






Carbon footprint methodologies & estimation for the pilot cities (WP5 Task 5.2.8)

Work realized under the project CLAiR-CITY - Citizen Led Air pollution Reduction in Cities

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1 FINALITY OF THE REPORT

1.1 Objectives and expected results

This document reports about the WP5 Task 5.2.8 Carbon footprint methodologies & estimation for the pilot cities.

The goal of the task is to integrate in the overall model a specific module to compute the carbon footprint of the cities and in particular its scope is to:

- Review existing carbon footprinting methodologies
- Establish best methodology and relevant emission factors.
- Apply footprinting methodologies to six pilot cities based on activity data from previous tasks

2 SPECIFICATIONS OF MODELLING TOOL SET

2.1 Review of existing carbon footprint methodologies

First of all, a complete review of existing carbon footprint methodologies was completed. Carbon footprint calculation methodologies usually follow the "emission inventory" or the "consumption-based" approaches. The review covered as the "emission inventory" approaches (such as WRI protocol for example¹) than input-output models approaches.

The "emission inventory" approaches usually include generating GHG emissions activities that occur inside the city/region boundary as well as outside the city/region boundary. To distinguish between these, the approaches group emissions into three categories based on where they occur: scope 1, scope 2 or scope 3 emissions. These approaches distinguish between emissions that physically occur within the city/region i.e. from sources located within the city boundary (scope 1), from those that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross city/region boundaries (scope 2), from those that occur outside the city/region but are driven by activities taking place within the city's/region's boundaries (scope 3). Scope 1 emissions may also be termed "territorial" emissions, because they are produced solely within the territory defined by the geographic boundary.

Cities, by virtue of their size and connectivity, inevitably give rise to GHG emissions beyond their boundaries. Measuring these emissions allows cities to take a more holistic approach to tackling climate change by assessing the GHG impact of their supply chains, and identifying areas of shared responsibility for upstream and downstream GHG emissions.

The usual methodologies for city (such as WRI Protocol) includes scope 3 accounting for a limited number of emission sources, including transmission and distribution losses associated with grid-supplied energy, and waste disposal and treatment outside the city boundary and transboundary transportation.

Cities may optionally report Other Scope 3 sources associated with activity in a city-such as GHG emissions embodied in fuels, water, food and construction materials.

Consumption-based accounting is an alternative to the sector-based approach to measuring city/region emissions. This focuses on the consumption of all goods and services by residents of a city/region, and use EFs expressed as emissions for unit of good and services including all the processes (production, transport, disposal).

GHG emissions are reported by consumption category rather than the emission source categories. The consumption-based approach allocates GHG emissions to the final consumers of goods and services, rather than to the original producers of those GHG emissions. Consumption-based inventories typically use an input-output model, which links household consumption patterns and trade flows to energy use and GHG emissions, and their categories cut across those set out in the GPC. This approach is complementary to the GPC and provides a different insight into a city's/region's GHG emissions profile. At conclusion of review work

¹ WRI(2014), Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. An Accounting and Reporting Standard for Cities

a best methodology has been established defining the selected approach and the activities included in scope 3 to take into consideration.

2.2 Clair city approach to carbon footprint

Clair city approach is to evaluate in an integrated way emissions inventory and carbon footprint. Future scenarios are produced for simultaneous reduction of air pollutants emission and carbon footprint.

Considering the general goals of the activities and to delimitate the efforts from other partners in data retrieval, we select scope 2 approach considering emissions that:

- physically occur within the city/region i.e. from sources located within the city boundary;
- occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross city/region boundaries.

As the project is finalized to produce strategies for the cities the carbon footprint evaluation will be conducted following an emission inventory approach similar to the approach followed in the Covenant of Mayors² and using both:

- “Standard” emission factors (emissions will be evaluated using methodologies and emission factors from 2006 IPCC Guidelines for National Greenhouse Gas Inventories³ and specific activity level); the methodology cover all the CO₂ emissions that occur due to energy consumption within the territory of the city/region, either directly due to fuel combustion within the city/region or indirectly via fuel combustion associated with electricity and heat/cold usage within their area; the standard emission factors are based on the carbon content of each fuel, like in national greenhouse gas inventories in the context of the UNFCCC and the Kyoto protocol; in the standard approach, the CO₂ emissions from the sustainable use of biomass/biofuels, as well as emissions of certified green electricity, are considered to be zero; emission are reported as:
 - CO₂ only emissions, the most important greenhouse gas,
 - CO₂ equivalent emissions, including calculation of the emissions of CH₄ and N₂O with emission factor from 2006 IPCC Guidelines for National Greenhouse Gas Inventories⁴ and reported as CO₂ using the Global Warming Potential (GWP) with 100 years, time horizon⁵:
$$1 \text{ Mg CO}_2 = 1 \text{ Mg CO}_2\text{-eq}$$
$$1 \text{ t CH}_4 = 21 \text{ Mg CO}_2\text{-eq}$$
$$1 \text{ t N}_2\text{O} = 310 \text{ Mg CO}_2\text{-eq};$$
- LCA (Life Cycle Assessment) emission factors, which take into consideration the overall life cycle of the energy carrier; this approach includes not only the emissions of the final combustion, but also all emissions of the supply chain; it includes

² [Covenant of Mayors \(2010\), How to develop a Sustainable Energy Action Plan \(SEAP\) – Guidebook Part II, Baseline emissions inventory](#)

³ [2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy](#)

⁴ [2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy](#)

⁵ [IPCC, 1995. Contribution of Working Group I to the Second Assessment of the Intergovernmental Panel on Climate Change](#)

emissions from exploitation, transport and processing (e.g. refinery) steps in addition to the final combustion; this hence includes also emissions that take place outside the location where the fuel is used; in this approach, the GHG emissions from the use of biomass/biofuels, as well as emissions of certified green electricity, are higher than zero; in the case of this approach, other greenhouse gases than CO₂ may play an important role, therefore the LCA approach will report emissions as CO₂ equivalent; as a default will be used the LCA emission factors given in Covenant of Mayors guidelines, based on JRC European Reference Life Cycle Database; specific national emission factors will be investigated.

Eventual local electricity production is not included in the model while district heating is included where data are available.

2.3 Carbon footprint modeling

The Carbon Footprint tool:

- evaluates emissions at most detailed administrative territorial units level;
- uses emission factors from Covenant of Mayors guidelines;
- calculates emissions as:

$$E_k = A_{ij} F_{ik}$$

where:

- A_{ij} is the indicator of the activity i in the territorial unit j
- F_{ik} is the emission factor for different Carbon footprint indicators k for activity i (expressed in grams per unit of activity);
- k is the carbon footprint indicator used: CO₂, CO_{2eq}, CO_{2eq,LCA}

2.4 Emission factors

In Table 1 standard emission factors are reported for different energy vectors while in Table 2 electricity consumptions national emission factors are reported to use for CO₂ indirect emissions from electricity consumptions. EFs from JRC⁹ are used to have a comparable set of data for all the cities.

Table 1 – CO₂ Emission Factors

Fuel	Standard Emission Factors ⁶ [Mg CO ₂ /MWh]	Standard Emission Factors ⁷ [Mg CO _{2eq} /MWh]	LCA Emission Factors ⁸ [Mg CO ₂ -eq/MWh]
Motor Gasoline	0.249	0.250	0.299
Gas oil, diesel	0.267	0.268	0.305
Residual Fuel Oil	0.279	0.279	0.310
Anthracite	0.354	0.356	0.393
Other Bituminous Coal	0.341	0.342	0.380

⁶ [2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy](#)

⁷ [2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy](#)

⁸ ELCD (2015), [European Reference Life Cycle Database \(ELCD\), Release 3.2. LCA data sets of key energy carriers, materials, waste and transport services of European scope](#)

Sub-Bituminous Coal	0.346	0.348	0.385
Lignite	0.364	0.365	0.375
Natural Gas	0.202	0.202	0.237
LPG	0.227	0.227	0.281
Municipal Wastes (non-biomass fraction)	0.330	0.337	0.330
Municipal Wastes (biomass fraction)	0	0.007	0.106
Industrial Wastes	0.515	0.522	0.522
Wood ^o	0 – 0.403	0.007 – 0.410	0.017 – 0.416
Plant oil ^o	0 – 0.287	0.001 – 0.302	0.182 – 0.484
Biodiesel ^o	0 – 0.255	0.001 – 0.256	0.156 – 0.411
Biogas/Greengas ^{oo}	0-0.197	0-0.197	0,087-0.284
Solar ^{ooo}	0	0	0.04
Geothermal ^{ooo}	0	0	0,05
Hydroelectric ^{ooo}	0	0	0,006
Wind ^{ooo}	0	0	0,01

^o Lower value if fuel meet carbon neutrality criteria, higher otherwise

^{oo} Default EC/JRC Emission factors⁹

^{ooo} Default EC/JRC Emission factors for local electricity production⁹

Table 2 – CO₂ National Electricity Emission Factors

Fuel	Standard Emission Factors [Mg CO ₂ /MWh]	Standard Emission Factors [Mg CO ₂ eq/MWh]	LCA Emission Factors [Mg CO ₂ -eq/MWh]
Bristol (UK)	0,515	0,517	0,589
Amsterdam (NL)	0,429	0,430	0,486
Ljubljana (SL)	0,399	0,401	0,424
Sosnowiec (PL)	1,013	1,017	1,09
Genoa (IT)	0,343	0,344	0,424
Aveiro (PT)	0,314	0,316	0,368
Bristol (UK)	0,515	0,517	0,589

2.5 Territorial domains and subdomains

The Carbon footprint is evaluated in the city domains defined in Table 3. Inside the city domains a lower level subdivision has been introduced as reported in Table 3.

Table 3 – Territorial domains

City/region partner	Territory selected	Lower level subdivision
Bristol	MSOA	LSOA
Amsterdam	Geemente	Buurt
Genoa	Comune	Census Sections
Aveiro		Freguesia
Ljubljana	Obcine	Naselje
Sosnowiec	Gminas	Gminas

For Bristol the carbon footprint evaluation is on LSOA belonging *City of Bristol* MSOA

⁹ [Koffi, Brigitte; Cerutti, Alessandro; Duerr, Marlene; Iancu, Andreea; Kona, Albana; Janssens-Maenhout, Greet \(2017\): CoM Default Emission Factors for the Member States of the European Union - Version 2017, European Commission, Joint Research Centre \(JRC\)](#)

(Figure 1), for Amsterdam the carbon footprint evaluation is on Buurt belonging *Amsterdam* Geemete (Figure 2), for Ljubljana the carbon footprint evaluation is on Naselje belonging *Ljubljana* Obcine (Figure 3), for Sosnowiec the carbon footprint evaluation is on *Sosnowiec* Gmina (Figure 4), for regione Liguria (Genoa comune) the carbon footprint evaluation is on Census Sections belonging *Genoa* commune (Figure 5), finally, for the carbon footprint evaluation is on Freguesia belonging *Aveiro* (Figure 6) .

