Louvain School of Management

Update of the carbon footprint estimation of Belgian consumption using updated French MRIO methodology

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Nicolas de Moreau d'Andoy

24/06/2025

Abstract :

This thesis aims to estimate the average carbon footprint per capita in Belgium for the year 2019 using a macroeconomic input-output methodology inspired by the one recently developed in France by the SDES and INSEE. Leveraging the FIGARO database from Eurostat, this approach captures the direct and indirect greenhouse gas (GHG) emissions generated by Belgian final consumption, both domestically and through imports.

The results show that the total carbon footprint of Belgian consumption in 2019 was approximately 194.6 million tonnes of CO_2 equivalent (tCO_2e), or 17.02 tCO_2e per capita. A significant share, 65% of these emissions originated abroad, highlighting the country's strong dependence on global value chains. Only 15% of emissions are directly visible to households, which may partly explain the difficulty in perceiving the real environmental impact of personal consumption.

The carbon footprint was broken down into six major categories: equipment (23.6%), transport (23.2%), market services (20.3%), housing (18.2%), food (11.7%), and public services (2.3%). This detailed analysis allows for better targeting of emission reduction strategies.

When compared to France (11.5 tCO_2e per capita in 2019), Belgium exhibits a considerably higher footprint. This difference can be explained by structural factors: a higher GDP per capita, greater reliance on imports, a less decarbonised electricity mix, and a colder climate requiring more heating.

While the study demonstrates consistency with other estimates, some methodological limitations remain, such as the level of sectoral aggregation (64 branches) and the lack of integration with Belgian national accounts. Nonetheless, this thesis provides a solid and operational framework to monitor and analyse the environmental impacts of consumption in Belgium, and offers a valuable foundation for future longitudinal, regional, and socio-economic analyses to guide effective and equitable climate policies.

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Abbreviations

- **AEA** – Air Emission Accounts
- **AWAC** – Agence Wallonne de l'Air et du Climat
- **CH_4** – Methane
- **CO_2** – Carbon Dioxide
- **CO_2e** – Carbon Dioxide Equivalent
- **FIGARO** – Full International and Global Accounts for Research in Input-Output analysis
- **GHGs** – Greenhouse Gases
- **GWP** – Global Warming Potential
- **HFCs** – Hydrofluorocarbons
- **IEA** – International Energy Agency
- **INSEE** – Institut national de la statistique et des études économiques
- **IPCC** – Intergovernmental Panel on Climate Change
- **IOTS** – Input-Output Tables
- **$ktCO_2e$** – Kilotonnes of CO_2 equivalent
- **LCA** – Life Cycle Assessment
- **MRIO** – Multi-Regional Input-Output
- **NACE** – Statistical classification of economic activities in the European Community
- **NF_3** – Nitrogen trifluoride
- **N_2O** – Nitrous Oxide
- **OCDE** – Organisation de Coopération et de Développement Économiques
- **PFCs** – Perfluorocarbons
- **SDES** – Service des Données et Études Statistiques
- **SDGs** – Sustainable Development Goals
- **SNAC** – Single National Accounts Consistent
- **SBTi** – Science Based Targets initiative
- **TES** – Tableaux Entrées-Sorties (Input-Output Tables)
- **tCO_2e** – Tonnes of CO_2 equivalent
- **UN** – United Nations
- **EU** – European Union

Introduction

Climate change stands as one of the most pressing challenges of our time. Human activities, particularly the emission of greenhouse gases (GHGs), are the primary driver of this global phenomenon. Its consequences are already visible: rising average temperatures, accelerated glacier melt, and the increasing frequency of extreme weather events such as droughts, hurricanes and floods etc. These disruptions have far-reaching effects on biodiversity, human health, food systems, and the resilience of economic and social infrastructure.

In response to this environmental crisis, it is a necessity to develop tools to better understand and mitigate their impact. France, for instance, publishes an annual national carbon footprint report through its Ministry of Ecological Transition and the SDES (Statistical Data and Studies Department). Since 2024, the carbon footprint estimate has been co-produced by INSEE and SDES. The carbon footprint measuring the GHG emissions associated with all human consumption activities, both direct and indirect, has become a key indicator for the public about the impact of its behaviours on its environment.

In light of this, it is increasingly important to conduct similar assessments in other countries, particularly those lagging in environmental performance. Belgium, which performs poorly compared to its European neighbours in several environmental indicators, lacks publicly available and detailed national carbon footprint analyses based on household consumption. Understanding the average Belgian carbon footprint and how it is distributed across various consumption categories could highlight key areas for targeted climate action and public awareness.

This thesis seeks to address that gap by answering the following research question: **What is the average Belgian carbon footprint ?**

The first section of the thesis will introduce the key concepts related to climate change and carbon footprint, placing Belgium within the broader international context. A review of the existing literature, particularly studies conducted in Belgium and elsewhere, will then identify current methodologies and highlight the relevance of adapting them to the Belgian case.

The methodology chapter will outline the approach used to calculate the Belgian carbon footprint, explaining in detail every step that has been needed to reach those results. The first stage of the analysis will examine the origin of emissions (domestic vs. imported), followed by a breakdown by household consumption categories: transport, housing, food, equipment, public services (education and administration), and other services.

Finally, a comparison with France will be carried out to identify behavioural and structural differences in consumption patterns between the two neighbouring countries. The thesis will conclude with a discussion of its limitations and the key findings of the research.

Literature review

1. Global context & relevance of the topic

Our world and our society are currently facing what are known as multi-dimensional challenges. Economic and political analysts talk about "polycrises" (World Economic Forum, 2023). In this context, the United Nations has structured these varied and complementary challenges into 17 UN SDGs (see Appendix 1). These 17 SDGs, linked to 169 sub-goals, are targets set by the United Nations to guide countries towards balanced, sustainable and inclusive development by 2030, addressing economic, social and environmental issues. They must "*form a plan of action to free humanity from poverty and put the planet on a path to sustainability. These goals are one and the same and are inseparable. They reflect the three dimensions of sustainable development: economic, social and ecological.*" (United Nations, 2023)

The three SDGs referring to the preservation of our environment are the numbers 13 "climate action", 14 "Life bellow water" and 15 "life on land". However, we can see that these three goals have recently suffered greatly from current evolution in global geopolitics. Political tensions and various wars in Ukraine and Gaza, for example, are causing a crisis in international institutions and undermining SDG 16, "Peace, justice and strong institutions". This is leading to a shift in efforts away from ecological transition towards global rearmament (European Council, 2025) or a political shift aimed at restoring competitiveness as a priority target (SDGs 8 and 9) (Draghi, 2024). The intensification of economic and political wars between global players also calls into question goal 17 "Partnerships for the goals". This can be illustrated by the withdrawal of the US from the Paris Agreement and the World Health Organisation (EPRS, 2025).

Although these international tensions are extremely important and must be addressed seriously, they represent short-term goals. That is why it is also very important not to lose sight of the longer-term goals and to continue to focus on environmental challenges, as they are an essential long-term foundation for all other SDGs (OneEarth, 2023). Indeed, achieving climate goals is a prerequisite for ecological, economic and social stability. Without strong climate action, progress in other areas of sustainable development will be fragile, if not compromised. Conversely, an ambitious climate policy can act as a cross-cutting accelerator for all SDGs.

2. Greenhouse gases as key driver of the environmental challenges

The environmental challenges facing our societies have many interconnected dimensions. The Stockholm Resilience Centre has proposed a clear structure for these issues in the form of nine planetary boundaries, a recognised framework that defines the thresholds that must not be exceeded in order to preserve the stability of the Earth (Stockholm University, 2023).

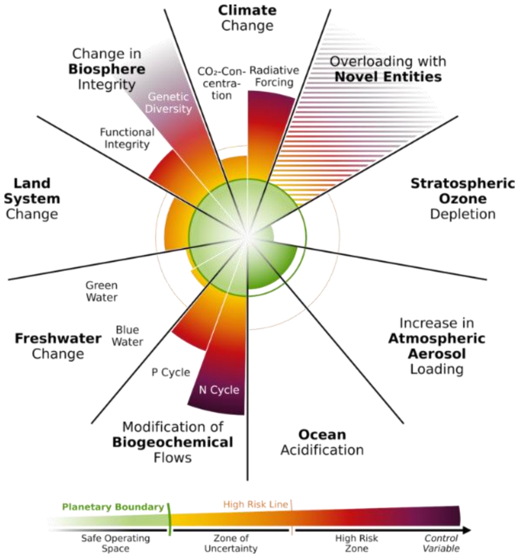


Figure 1 : Planetary boundaries

These nine boundaries are also incorporated into the doughnut economy model developed by Kate Raworth (Cheung, 2021). This visual model proposes a balance between a social floor (satisfaction of basic human needs) and an ecological ceiling (respect for planetary boundaries), thus providing a coherent framework for sustainable development.

Among these nine boundaries, carbon dioxide (CO_2) and more generally greenhouse gases (GHGs) occupy a central place, but all GHG do not have the same impact on our planet and to measure those different impact, we can use the Global Warming Potential (GWP). It is a scientific measure used to compare the impacts of different greenhouse gases on global warming. It measures the amount of heat that a gas traps in the atmosphere over a given period, usually 100 years, relative to carbon dioxide (CO_2), which serves as a reference with a GWP of 1. For example, methane (CH_4) has a GWP of around 25 to 28, which means that one kilogram of methane contributes as much to global warming as 25 to 28 kilograms of CO_2. Nitrous oxide (N_2O), on the other hand, has a GWP of around 298. This indicator therefore makes it possible to convert emissions of various gases into CO_2 equivalents (CO_2e), facilitating their comparison and aggregation. Worth mentioning, they directly influence climate change, one of the most critical boundaries, but also have major indirect impacts on other environmental dimensions.

For example, increasing atmospheric CO_2 contributes to ocean acidification, which severely affects marine ecosystems. In addition, climate disturbances induced by GHGs affect terrestrial and aquatic biodiversity, alter freshwater cycles and destabilise entire ecosystems. These multiple interactions are highlighted in the reports of the IPCC (Intergovernmental Panel on Climate Change), which are now the global scientific reference on climate issues (IPCC sixth report, 2023). The latest findings of this sixth report highlight the unprecedented scale of the challenge facing humanity in terms of reducing greenhouse gas (GHG) emissions. In 2019, global GHG emissions reached 59 gigatonnes of carbon dioxide equivalent ($GtCO_2e$), continuing on a trajectory that is incompatible with international climate targets. In order to limit global warming to 1.5°C with a 50% probability, the remaining carbon budget after 2020 is estimated at around 500 $GtCO_2$. At the current rate, this budget would be completely used up in less than a decade. To meet this target, global emissions will need to be reduced by 43% by 2030 compared to 2019 levels, requiring rapid, deep and systemic transformations across all sectors. The scientific community has agreed on an indicative target of around 2 tonnes of CO_2 equivalent per capita per year by 2050 (2Tonnes, 2024), more than eight times less than the 17.02 tCO_2e per Belgian in 2019.

In this context, it is crucial to improve the knowledge, robustness and operationality of greenhouse gas emission measurement tools. Accurate understanding of the GHG flows generated by our production and consumption systems is a prerequisite for any coherent reduction action. This study is part of this approach, proposing a rigorous method for estimating a country's carbon footprint based on macroeconomic data and input-output matrices. It thus aims to provide a solid quantitative basis for the ecological transition.

3. CO_2e : emissions, measurement and footprint

3.1 Understand in order to act

Climate change is primarily the result of the accumulation of greenhouse gases (GHGs) in the atmosphere, mainly linked to human activities. Our final consumption plays a central role: every good or service consumed generates GHG emissions throughout its life cycle, whether during its production, transport, use or end of life. These emissions can be analysed in a disaggregated manner, distinguishing between different categories of consumption (housing, food, transport, manufactured goods, services, etc.), which makes it easier to identify levers for action at each level. To do this, analyses are often based on a standardised economic classification of productive activities: the NACE codes. These codes make it possible to break down emissions by economic activity and thus link consumption to the sectors that generate it (data.be, 2025). In this paper, we will use NACE codes at level 64, we will divide the total economy into 64 economic activities (see appendix 4).

