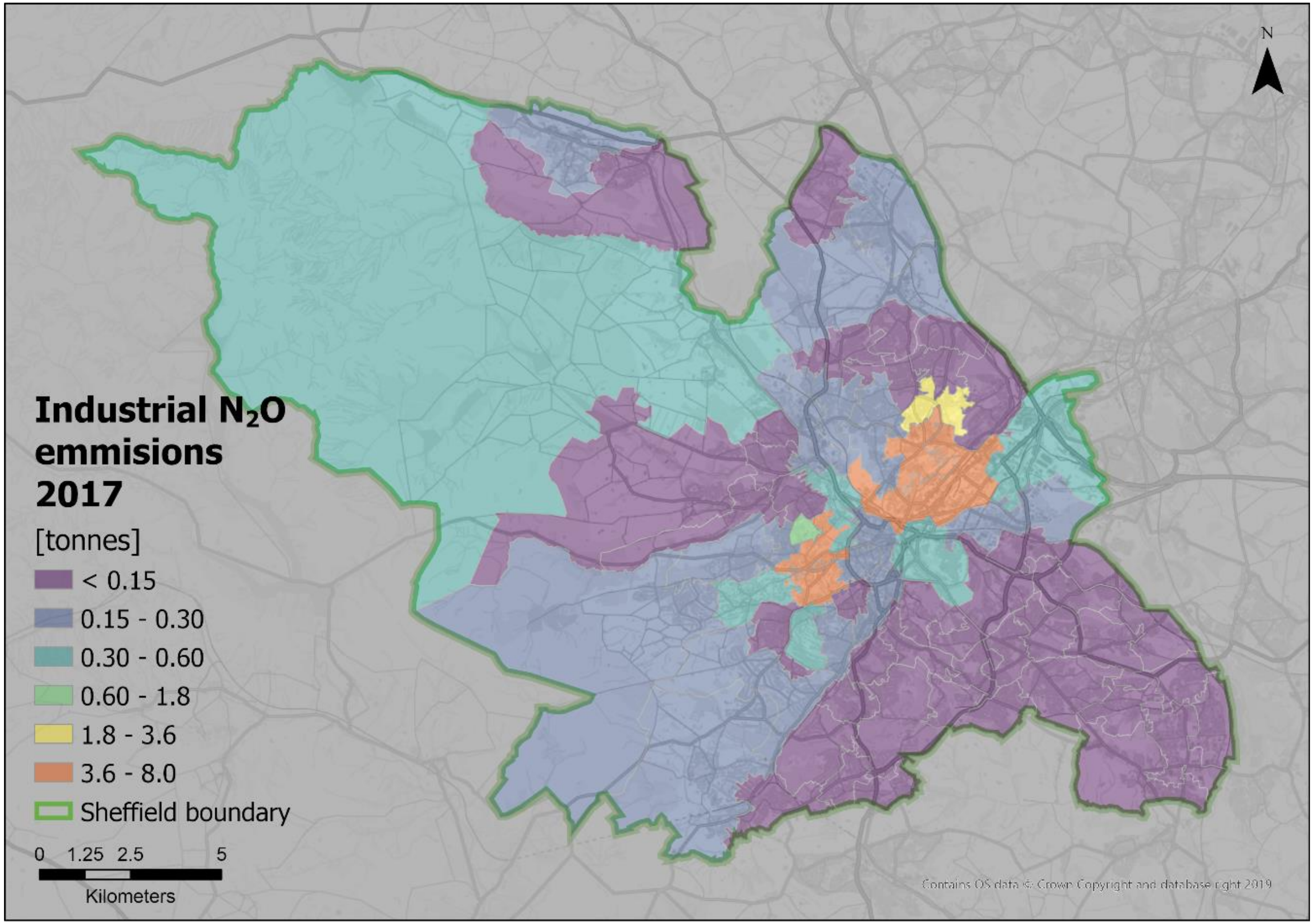
A3.1 CO_2 emissions from industrial and commercial 'other fuels' in Sheffield at MSOA level



A3.2 Methane emissions from industrial and commercial at MSOA level in Sheffield.