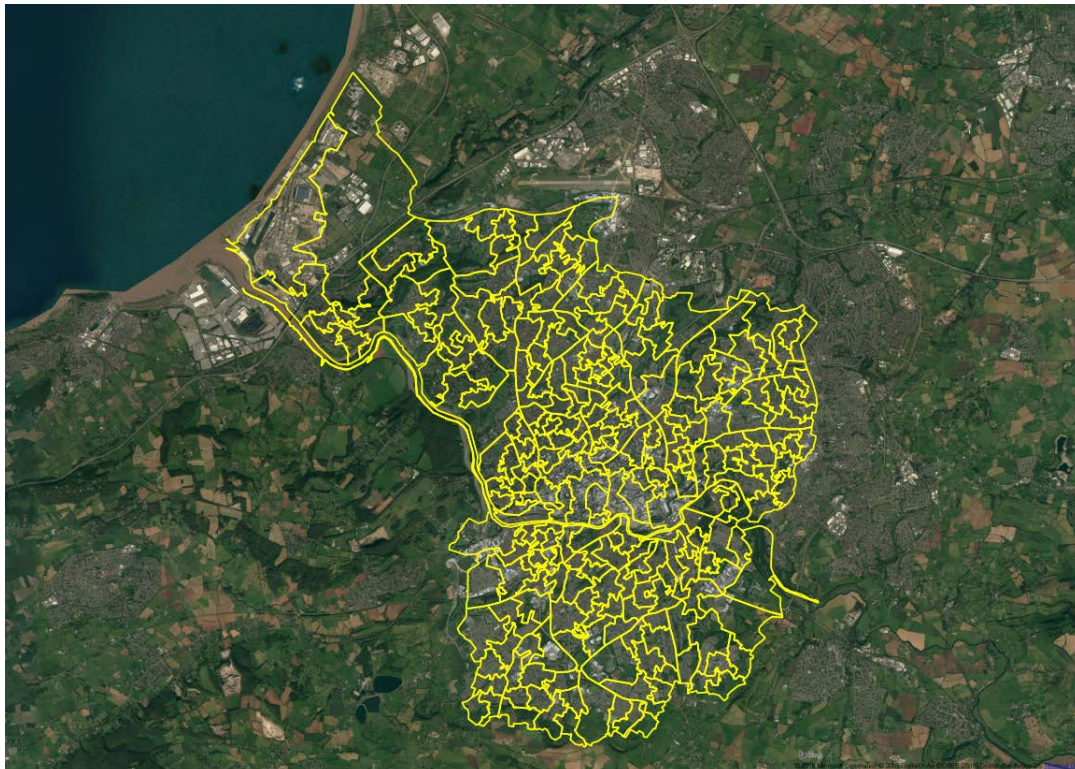


Figure 1 – Bristol domain with LSOA subdivision

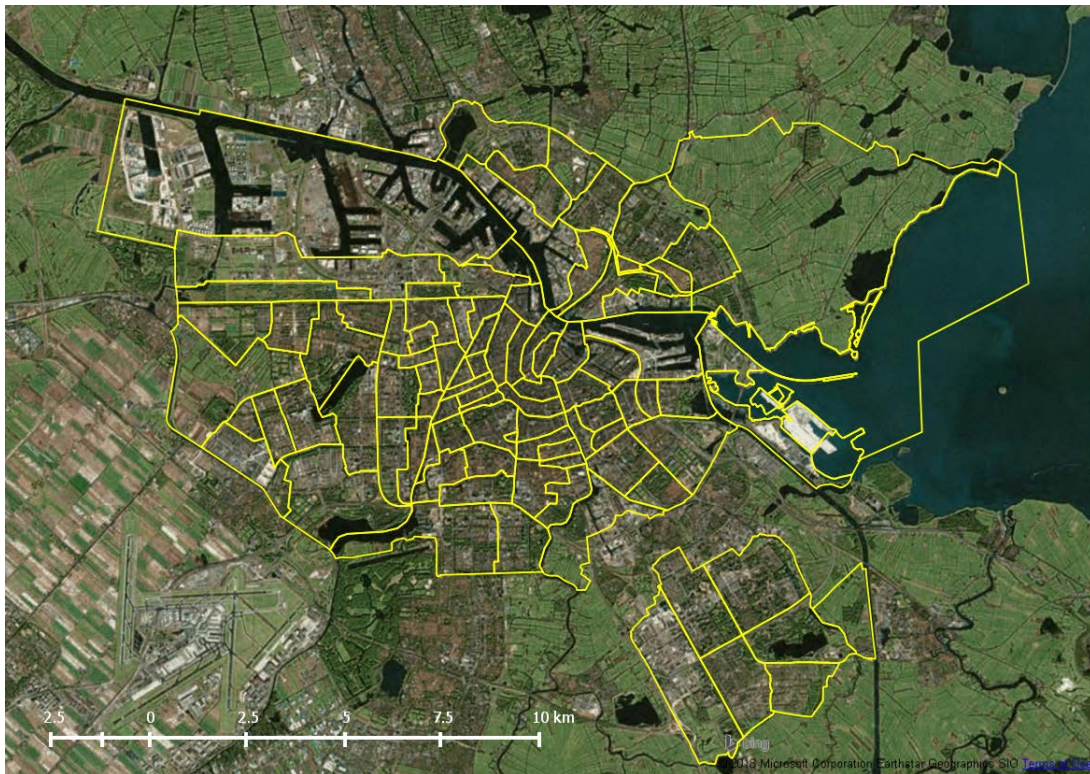


Figure 2 – Amsterdam domain with Buurt subdivision

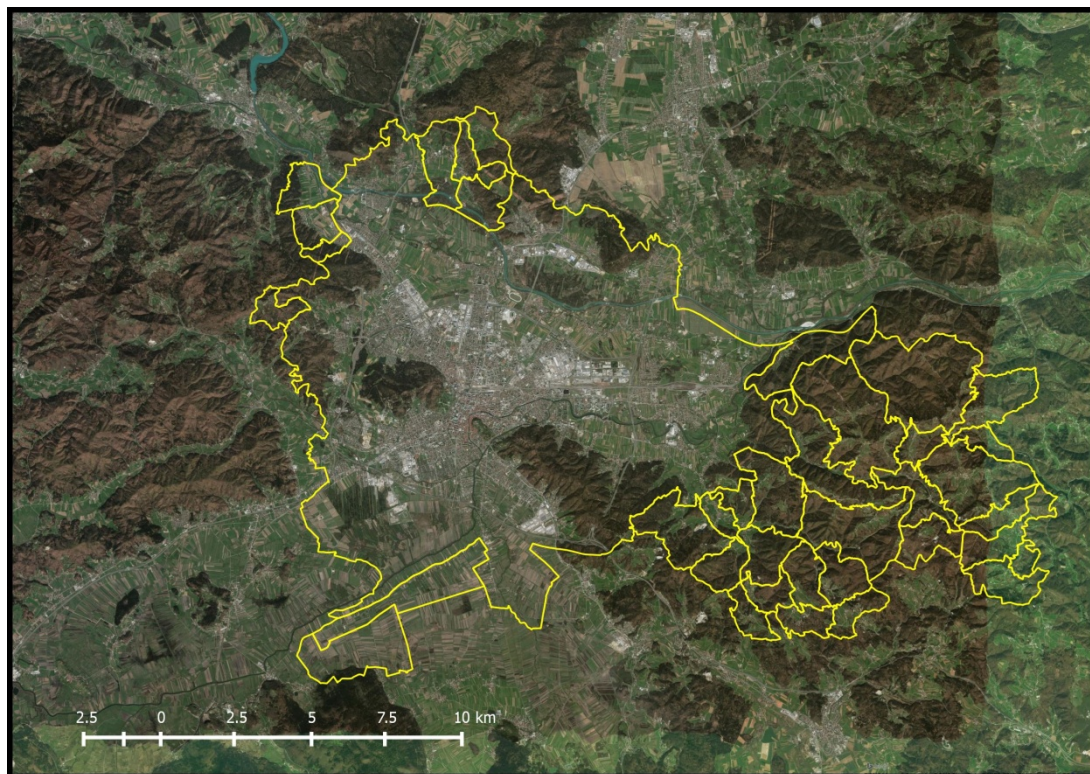


Figure 3 – Ljubljana domain with Naselje subdivision



Figure 4 – Sosnowiec domain with Gminas subdivision

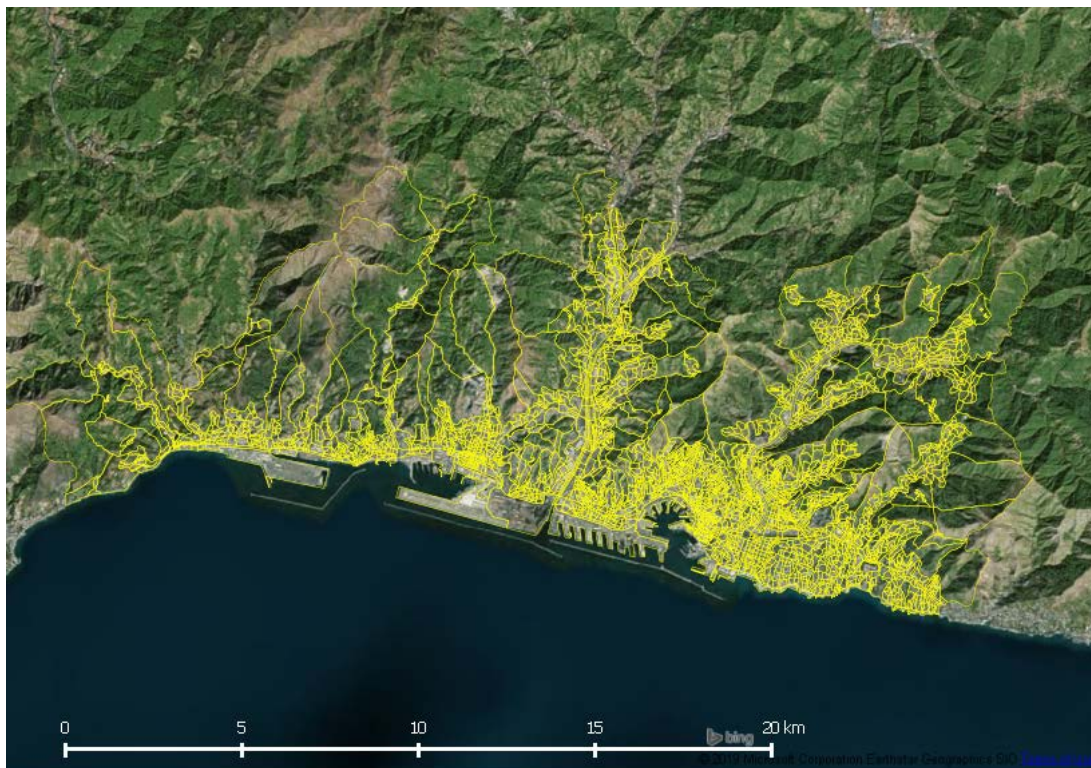


Figure 5 – Regione Liguria (Genoa comune) domain with Census Sections subdivision



Figure 6 – with Freguesia subdivision

2.6 Classification of activities and fuels for carbon footprint estimates

The module needs in input data for fuel consumptions in industrial, traffic, residential, commercial and institutional sector, detailed by subsector and, where defined, fuel as in the following Table 4.

Table 4 – Variable used to evaluate carbon footprint

Code	Name
CF1010A0	Final Consumptions in Industry - Hard Coal
CF1010F0	Final Consumptions in Industry – LPG
CF1010I0	Final Consumptions in Industry - Gas/ Diesel Oil
CF1010M1	Final Consumptions in Industry - Natural gas
CF1010Q0	Final Consumptions in Industry – Electricity
CF1010J0	Final Consumptions in Industry – Biogas
CF1010N0	Final Consumptions in Industry - Solid biomass
CF1010P0	Final Consumptions in Industry - Motor Gasoline
CF3040A0	Final Consumptions in Other Sectors: Residential - Hard Coal
CF3040F0	Final Consumptions in Other Sectors: Residential - LPG
CF3040I0	Final Consumptions in Other Sectors: Residential - Gas/ Diesel Oil
CF3040M1	Final Consumptions in Other Sectors: Residential - Natural gas
CF3040N0	Final Consumptions in Other Sectors: Residential - Biomass
CF3040Q0	Final Consumptions in Other Sectors: Residential - Electricity
CF3040M2	Final Consumptions in Other Sectors: Residential - Green gas
CF3040M3	Final Consumptions in Other Sectors: Residential - Biogas

Table 4 – Variable used to evaluate carbon footprint

Code	Name
CF3010A0	Final Consumptions in Services - Hard Coal
CF3010F0	Final Consumptions in Services – LPG
CF3010I0	Final Consumptions in Services - Gas/ Diesel Oil
CF3010M1	Final Consumptions in Services - Natural gas
CF3010Q0	Final Consumptions in Services - Electricity
CF3020N0	Final Consumptions in Services - Biomass
CF3010G0	Final Consumptions in Services - Motor Gasoline
CF3010J0	Final Consumptions in Services – Biogas
CF3010M2	Final Consumptions in Services - Green gas
CF2010I0	Final Consumptions in Transport: Road - private car - Gas/ Diesel Oil
CF2010P0	Final Consumptions in Transport: Road - private car - Motor Gasoline
CF2010Q0	Final Consumptions in Transport: Road - private car – Electricity
CF2010R0	Final Consumptions in Transport: Road - private car – Hydrogen
CF2020P0	Final Consumptions in Transport: Road - motorcycles - Motor Gasoline
CF2030I0	Final Consumptions in Transport: Road - buses - Gas/ Diesel Oil
CF2030M1	Final Consumptions in Transport: Road - buses – CNG
CF2030Q0	Final Consumptions in Transport: Road - buses – Electricity
CF2040I0	Final Consumptions in Transport: Road - light duty vehicles - Gas/ Diesel Oil
CF2040P0	Final Consumptions in Transport: Road - light duty vehicles - Motor Gasoline
CF2050I0	Final Consumptions in Transport: Road - trucks - Gas/ Diesel Oil
CF2010M1	Final Consumptions in Transport: Road - private car - Natural Gas
CF5002N0	Final Consumptions in Other Sectors: Residential (district heating) - Solid biomass
CF5001A0	Final Consumptions in Services (district heating) -Hard Coal
CF5001M1	Final Consumptions in Services (district heating) - Natural gas
CF5001N0	Final Consumptions in Services (district heating) - Solid biomass
CF5002A0	Final Consumptions in Other Sectors: Residential (district heating) - Hard Coal
CF5002M1	Final Consumptions in Other Sectors: Residential (district heating) - Natural gas

2.7 Data evaluation at domains and subdomains

Carbon footprint is evaluated at defined subdomains. When data are available only in aggregate figures (overall domain) or at national level, it is allocated to subdomains using a “proxy” variable available at subdomains.

When data are available at city/region domain, data at subdomain level is evaluated using the following equation:

$$A_i = A * P_i / \sum_i P_i$$

where: A_i and P_i are the values of variable A and proxy variable P in the subdomain i, and A is the total of variable A in the domain.

When data are available at national level, data at subdomain level is evaluated using the following equation:

$$A_i = (N * Q_d / \sum_d Q_d) * P_i / \sum_i P_i$$

where: A_i and P_i are the values of the variable A and proxy variable P in the subdomain i, Q_d is the values of the proxy variable Q in domain d, and N is the national value of proxy variable Q.



3 BASELINE RESULTS

In the following the data collection and evaluation procedures are detailed for Bristol (par. 3.1), Amsterdam (par. 3.1.2), Ljubljana (par. 3.2.2), Sosnowiec (par. 3.3.2), Liguria Region (Genoa Area) (par. 3.4.2) and Aveiro Region (par. 3.5.2).

Fuel consumptions from road traffic are evaluated in the ClairCity project, task 5.2.2 Design & development of transport module.

3.1 Bristol

3.1.1 Data retrieval and fuel consumptions evaluation

The following tables document the methodology and data used for:

- Industrial sources (Table 5)
- Residential and commercial sources (Table 6)
- Aggregate fuel consumptions data subdivision (Table 7)
- LSOA disaggregation variables (Table 8).

Table 5 – Methodology and source of data for Bristol fuel consumptions evaluation - Industrial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Field	Disaggregation variable
Industrial sector	Natural Gas	Level 2 (MSOA)	UK Department for Business, Energy & Industrial Strategy	Lower and Middle Super Output Areas gas consumption 2018 update	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/676344/MSOA_non_dom_gas_2015.xlsx	52% of non-domestic Consumption (kWh) [see Table 7 for percentage]; totals at LA level obtained as sum from MSOA data are directly allocated to LSOA (°)	Employees (Table 7)
	LPG	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Residual fuel consumption at regional and local authority level	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647698/residual_fuels_2005-2015.xlsx	11% of Column D (Petroleum; Industrial) [see Table 7 for percentage]	Employees (Table 7)
	Gasoil	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Residual fuel consumption at regional and local authority level	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647698/residual_fuels_2005-2015.xlsx	89% of Column D (Petroleum; Industrial) [see Table 7 for percentage]	Employees (Table 7)
	Coal	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Residual fuel consumption at regional and local authority level	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647698/residual_fuels_2005-2015.xlsx	98,5% of Columns I+K (Coal+ Manufactured Solid Fuels; Industrial+Commercial) [see Table 7 for percentage]	Employees (Table 7)
	Electricity	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Lower and Middle Super Output Areas electricity consumption - MSOA non domestic electricity 2015	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/676475/MSOA_non_dom_electricity_2015.xlsx	Consumption (kWh) 50% [see Table 7 for percentage]; totals at LA level obtained as sum from MSOA data are directly allocated to LSOA (°)	Employees (Table 7)

(°) if MSOA data are used to evaluate LSOA a bias is introduced due to different distribution industry/services in different MSOA

Table 6 – Methodology and source of data for Bristol fuel consumptions evaluation - Residential and services sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Field	Disaggregation variable
Residential sector	Natural gas	Level 3 (LSOA)	UK Department for Business, Energy & Industrial Strategy	Lower and Middle Super Output Areas gas consumption 2018 update	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/676340/LSOA_domestic_gas_2015.xlsx	Consumption (kWh) 42% [see Table 7 for percentage]	None
	Wood	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Residual fuel consumption at regional and local authority level	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647698/residual_fuels_2005-2015.xlsx	56% of Column M (Bioenergy & Waste) [see Share of wood on biomass in Table 7 for percentage]	households not connected to the gas network (Table 8)
	LPG	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Residual fuel consumption at regional and local authority level	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647698/residual_fuels_2005-2015.xlsx	10% of Column D (Petroleum; domestic) [see Table 7 for percentage]	households not connected to the gas network (Table 8)
	Gasoil	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Residual fuel consumption at regional and local authority level	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647698/residual_fuels_2005-2015.xlsx	90% of Column D (Petroleum; domestic) [see Table 7 for percentage]	households not connected to the gas network (Table 8)
	Coal	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Residual fuel consumption at regional and local authority level	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647698/residual_fuels_2005-2015.xlsx	Columns J+L (Coal+ Manufactured Solid Fuels; domestic) [see Table 7 for percentage]	households not connected to the gas network (Table 8)
	Electricity	Level 3 (LSOA)	UK Department for Business, Energy & Industrial Strategy	Lower and Middle Super Output Areas electricity consumption - MSOA non domestic electricity 2015	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/676473/LSOA_domestic_electricity_2015.xlsx	Consumption (kWh)	None
Service sector	Natural gas	Level 2 (MSOA)	UK Department for Business, Energy & Industrial Strategy	Lower and Middle Super Output Areas gas consumption 2018 update	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/676344/MSOA_non_dom_gas_2015.xlsx	Consumption (kWh) 42% [see Table 7 for percentage]; totals at LA level obtained as sum from MSOA data are directly allocated to LSOA (°)	Employees (Table 8)
	LPG	Level 1,5	UK Department	Residual fuel	https://www.gov.uk/government	30% of Column F+G	Employees

Table 6 – Methodology and source of data for Bristol fuel consumptions evaluation - Residential and services sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Field	Disaggregation variable
		(LA)	for Business, Energy & Industrial Strategy	consumption at regional and local authority level	nt/statistical-data-sets/estimates-of-non-gas-non-electricity-and-non-road-transport-fuels-at-regional-and-local-authority-level	(Petroleum; Administration + Commercial) [see Table 7 for percentage]	(Table 8)
	Gasoil	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Residual fuel consumption at regional and local authority level	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647698/residual_fuels_2005-2015.xlsx	70% of Column F+G (Petroleum; Administration+Commercial) [see Table 7 for percentage]	Employees (Table 8)
	Wood	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Residual fuel consumption at regional and local authority level	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647698/residual_fuels_2005-2015.xlsx	Negligible share of Column M (Bioenergy & Waste) [see Table 7 for percentage]	Value=0 no disaggregation
	Coal	Level 1,5 (LA)	UK Department for Business, Energy & Industrial Strategy	Residual fuel consumption at regional and local authority level	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/647698/residual_fuels_2005-2015.xlsx	Columns I (Coal; Industrial & Commercial) [Commercial share 1,5%; see Table 7 for percentage]	Employees (Table 8)
	Electricity	Level 2 (MSOA)	UK Department for Business, Energy & Industrial Strategy	Lower and Middle Super Output Areas electricity consumption - MSOA non domestic electricity 2015	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/676475/MSOA_non_dom_electricity_2015.xlsx	Consumption (kWh) 50% [see Table 7 for percentage]; totals at LA level obtained as sum from MSOA data are directly allocated to LSOA (°)	Employees (Table 8)