Measuring the carbon footprint of consumption is therefore essential. Firstly, to obtain comparable and standardised data for the purpose of monitoring developments, making diagnoses and constructing robust indicators. Secondly, because measuring is knowing, and knowledge enables effective action. Without reliable measurement, climate strategies, whether individual or collective, will remain ineffective or misguided.

Measuring the carbon footprint of consumption is important at several levels. At the individual level, it allows everyone to know their own impact, as is the case with the online tool offered by AWAC (Walloon Air and Climate Agency) (AWAC, 2025), or at the company level through tools such as SBTi (Science Based Targets initiative) (Sciencebasedtargets, 2024), which guides companies in defining trajectories compatible with climate objectives. These tools facilitate the implementation of concrete action plans to reduce emissions, tailored to the specific practices of individuals or organisations.

3.2 Carbon emissions or carbon footprints

At the macroeconomic level, measuring the footprint is just as crucial. It enables states, regions or institutions such as the European Union to monitor their transition trajectory, develop relevant climate policies and guide their investments. This is particularly the case in the context of the European Green Deal, which aims to make the EU the first climate-neutral continent by 2050 (European Commission, 2025). To achieve this ambition, it is essential to have accurate data on the origin of emissions: those produced within a country (territorial emissions) and those induced by final consumption, including imports (carbon footprint).

This leads us to a fundamental distinction between emissions and carbon footprint. Territorial emissions correspond to GHGs emitted within a country's borders, according to inventories established by the United Nations. Conversely, carbon footprint refers to all GHGs emitted worldwide to satisfy the final consumption of a given country, including emissions associated with imported goods and services. This approach is therefore better suited to understanding the real responsibility of citizens in global warming.

3.3 A common methodology for a common goal

This reflection is part of a broader context of international cooperation. Numerous global agreements, protocols and initiatives aim at framing and harmonising efforts to reduce emissions on a global scale: the Paris Agreement, the United Nations Sustainable Development Goals (SDGs), the IPCC reports and the European commitments through the Green Deal. All of these highlight the climate emergency and the need to better understand emissions flows in order to better control them.

In this context, the macroeconomic approach, and more specifically input-output analysis, is now the method preferred by international organisations (OCDE, 2006) and the scientific community for measuring countries' carbon footprints in a consistent manner. It enables detailed traceability of emissions in global value chains and provides a robust basis for informing political, economic and individual decisions.

4. Belgium’s case

Several studies have estimated Belgium's carbon footprint using a variety of methodological approaches, ranging from models based on final consumption to those focused on territorial production. These analyses broadly converge towards similar results in terms of scale, while providing complementary insights into the mechanisms underlying emissions.

One of the first notable studies in this field is that of Hertwich and Peters (2009), which is based on multi-regional input-output (MRIO) tables constructed from the GTAP (Global Trade Analysis Project) database, with 2001 as the reference year. This study estimates Belgium's carbon footprint at 16.5 tonnes of CO_2 equivalent (tCO_2e) per capita. It highlights the importance of global supply chains, which are often invisible to end consumers, in the formation of the carbon footprint. The sectors identified as the biggest emitters are transport, housing and food.

In a similar vein, Hambÿe et al. (2017) calculate a carbon footprint of 16.53 tCO_2e per capita for 2007. Their approach combines domestic production data with direct household emissions, while emphasising the relevance of MRIO tables for small, highly open countries such as Belgium. This method provides a more accurate representation of foreign technologies integrated into imported goods.

A study by Vercalsteren et al. (2017), focusing on Flemish citizens, estimates the carbon footprint at around 20 tCO_2e per capita for 2010. This calculation is based on an input-output environmental model linked to the EXIOBASE database. The categories of consumption with the highest emissions remain similar: housing, transport and food.

In an analysis covering the period 1995-2002, Sissoko and Vandille (2008) show that Belgium was a net exporter of emissions: emissions linked to the production of exported goods exceeded those generated by domestic consumption. This phenomenon highlights the complexity of international carbon flows for a country that is highly integrated into global value chains.

The Global Resource Footprint of Nations report (2014) corroborates these findings, ranking Belgium 13th in the world in terms of carbon footprint per capita. For 2007, the footprint is estimated at 16.46 tCO_2e, nearly three times the global average (2.88 times).

Furthermore, Goedemé et al. (2020), using the PEACH2AIR model, highlight social disparities in emissions profiles. Their work reveals that low-income households have a higher footprint per euro spent. This trend can be explained by consumption that is more concentrated on essential but high-emission items, such as housing and electricity. Their study also confirms that most emissions come from the production phase of goods and services.

Finally, data published by Our World in Data, compiled by a research team at the University of Oxford in collaboration with the non-profit organisation Global Change Data Lab, estimates CO_2 emissions per capita based on consumption in Belgium at 17.6 tonnes for 2019. This data is also available for many other countries, allowing for greater comparability. It confirms the orders of magnitude reported in other studies and highlight the persistence of a high carbon footprint, despite the political and technological efforts made.

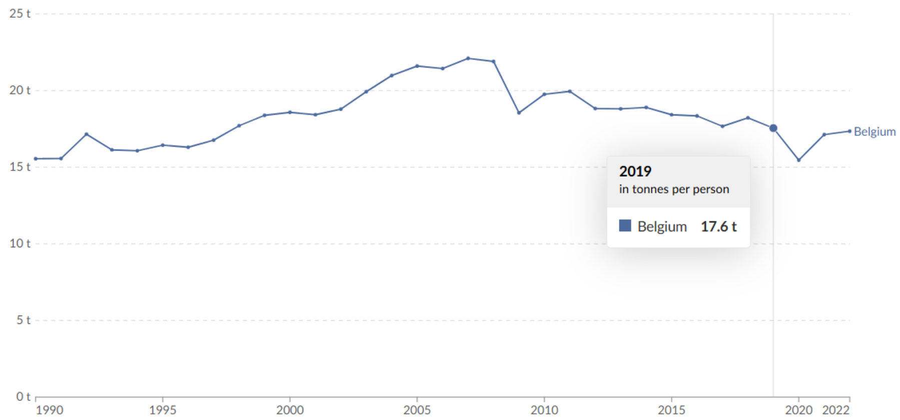


Figure 2 : Evolution of Belgium's carbon footprint according to OurWorldInData

We can therefore observe that, relatively few comprehensive studies on the subject have been published concerning Belgium and that different methods are systematically used, leading to varied results. These results nevertheless generally hover around 16.4t - 17.6t, which reveals an order of magnitude to keep in mind for the rest of this study.

5. Motivation and objectives of the research

Given the growing number of studies on Belgium's carbon footprint, it seems essential to continue efforts to refine our understanding of this complex phenomenon and to make better use of the available data. Calculation methods and databases are evolving rapidly with each new publication, making it necessary to update analyses regularly to reflect the latest advances.

With this in mind, this thesis is a continuation of work carried out last year at the Louvain School of Management, entitled "*Breakdown of the Average Belgian Carbon Footprint by Consumption Category in 2019*" (M'Rabet, Yasmine & Cornet Fontaine, Rosalie). This thesis was a first structured attempt to break down the Belgian carbon footprint by consumption category, drawing heavily on the method developed by the French Ministry for Ecological Transition and Territorial Cohesion.

Since the publication of this previous work, there have been significant developments in official calculation methods. In particular, at the end of 2024, a new methodology was published by the Service des données et études statistiques (SDES), in collaboration with INSEE, under the direction of Manuel Baude and Sylvain Larrieude. This updated method differs from the previous one in that it adopts the FIGARO database developed by Eurostat. FIGARO is a multi-regional input-output (MRIO) table covering all global economic flows, thus providing a better representation of international trade and the imported carbon footprint.

This thesis is therefore mainly based on this new French methodology, adapting it to the Belgian context and incorporating the findings of last year's thesis. The objective is twofold: on the one hand, to update the estimate of the average carbon footprint of Belgians using the most recent tools; on the other hand, to propose an improvement in the breakdown by consumption item, in light of the new data available. The technical aspects of this approach will be detailed in the methodological section.

Methodology

1. General methodological framework

The objective of this master thesis is to calculate Belgium's carbon footprint, and more specifically the carbon footprint per capita for the year 2019. The methodology used is largely inspired by the methodology developed by the French *Service des données et études statistiques (SDES)* in collaboration with the *Institut national de la statistique et des études économiques (INSEE).* This collaboration, established to calculate France's carbon footprint, has been in place since 2024 and has been accompanied by a comprehensive review of the estimation method used until then. Unlike other environmental indicators, there are no internationally established standards that precisely regulate the calculation of a country's carbon footprint. This opens the way for a variety of methodological approaches (SDES, 2023). Among these, macroeconomic modelling, and more specifically input-output analysis, is the method preferred by international statistical organizations and the scientific community (OCDE, 2006). It is precisely this approach that has been adopted by the SDES and INSEE in France (Baude, 2024). The use of this methodology ensures that the results obtained are relevant and comply with practices recognized by specialized institutions.

The methodology adopted consists of calculating the carbon footprint based on the place of consumption of goods and services, in this case in Belgium, rather than the place of production of the emitting activities. The emissions taken into account can be direct, such as CO_2 emitted by an oil-fired boiler in Belgium, or indirect, such as those linked to the cultivation of tomatoes in Spain, which are then imported for consumption in Belgium. It is also important to understand that the greenhouse gases emitted on Belgium’s territory for good and services consumed outside of Belgium are voluntarily subtracted since they are produced for citizens in other countries for their own consumption.

The decision to adopt a proven methodology offers several advantages: it ensures a certain degree of comparability between countries, while relying on a rigorous approach that has been validated by specialized institutions. This methodological choice is also particularly relevant in the current context of globalized trade, as it allows for the inclusion of indirect emissions associated with imported products that would otherwise be invisible in traditional territorial accounting. The revised method is based on a symmetrical international input-output table (or MRIO model, Multi Region Input Output), developed by Eurostat: the Figaro model (Baude, 2024). This makes it possible to trace all direct and indirect emissions generated throughout the production chain for every euro spent on final consumption. This approach provides a systemic view of the climate impacts of consumption, taking into account the complexity of international value chains. Also, the use of the Figaro IOTS significantly improves the measurement of the emissions content of imports and the identification of the geographical origin of emissions.

2. Belgian carbon footprint's scope

2.1 Economic framework

The emissions taken into account in this calculation are those resulting from household consumption, public administration consumption, final consumption of non-profit institutions serving households, and gross capital formation. All these emissions have been calculated using several categories :

- Emissions related to local production for final demand
- Emissions related to imports for final demand
- Emissions related to imports for intermediate demand
- Direct emissions from households

For each of these categories, emissions are also separated into production sectors according to the initial classification made by Eurostat in its FIGARO database. Eurostat uses the NACE codes, which divide economic flows into 64 branches of activity.

2.2 Greenhouse gases framework

The carbon footprint taken into account in this study includes all the main greenhouse gases (GHGs) recognized by the Intergovernmental Panel on Climate Change (IPCC) like it has been done in the French methodology. These are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (HFCs, PFCs, SF_6 and NF_3), this is in accordance with the Air Emission Accounts (AEA) also published by Eurostat in the FIGARO database. To enable consistent comparison and aggregation, the emissions of these different gases are expressed in CO_2 equivalents (CO_2e), applying their global warming potential (GWP) over a 100-year period, in accordance with IPCC recommendations.

Those conversion rates are as follows :

Greenhouse gases	Formula	Global warming potential (GWP)
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	273
Sulphur hexafluoride	SF_6	25 200
Nitrogen trifluoride	NF_3	17 400
Fluorinated gas	HFC, PFC, HFE, CFC, HCFC	10 - 14 800

source : AR6 regulation EU 2024/590 and 2024/573 CLIMAT.BE

Figure 3 : Global Warming Potential

Carbon dioxide (CO_2)

CO_2 is the main greenhouse gas emitted by human activities. It is mainly generated by the combustion of fossil fuels (oil, coal, natural gas) in the energy, transport, industry, and heating sectors. It is also emitted during certain industrial processes, such as cement or steel production. Due to its long lifetime in the atmosphere and its massive contribution to global emissions, CO_2 is the central benchmark in carbon footprint measurement. Although it has a GWP of 1 (by definition), it alone accounts for about three-quarters of global GHG emissions.