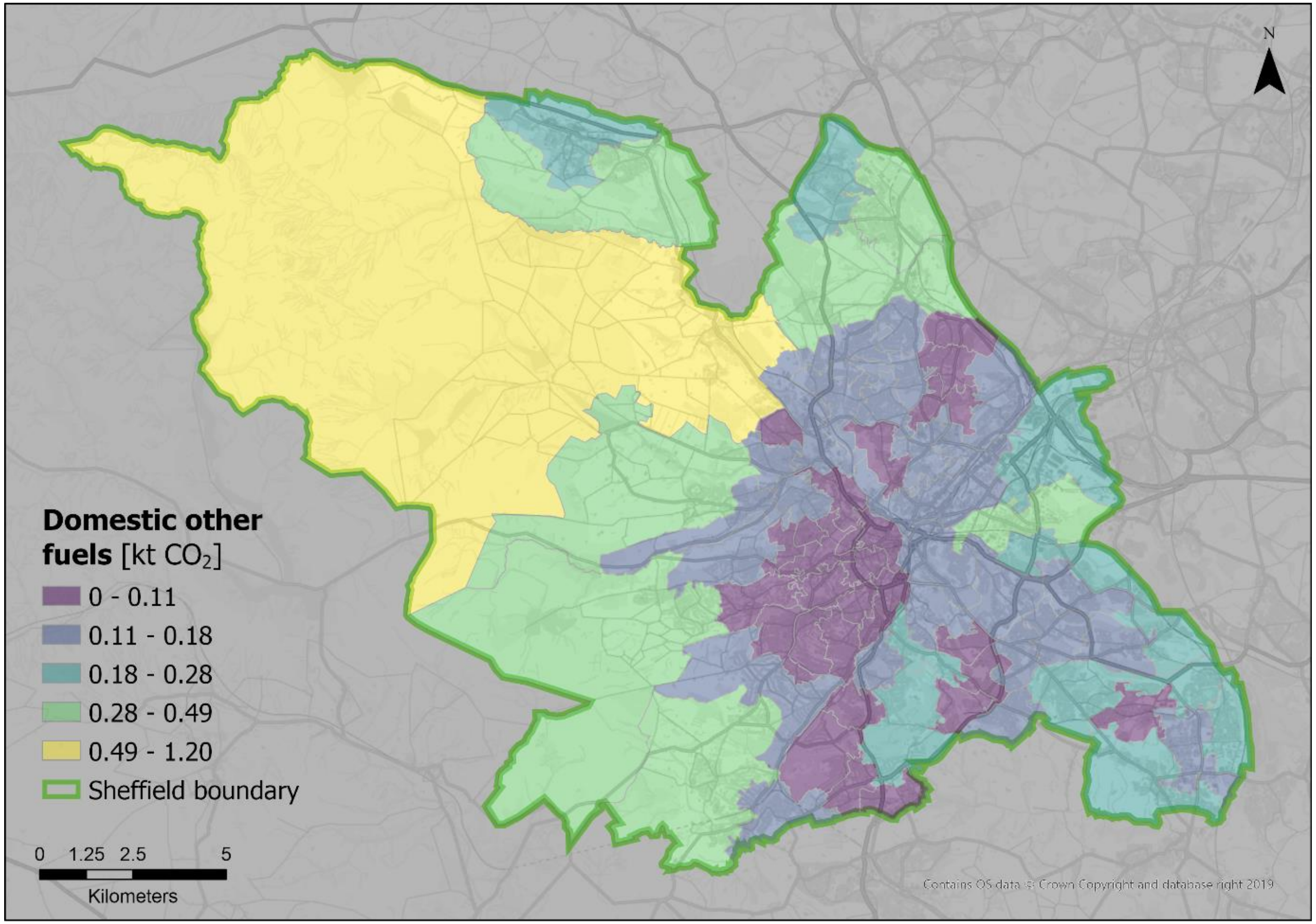


A3.3 Nitrous oxide emissions from industrial and commercial at MSOA level in Sheffield.