(°) if MSOA data are used to evaluate LSOA a bias is introduced due to different distribution industry/services in different MSOA

Table 7 – Methodology and source of data for Bristol fuel consumptions evaluation – aggregate fuel consumptions data subdivision

Energy vector	Data availability	Source	Publication	Reference	Note
Wood	Level 3 (National)	UK Department for Business, Energy & Industrial Strategy	Digest of UK Energy Statistics (DUKES): renewable sources	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/632546/DUKES_6.1-6.3.xls	On the basis of available data the following share is evaluated: wood domestic 56%. In commercial sector only wood wastes and plant biomass assumed; consumptions valuated as included in point sources and globally negligible

Natural Gas	Level (National)	3	UK Department for Business, Energy & Industrial Strategy	Digest of UK Energy Statistics: natural gas: commodity balances (DUKES 4.1)	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/632524/DUKES_4.1.xls	On the basis of available data the following share is evaluated: SERVICES Natural gas 42%, industrial 52%, others (agriculture, miscellaneous) 6%
LPG, Gaoil	Level (National)	3	UK Department for Business, Energy & Industrial Strategy	Digest of UK Energy Statistics: Petroleum products: commodity balances (DUKES 3.2-3.4)	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/632507/DUKES_3.2-3.4.xls	On the basis of available data the following shares are evaluated: SERVICES LPG 30% Gasoil 70% (in gasoil we include also a 8% of fuel oil) RESIDENTIAL LPG 10% Gasoil 90% (in gasoil kerosene is included). INDUSTRIAL LPG 11% Gasoil 89% (in gasoil we include also a 5% of fuel oil)
Coal	Level (National)	3	UK Department for Business, Energy & Industrial Strategy	Digest of UK Energy Statistics: : solid fuels and derived gases: commodity balances (DUKES)	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/632497/DUKES_2.4.xls	On the basis of available data the following shares are evaluated for Coal: SERVICES 1,5% INDUSTRIAL 98,5%
Electricity	Level (National)	3	UK Department for Business, Energy & Industrial Strategy	Digest of UK Energy Statistics: Electricity: commodity balances (DUKES 5.1)	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/632598/DUKES_5.1.xls	On the basis of available data the following shares are evaluated for electricity: SERVICES 50% INDUSTRIAL 50%

Table 8 – Methodology and source of data for Bristol fuel consumptions evaluation – LSOA disaggregation variables

Variable	Data availability	Sources	Publication	Reference	Fields
households not	Level 3 (LSOA)	UK Department for Business, Energy &	Lower and Middle Super	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/632598/DUKES_5.1.xls	Estimated number of households not connected to the gas network

Table 8 – Methodology and source of data for Bristol fuel consumptions evaluation – LSOA disaggregation variables

Variable	Data availability	Sources	Publication	Reference	Fields
connected to the gas network		Industrial Strategy	Output Areas gas consumption 2018 update	ata/file/676466/LSOA_domestic_nongas_2016.xlsx	
Employees	Level 3 (LSOA)	UK Office for National Statistics	All people aged 16 to 74 in employment the week before the Census Occupation by industry 2011 Occupies	https://www.nomisweb.co.uk/census/2011/ks605uk	Geography All of the following: 2001 super output areas - lower layer Cell SERVICE SECTOR Table CAS039 Occupation by industry select columns <ul style="list-style-type: none"> • G Wholesale and retail trade; repair of motor vehicles and motor cycles • H Transport and storage • I Accommodation and food service activities • J Information and communication • K Financial and insurance activities • L Real estate activities • M Professional, scientific and technical activities • N Administrative and support service activities • O Public administration and defence; compulsory social security • P Education • Q Human health and social work activities • R, S, T, U Other INDUSTRIAL SECTOR select columns <ul style="list-style-type: none"> • B Mining and quarrying • C Manufacturing • D Electricity, gas, steam and air conditioning supply • E Water supply; sewerage, waste management and



Table 8 – Methodology and source of data for Bristol fuel consumptions evaluation – LSOA disaggregation variables

Variable	Data availability	Sources	Publication	Reference	Fields
					remediation activities • F Construction The table provides information that classifies usual residents aged 16 to 74 in employment the week before the census by the industry in which they work, for United Kingdom as at census day, 27 March 2011.

3.1.2 Carbon footprint results

In Table 9 Carbon Footprint by fuel is reported for Bristol expressed as CO₂, CO₂ equivalent and CO₂ equivalent on Life Cycle.

Table 9 – Bristol Carbon Footprint by Fuel (Mg)

Energy Vector	CO ₂	CO _{2eq}	CO _{2eq,LCA}
Biomass	-	2.711	6.706
Gasoil/diesel	210.902	211.471	241.599
Gasoline	160.192	160.655	201.860
Hard Coal	9.037	9.093	9.479
LPG	3.678	3.678	4.552
Natural gas	544.097	544.097	646.903
Electricity	953.299	956.630	1.089.865
Total	1.881.204	1.888.334	2.200.964

In Figure 7 Carbon Footprint expressed as CO₂ equivalent on Life Cycle is reported by fuel and sector.

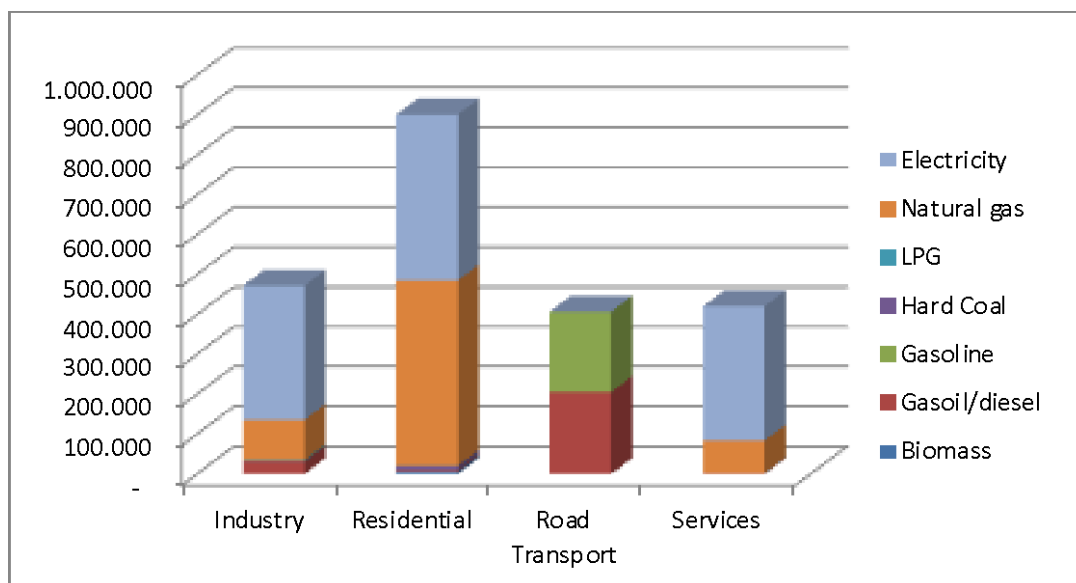


Figure 7 – Bristol Carbon Footprint (Mg CO₂ equivalent on Life Cycle)

In the following maps the results for sectors Carbon footprint are finally reported