Methane (CH_4)

Methane is a greenhouse gas with a global warming potential approximately 28 times greater than that of CO_2 over a century. It is emitted mainly by agricultural activities (ruminant digestion, manure management), organic waste landfills, and leaks during the extraction and transport of fossil fuels. Although its lifespan in the atmosphere is shorter than that of CO_2 (approximately 12 years), its impact on the climate is very high in the short term. It is therefore essential to take it into account when assessing the real impact of food systems and agriculture.

Nitrous oxide (N_2O)

N_2O is a greenhouse gas with a global warming potential approximately 265 times greater than that of CO_2. It is mainly emitted during the use of nitrogen fertilizers in agriculture, but also during certain industrial processes and in wastewater treatment. Although it is present in smaller quantities, its very high warming potential justifies its inclusion in any rigorous calculation of carbon footprints, particularly when considering the environmental impacts of agricultural production.

Fluorinated gases (HFCs, PFCs, SF_6, NF_3)

Fluorinated gases are synthetic compounds used mainly as refrigerants (air conditioning, refrigeration), in certain industrial processes, or in electronic equipment. Their GWP can exceed several thousand times that of CO_2. Although their impact is relatively low, considered <1% of GHG, it is nevertheless important to consider them particularly in assessments related to household equipment, electronics, and the cold chain.

2.3 Time framework

The year 2019 was chosen as the reference year for this study for several key reasons. First, the economic and environmental data needed to calculate the carbon footprint are available and consolidated for this year, both at the national and European levels. Input-output tables, emissions inventories, and sectoral emission factors have all been published in full, ensuring the reliability of the results.

Second, 2019 represents a “neutral” year in economic terms, it was not affected by major events that could significantly disrupt consumption patterns or supply chains. It thus precedes the COVID-19 health crisis, which has profoundly changed mobility, work and consumption habits, as well as the start of the war in Ukraine, which has led to severe energy and economic tensions. These disruptions would have introduced significant biases in the analysis of a more recent year.

Finally, the choice of 2019 ensures direct comparability with other existing work, in particular the official reports published by the SDES in France, as well as the master thesis produced in 2024. This temporal consistency allows the Belgian results to be placed in a solid and relevant comparative perspective.

3. Required data

All data used to calculate Belgium's carbon footprint comes from the FIGARO database of Eurostat. FIGARO is a new European dataset created in 2024 that provides harmonised multi-country input-output tables, enabling detailed modelling of economic relationships between countries and thus estimating imported emissions as part of a footprint approach. The publication of this new dataset is one of the main reasons that enabled the SDES and INSEE to develop the new methodology. This dataset meet European methodological standards and cover the year 2019. Three tables were used to estimate the carbon footprint, taking into account both direct and indirect emissions:

1. Air Emission Accounts (AEA) are the air emission accounts published by Eurostat, which indicate annual greenhouse gas emissions (CO_2, CH_4, N_2O and others) by economic sector, according to the NACE nomenclature (see Appendix 4). These data are expressed in thousands of tonnes of CO_2 equivalent and are used to calculate emission intensities (e.g. kg CO_2/€ of production) for each Belgian production sector. These accounts also include direct emissions from households.

2. The EU inter-country input-output table at basic prices, industry by industry, presents production and consumption flows in € between economic sectors. It makes it possible to model the interdependencies between all sectors in all countries and to calculate the technical coefficient matrix (A) used in input-output analysis. This table is available for 45 countries plus one region "rest of the world". This provides an understanding of Belgium's production structure and also makes it possible to track the flows of goods and services incorporated into imports and exports. This dimension is essential for estimating the indirect emissions associated with international trade.

3. The Belgian Use Table at Basic Prices describes the distribution of intermediate and final consumption of goods and services by industry and by product. It provides information on the volumes of products used in each sector and final consumption expenditure by category.

When combined, these three tables make it possible to reconstruct all emissions generated by domestic production to meet domestic demand, while complying with the principles of environmental accounting used at European level.

3.1. FIGARO vs SNAC

In the methodology described by the SDES (Statistical Data and Studies Department), the authors used the simplified SNAC (Single National Accounts Consistent) method, an approach designed to adapt the results of multiregional databases such as FIGARO to specific national economic characteristics. This method is based on the observation that, although databases such as FIGARO allow trade and value chains between countries to be traced in great detail, they are not always fully consistent with national macroeconomic data (from national accounts).

The aim of the SNAC method is therefore to reconcile these two sources. It retains FIGARO's interconnected global structure, but corrects or adjusts certain key values (such as final demand, production or imports) to make them compatible with official national statistics, which are considered more reliable and up to date.

In concrete terms, the simplified SNAC method applies adjustments to the national input-output table in order to maintain the macroeconomic balances observed by the country (e.g. in Belgium or France), while taking advantage of the richness of the international production chains described by FIGARO. This makes it possible to obtain a carbon footprint of consumption that is both accurate in international detail and faithful to domestic economic realities.

The simplified SNAC only modifies flows for a single country without seeking to harmonise all the countries in the database (hence the term “single”).

The SNAC method was not applied in this study. The calculations were made directly from the raw data in the FIGARO database, without adjustment to the Belgian national accounts.

The main difference with the SNAC method lies in the treatment of imports. An inter-country input-output table (MRIO) such as FIGARO cannot perfectly match the national accounts of each country, as its authors are faced with a problem of inconsistency between the data reported by countries. This is because what country A reports as imports from country B generally differs from what country B reports as exports to country A, both in terms of total value and by product. This inconsistency forces MRIO designers to make trade-offs: to ensure the overall consistency of global flows, they must modify either imports, exports, or both.

In the case of FIGARO, the exports reported by countries are kept as they are, while imports are adjusted. In practice, this means that Belgium's imports (or those of any other country) in FIGARO do not correspond exactly to those presented in its national accounts. More precisely, the total remains the same, but the breakdown by product may differ significantly.

In general, Belgium imports in FIGARO consist of a relatively smaller share of goods and a larger share of services. This will have the effect of overestimating the share of services in the breakdown of Belgium's carbon footprint.

Although simplifying, this methodological choice ensures complete consistency with the internal structure of the FIGARO database, without introducing any exogenous corrections.

4. Estimating Belgium citizen's carbon footprint

There are two main approaches to estimating the carbon footprint of consumption. The first, microeconomic in nature, is based on combining detailed data on household consumption habits with specific emission factors, generally derived from product-by-product life cycle assessments (LCA). The second is a macroeconomic approach, which combines aggregated monetary and physical statistical data.

This second method is the one used by institutions such as INSEE and SDES to assess the carbon footprint of French domestic demand. In this context, the carbon footprint corresponds to all greenhouse gas emissions generated, directly or indirectly, by a country's final domestic demand, regardless of where the goods and services concerned are produced, whether locally manufactured or imported.

Input-output accounting in economics originated in the intersectoral analysis work of economist Wassily Leontief, who developed the first input-output tables (IOTs) in the 1930s and 1940s (J.M. Guilhoto, 2021). This method is now widely recognised and extensively described in economic literature.

Input-output analysis applied to environmental issues is also based on work carried out by Leontief in the 1970s, when he combined IOTs with environmental data expressed in physical units. This approach was revived in the 1990s by the Dutch statistical office, notably through the proposal of an inventory format compatible with air emissions accounts (AEA) (Keuning et al., 1999). Since then, environmental input-output analysis has become a well-established field.

a. Formula breakdown

To perform this calculation, we start with the classic Leontief equation for a IOTS:

$$E = e\,(I-A)^{-1}FD$$

Whereas, **E** is the total emissions, **e** is the emission vector, **I** is identity matrix, **A** is the technical coefficient matrix and **FD** is the final demand.

As shown in Appendix 3, this equation can be broken down as follows:

$$E = e_{BE}\,.\,(I - A^{BE}{}_{BE})^{-1}\,.(FD_{BE}) + e\,.\,(I-A)^{-1}\,.\,A^{BE}{}_{M}\,.\,(I-A^{BE}{}_{BE})^{-1}\,.\,FD_{BE} + e\,.\,(I-A)^{-1}\,.\,FD_{M} + DHe$$

Where each part represents CO_2e emissions linked to: final demand for domestic production, intermediate demand for imports, and final demand for imports. To this total is also being added the direct household emissions (DHe).

i. *Details of the calculation of domestic production*

This part aims to estimate greenhouse gas emissions generated solely by production carried out on Belgian territory, with the aim of meeting final domestic demand in Belgium.

Domestic emission intensity vector: e_{BE}

This vector of dimension 64×1 represents the emission intensity of each Belgian industry i . It is obtained by relating the GHG emissions expressed in CO_2e of each industry, coming from the Air Emission Accounts, to the corresponding economic output. Each element e_i indicates the amount of CO_2e emitted per monetary unit produced in the Belgian sector i.

Domestic technical coefficient matrix: $A^{BE}{}_{BE}$

This is a square matrix (64×64) representing the intermediate inputs used by Belgian industries. Each coefficient a_{ij} indicates the quantity of input i needed to produce one unit of output j. This matrix describes the sectoral interdependencies within the Belgian economy, excluding any effects related to imports.

Domestic final demand vector: DF_{BE}

This vector (64×1) reflects Belgian final demand expressed solely in Belgian products. It is calculated by subtracting the exports of goods and services of each industry to their total final use.

Calculation steps

The calculation is based on the following Leontief equation:

$$E_{\text{domestic emissions}} = e_{BE} \, . \, (I - A^{BE}{}_{BE})^{-1} \, .(FD_{BE})$$

Here are the details of each step:

1. Construction of the inverse Leontief matrix: We start by calculating the inverse matrix $(I - A^{BE}{}_{BE})^{-1}$, which represents the total production required (both direct and indirect) in each Belgian sector to deliver one unit of final demand. This step

captures the interdependencies between sectors, taking into account all upstream production required to meet final demand.

2. Application of the emission intensity vector: The emission intensity vector e_{BE}, which contains the direct emissions per unit of output for each Belgian sector, is then multiplied by the Leontief inverse matrix. The result is a new vector where each element reflects the total emissions associated with one monetary unit of final demand in each product category.

3. Multiplication by the final demand vector: This new vector is then multiplied by the vector FD_{BE}, which represents the Belgian final demand expressed in domestic products. This final step aggregates the emissions over all sector, yielding the total volume of CO_2e emissions generated by domestic production to satisfy the Belgian final demand.

After all those steps, we end up with a vector (64x1) representing the total amount of CO_2e emitted by each branch for final demand of domestic production. We can than add up every value to get the total emissions.

ii. Details of the calculation of imports for intermediate demand

This part estimates the greenhouse gas emissions associated with the share of foreign production used as inputs by Belgian production sectors. These are therefore emissions imported indirectly via international supply chains.

<u>Total emission intensity</u>: $e(I - A)^{-1}$

This vector (2880×1) represents the total emission intensity (direct and indirect) associated with each industry of every 44 countries (outside of Belgium) and the region "rest of the world", in the economic system under consideration. It is calculated by multiplying the direct emission intensity vector e, expressed in tonnes of CO_2e per monetary unit produced, by the inverted Leontief matrix $(I-A)^{-1}$ (2880×2880), which reflects the interdependencies between productive sectors at the international level and makes it possible to simulate the effects of Belgian demand on the entire global value chain.

Imports technical coefficient matrix: $A^{BE}{}_{M}$

Those are the technical coefficients of foreign products used as inputs by Belgian industries. This sub-matrix (2880×64) extracts from matrix A the intermediate flows that relate only to foreign inputs consumed by Belgian sectors. It allows foreign contributions to Belgian production to be targeted.

Matrix $A^{BE}{}_{BE}$ and vector FD_{BE}

These two elements are identical to those described in the first step. They represent, respectively, the internal interdependencies of Belgian production and the final domestic demand.

Calculation steps

The calculation also follows a three-step logic, but incorporates the effects of global value chains. We use this equation:

$$E_{\text{imports for intermediate demand}} = e \;.\; (I\text{-}A)^{-1} \;.\; A^{BE}{}_{M} \;.\; (I\text{-}A^{BE}{}_{BE})^{-1} \;.\; FD_{BE}$$

Here are the calculation steps:

1. The vector FD_{BE} (Belgian final domestic demand for Belgian products) is multiplied by the inverse matrix $(I - A^{BE}{}_{BE})^{-1}$. This operation determines the total production required from each Belgian industry to meet this demand, including domestic intermediate consumption.