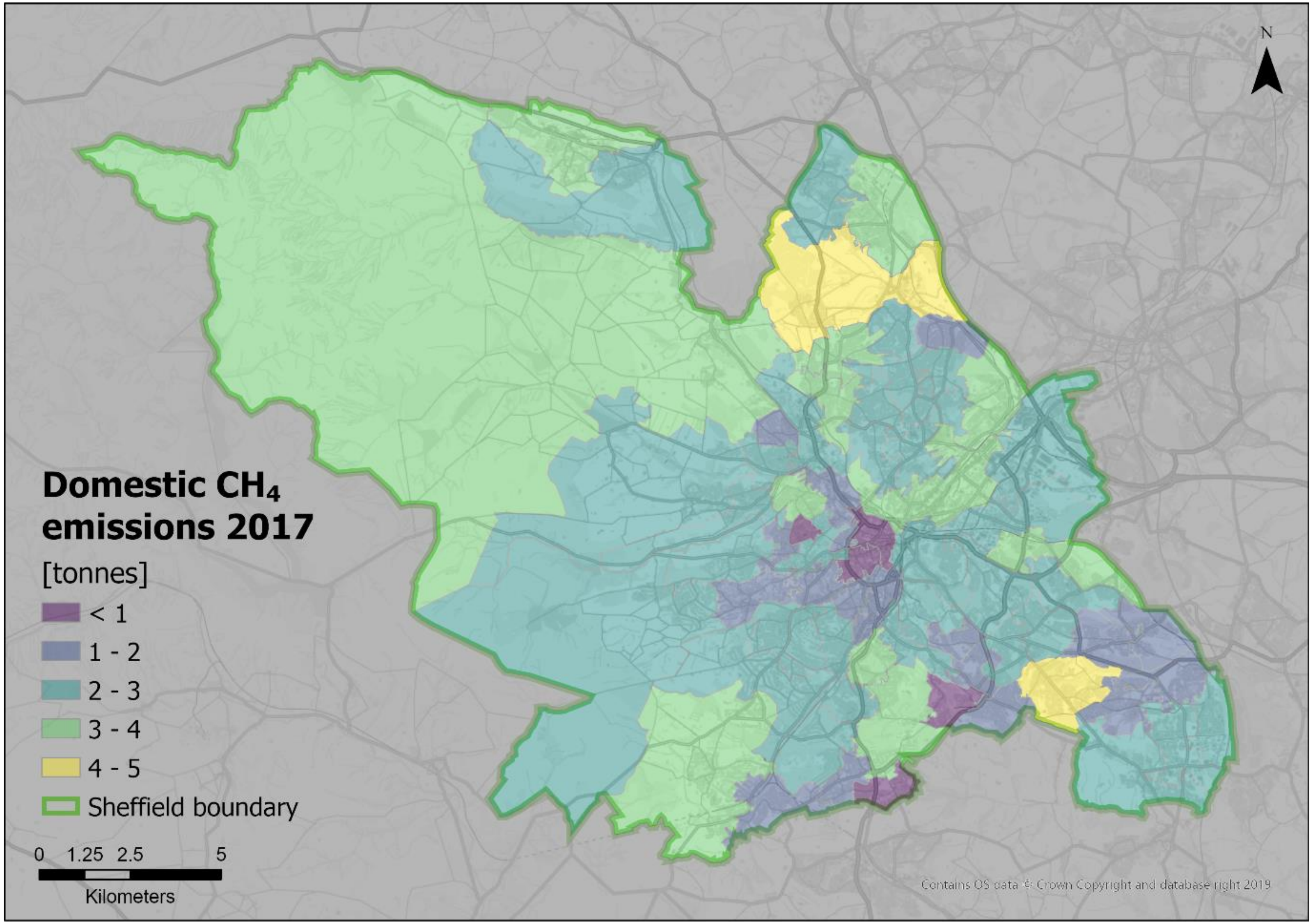


A4 Domestic emissions – MSOA maps