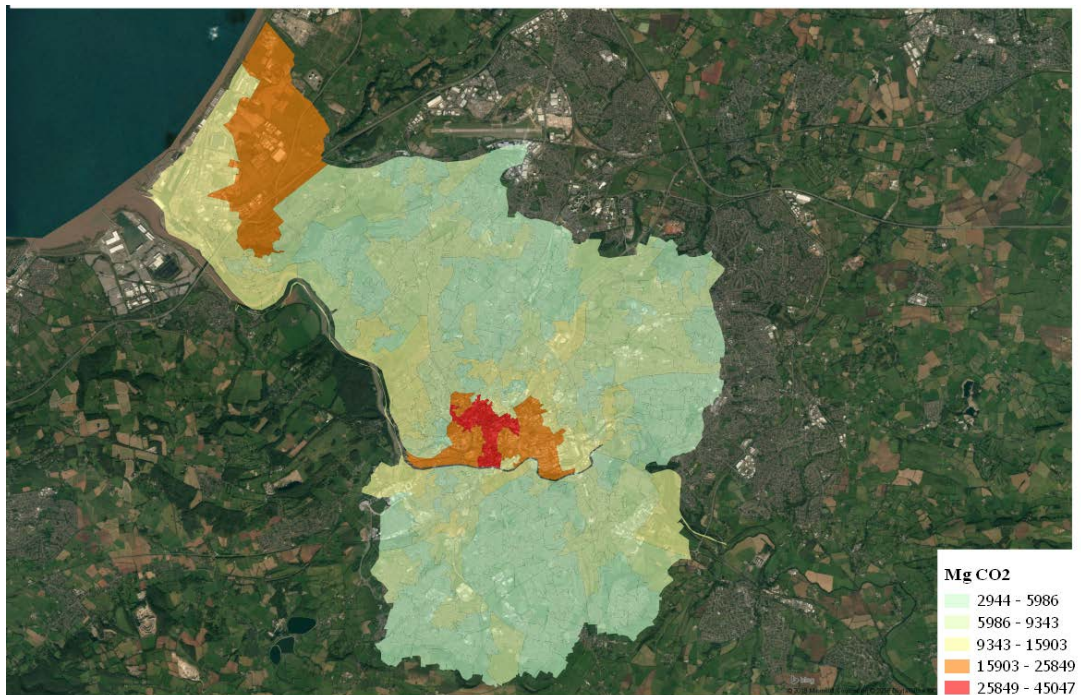


Figure 8 – Bristol LSOA Carbon Footprint – all sectors

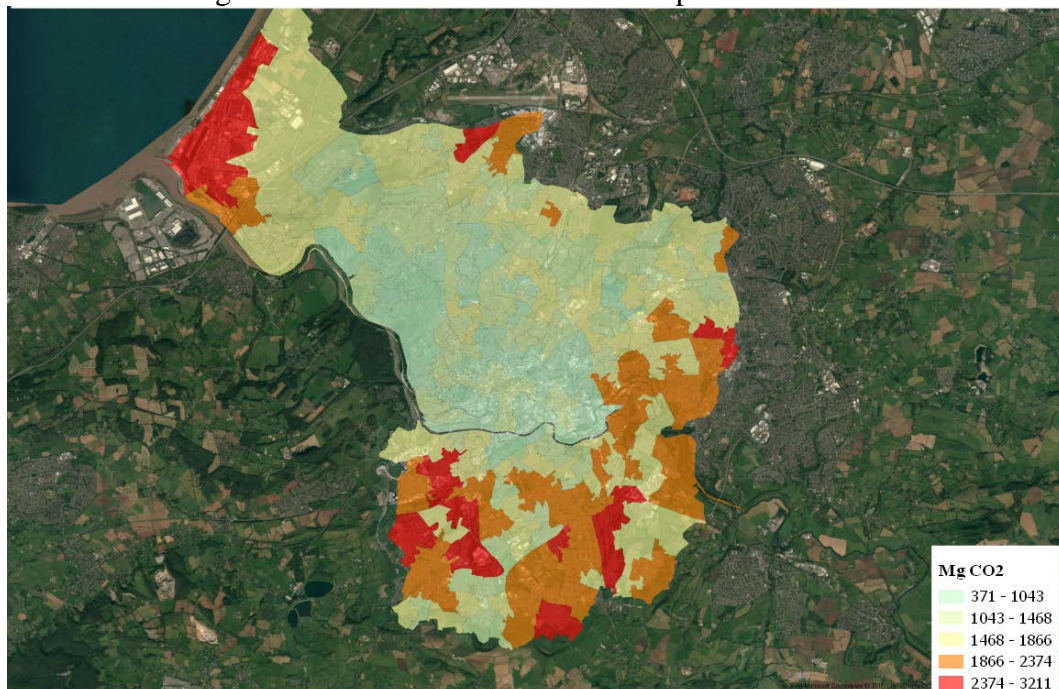


Figure 9 – Bristol LSOA Carbon Footprint – industry sector

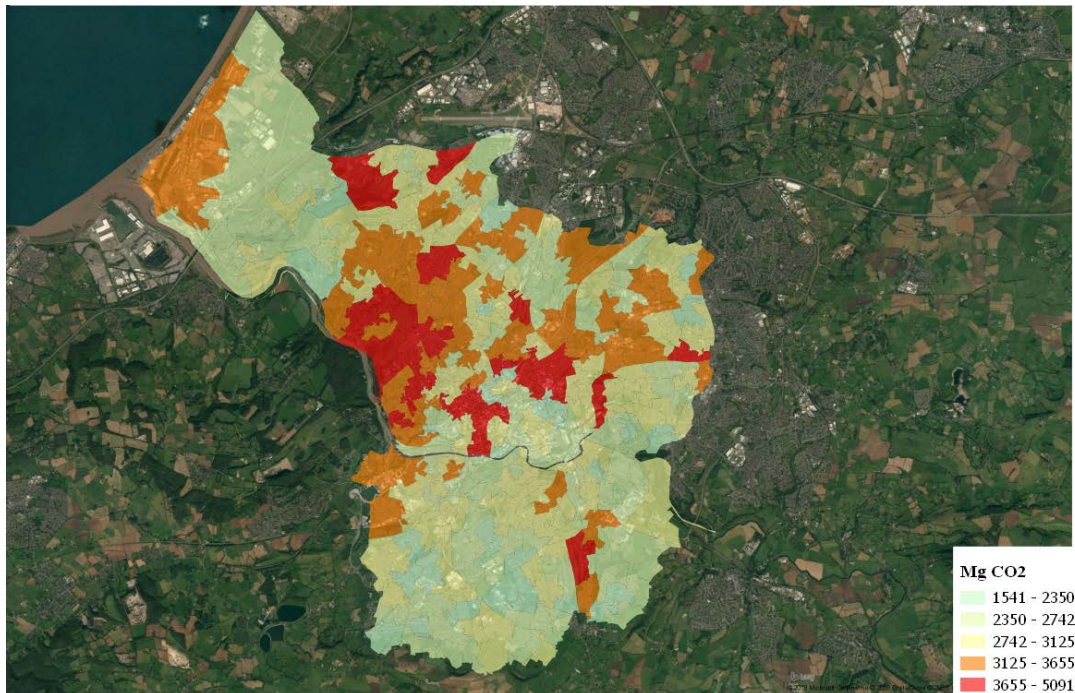


Figure 10 – Bristol LSOA Carbon Footprint – residential sector

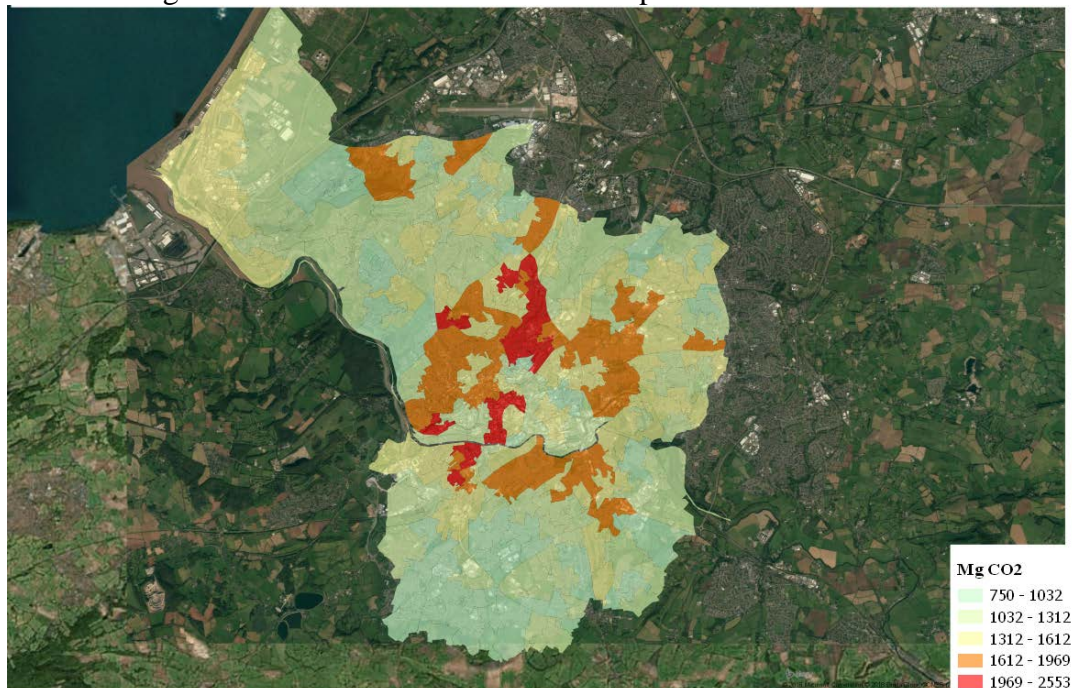


Figure 11 – Bristol LSOA Carbon Footprint – services sector

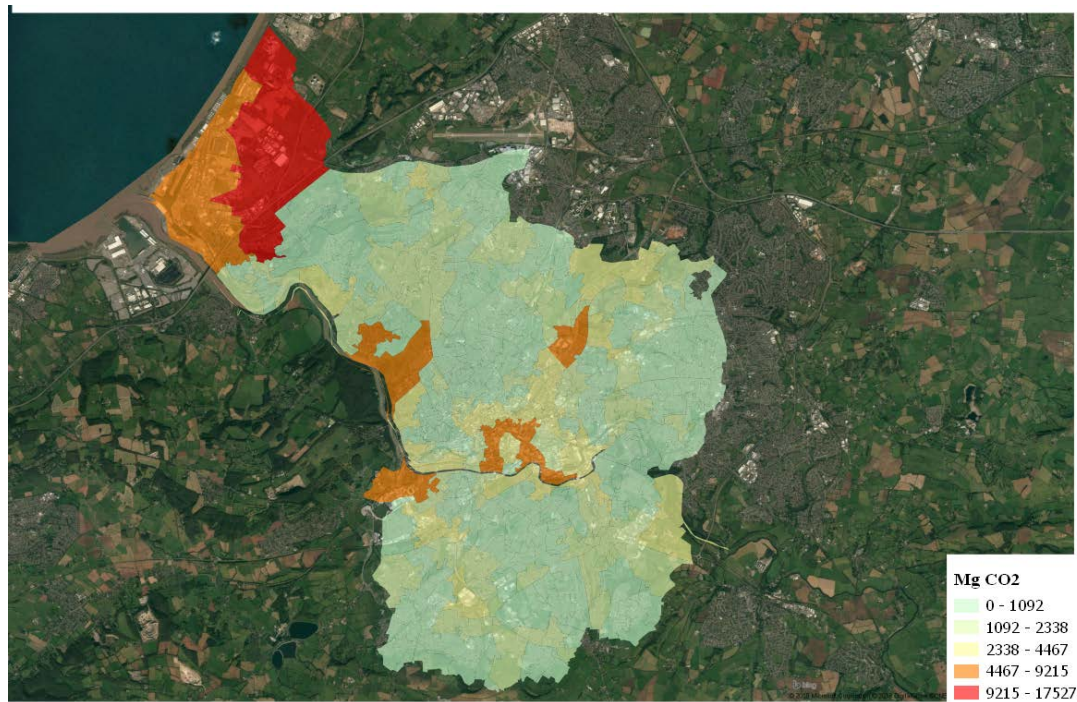


Figure 12 – Bristol LSOA Carbon Footprint – road transport

3.2 Amsterdam

3.2.1 Data retrieval and fuel consumptions evaluation

The following tables document the methodology and data used for:

- Industrial sources (Table 10),
- Residential and commercial sources (Table 11),
- Buurt disaggregation variables (Table 12).

Table 10 – Methodology and source of data for Amsterdam fuel consumptions evaluation - Industrial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Field	Disaggregation variable
Industrial sector	Natural Gas	Level 1 (National)	CBS	Energy balance sheet supply consumption	https://opendata.cbs.nl/statline/porta1.html?la=en&catalog=CBS&tableId=83140ENG&theme=1028	Topic: Industry (Total_26) Period: 2015 Energy commodities: Natural gas	Industry Companies number (Table 12)
	Gasoil	Level 1 (National)	CBS	Energy balance sheet supply consumption	https://opendata.cbs.nl/statline/porta1.html?la=en&catalog=CBS&tableId=83140ENG&theme=1028	Topic: Industry (Total_26) Period: 2015 Energy commodities: heating and other gasoil	Industry Companies number (Table 12)
	Coal	Level 1 (National)	CBS	Energy balance sheet supply consumption	https://opendata.cbs.nl/statline/porta1.html?la=en&catalog=CBS&tableId=83140ENG&theme=1028	Topic: Industry (Total_26) Period: 2015 Energy commodities: Total Coal Product	Industry Companies number (Table 12)
	Electricity	Level 1 (National)	CBS	Energy balance sheet supply consumption	https://opendata.cbs.nl/statline/porta1.html?la=en&catalog=CBS&tableId=83140ENG&theme=1028	Topic: Industry (Total_26) Period: 2015 Energy commodities: Electricity	Industry Companies number (Table 12)

Table 11 – Methodology and source of data for Amsterdam fuel consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Field	Disaggregation variable
Residential sector	Natural Gas	Level 3 (Buurt)	CBS	Wijk - en buurtkaart 2015	https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische%20data/wijk-en-buurtkaart-2015	G_GAS_TOT*WONINGEN where: [G_GAS_TOT]: Average total natural gas consumption [WONINGEN]: Housing stock	None
	Wood	Level 2 (Gemeente)	RIVM	Klimaatmonitor or	https://klimaatmonitor.data.bank.nl/dashboard/	Wood burning stoves dwellings hern. heat [TJ]	Population (Table 12)
	LPG	Level 1 (National)	CBS	Energy balance sheet supply consumption	https://opendata.cbs.nl/statline/portal.html?la=en&catalog=CBS&tableId=83140ENG&theme=1028	Topic: households Period: 2015 Energy commodities: LPG	Population (Table 12)

Table 11 – Methodology and source of data for Amsterdam fuel consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Field	Disaggregation variable
	Gasoil	Level 1 (National)	CBS	Energy balance sheet supply consumption	https://opendata.cbs.nl/statline/portal.html?la=en&catalog=CBS&tableId=83140ENG&theme=1028	Selection: Topic: households Period: 2015 Energy commodities: Heating and other gas oil	Population (Table 12)
	Electricity	Level 3 (Buurt)	CBS	Wijk - en buurtkaart 2015	https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische%20data/wijk-en-buurtkaart-2015	G_ELEK_TOT*WONINGEN where: [G_ELEK_TOT]: Average total Electricity consumption [WONINGEN]: Housing stock	None
Service sector	Natural gas	Level 2 (Gemeente)	RIVM	Klimaatmonitor	https://klimaatmonitor.databank.nl/dashboard/	Gas use commercial Services [m3] + Gas use Public Services [m3]	Services Companies number (Table 12)
	Wood	Level 1 (National)	CBS	Energy balance sheet supply consumption	https://opendata.cbs.nl/statline/portal.html?la=en&catalog=CBS&tableId=83140ENG&theme=1028	Topic: services waste and repairs Period: 2015 Energy commodities: Solid and liquid biomass	Services Companies number (Table 12)
	LPG	Level 1 (National)	CBS	Energy balance sheet supply consumption	https://opendata.cbs.nl/statline/portal.html?la=en&catalog=CBS&tableId=83140ENG&theme=1028	Topic: services waste and repairs Period: 2015 Energy commodities: LPG	Services Companies number (Table 12)
	Gasoil	Level 1 (National)	CBS	Energy balance sheet supply consumption	https://opendata.cbs.nl/statline/portal.html?la=en&catalog=CBS&tableId=83140ENG&theme=1028	Topic: services waste and repairs Period: 2015 Energy commodities: Heating and other gas oil	Services Companies number (Table 12)
	Electricity	Level 2 (Gemeente)	RIVM	Klimaatmonitor	https://klimaatmonitor.databank.nl/dashboard/	Electricity use commercial Services [kWh] + Electricity use Public Services [kWh]	Services Companies number (Table 12)



Table 12 – Methodology and source of data for Amsterdam fuel consumptions evaluation – Buurt disaggregation variables

Variable	Data availability	Sources	Publication	Reference	Fields
Population	Level (Buurt)	3 CBS	Wijk-en buurtkaart 2015	https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische%20data/wijk-en-buurtkaart-2015	AANT_INW (Number of inhabitants)
Services Companies number	Level (Buurt)	3 CBS	Wijk-en buurtkaart 2015	https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische%20data/wijk-en-buurtkaart-2015	[A_BED_GI]+[A_BED_HJ]+[A_BED_KL]+[A_BED_MN]+[A_BED_RU] where: [A_BED_GI]: Number of companies and catering trade [A_BED_HJ]: Number of companies transport, information, communication [A_BED_KL]: Number of firms financially property [A_BED_MN]: Number of companies business services [A_BED_RU]: Number of companies culture, recreation, other
Industry Companies number	Level (Buurt)	3 CBS	Wijk-en buurtkaart 2015	https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische%20data/wijk-en-buurtkaart-2015	[A_BED_BF]: Number of companies industry and energy

3.2.2 Carbon footprint results

In Table 13 Carbon Footprint by fuel is reported for Amsterdam expressed as CO₂, CO₂ equivalent and CO₂ equivalent on Life Cycle.

Table 13 – Amsterdam Carbon Footprint by Fuel (Mg)

Energy Vector	CO ₂	CO _{2eq}	CO _{2eq,LCA}
Biomass	-	97	240
Gasoil/diesel	362.400	363.376	415.148
Gasoline	559.240	560.856	704.707
Hard Coal	67.044	67.462	70.323
LPG	19.970	19.970	24.718
Natural gas	1.737.363	1.737.363	2.065.635
Electricity	2.389.257	2.393.265	2.705.953
Total	5.135.273	5.142.391	5.986.723

In Figure 13 Carbon Footprint expressed as CO₂ equivalent on Life Cycle is reported by fuel and sector.

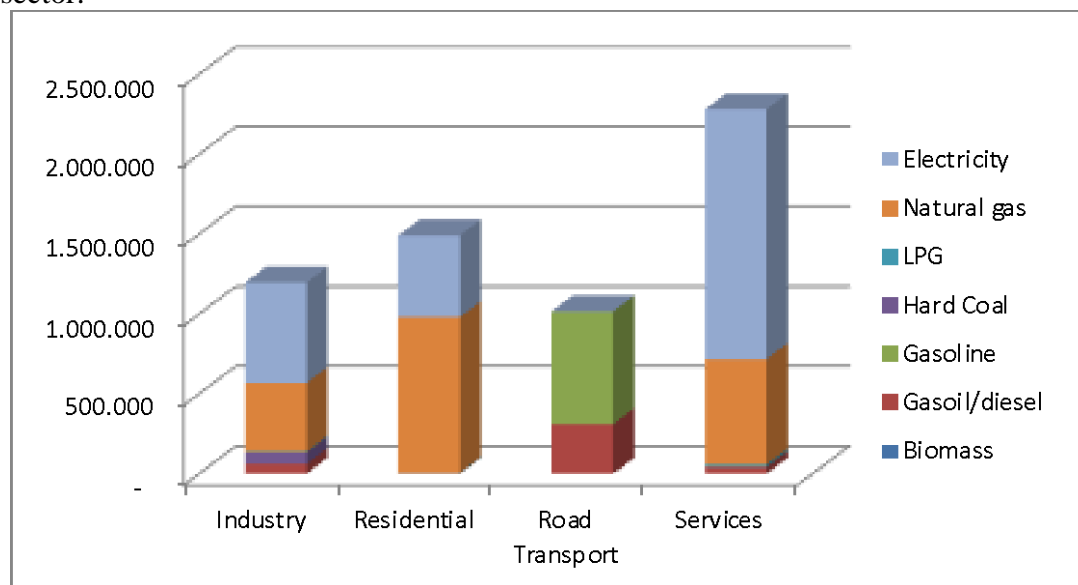


Figure 13 – Amsterdam Carbon Footprint (Mg CO₂ equivalent on Life Cycle)

In the following maps the results for sectors Carbon footprint are finally reported