2. The result is then multiplied by the matrix $A^{BE}{}_{M}$, which represents foreign products used as inputs by Belgian industries. This calculation isolates the volumes of foreign products needed for domestic production destined for Belgian final demand.

3. The vector obtained is then multiplied by the vector $e(I - A)^{-1}$, constructed from global technical coefficients and the global emission intensity vector. This makes it possible to take into account the direct and indirect effects on the global value chain and converts these production volumes into imported CO_2e emissions.

This calculation makes it possible to identify the external carbon impact required for domestic production and to better understand the Belgian economy's dependence on global value chains.

iii. *Details of the calculation of imports for final demand*

The calculation is based on the same structure as that used for global emission intensities. The product $e(I-A)^{-1}$ is already obtained when estimating imported emissions via intermediate demand. It is then used to calculate the emissions associated with goods and services imported directly as final consumption.

$$E_{\text{imports for final demand}} = e \,.\, (I\text{-}A)^{-1} \,.\, FD_M$$

1. Use of the global total emission intensity vector: The vector $e(I-A)^{-1}$ representing the total emissions per unit of final demand for each sector and each country in the inter-country model. It includes all emissions generated at each stage of global value chains.

2. Multiplication by imported final demand: The FD_M vector corresponds to Belgian final demand for imported products, broken down by product and country of origin, it is extracted from the $A^{BE}{}_M$. Multiplying this vector by the global total emission intensity vector makes it possible to estimate the total amount of CO_2e emissions incorporated into imported goods and services as final consumption by Belgium.

This calculation completes the Belgian carbon footprint by including emissions generated abroad that are directly linked to the final consumption choices of Belgian economic agents.

iv. *Details of direct household consumption*

In addition, emissions associated with the production of goods and services, the carbon footprint also includes direct emissions generated by households themselves, mainly emissions from the combustion of fossil fuels for domestic use. These emissions are directly attributed to households because they do not pass through a market production process. They are therefore accounted for separately, without going through the input-output approach.

The data comes from the AEA, which break down greenhouse gas emissions by sector of activity, including a specific sector dedicated to ‘households as final consumers’. They are separated into three categories :

- *Heating/cooling activities by households*
- *Transport activities by households*

- *Other activities by households*

b. Final outcome

Once all these steps have been completed, we need to add the four components together to get to Belgium's total carbon footprint.

Finally, the last step is to divide this total by the population of Belgium in 2019 to determine the carbon footprint per capita in Belgium in 2019.

5. Breakdown by consumption category

The input-output calculation is based on the NACE classification and breaks down the carbon footprint into 64 categories of goods and services, supplemented by three specific items related to direct household emissions. However, to make the results easier to read and understand for a non-expert audience, and to enable better comparison with so-called 'microeconomic' approaches (based on emission factors multiplied by activity data), it is useful to group these detailed items into broad categories of final consumption. These groupings highlight the major sources of emissions in everyday life:

- Food
- Housing
- Transport
- Equipment (purchases of durable goods)
- Commercial services
- Administration, Health, Education, Social work

To allocate the 64 industry branches to these six final consumption categories, we can use the conversion table A2.1 (Baude, 2024) available in the Appendix 5+. Some NACE branches cover several end uses, so their emissions are allocated to different consumption categories according to specific criteria:

- Product C19 (coke and petroleum products): emissions are allocated between the 'transport' and 'housing' categories according to the share of fuels used for transport and fuels used for domestic heating.

- Product D35 (electricity, gas, steam): emissions are broken down between “housing” and ‘food’ according to the uses of electricity (heating, hot water, cooking, etc.).
- Product I (hotels and restaurants): emissions are divided between ‘food’ and ‘market services’ according to the added value of the sub-categories “catering” and ‘hotels’.
- Product E37-39 (waste and wastewater management): emissions are divided between ‘food’, “housing” and ‘equipment’ based on the composition of household waste from the “MODECOM” survey done by the Ademe.

The rest of the 64 branches are allocated to only one consumption category.

6. Operated tools

The entire analysis was carried out mainly using Microsoft Excel, which was the central tool for data processing, supplemented by Python for certain specific operations.

Excel was used to extract data directly from Eurostat databases, in .xlsx formats. It enabled the input-output tables to be structured, cleaned and formatted, whether they were national or from the FIGARO global database. All calculations involving matrices of a reasonable size, such as those limited to Belgium (64×64), were carried out directly in Excel. Sectoral aggregations, unit checks and graphical visualisations were also carried out in this environment.

However, some operations exceeded Excel's technical capabilities, particularly those involving the manipulation of very large matrices (such as the global matrix of technical coefficients with dimensions 2880×2880) or the inversion of matrices. In these cases, Python was used, in particular with the Numpy function, in order to guarantee both fast processing and accurate results.

The complementary use of these two tools made it possible to combine methodological rigour, robustness of calculations and accessibility, while ensuring the reproducibility of the processing.

Results

1. Overall results and key figures

The approach used in this work allows for a comprehensive assessment of the greenhouse gas emissions associated with the final consumption of goods and services by Belgian residents, whether those emissions occur domestically or abroad.

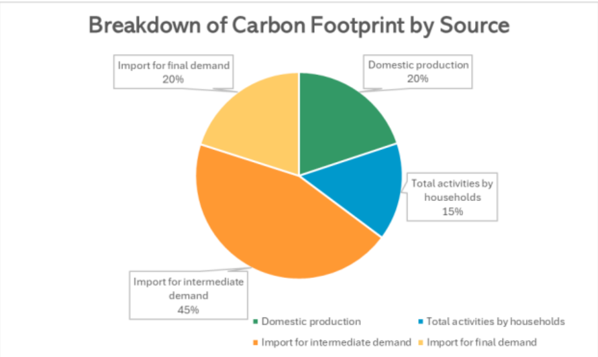
The final results are expressed in tonnes of CO_2 equivalent (CO_2e), although the detail of those results will be expressed in thousands of tonnes of CO_2 equivalent ($ktCO_2e$).

The methodology accounts for four distinct emission components:

1. *Domestic emissions*, generated on Belgian territory to produce goods and services consumed by Belgian residents;
2. *Imported intermediate emissions*, are emissions produced abroad during the manufacturing of intermediate goods used in Belgian production processes;
3. *Imported final demand emissions*, which correspond to emissions generated abroad for final imported goods and services directly consumed in Belgium.
4. *Activities by households*, as its name suggests, includes CO_2 emitted directly by households, such as heating, transport, etc.

The aggregation of these four components yields the total Belgian carbon footprint for 2019, estimated at **194.577.848** tCO_2e. This represents an average of **17,02** tCO_2e per capita, based on **11.431.406** inhabitants as of the first of January 2019. (Statbel, 2019)

Those figures reflect the full climate impact of Belgian consumption, capturing both local and international production chains.



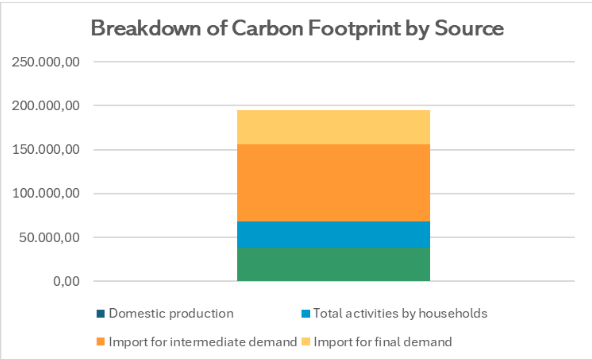


Figure 4 : Breakdown of Belgium's carbon footprint by source

The four components account respectively for :

- Domestic production : **38.751.170** tCO_2e
- Import for intermediate demand : **87.027.380** tCO_2e
- Import for final demand : **39.041.580** tCO_2e
- Activities by households : **29.757.700** tCO_2e

We can easily see that a large proportion of the CO_2e induced by Belgian consumption is emitted abroad and therefore imported (65%). We can also note that the CO_2e emissions we can see with our own eyes ultimately account for only 15% of our total emissions, which could be one reason why humans struggle to be aware of their environmental impact (BBC, 2019).

1.1 Household activities in details

The majority of the **29.757** $ktCO_2e$ generated by household activities consist mainly in heating or cooling homes (52%) and burning fuel in transport mean to get around (45%). The rest, which consists of various activities, mainly leisure, accounts for only a minor proportion (2%).

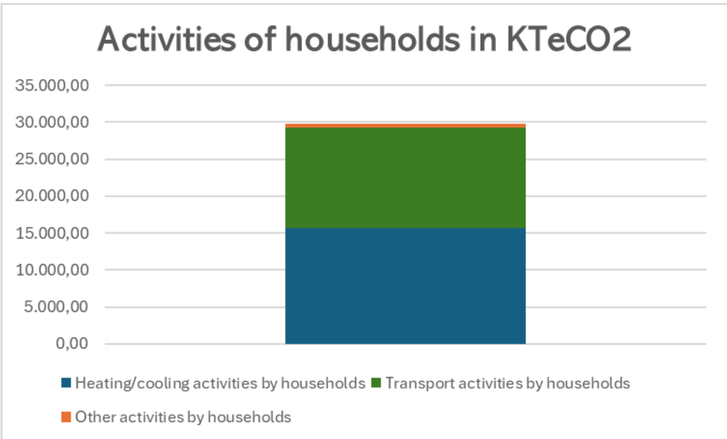


Figure 5 : Activities of Belgium's households

1.2 Breakdown by industry

One of the reasons why the method used is interesting is that we directly obtain results broken down by sector of activity (64 NACE codes) (see Appendix 4). This provides a clearer understanding of the origin of our emissions and therefore potential areas for improvement.

With the detail of the graphs below being available in the appendix, there are several interesting figures that can be discuss.

Local production

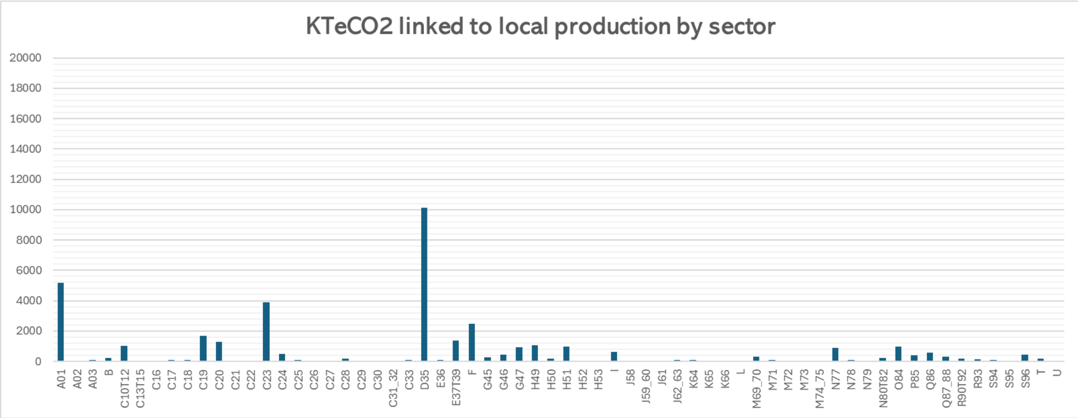


Figure 6 : kteCO_2 linked to local production by sector

For CO_2e produced directly on Belgian soil for Belgian's consumption, which is equal to **38.751** *ktCO_2e*, two categories stand out, with *Electricity, gas, steam and air conditioning supply (D35)* in first place, corresponding to the production and distribution of electricity, air conditioning and gas. This is followed by *Crop and animal production, hunting and related service activities (A01)*, which corresponds to food production. The last category to stand out slightly is *Manufacture of other non-metallic mineral products (C23)*. Those 3 categories alone account for almost 50% of the local production for Belgian's consumption, highlighting the highly specific Belgian industrial sector.