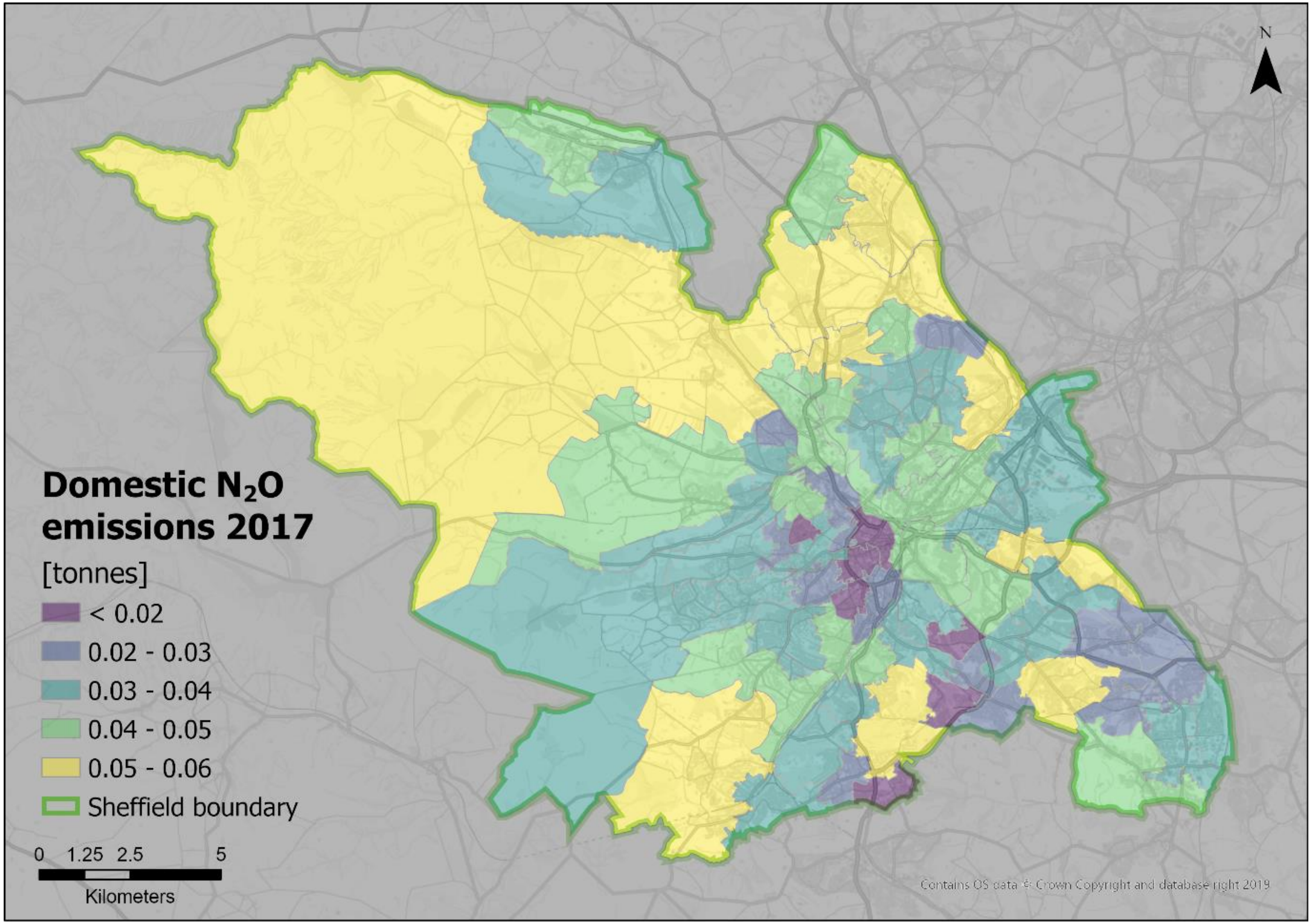
A4.1 CO_2 emissions from domestic ‘other fuels’ at MSOA level in Sheffield