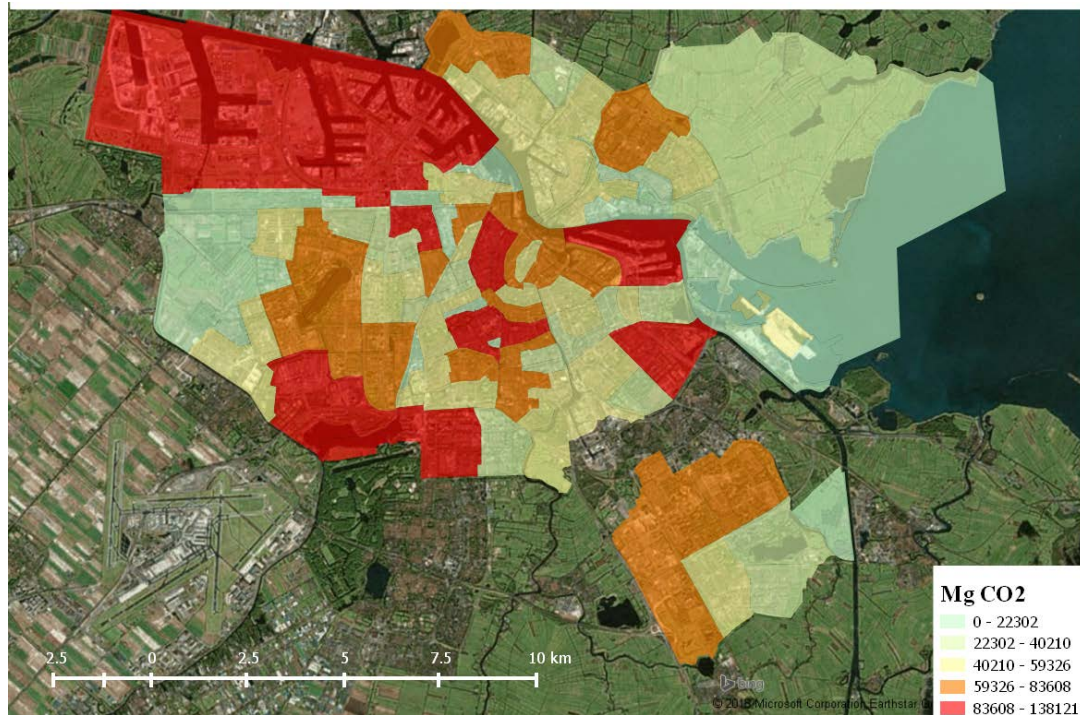


Figure 14 – Amsterdam Buurt Carbon Footprint – all sectors

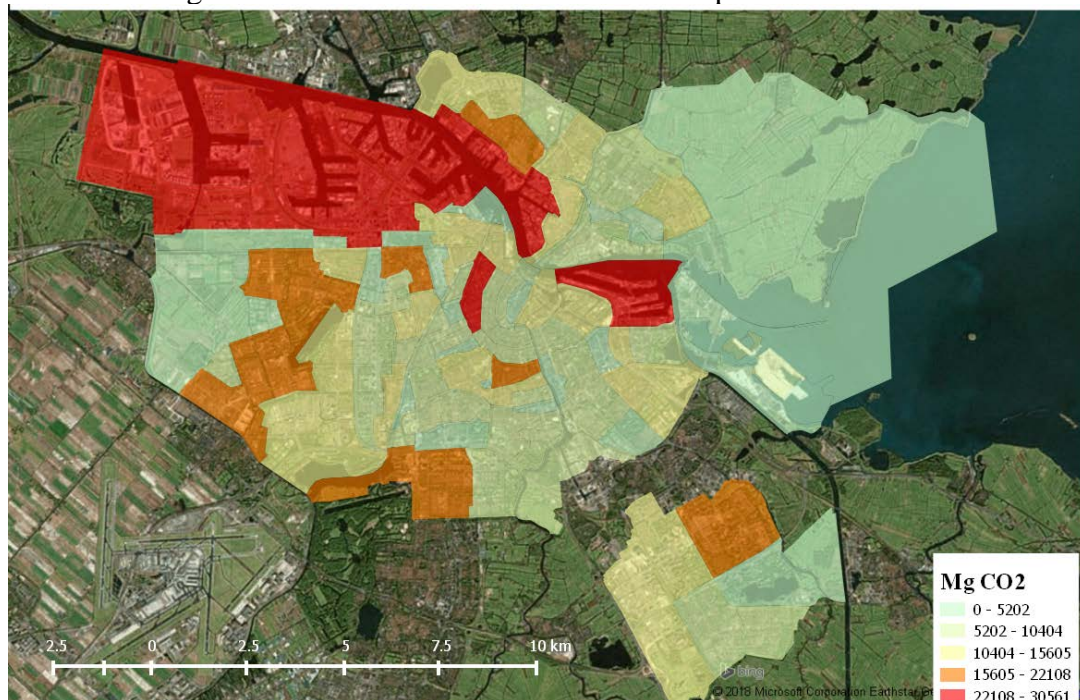


Figure 15 – Amsterdam Buurt Carbon Footprint – industry sector

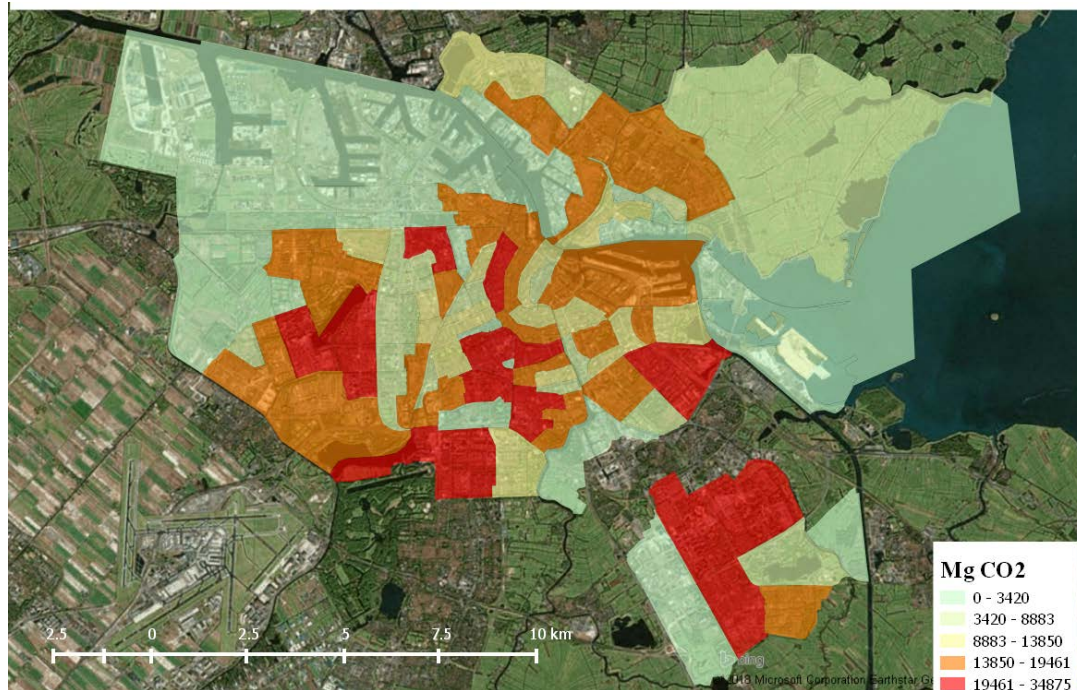


Figure 16 – Amsterdam Buurt Carbon Footprint – residential sector

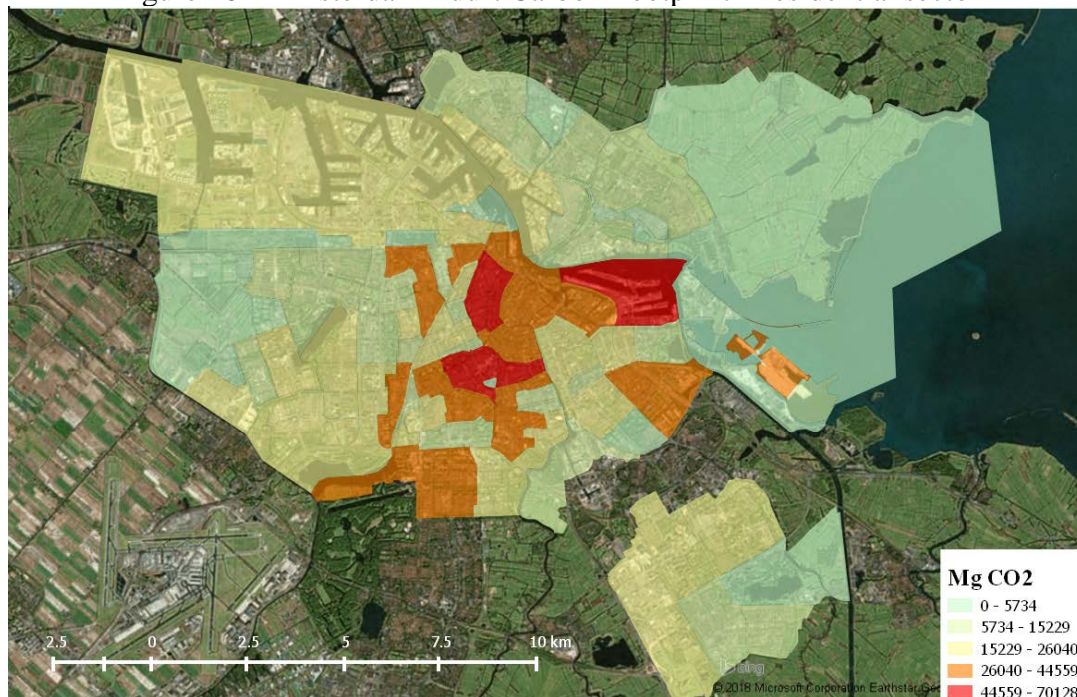


Figure 17 – Amsterdam Buurt Carbon Footprint – services sector

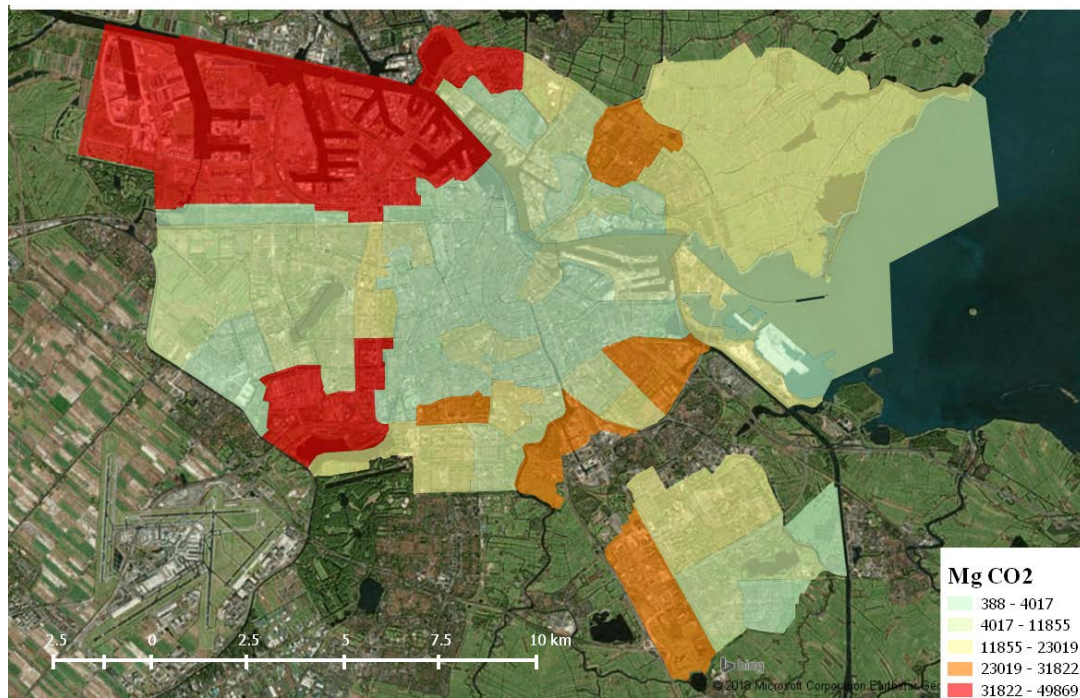


Figure 18 – Amsterdam Buurt Carbon Footprint – road transport

3.3 Ljubljana

3.3.1 Data retrieval and fuel consumptions evaluation

The following tables document the methodology and data used for:

- Industrial sources (Table 14);
- Residential and commercial sources (Table 15);
- Naselje disaggregation variables (Table 16).

Table 14 – Methodology and source of data for Ljubljana fuel consumptions evaluation - Industrial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Disaggregation variable
Industrial sector	Gasoil	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Corine Land Cover for industrial plants
	Gasoline	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Corine Land Cover for industrial plants
	LPG	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Corine Land Cover for industrial plants
	Electricity	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Corine Land Cover for industrial plants

Table 15 – Methodology and source of data for Ljubljana fuel consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Disaggregation variable
Residential sector	Natural Gas	Level 2 (Občine) only for Ljubljana	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Population
	Wood	Level 2 (Občine) only for Ljubljana	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Population
	LPG	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL)	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Population

Table 15 – Methodology and source of data for Ljubljana fuel consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Disaggregation variable
		only for Ljubljana		(Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	MOL/energy-balance	
	Gasoil	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Population
	Coal	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Population
	Electricity	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Population
Service sector	Natural Gas	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Population
	Wood	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Population
	LPG	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Population
	Gasoil	Level 2 (Občine)	EnerGisSolution	Energy Balance And Emission Estimation - City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	http://www.energis-solutions.com/en/EB-Ljubljana-MOL/energy-balance	Population
	Electricity	Level 2	EnerGisSolution	Energy Balance And Emission Estimation -	http://www.energis-	Population



Table 15 – Methodology and source of data for Ljubljana fuel consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Disaggregation variable
		(Občine)		City Of Ljubljana (MOL) (Project version: 2016.MOL.1996-2015) Table EB-A: Energy Balance	solutions.com/en/EB-Ljubljana-MOL/energy-balance	

Table 16 – Methodology and source of data for Ljubljana fuel consumptions evaluation – Naselje disaggregation variables

Variable	Data availability	Sources	Publication	Reference	Note
Population	Level (Naselje)	3 Statistical Office of the Republic of Slovenia	SI-Stat Database	https://pxweb.stat.si/pxweb/Dialog/varval.asp?ma=05C5004E&ti=&path=../Database/Demographics/05_population/10_Number_Population/25_05C50_Population_naselja/&lang=1	Population by large and 5-year age groups and sex, settlements, Slovenia, annually
Industrial areas coverage	Level (Naselje)	3 Copernicus Land Monitoring Service	CORINE Land Cover	https://land.copernicus.eu/pan-european/corine-land-cover	A GIS query has been used to evaluate the coverage of industrial area on each Naselje and industrial emissions are allocated to the area based on dimension of area itself.

3.3.2 Carbon footprint results

In Table 17 Carbon Footprint by fuel is reported for Ljubljana expressed as CO₂, CO₂ equivalent and CO₂ equivalent on Life Cycle.

Table 17 – Ljubljana Carbon Footprint by Fuel (Mg)

Energy Vector	CO ₂	CO _{2eq}	CO _{2eq,LCA}
Biomass	-	863	2.134
Gasoil/diesel	260.000	260.701	297.844
Gasoline	124.496	124.855	156.879
LPG	15.643	15.643	19.362
Natural gas	217.185	217.185	258.221
Industrial wastes	1.260	1.277	1.277
Electricity	672.443	676.084	714.926
Total	1.291.026	1.296.608	1.450.643

In Figure 19 Carbon Footprint expressed as CO₂ equivalent on Life Cycle is reported by fuel and sector.

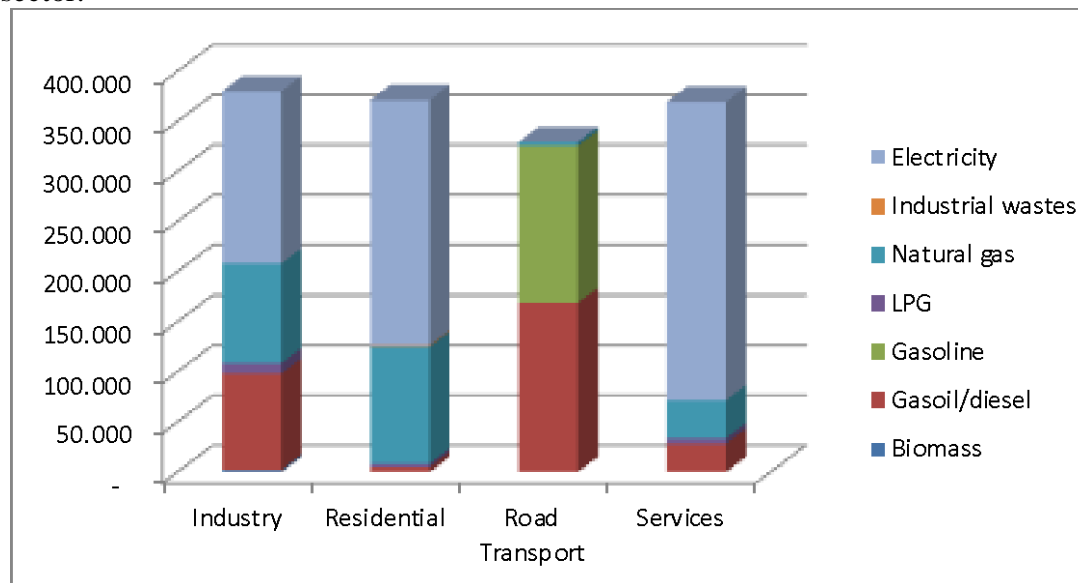


Figure 19 – Ljubljana Carbon Footprint (Mg CO₂ equivalent on Life Cycle)

In the following maps the results for sectors Carbon footprint are finally reported