Imported production

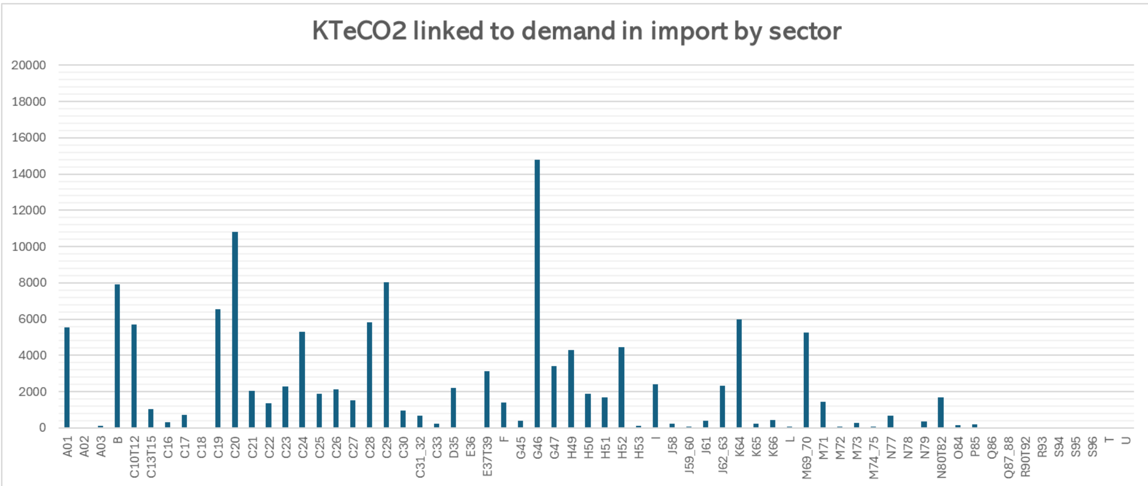


Figure 7 : kteCO_2 linked to demand in import by sector

From the **126.068** *ktCO_2e* attributed to import, *The wholesale trade (G46)* sector ranks first with 14,787 ktCO_2 equivalent imported. Although indirect in terms of production, this category includes a wide variety of imported products, ranging from electronics to clothing, food products and capital goods. Other sectors such as *chemical manufacturing* (10,815 ktCO_2e), *motor vehicle manufacturing* (8,047 ktCO_2e), *mining and quarrying* (7,894 ktCO_2e) and the *manufacture of food, beverages and tobacco* (5,685 ktCO_2e) also stand out as major CO_2e import sectors for Belgium.

Average carbon content of imports by product (e (I-A)$^{-1}$)

The term " $e(I - A)^{-1}$ " represents the total carbon content per unit of final demand, taking into account the direct and indirect effects of production, thus providing a vector that expresses, for each final product or sector, the total emissions generated throughout the global production chain in euros. Here is the graph depicting the average by sector.

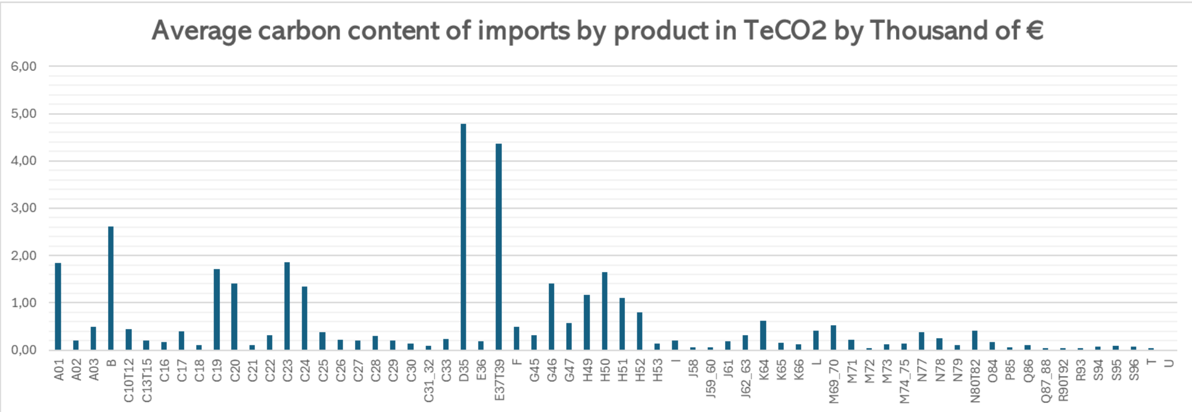


Figure 8 : Average carbon content of imports by sector

Proportionally, the sectors where imports emit the most are therefore *Electricity, gas, steam and air conditioning supply* and *Sewerage, waste management, remediation activities*. These are therefore the sectors for which €1of imports will produce the highest amount of CO_2e, almost 5 tCO_2e for each thousands of €. On the other hand, sector *like Education* or *Sportive activities* proportionally produces very few CO_2e.

1.3 Imports breakdown by country

By examining the CO_2e emitted through imports, we can also get some very interesting facts about the geographical origin of these imports, as the calculation method allows us to trace the entire global value chain.

Intermediate demand in imports by country

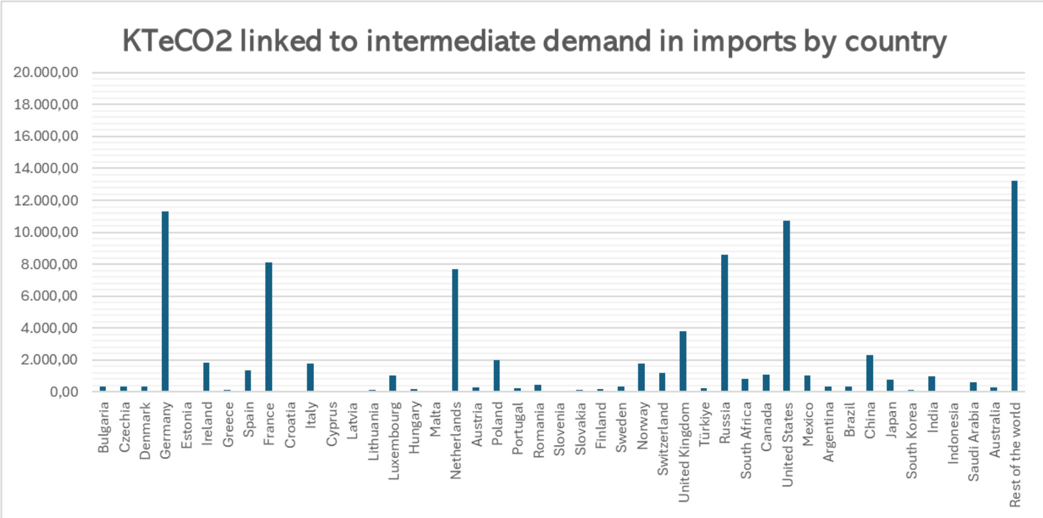


Figure 9 : ktCO₂e linked to intermediate demand in import by country

For example, in the intermediate demand, which account for **87.027.380** *tCO_2e*, we can highlight the biggest exporters toward Belgium being Germany, France, The Netherlands, The USA, Russia or the group " Rest of the world" which encompass every other country outside of those already listed. Each of those 6 regions represent between 4% and 7% of Belgian's total carbon footprint for the intermediate demand only.

Final demand in imports by country

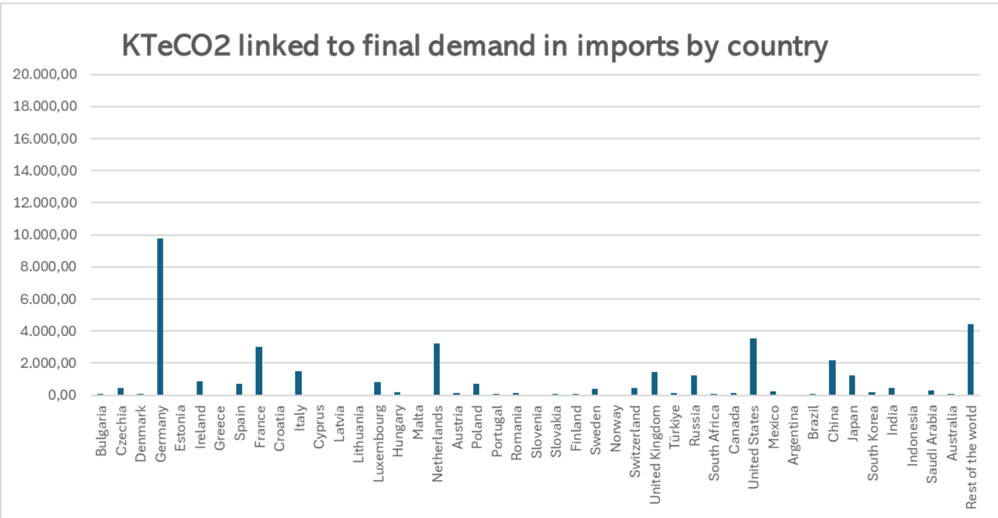


Figure 10 : ktCO₂e linked to final demand in import by country

For the final demand, which account for **39.041** *$ktCO_2e$*, it is largely the same exporting countries that stand out, with Germany clearly being the biggest exporting country for Belgium's final demand.

Average carbon content of imports by country ($e\ (I\text{-}A)^{-1}$)

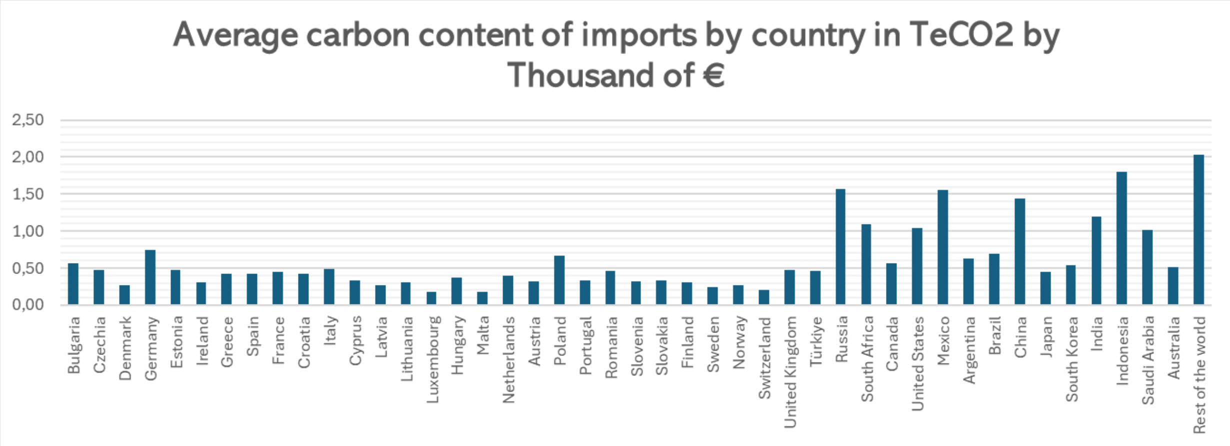


Figure 11 : Average carbon content of imports by country

Again, we can get very interesting information regarding the carbon emissions intensity of the exporting country. The EU countries, stack on the left side of the graph, are clearly proportionally lower emitters than countries outside of Europe, on the right.

2. Breakdown by consumption item

In 2019, the average carbon footprint of a person living in Belgium was thus estimated at 17.02 tonnes of CO_2 equivalent. This footprint can be divided between several major consumption categories, as it has been done by the French organisation. This breakdown is based on the table provided in the appendix 5.

Transport	Housing	Food	Equipment	Public services	Market services	
45.141	37.044	22.756	45.936	4.537	39.613	KTCO2e
3,93	3,22	1,98	3,99	0,39	3,44	TCO2e par capita

Table 1 : Carbon footprint by consumption category

Equipment (clothing, electronic devices, furniture, etc.) is the largest item, accounting for 23.55% of emissions, or 3.99 tonnes of CO_2e per capita.

Transport, whether individual or collective (car, plane, train, bus, etc.), follows with 23.15% of emissions, or approximately 3.93 tonnes of CO_2e per capita.

Then, *market services*, which encompass every private services, account for 20.31% of the footprint, or 3.44 tonnes of CO_2e per capita.

Housing, account for 18.22% of the total footprint, or approximately 3.22 tonnes of CO_2e per capita.

Food, including animal and plant products as well as their transport and processing, accounts for 11.67% of the footprint, or 1.98 tonnes of CO_2e per capita.

Finally, the last category is the *Public services* which account for 2.33% of the total carbon footprint, or 0.39 tonnes of CO_2e per capita.