A4.2 Methane emissions from residential at MSOA level in Sheffield



A4.3 Nitrous oxide emissions from residential at MSOA level in Sheffield



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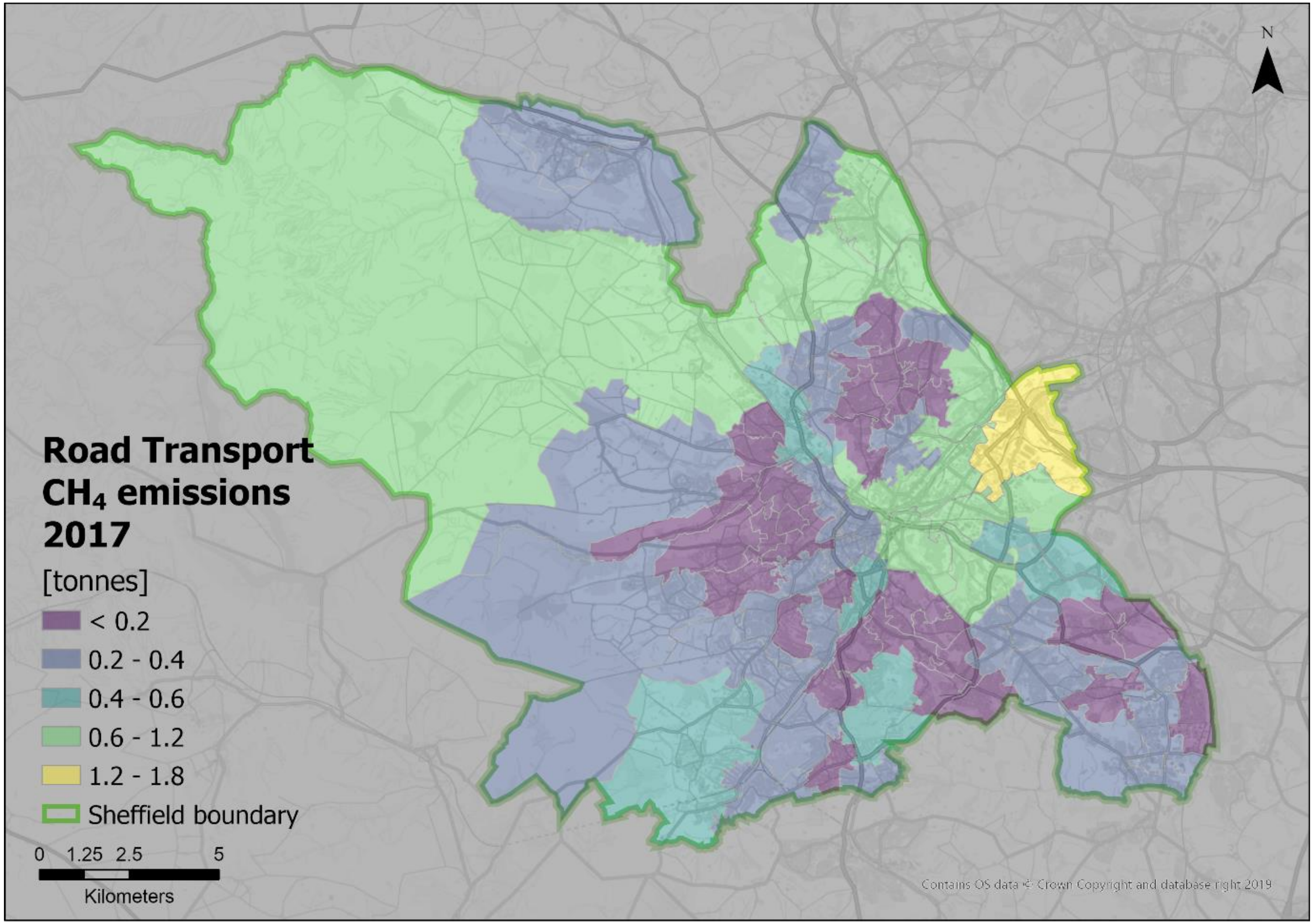
A5 Road transport emissions – MSOA maps