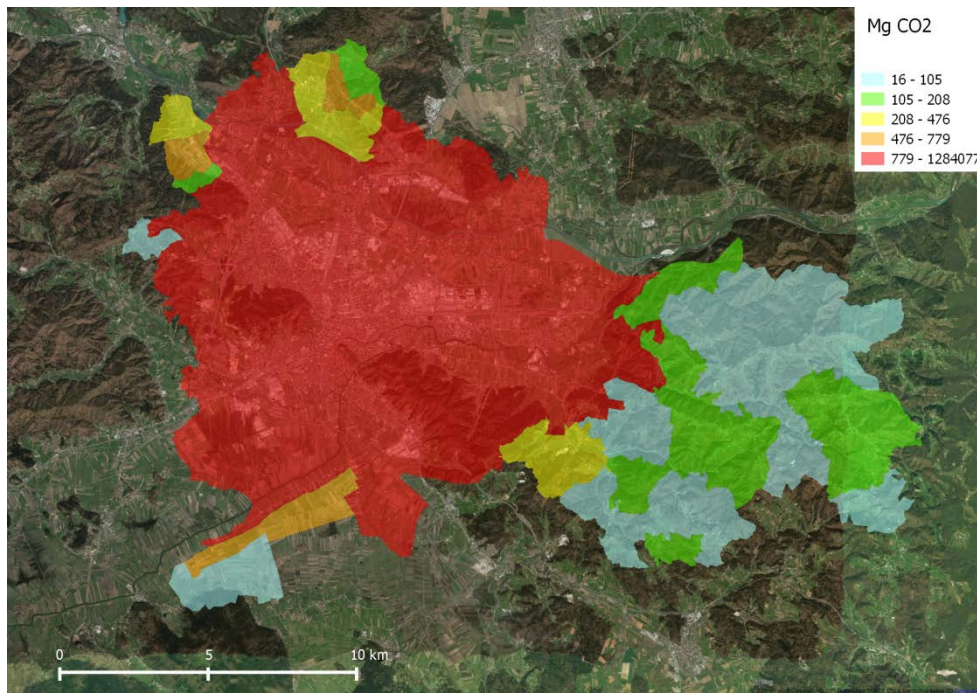


Figure 20 – Ljubljana Naselje Carbon Footprint – all sectors

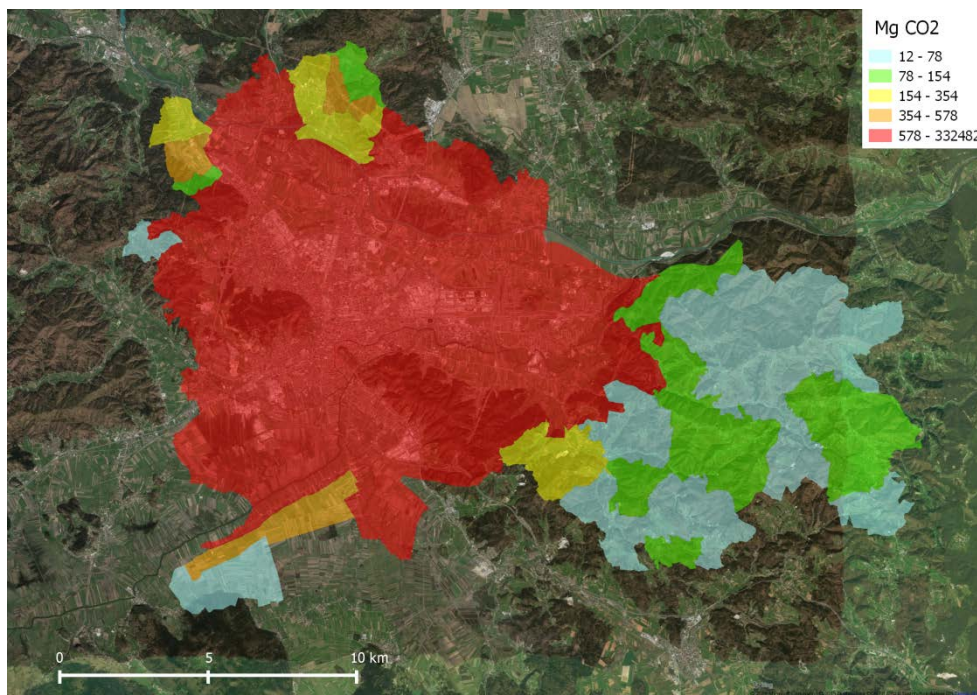


Figure 21 – Ljubljana Naselje Carbon Footprint – residential sector

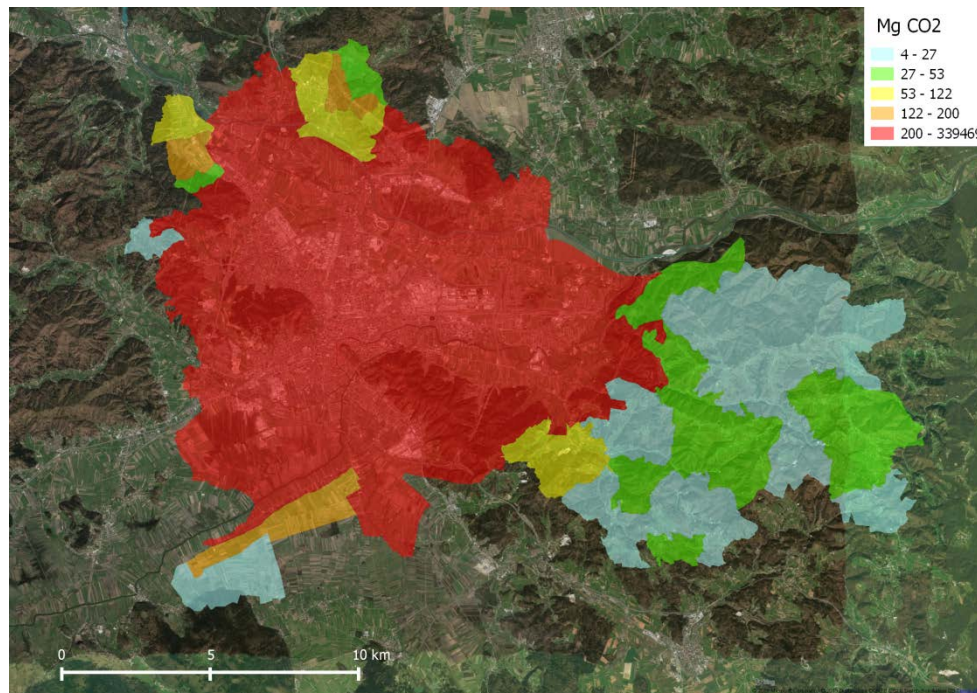


Figure 22 – Ljubljana Naselje Carbon Footprint – services sector

3.4 Sosnowiec

3.4.1 Data retrieval and fuel consumptions evaluation

The following tables document the methodology and data used for:

- Industrial sources (Table 18);
- Residential and commercial sources (Table 19)

For heating networks (district heating) we assume the following split between fuels, using national figures excluding waste derived fuels more territorial specific¹⁰: coal (89%), natural gas (7%), wood (4%).

¹⁰ [Statistics Poland, Energy statistics in 2015 and 2016. Table 8 \(13\). Public Thermal Plants - Heat Generation](#)

Table 18 – Methodology and source of data for Sosnowiec fuel consumptions evaluation - Industrial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Note	Disaggregation variable
Industrial sector	Natural Gas	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	LPG	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Gasoil	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Coal	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej dla Miasta Sosnowiec, Tabela 16-1. życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Electricity	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None

Table 19 – Methodology and source of data for Sosnowiec fuel consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Note	Disaggregation variable
Residential sector	Natural Gas	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None

Table 19 – Methodology and source of data for Sosnowiec fuel consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Note	Disaggregation variable
	Heat ¹¹	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Wood	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej dla Miasta Sosnowiec, Tabela 16-1. życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	LPG	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej dla - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Gasoil	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Coal	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Electricity	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None

¹¹ For heating networks (district heating) we assume the following split of fuel, using national figures excluding waste derived fuels more territorial specific: coal (89%), natural gas (7%), wood (4%).

Table 19 – Methodology and source of data for Sosnowiec fuel consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Note	Disaggregation variable
				- życie energii w roku 2013	2011.09.2015%20a.pdf		
Service sector (included in industrial sector statistics)	Natural Gas	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Heat ¹²	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Wood	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	LPG	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej dla Miasta Sosnowiec, Tabela 16-1. życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Gasoil	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None

¹² For heating networks (district heating) we assume the following split of fuel, using national figures excluding waste derived fuels more territorial specific: coal (89%), natural gas (7%), wood (4%).



Table 19 – Methodology and source of data for Sosnowiec fuel consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Note	Disaggregation variable
	Coal	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	2013 Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None
	Electricity	Level 3 (Gminy)	Urzędu Miasta Sosnowiec	2013 Energoekspert. Kompleksowy Plan Gospodarki Niskoemisyjnej - życie energii w roku 2013	http://www.sosnowiec.pl/_upload/PGN%20Sosnowiec%2011.09.2015%20a.pdf	2013 to 2015 with Wojewodztwa data	None

3.4.2 Carbon footprint results

In Table 20 Carbon Footprint by fuel is reported for Sosnowiec expressed as CO₂, CO₂ equivalent and CO₂ equivalent on Life Cycle.

Table 20 – Sosnowiec Carbon Footprint by Fuel (Mg)

Energy Vector	CO ₂	CO _{2eq}	CO _{2eq,LCA}
Biomass	-	477	193
Gasoil/diesel	74.085	84.868	74.285
Gasoline	30.010	37.816	30.097
LPG	772	956	772
Natural gas	103.449	122.996	103.449
Coal	424.056	444.796	426.704
Electricity	832.889	896.229	836.145
Total	1.465.262	1.588.137	1.471.644

In Figure 23 Carbon Footprint expressed as CO₂ equivalent on Life Cycle is reported by fuel and sector. The data source used reports aggregate values for industry and services fuel consumptions; in consequence also in carbon footprint the data are reported together.

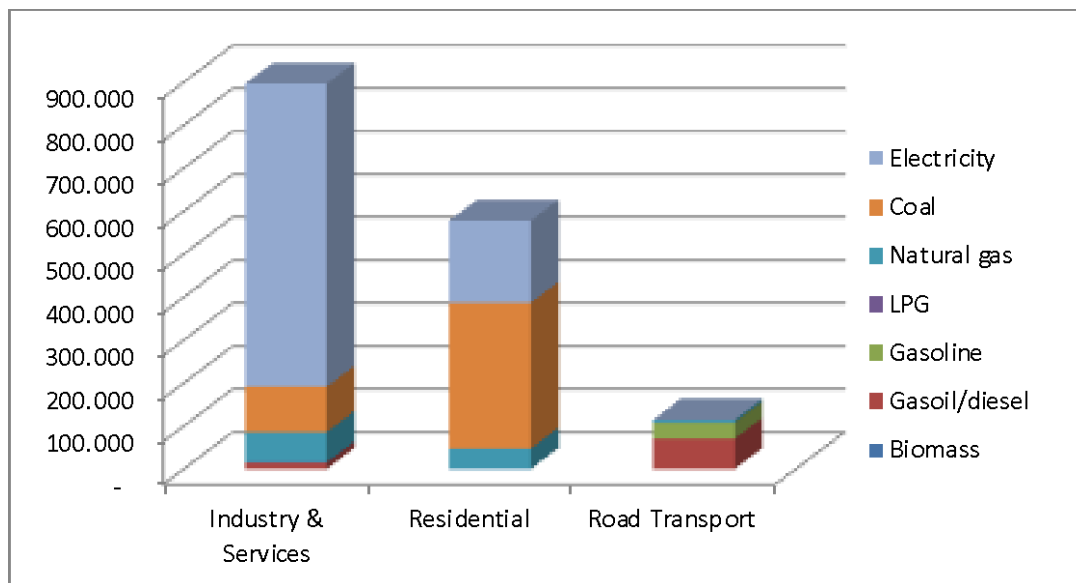


Figure 23 – Sosnowiec Carbon Footprint (Mg CO₂ equivalent on Life Cycle)

For Sosnowiec Gminas is not defined a subdivision of the territory and the maps are not reported as not relevant (the map would report only one territory).

3.5 Liguria Region (Genoa Area)

3.5.1 Data retrieval and fuel consumptions evaluation

The following tables document the methodology and data used for:

- Industrial sources (Table 21);
- Residential and commercial sources (Table 22);
- Wood statistics (Table 23);
- Residential fuel energy demand (Table 24);
- Sezione di censimento disaggregation variables (Table 25).

Table 21 – Methodology and source of data for Liguria Region (Genoa Area) fuel consumptions/emissions evaluation - Industrial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Note	Disaggregation variable
Residential sector	Natural Gas	Level 2 (Comune)	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Original data from regional gas distributors	Employees (Table 25)
	Electricity	Level 1 (Regione)	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Original data from national electricity transmission grid operator	Employees (Table 25)

Table 22 – Methodology and source of data for Liguria Region (Genoa Area) consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Note	Disaggregation variable
Residential sector	Natural Gas	Level 2 (Comune)	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Original data from regional gas distributors	Dwelling area (Table 25)
	Wood	Level 1 (Regione)	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Data at level 1 (regione) allocated to Level 2 with energy demand (Table 24)	Dwelling area (Table 25)
	LPG	Level 1 (Regione)	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Aggregated Residential & Service sector data at level 1 (regione) splitted with national (level 0) figure and then allocated to Level 2 with energy demand (Table 24)	Dwelling area (Table 25)
	Gasoil	Level 1 (Regione)	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Aggregated Residential & Service sector data at level 1 (regione) splitted with national (level 0) figure and then allocated to Level 2 with energy demand (Table 24)	Dwelling area (Table 25)
	Electricity	Level 2	Regione	Regional	https://www.regione.liguria.it	Original data from municipal electricity transmission	Dwelling area

Table 22 – Methodology and source of data for Liguria Region (Genoa Area) consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Note	Disaggregation variable
		(Comune)	Liguria	Energy Balance 2016	t/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	grid operators	(Table 25)
Service sector	Natural Gas	Level 2 (Comune)	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Original data from regional gas distributors	Employees (Table 25)
	Wood	Single facility	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Original data from Gestore dei Servizi Energetici GSE S.p.A.	None
	LPG	Level 1 (Regione)	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Aggregated Residential & Service sector data at level 1 (regione) splitted with national (level 0) figure and then allocated to Level 2 with employees (Table 25)	Employees (Table 25)
	Gasoil	Level 1 (Regione)	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Aggregated Residential & Service sector data at level 1 (regione) splitted with national (level 0) figure and then allocated to Level 2 with employees (Table 25)	Employees (Table 25)
	Electricity	Level 2 (Comune)	Regione Liguria	Regional Energy Balance 2016	https://www.regione.liguria.it/giunta/26-servizi-online/14414-bilancio-energetico-regionale.html	Original data from municipal electricity transmission grid operators	Employees (Table 25)

Table 23 – Methodology and source of data for Liguria Region (Genoa Area) fuel consumptions evaluation – Wood statistics

Variable	Data availability	Sources	Publication	Reference	Note
Technologies split	Level 1 (Liguria)	ISTAT	ISTAT I consumi energetici delle famiglie	https://www.istat.it/it/files/2014/12/Tab_elle_appendice_consumi_energetici.zip	On the basis of available data the following shares are evaluated: traditional 85% and advanced 15%

Region)	ENEA	ENEA Rapporto Energia Ambiente (2005)	http://old.enea.it/produzione_scientifica/pdf_volumi/V06_01Analisi_05.pdf	(ISTAT); fireplaces (2/3) and stoves (1/3) (ENEA) Service sector allocated to boilers.
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Table 24 – Methodology and source of data for Liguria Region (Genoa Area) residential energy demand evaluation –

Variable	Data availability	Sources	Publication	Reference	Note
Energy demand	Level 2 (Comune)	ISTAT ENEA	ISTAT, Censimento Popolazione ed Abitazioni, Abitazioni con impianto di riscaldamento per tipo di combustibile o energia che alimenta l'impianto di riscaldamento) Tabella dei gradi/giorno dei Comuni italiani raggruppati per Regione e Provincia	http://dati-censimentopopolazione.istat.it/Index.aspx?DataSetCode=dica_alloggi http://efficienzaenergetica.acs.enea.it/doc/dpr412-93_alla_tabellagradiogiorno.pdf	Energy demand (F) of each comune is computed as: where j fuel, i comune, N number of dwelling, S average area of occupied dwellings, G degrees days, D volume dispersion coefficient

Table 25 – Methodology and source of data for for Liguria Region (Genoa Area) level 3 fuel consumptions evaluation

Variable	Data availability	Sources	Publication	Reference	Fields
Dwelling area	Level 3 (CensusSection)	ISTAT	Censimento della popolazione e delle abitazioni 2011	http://www.istat.it/storage/cartografia/variabili-censuarie/dati-sce_2011.zip	Average area of occupied dwellings
Industrial employees	Level 3 (CensusSection)	ISTAT	Censimento dell'industria e dei servizi, 2011	http://www.istat.it/storage/cartografia/variabili-censuarie/dati-cpa_2011.zip	Field ADDETTI with field ATECO3 <=400
Service employees	Level 3 (CensusSection)	ISTAT	Censimento dell'industria e dei servizi, 2011	http://www.istat.it/storage/cartografia/variabili-censuarie/dati-cpa_2011.zip	Field ADDETTI with field ATECO3 >400

3.5.2 Carbon footprint results

In Table 26 Carbon Footprint by fuel is reported for Genoa expressed as CO₂, CO₂ equivalent and CO₂ equivalent on Life Cycle.