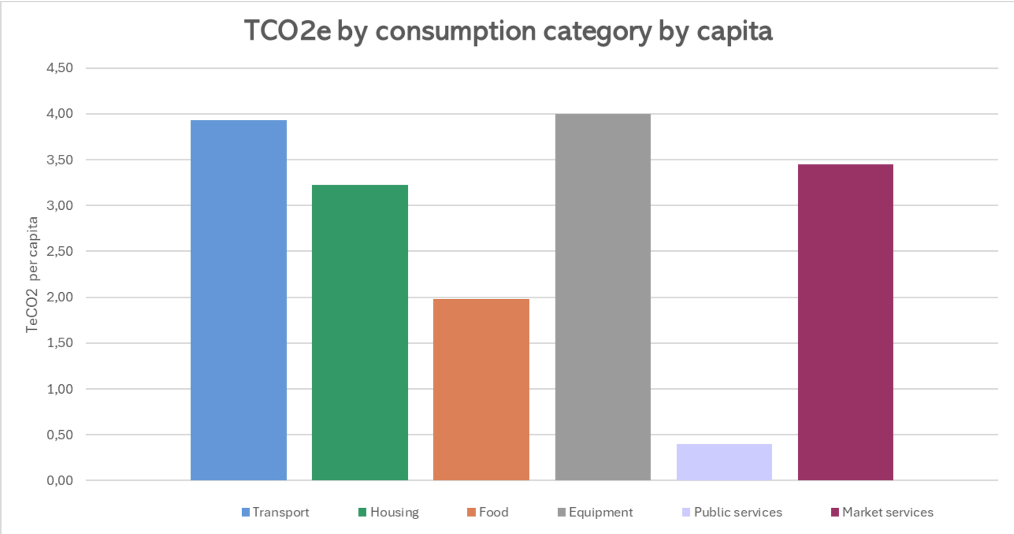


Figure 12 : Carbon footprint by consumption category per capita

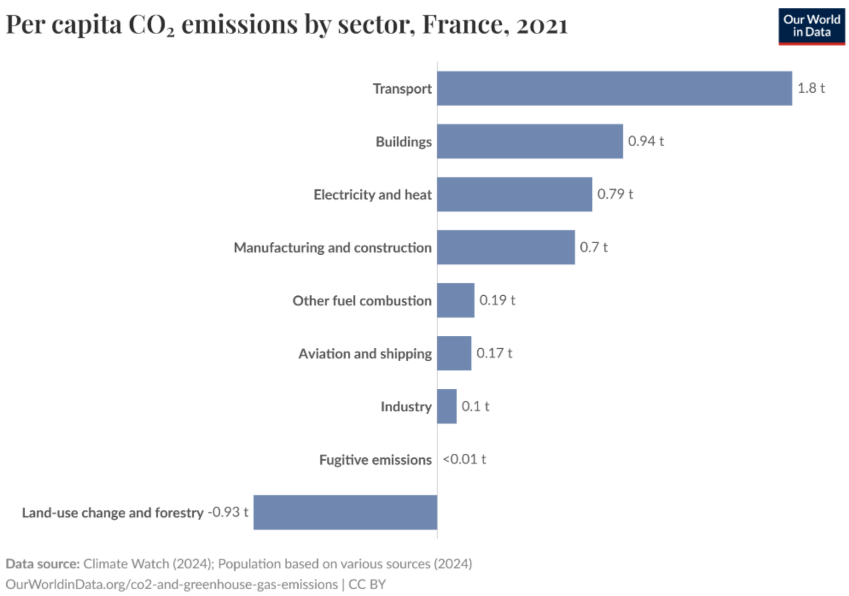
Breaking down results by consumption category makes it possible to identify the areas with the highest emissions (housing, transport, food, etc.) and to link carbon footprints more specifically to household lifestyles.

It also facilitates comparisons between countries or over several years by revealing differences in consumption patterns. This approach is essential for targeting climate policies by focusing on the sectors with the greatest impact. Finally, it enables the effects of the measures implemented to be assessed more accurately by observing their impact on the categories concerned.

3. Comparison with other countries

In their November 2024 publication, the SDES and INSEE shared some of the results they obtained for France. To make a comparison for 2019, we can look at their result for that year, which is 10.3 tonnes of CO_2e per capita. As previously discussed, the method applied in this study for calculating Belgium's carbon footprint differs slightly from that used in official French statistics. It is therefore interesting to apply the method used here for Belgium, to France, not only to gain an insight into the impact of these methodological changes on the final result, but also to obtain a much more appropriate point of comparison for assessing the structural differences between the two countries. The resulting footprint for France in the year 2019 is approximately **11.5** tonnes of CO_2 equivalent per capita (See appendix 10), so 1.2 more than the results obtained by French themselves. Still, this is significantly lower than Belgium's figure of **17,02** tCO_2e per capita, which could be explained by several economic, politic and geographic factors. There would also be several differences in the detail of the carbon footprint between the two countries.

If there is such a big difference between France and Belgium, it is because there are structural differences between how the two countries operate. Firstly, Belgium has a higher GDP per capita than France (Ceicdata, 2021), and GDP is directly correlated with greenhouse gases production. Indeed, citizens in a country with a higher GDP per capita buy more, travel more and therefore consume more, which leads to an increase in CO_2 production (Frontiers, 2022).



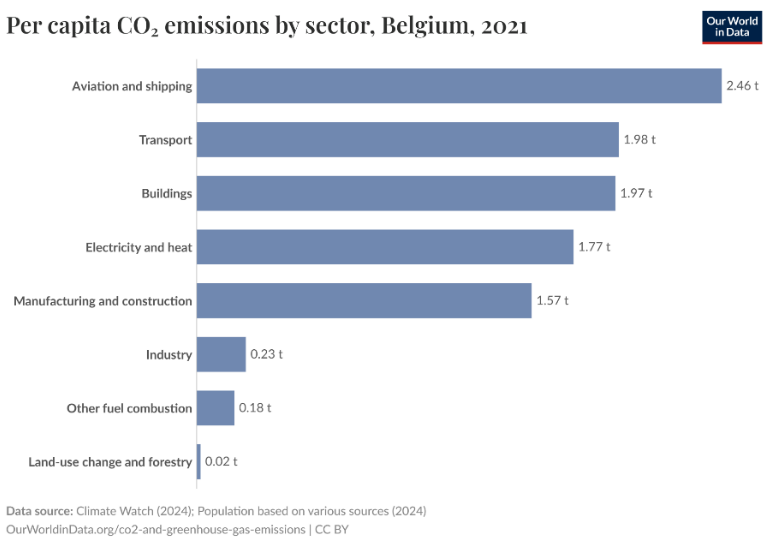


Figure 13 : Per capita footprint for Belgium and France according to OurWorldInData

It should also be noted that France has the advantage of reforestation, which has a negative impact on CO_2 emissions, an advantage that Belgium does not have. (Ourworldindata, 2024)

Another economic factor is the significant difference in the way the two countries import goods. In Belgium, imports account for around 83% of GDP. In France, this proportion is around 31%. These figures vary slightly depending on the year and the source, but they clearly indicate a much greater dependence on imports in Belgium than in France. (Ourworldindata, 2024) Indeed, Belgium is top 4 worldwide in import export balance per capita, which gives us a very high impact of imports. This may be partly due to the aviation and maritime hubs of Antwerp, Zeebrugge and Liège, which are very significant in comparison to the size of Belgium.

Belgium has a net import-export balance of 9.71 tonnes of CO2 per capita, compared to 1.73 tonnes of CO2 per capita for France.

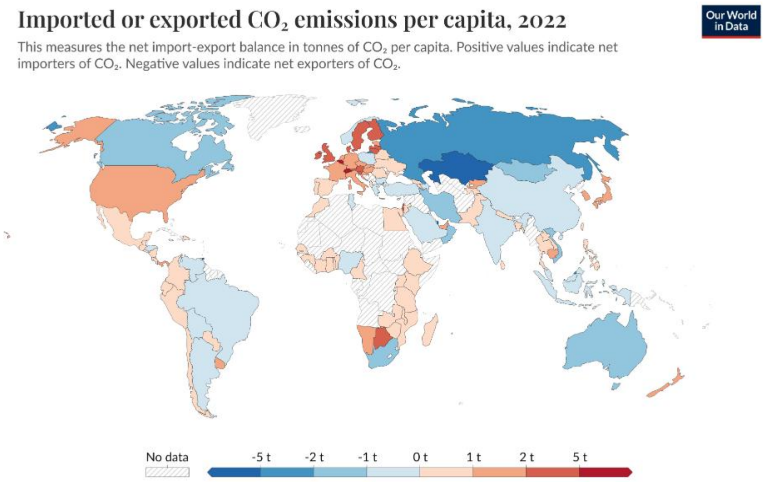


Figure 14 : CO_2 exchange per capita

In addition, there is also a significant difference between the two countries in terms of how they generate their energy. France produces most of its electricity from nuclear power (67%), which is carbon-free, as well as a significant proportion from hydroelectricity (14%), wind power (9%) and solar power (4%). In contrast, Belgium produces only 42% of its electricity from nuclear power, with a significant proportion coming from gas (17.6%), negatively impacting the carbon footprint of Belgium's citizens.

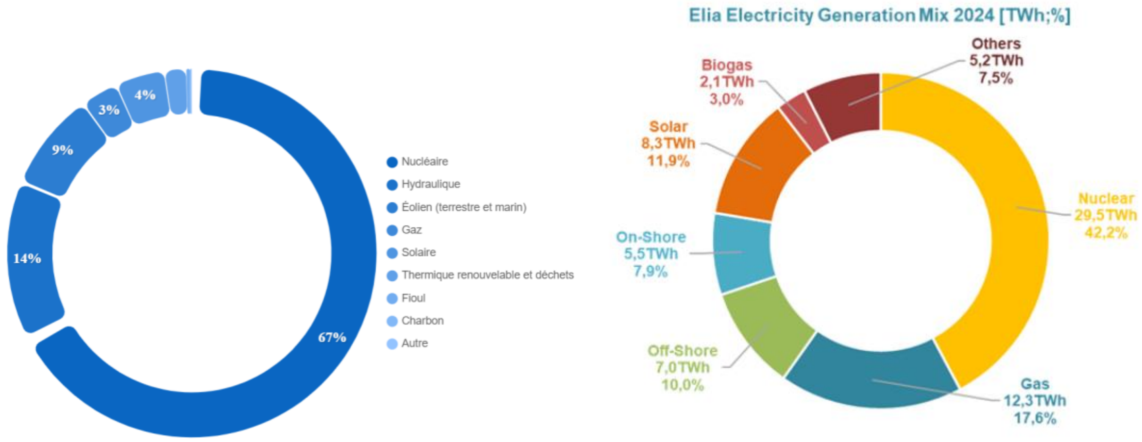


Figure 15 : Electrical mix of France (left) and Belgium (right)

In addition to all these factors, there are also geographical differences. Belgium is located further north, which means a colder climate and therefore a greater demand for heating.

All those differences, could each partially explain the big differences of **5,52** tonnes of CO_2e per capita between the 2 countries. Ideally, a more in-depth analysis of all these reasons and differences could be very interesting to explore.

Limitations and discussion

1. Limitations of the method

Despite its robustness, the input-output method applied to carbon footprint estimation has several structural limitations. Firstly, it relies entirely on data from Eurostat, in particular FIGARO tables and AEA environmental accounts. Although Eurostat is a reliable and consistent source at global level, these data have not been cross-checked or validated with other independent international sources, which may introduce undetected biases.

Secondly, the use of a 64-branch NACE aggregation in FIGARO tables and national matrices is a necessary simplification for modelling purposes, but this level of granularity remains too coarse to accurately capture the diversity of specific products or consumption patterns. This poses particular difficulties in accurately matching sectoral emissions to household consumption items as defined in national statistics (like food, clothing, services, etc.).

Finally, the input-output model is based on the assumption that a branch produces a single type of good with average technology that is homogeneous across its entire production. However, this assumption overlooks the diversity of production processes and by-products and does not take into account fragmented and globalised value chains, particularly for imported products. Thus, the same industry may produce both high-emission goods and much lower-emission goods, without the model making this distinction. This approximation is one of the main challenges of macroeconomic modelling of environmental footprints.

However, as we saw in the literature review section, the few similar studies on the same subject have shown relatively similar results, such as The Global Resource Footprint of Nations report, which gives a result of 16.46 tCO_2e, and the data from Our World in Data, which puts Belgium's carbon footprint per capita at 17.6 tonnes for 2019. This indicates that this method is on the right track to achieving a comprehensive and reliable measurement of Belgium's carbon footprint.