A5.1 Methane emissions from transport at MSOA level in Sheffield



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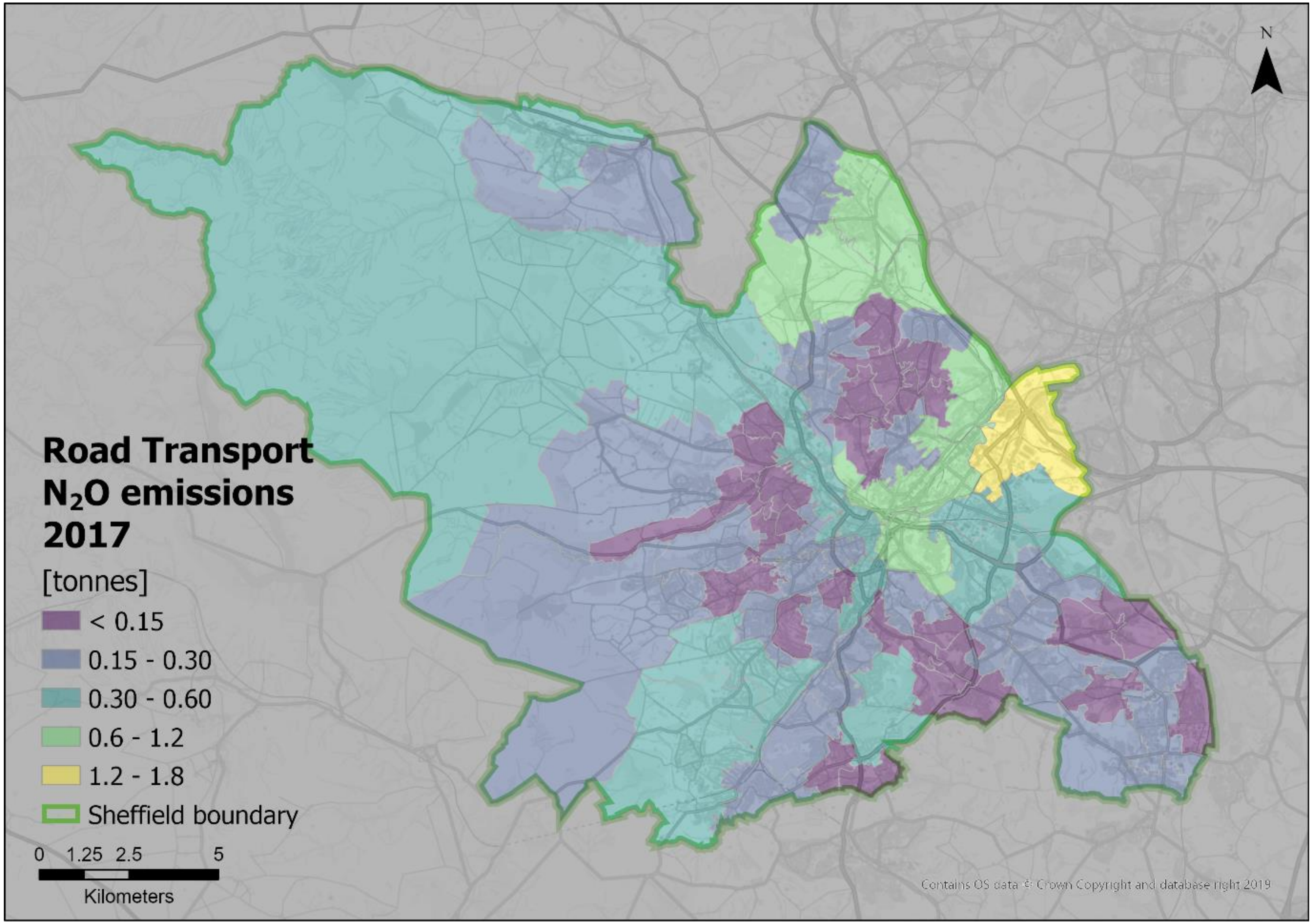
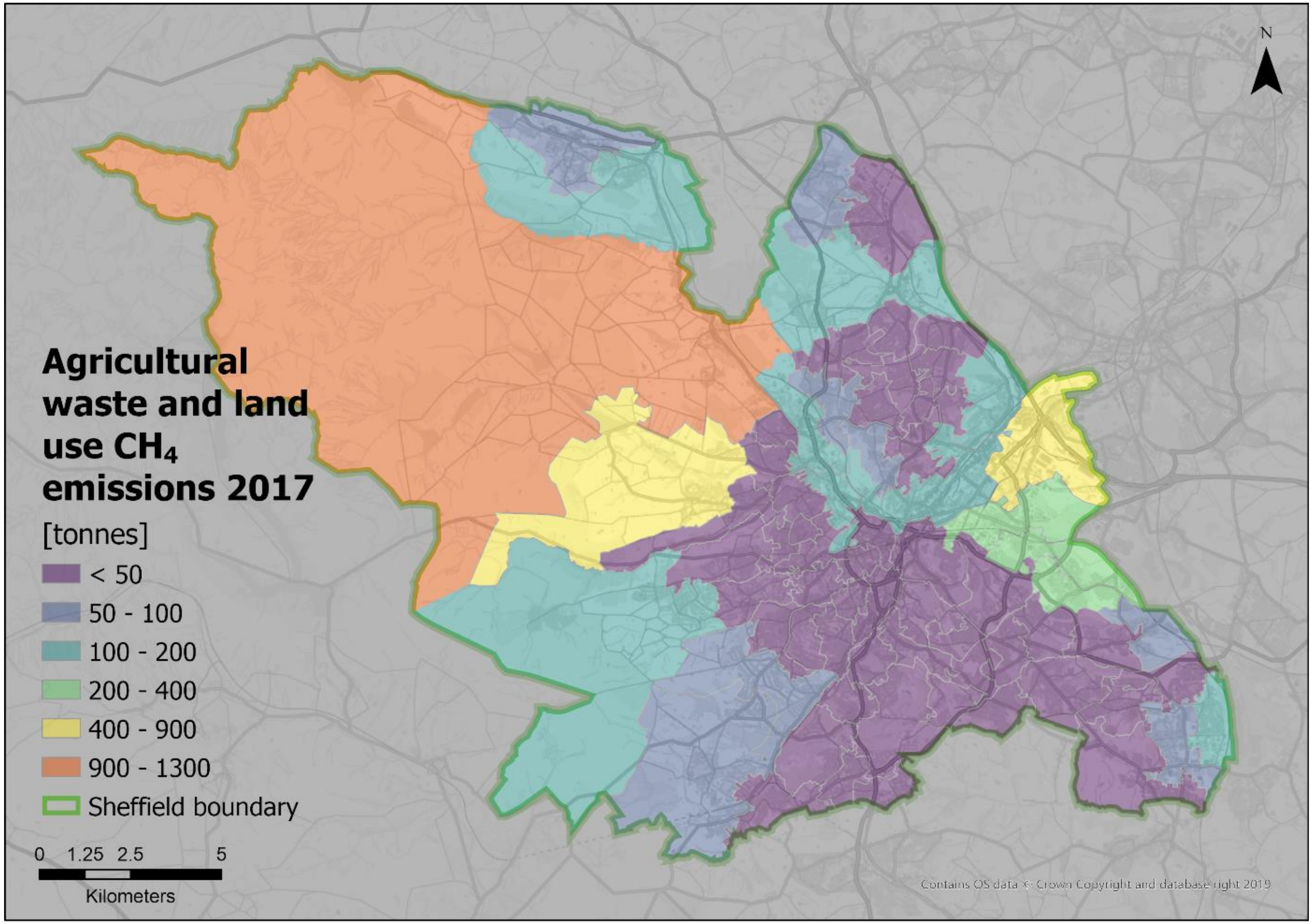
A5.2 Nitrous oxide emissions from transport at MSOA level in Sheffield