Table 26 – Genoa Carbon Footprint by Fuel (Mg)

Energy Vector	CO ₂	CO _{2eq}	CO _{2eq,LCA}
Biomass	-	487	1.204
Gasoil/diesel	192.266	192.785	220.251
Gasoline	100.700	100.991	126.893
LPG	15.313	15.313	18.953
Natural gas	556.601	556.601	661.770
Electricity	655.926	657.991	810.788
Total	1.520.806	1.524.167	1.839.859

In Figure 13 Carbon Footprint expressed as CO₂ equivalent on Life Cycle is reported by fuel and sector.

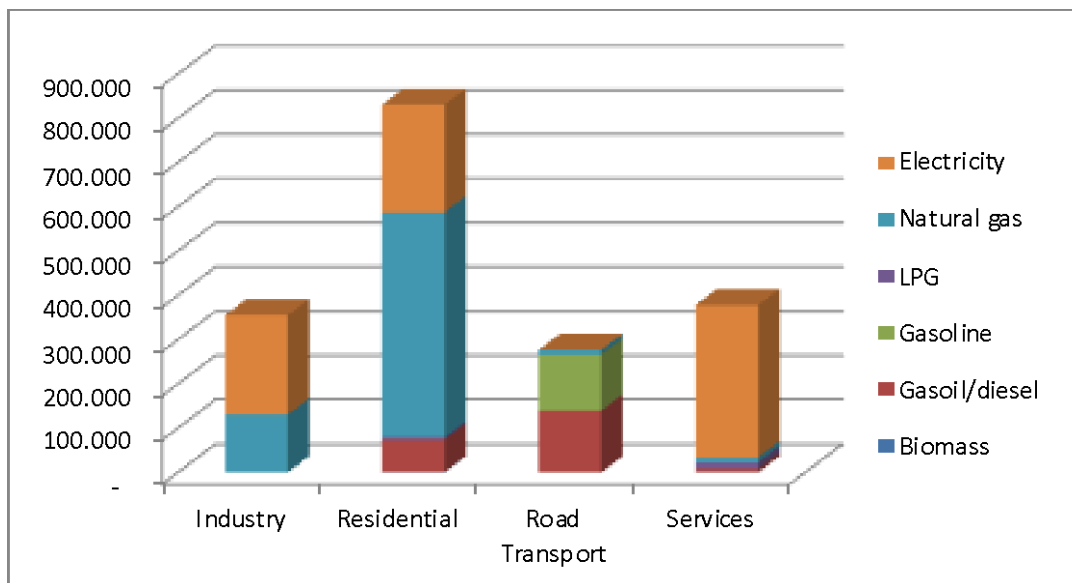


Figure 24 – Genoa Carbon Footprint (Mg CO₂ equivalent on Life Cycle)

In the following maps the results for sectors Carbon footprint are finally reported

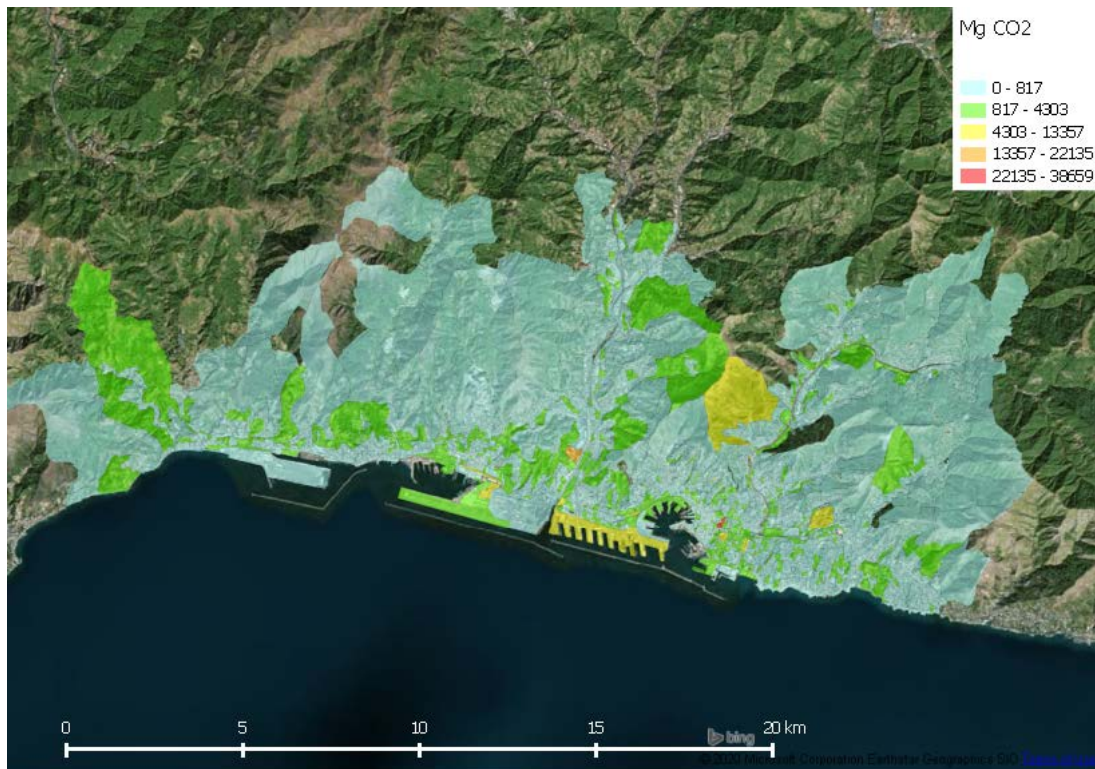


Figure 25 – Genoa Census Sections Carbon Footprint – all sectors

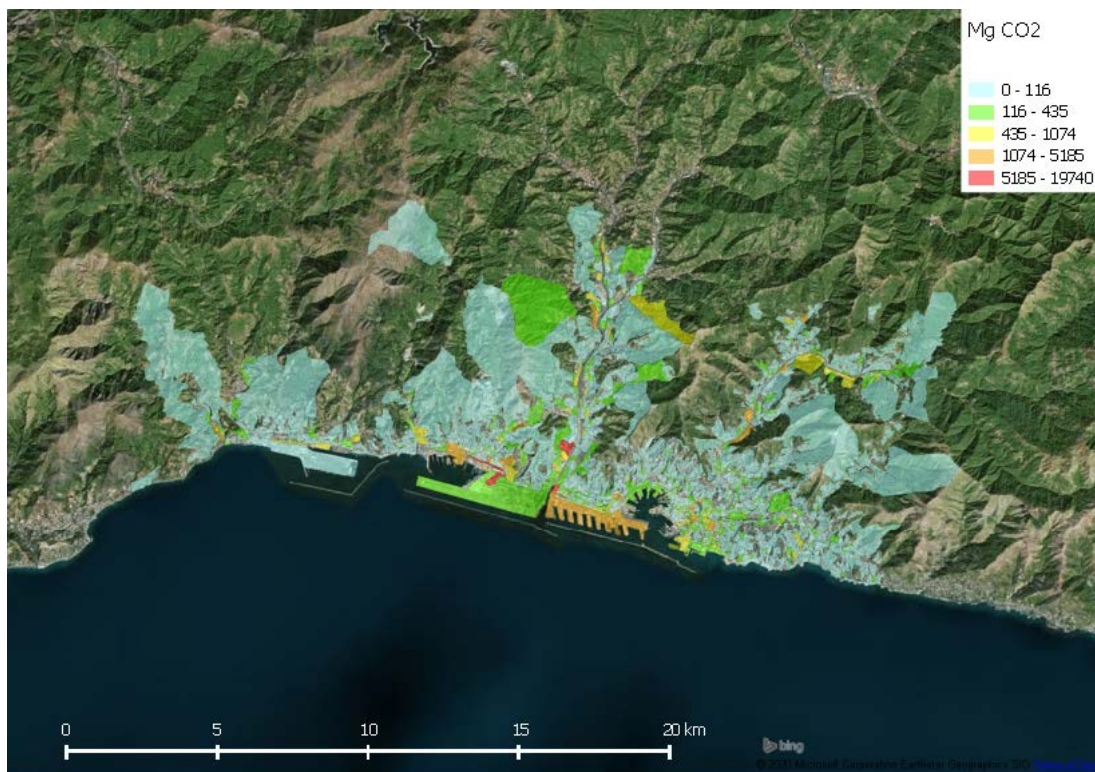


Figure 26 – Genoa Census Sections Carbon Footprint – industry sector

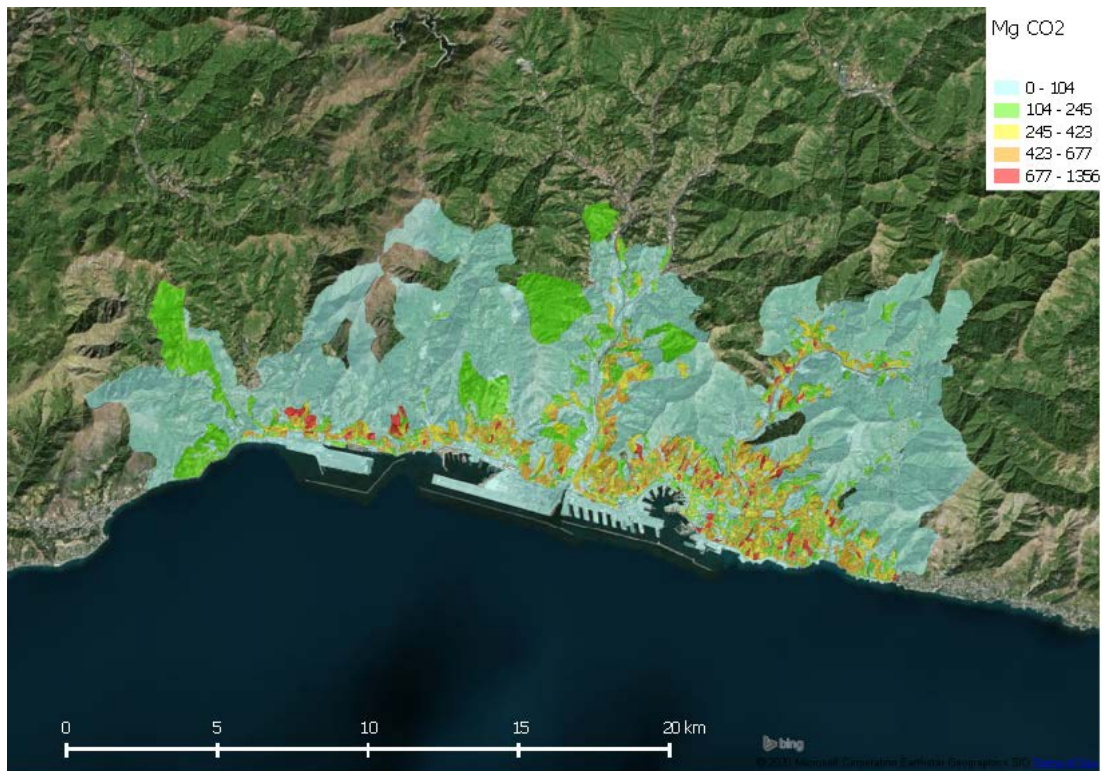


Figure 27 – Genoa Census Sections Carbon Footprint – residential sector

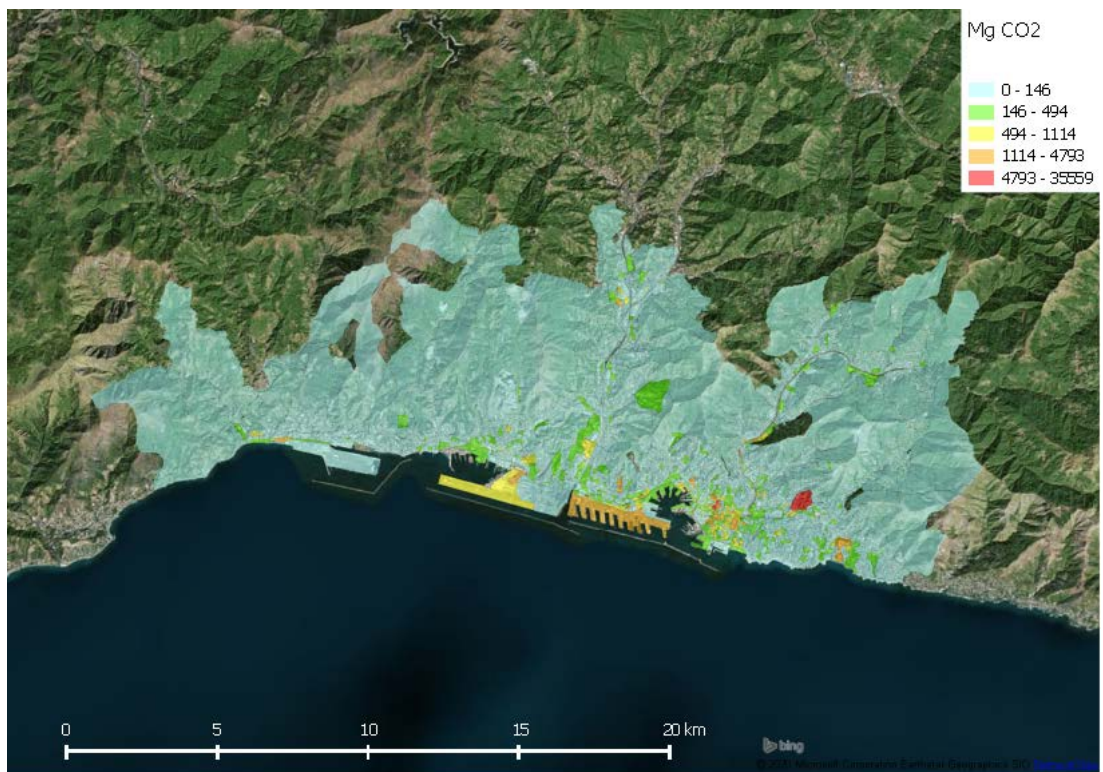


Figure 28 – Genoa Census Sections Carbon Footprint – services sector

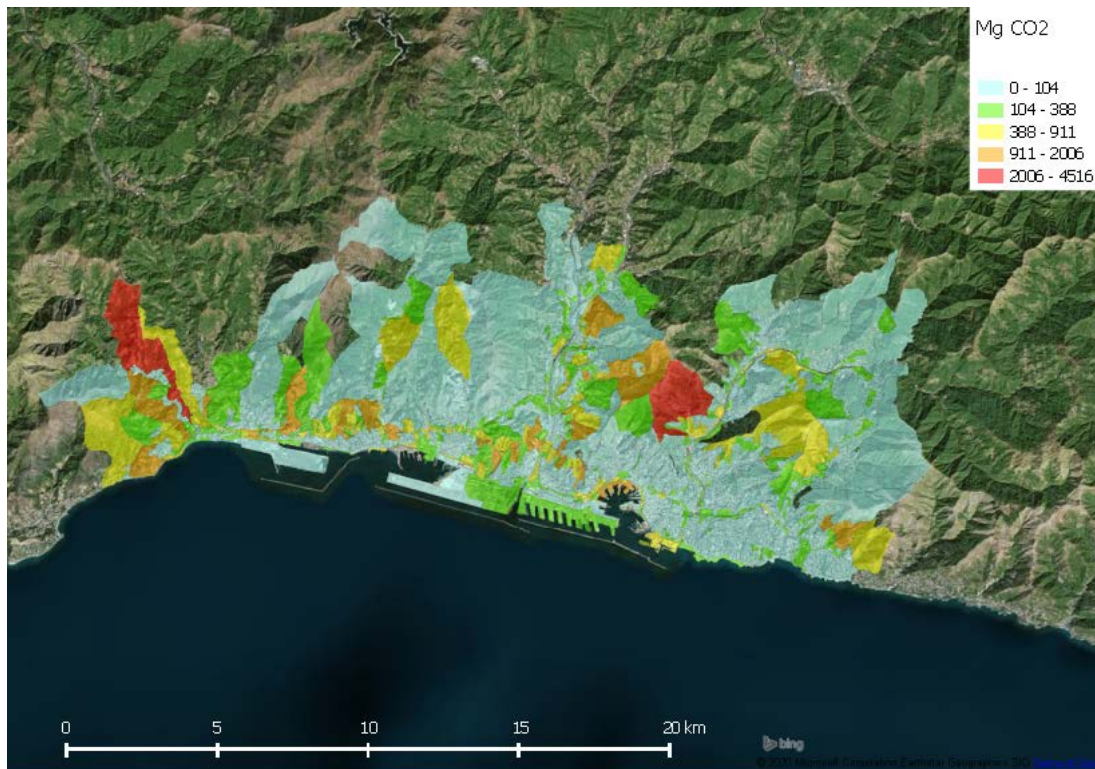


Figure 29 – Genoa Census Sections Carbon Footprint – road transport

3.6 Aveiro Region

3.6.1 Data retrieval and fuel consumptions evaluation

The following tables document the methodology and data used for:

- Industrial sources (Table 27);
- Residential and commercial sources (Table 28);
- Freguesia disaggregation variables (Table 29).