2. Differences with French methodology

Although the method used to calculate Belgium's carbon footprint in this thesis is entirely based on the methodology developed by France through the SDES and INSEE, it has been highlighted that there are still significant differences that have an impact on the final result and therefore on its possible interpretations. Those differences, that leads to an overestimation of French's carbon footprint of **1.2** tCO_2 equivalent per capita, may be leading to a similar overestimation regarding Belgium's carbon footprint estimation. They may be the result of restricted access to certain resources, limited time, or simply methodological choices.

2.1 Smoothing out outlier

As part of the French methodology, particular attention was paid to detecting outliers in the series of unit content for greenhouse gases (vector $e(I-A)^{-1}$) derived from the FIGARO database. These statistical anomalies, although rare, can have a significant impact on footprint results, as was the case for France in 2011 (Baude, 2024). The French approach is based on the analysis of complete time series (2010–2021) for each foreign product thus 2.880 series for each year. A point is considered atypical if it deviates significantly from the average of its series and its direct neighbours in time, and is then corrected by interpolation.

In the context of this thesis, it was not possible to apply this correction procedure. This would have required reconstructing the FIGARO global matrices and recalculating the unit contents for around ten years, which exceeds the scope and resources of this research. The work is therefore based solely on data for 2019, as provided by Eurostat, without adjusting for potentially outlying points. This methodological choice is justified by time and feasibility constraints, but it is a limitation that should be kept in mind when interpreting the results. This can easily be the subject of a future step to achieve even more accurate and interpretable results.

2.2 SNAC vs FIGARO

Another significant improvement to the method, as applied in France, consists of replacing some of the data from the FIGARO global database with more appropriate national data. The FIGARO tables are designed to ensure consistency between countries at the global level, which can lead to significant discrepancies with national statistics (IOT, emissions accounts, etc.). Recalibration with Belgian data would anchor the analysis more firmly in the national economic reality and thus improve accuracy.

However, this step could not be implemented within the scope of this thesis, mainly due to technical complexity. It requires a partial overhaul of the trade and emissions matrices, and reconciliation between FIGARO and Belgian sources such as the IOT or AEA accounts. This realignment is therefore a clear avenue for future work, which would further improve the robustness of Belgium's carbon footprint estimates. The main influence on the results is that the FIGARO database significantly overestimates services compared to reality, which is clearly seen in the breakdown by consumption post, where a large part of the carbon footprint is attributed to commercial services. This part of the analysis should therefore be viewed with caution.

2.3 Type of NACE category

A methodological difference from the French approach concerns the format of the tables used. In France, the carbon footprint is calculated using symmetrical product × product tables, which are considered more relevant for economic interpretation because they directly reflect flows between categories of goods. However, this format is generally more complex to use in calculations, particularly because of the product-industry conversion matrices required.

For the purposes of this thesis, the use of industry × industry tables has been chosen, which are more consistent with the rest of the FIGARO data (which are also in industry × industry format) and can be used directly in matrix calculations. This choice facilitates technical processing, but may make interpretation by product type or consumption function slightly less intuitive. A future improvement would be to replicate the calculations using product × product tables to make it easier to read the results by sector.

2.4 Emission intensity ‘rest of the world’

The French method applies a specific correction to the extractive industries (NACE code B) in the ‘rest of the world’ region (FIGW1 code) of the FIGARO table. This correction aims to compensate for a probable underestimation of the monetary output of this sector in this area, which could lead to an overestimation of the carbon intensity (kg CO_2/€) of these activities. Comparisons with physical data from the International Energy Agency (IEA) suggest that the monetary value of extraction (coal, oil, gas, etc.) in FIGARO is underestimated for FIGW1, unlike in other countries.

However, this correction was not deemed necessary in the context of this thesis, as the new FIGARO data published in July 2025 no longer show such a marked bias. The discrepancy observed previously is not found in the updated version of the database. As a result, I have made a deliberate choice to retain the carbon intensity values for the extractive industry as they appear in the FIGARO 2025 database, without applying any additional adjustments. This choice preserves the consistency of the original data while relying on the most recent and corrected versions available.

3. Challenges and continuation

Challenges

One of the main challenges encountered in carrying out this work lies in the evolving nature of the methods and data used to estimate carbon footprints. The field of territorial carbon accounting and environmental footprints is still relatively young, and reference institutions such as Eurostat and ADEME in France regularly update their datasets, methodologies and recommendations. For example, the French method, on which this study is based, has undergone several adjustments in recent years, both in terms of methodology and the processing of source data.

In addition, Eurostat frequently publishes new versions of the FIGARO tables and environmental accounts, which makes modelling work dependent on specific versions and potentially subject to revision. These regular updates reflect progress in data collection, improvements in consistency between countries, and the integration of new statistical sources (such as FIGARO data or international prices for certain sectors).

In this context, it seems necessary to consider this type of study as an iterative, evolving process, rather than a fixed one. The ability to adapt quickly to new versions of databases or methodological changes is essential, not only to ensure the rigour of the results, but also to better guide public policy based on the best information available at any given time. This thesis is therefore part of a process of continuous improvement, drawing on the state of the art at the time of its completion, while paving the way for future updates and further research.

Continuation

The next step in this work will be to extend the application of this method over several years, in order to enable an evolutionary analysis of Belgium's carbon footprint. Such a longitudinal approach would provide a better understanding of transition dynamics and the effects of public policies or economic crises on imported and domestic emissions. It would also make it possible to identify the sectors most resistant to decarbonisation or, conversely, those where significant improvements have been observed.

Following on from this study, it would be particularly relevant to develop more in-depth analyses of Belgium's carbon footprint by refining the territorial and social granularity of the results. While this study provides a national average estimate of the carbon footprint per capita, it does not take into account the significant internal disparities that may exist within the country.

Future studies could focus on differentiating emissions by region (Flanders, Wallonia, Brussels-Capital) or even by province, in order to better understand the influence of economic structures, transport infrastructure and local energy sources on emission levels.

Furthermore, a more detailed socio-economic approach would make it possible to identify inequalities in environmental impact between different categories of households. For example, it would be interesting to cross-reference consumption data with indicators of income, education level or family structure in order to explore the links between living conditions and carbon footprint. Such an approach, inspired by the work of Goedemé et al. (2020), would provide a fairer and more nuanced view of responsibilities and capacities for action according to social profiles, and would contribute to the design of more targeted and equitable climate policies.

These further developments would represent an essential step towards a comprehensive and operational understanding of the carbon footprint in Belgium, in the service of a fair and effective transition.

Based on these results, it will also be crucial to make them accessible and understandable to a wider audience, with a view to popularising and raising awareness. One of the objectives of the carbon footprint by consumption is precisely to bring global issues closer to individual and collective behaviour. In this sense, clear and effective communication of the results obtained could help to move the needle by guiding political decisions, consumer choices and industrial practices towards more sustainable paths. This work is therefore not an end in itself, but a starting point for a more informed understanding and action on the environmental impact of our consumption model.

Conclusion

The main objective of this thesis was to estimate the average carbon footprint per capita in Belgium for the year 2019. This approach aimed to fill a methodological and statistical gap in the Belgian context, drawing inspiration from the method recently developed in France by the Service des Données et Études Statistiques (SDES) and INSEE. The aim was to transpose and adapt a robust macroeconomic approach to provide a consistent, comparable and operational measure of the climate impact of Belgian consumption.

The methodology adopted is based on the use of a simplified version of the SNAC method, applied to data from the FIGARO database published by Eurostat in 2025. This database provides multi-regional input-output tables, which make it possible to trace all economic flows and therefore the associated emissions, both at national and international level. The work was carried out using complementary IT tools such as Microsoft Excel for national calculations and Python for processing large matrices like international ones. Although the choice of the industry × industry format introduces certain limitations in terms of interpretation by product, it allowed for a more direct technical implementation that was consistent with the available data.

The results obtained indicate that the total carbon footprint of Belgian consumption in 2019 amounted to 194.58 million tonnes of CO_2e, an average of 17.02 tonnes of CO_2e per capita. The sectoral analysis shows that most emissions come from five major categories: equipment (23.55%), transport (23.15%), market services (20.31%), housing (18.22%) and food (11.67%), with public services bringing up the rear (2.33%). These results reveal that more than 65% of emissions linked to Belgian consumption are generated abroad, highlighting the country's structural dependence on globalised supply chains. Furthermore, only a marginal share (15%) of emissions is directly visible to households, which may explain the difficulty in fully grasping the extent of their environmental impact.

These results are broadly consistent with previous studies mentioned in the literature review, which estimated Belgium's footprint at between 16.4 and 17.6 tCO_2e per capita, depending on the sources, methods and target year. They also confirm the trend of a relatively high footprint compared to neighbouring countries such as France (11.5 tCO_2e/capita in 2019), which can be explained by structural factors: higher GDP per capita, greater dependence on imports, a lower share of decarbonised electricity, and more demanding climatic conditions for heating.

One of the major contributions of this thesis lies in the transposition of a reference method to a national context that has so far been little explored in such detail. This approach allows for international comparability while ensuring the reliability of the results through the use of harmonised and validated data at European level. The work also provides a precise sectoral reading of Belgium's carbon footprint, paving the way for targeted analyses by consumption area.

However, this thesis has several limitations. First, the granularity of the data used, which is limited to 64 branches of activity in the FIGARO tables, does not allow for a completely detailed reading by product type or consumption behaviour. Secondly, the entire model is based exclusively on data published by Eurostat, without any adjustment to Belgian statistical sources (IOTS, AEA, etc.), which could introduce certain biases such as the overestimation of the economic quantity associated with commercial services. Finally, certain methodological improvements used in the French context, such as the smoothing of outliers could not be implemented here for technical and time reasons.

Several areas for improvement could be considered in future work. It would be particularly useful to extend this method to several years in order to track the evolution of Belgium's footprint over time, notably by incorporating the effects of recent crises (COVID-19, energy crisis, inflation). In addition, better integration of national data would improve the accuracy of estimates. Finally, it would be extremely relevant to break down the results by region, province or socio-economic category in order to identify territorial and social inequalities in terms of carbon footprint. Such an approach would make it possible to better target climate policies according to the consumption profiles and capacities for action of different population groups.

The results obtained in this research can be used in various operational contexts. They provide a solid basis for communicating with the general public, raising awareness of the impacts of consumption and designing decision-making tools for public authorities and businesses. By making the invisible visible, particularly the carbon footprint of imports, they contribute to a better understanding of the levers for transition.

Ultimately, this thesis illustrates the importance of having appropriate, transparent and scalable methodological tools to monitor the climate impact of our lifestyles. In a context marked by climate urgency and accelerating ecological transitions, it is crucial to continue efforts to quantify and monitor emissions, while integrating territorial, social and behavioural dimensions. Because beyond national averages, it is individual and collective choices, informed by data, that will shape the sustainability of our societies.

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Appendices

Appendix 1 : 17 UN's SDG's goals

Figure 16 : UN's SDG's goals

Appendix 2 : AEA precision

AEA : For the transport sector, this inventory accounts for emissions generated by resident units when operating abroad, while excluding those produced by non-residents on national territory. This applies in particular to the international activities of air and maritime transport companies.

Appendix 3 : construction of the general formula

As described in the methodological report on France's carbon footprint estimate, the formula used breaks down as follows:

We start with the classic Leontief equation to calculate the carbon footprint in a TIES.

$$E = e\,(I - A)^{-1} .(FD_{BE}) \quad (1)$$

We begin by separating the demand for Belgian products from the demand for foreign products within the final demand.

$$E = e\,(I - A)^{-1} .FD_{BE} + e\,.\,(I\text{-}A)^{-1}\,.\,FD_M \quad (2)$$

Where FD_{BE} represents Belgian final demand for Belgian products, with zeros for foreign products, and FD_M represents Belgian final demand for foreign products, with zeros for Belgian products. For final demand for foreign products (second term), we will directly use the carbon content $e \cdot (I - A)^{-1}$ from FIGARO. The rest of the breakdown only concerns the footprint linked to final demand for Belgian products (first term).