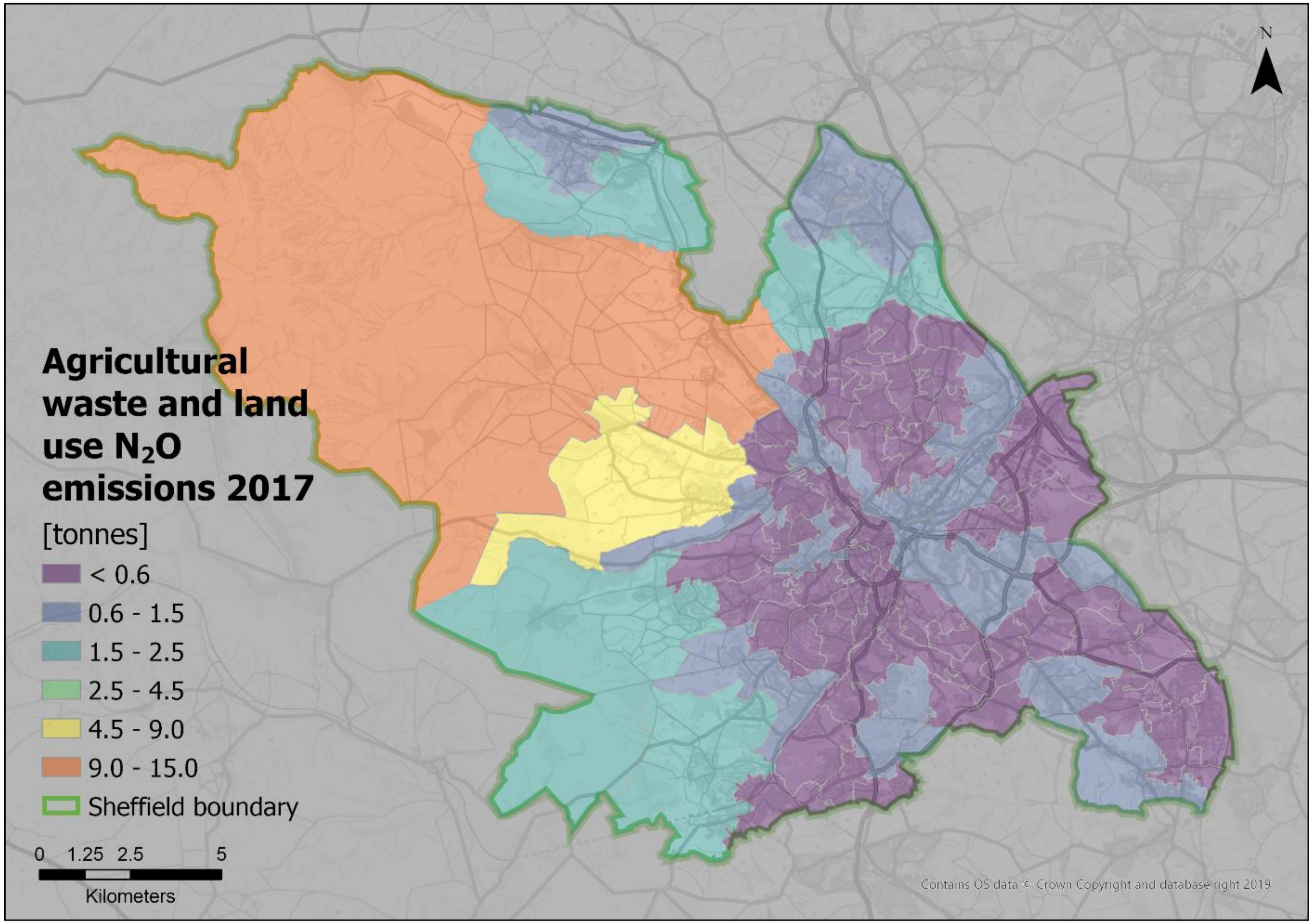


A6 Agriculture, waste and land use emissions – MSOA maps

A6.1 Methane emissions from Agriculture, waste and land use emissions at MSOA level in Sheffield



A6.2 Nitrous oxide emissions from Agriculture, waste and land use emissions at MSOA level in Sheffield



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