Note that we use Freguesia subdivision at time of 2011 census.

Table 27 – Methodology and source of data for Aveiro Region fuel consumptions/emissions evaluation - Industrial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Note	Disaggregation variable
Industrial sector	Natural Gas	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Employees (Table 29)
	Coal	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Employees (Table 29)
	LPG	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Employees (Table 29)
	Gasoil	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Employees (Table 29)
	Fuel oil	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Employees (Table 29)
	Wood	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Employees (Table 29)
	Biogas	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Employees (Table 29)
	Electricity	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Employees (Table 29)

Table 28 – Methodology and source of data for Aveiro Region consumptions evaluation - Residential and commercial sources

Activity	Energy vector	Data availability	Source	Publication	Reference	Note	Disaggregation variable
Residential sector	Natural Gas	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Dwelling total area (Table 29)
	Wood	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Dwelling total area (Table 29)
	LPG	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Dwelling total area (Table 29)
	Gasoil	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Dwelling total area (Table 29)
	Charcoal	Level 1 (National)	-Geral de Energia e Geologia	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697		Dwelling total area (Table 29)

	Electricity	Level 1 (National)	Geologia	-Geral de Energia e	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697	Dwelling total area (Table 29)
Service sector	Natural Gas	Level 1 (National)	Geologia	-Geral de Energia e	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697	Employees (Table 29)
	Wood	Level 1 (National)	Geologia	-Geral de Energia e	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697	Employees (Table 29)
	LPG	Level 1 (National)	Geologia	-Geral de Energia e	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697	Employees (Table 29)
	Gasoil	Level 1 (National)	Geologia	-Geral de Energia e	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697	Employees (Table 29)
	Electricity	Level 1 (National)	Geologia	-Geral de Energia e	ENERGIA em Portugal 06-03-2017	http://www.dgeg.gov.pt?cr=15697	Employees (Table 29)

Table 29 – Methodology and source of data for Aveiro Region level 3 fuel consumptions evaluation

Variable	Data availability	Sources	Publication	Reference	Fields
Dwelling numbers and area	Level 3 (Freguesia)	Instituto Nacional de Estatistica	Censos 2011	https://censos.ine.pt/xportal/xmain	Number of dwelling by fuel and technology* Average area of dwelling For wood combustion technologies the following association was defined: <i>Aquecimento central</i> with boiler, <i>Aquecimento nao central - lareira aberta</i> with conventional fireplaces, <i>Aquecimento nao central - recuperador de calor</i> with advanced stoves, <i>Aquecimento nao central</i> with conventional stoves
Service sector employees	Level 3 (Freguesia)	Instituto Nacional de Estatistica	Censos 2011	https://censos.ine.pt/xportal/xmain	

3.6.2 Carbon footprint results

In Table 30 Carbon Footprint by fuel is reported for Aveiro expressed as CO₂, CO₂ equivalent and CO₂ equivalent on Life Cycle.

Table 30 – Aveiro Carbon Footprint by Fuel (Mg)

Energy Vector	CO ₂	CO _{2eq}	CO _{2eq,LCA}
Biomass	-	6.330	15.659
Gasoil/diesel	999.419	1.002.113	1.144.887
Gasoline	518.717	520.216	653.644
LPG	72.948	72.948	90.290
Natural gas	320.152	320.152	380.644
Coal	950.909	957.452	1.114.483
Electricity	5.510	5.545	5.780
Total	2.867.656	2.884.757	3.405.387

In Figure 30 Carbon Footprint expressed as CO₂ equivalent on Life Cycle is reported by fuel and sector.

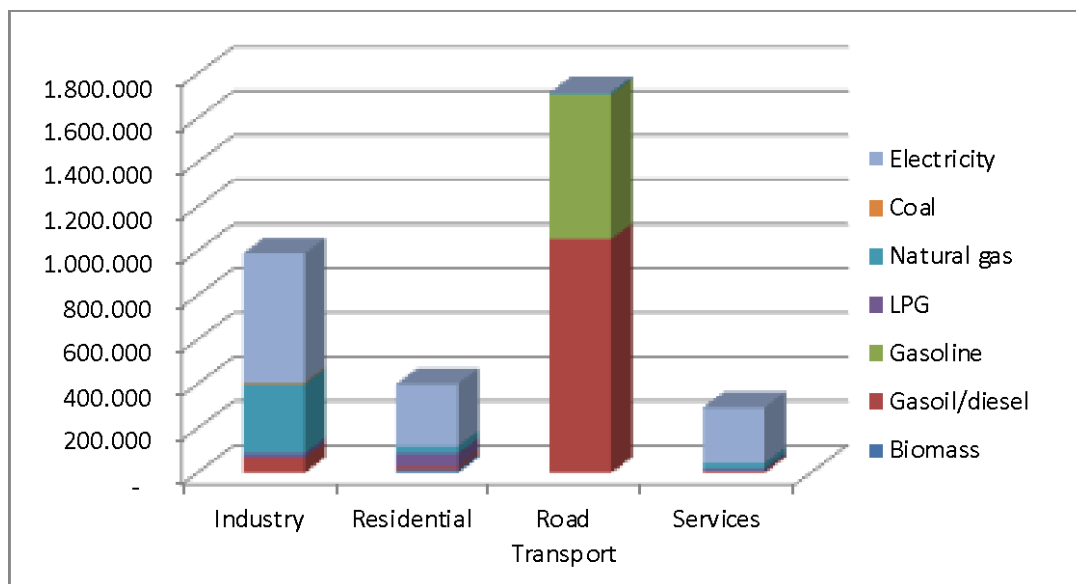


Figure 30 – Aveiro Carbon Footprint (Mg CO₂ equivalent on Life Cycle)

In the following maps the results for sectors Carbon footprint are finally reported

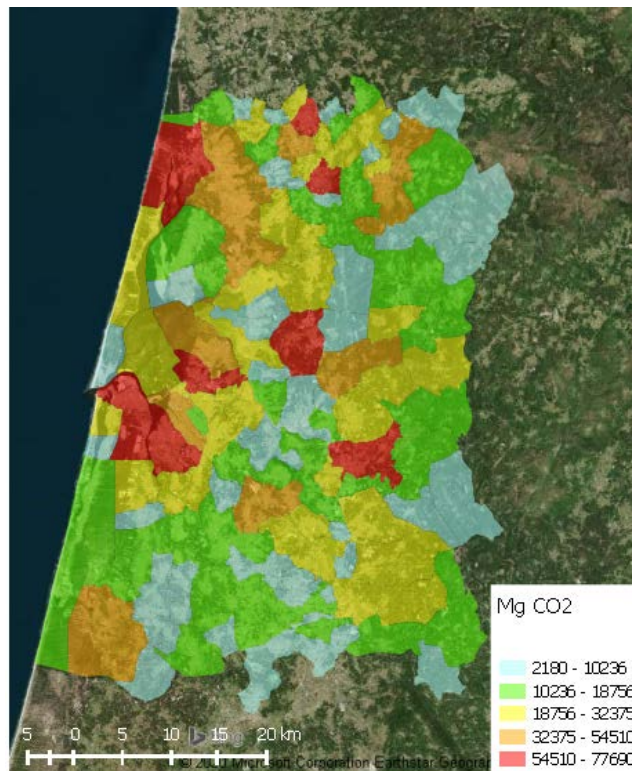


Figure 31 – Aveiro Freguesia Carbon Footprint – all sectors

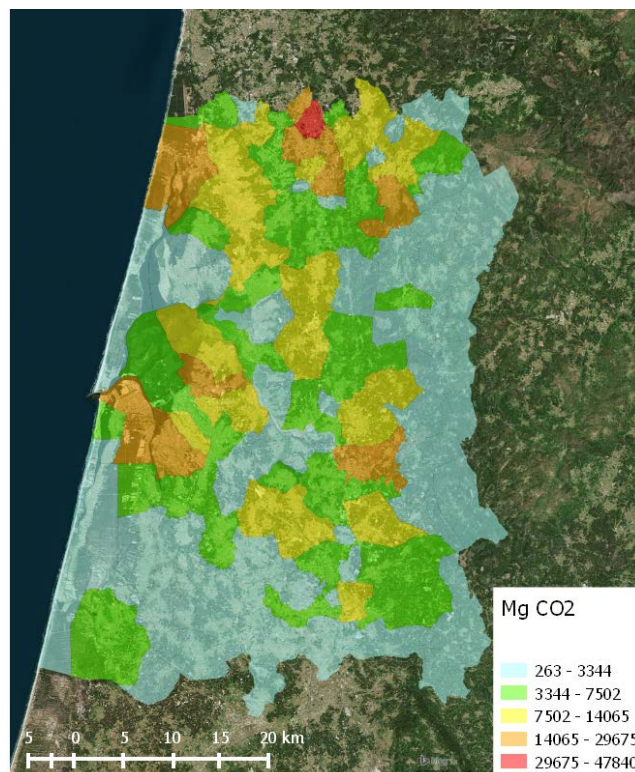


Figure 32 – Aveiro Freguesia Carbon Footprint – industry sector

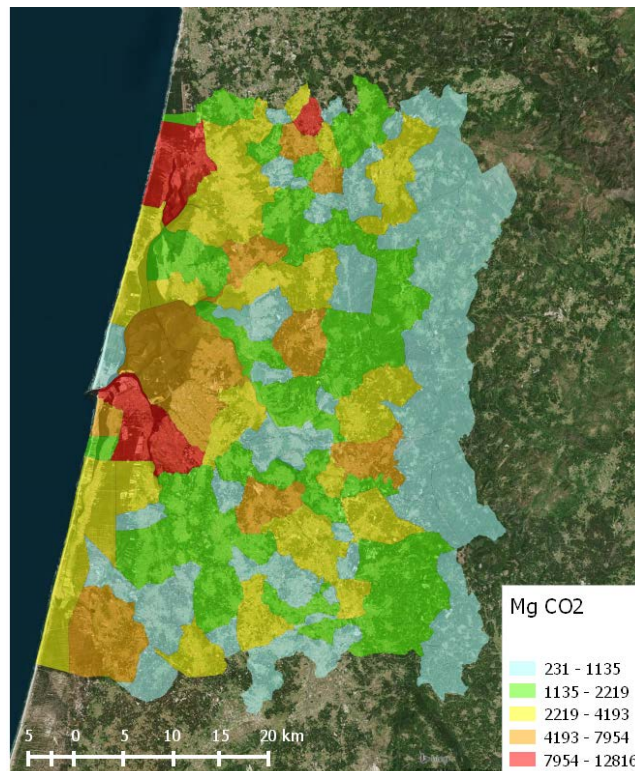


Figure 33 – Aveiro Freguesia Carbon Footprint – residential sector

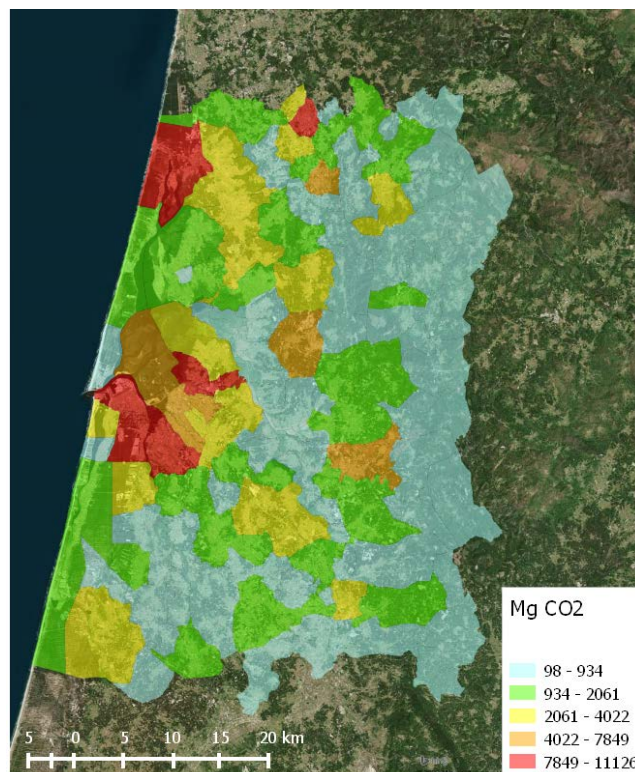


Figure 34 – Aveiro Freguesia Carbon Footprint – services sector

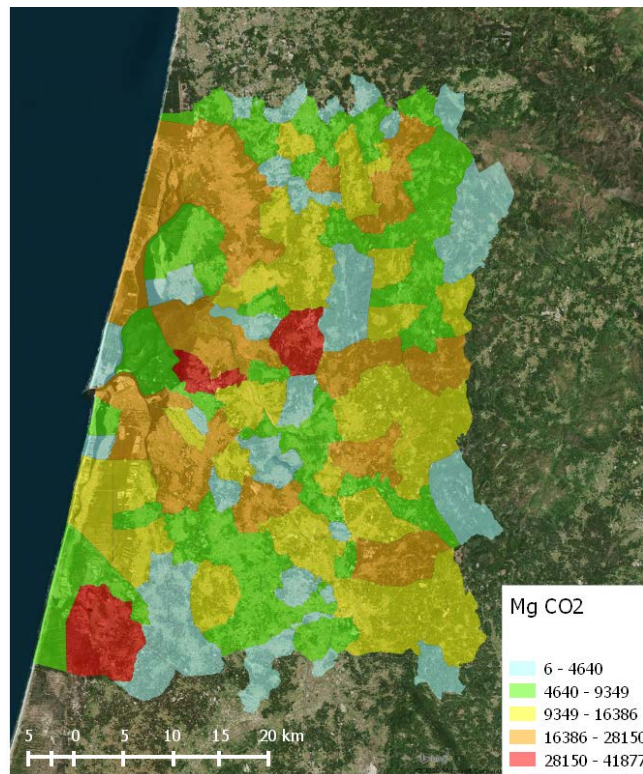


Figure 35 – Aveiro Freguesia Carbon Footprint – road transport