The challenge is to develop a way of expressing the carbon content of French products that separates purely domestic contributions from imported contributions. We refer to P_{BE} as the vector representing production induced in Belgium by final demand.

$$P_{BE} = (I - A^{BE}_{BE})^{-1} FD_{BE} \quad (3)$$

Which is equal to :

$$FD_{BE} = (I - A^{BE}_{BE})^{-1} P_{BE} \quad (4a)$$

Without changing the result, we can extend P_{BE} and A^{BE}_{BE} to the full dimension of the TIES, adding 0 for all foreign products (we can verify that all terms added to the matrix product are zero). We denote the vectors and matrices thus extended with a hat.

$$FD\hat{}_{BE} = (I - A\hat{}^{BE}_{BE})^{-1} P\hat{}_{BE} \quad (4b)$$

We then break down the matrix A of the technical coefficients of the TIES into two blocks: $A = A\hat{}^{BE}_{BE} + A\hat{}^{BE}_{M}$. The matrix $A\hat{}^{BE}_{M}$ is equal to matrix A, in which all technical coefficients of Belgian ICs in Belgian products have been replaced by zeros.

By replacing $A\hat{}^{BE}_{BE}$ with $A - A\hat{}^{BE}_{M}$ in equation (4b), we obtain :

$$FD\hat{}_{BE} = (I - A + A\hat{}^{BE}_{M})\, P\hat{}_{BE} = (I-A)\, P\hat{}_{BE} + A\hat{}^{BE}_{M}\, P\hat{}_{BE} \quad (5)$$

Finally, we can multiply by $e\,(I - A)^{-1}$ on the left to find the expression for the carbon footprint of French products that we were looking for:

$$e\,(I - A)^{-1} FD\hat{}_{BE} = e\, P\hat{}_{BE} + e\,(I - A)^{-1} A\hat{}^{BE}_{M}\, P\hat{}_{BE} \quad (6)$$

Without changing the result, we can now reduce the size of certain terms. The scalar product $e\, P\hat{}_{BE}$ is equal to the product $e_{BE} P_{BE}$. The matrix product $A\hat{}^{BE}_{M}\, P\hat{}_{BE}$ is equal to the product A^{BE}_{M}. Combining equations (2) and (6) gives the expression for Belgium's carbon footprint, which is used to apply the simplified SNAC method:

$$E = e_{BE} \,.\, (I - A^{BE}_{BE})^{-1} .(FD_{BE}) + e \,.\, (I-A)^{-1} \,.\, A^{BE}_{M} \,.\, (I-A^{BE}_{BE})^{-1} \,.\, FD_{BE} + e \,.\, (I-A)^{-1} \,.\, FD_{M}$$

Now we just need to add the direct consumption of households depicted by DHe, which gives us :

$$E = e_{BE} \,.\, (I - A^{BE}_{BE})^{-1} .(FD_{BE}) + e \,.\, (I-A)^{-1} \,.\, A^{BE}_{M} \,.\, (I-A^{BE}_{BE})^{-1} \,.\, FD_{BE} + e \,.\, (I-A)^{-1} \,.\, FD_{M} + DHe$$

Appendix 4 : NACE codes

NACE code	Name
A01	Crop and animal production, hunting and related service activities
A02	Forestry and logging
A03	Fishing and aquaculture
B	Mining and quarrying
C10T12	Manufacture of food products; beverages and tobacco products
C13T15	Manufacture of textiles, wearing apparel, leather and related products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31_32	Manufacture of furniture; other manufacturing
C33	Repair and installation of machinery and equipment
D35	Electricity, gas, steam and air conditioning supply
E36	Water collection, treatment and supply
E37T39	Sewerage, waste management, remediation activities
F	Construction
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
G46	Wholesale trade, except of motor vehicles and motorcycles
G47	Retail trade, except of motor vehicles and motorcycles
H49	Land transport and transport via pipelines
H50	Water transport
H51	Air transport
H52	Warehousing and support activities for transportation
H53	Postal and courier activities
I	Accommodation and food service activities
J58	Publishing activities
J59_60	Motion picture, video, television programme production; programming and broadcasting activities
J61	Telecommunications
J62_63	Computer programming, consultancy, and information service activities
K64	Financial service activities, except insurance and pension funding
K65	Insurance, reinsurance and pension funding, except compulsory social security
K66	Activities auxiliary to financial services and insurance activities
L	Real estate activities
M69_70	Legal and accounting activities; activities of head offices; management consultancy activities
M71	Architectural and engineering activities; technical testing and analysis
M72	Scientific research and development
M73	Advertising and market research
M74_75	Other professional, scientific and technical activities; veterinary activities
N77	Rental and leasing activities
N78	Employment activities
N79	Travel agency, tour operator and other reservation service and related activities
N80T82	Security and investigation, service and landscape, office administrative and support activities
O84	Public administration and defence; compulsory social security
P85	Education
Q86	Human health activities
Q87_88	Residential care activities and social work activities without accommodation
R90T92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities
R93	Sports activities and amusement and recreation activities
S94	Activities of membership organisations
S95	Repair of computers and personal and household goods
S96	Other personal service activities
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
U	Activities of extraterritorial organisations and bodies

Figure 17 : NACE codes

Appendix 5 : NACE correspondence table for consumption items

final_product	demand_category	coeff
A01	food	1,00
A02	housing	1,00
A03	food	1,00
B	equipements	1,00
C10T12	food	1,00
C13T15	equipements	1,00
C16	equipements	1,00
C17	equipements	1,00
C18	equipements	1,00
C19	transportation	0,88
C19	housing	0,12
C20	equipements	1,00
C21	public_services_and_health	1,00
C22	equipements	1,00
C23	equipements	1,00
C24	equipements	1,00
C25	equipements	1,00
C26	equipements	1,00
C27	equipements	1,00
C28	equipements	1,00
C29	transportation	1,00
C30	transportation	1,00
C31_32	equipements	1,00
C33	equipements	1,00
D35	housing	0,93
D35	food	0,07
E36	food	1,00
E37T39	housing	0,43
E37T39	food	0,30
E37T39	equipements	0,27
F	housing	1,00
G45	transportation	1,00
H49	transportation	1,00
H50	transportation	1,00
H51	transportation	1,00
H52	transportation	1,00
H53	market_services	1,00
I	food	0,77
I	market_services	0,23
J58	market_services	1,00
J59_60	market_services	1,00
J61	market_services	1,00
J62_63	market_services	1,00
K64	market_services	1,00
K65	market_services	1,00
K66	market_services	1,00
L	housing	1,00
M69_70	market_services	1,00
M71	housing	1,00
M72	market_services	1,00
M73	market_services	1,00
M74_75	market_services	1,00
N77	housing	1,00
N78	public_services_and_health	1,00
N79	market_services	1,00
N80T82	market_services	1,00
O84	public_services_and_health	1,00
P85	public_services_and_health	1,00
Q86	public_services_and_health	1,00
Q87_88	public_services_and_health	1,00
R90T92	market_services	1,00
R93	market_services	1,00
S94	market_services	1,00
S95	equipements	1,00
S96	market_services	1,00
T	market_services	1,00

Figure 18 : NACE correspondence table for consumption items

Appendix 6 : Final results by sector for Belgium

Total emissions	**194.577.848,20**	TeCO2
Belgum's inhabitants	11.431.406	
Emission per capita	**17,02**	TeCO2 per capita

Table 2 : Final carbon footprint for Belgium

Import for intermediate demand		87.027,38 KTeCO2
A01	Crop and animal proc	2.409,93
A02	Forestry and logging	11,30
A03	Fishing and aquacult	33,31
B	Mining and quarrying	9.194,26
C10T12	Manufacture of food p	2.068,13
C13T15	Manufacture of textile	79,28
C16	Manufacture of wood	210,82
C17	Manufacture of paper	463,15
C18	Printing and reproduc	29,31
C19	Manufacture of coke	4.002,04
C20	Manufacture of chem	7.251,61
C21	Manufacture of basic	1.147,76
C22	Manufacture of rubbe	839,03
C23	Manufacture of other	1.709,97
C24	Manufacture of basic	4.059,17
C25	Manufacture of fabric	737,12
C26	Manufacture of comp	509,77
C27	Manufacture of electr	521,88
C28	Manufacture of mach	1.600,23
C29	Manufacture of motor	827,60
C30	Manufacture of other	171,40
C31_32	Manufacture of furnitu	142,37
C33	Repair and installatio	237,02
D35	Electricity, gas, stear	1.292,84
E36	Water collection, trea	5,52
E37T39	Sewerage, waste ma	1.646,91
F	Construction	1.165,35
G45	Wholesale and retail	330,47
G46	Wholesale trade, exc	19.410,72
G47	Retail trade, except c	3.286,64
H49	Land transport and tr	2.980,22
H50	Water transport	1.345,70
H51	Air transport	1.250,84
H52	Warehousing and su	1.340,03
H53	Postal and courier ac	155,36
I	Accommodation and	300,26
J58	Publishing activities	123,52
J59_60	Motion picture, video,	122,47
J61	Telecommunications	241,41
J62_63	Computer programm	1.687,36
K64	Financial service acti	3.700,87
K65	Insurance, reinsuranc	125,78
K66	Activities auxiliary to f	111,88
L	Real estate activities	135,13
M69_70	Legal and accounting	3.369,59
M71	Architectural and eng	273,25
M72	Scientific research ar	24,78
M73	Advertising and mark	85,36
M74_75	Other professional, s	280,46
N77	Rental and leasing ac	1.173,43
N78	Employment activities	125,47
N79	Travel agency, tour o	306,63
N80T82	Security and investiga	2.229,49
O84	Public administration	89,89
P85	Education	15,26
Q86	Human health activitie	12,38
Q87_88	Residential care activ	0,93
R90T92	Creative, arts and en	6,62
R93	Sports activities and	2,55
S94	Activities of members	1,11
S95	Repair of computers	0,89
S96	Other personal servic	13,54
T	Activities of househol	0,00
U	Activities of extraterri	0,00

Table 3 : CO_2e linked to intermediate demand in imports

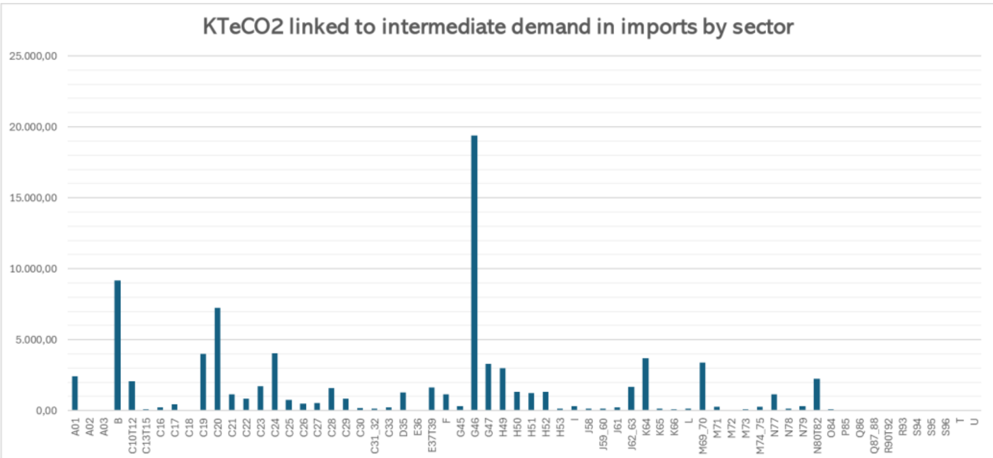

Figure 19 : CO_2e linked to intermediate demand in imports

Import for final demand		39.041,58 *KTeCO2*
A01	Crop and animal	2.025,02
A02	Forestry and logg	4,36
A03	Fishing and aqua	68,67
B	Mining and quarry	362,57
C10T12	Manufacture of fo	3.056,92
C13T15	Manufacture of te	930,13
C16	Manufacture of w	24,84
C17	Manufacture of pa	154,70
C18	Printing and repro	2,50
C19	Manufacture of co	2.273,88
C20	Manufacture of ch	2.940,01
C21	Manufacture of ba	864,31
C22	Manufacture of ru	406,93
C23	Manufacture of ot	302,72
C24	Manufacture of ba	346,79
C25	Manufacture of fa	974,81
C26	Manufacture of co	1.737,58
C27	Manufacture of el	891,76
C28	Manufacture of m	4.200,61
C29	Manufacture of m	7.114,93
C30	Manufacture of ot	840,34
C31_32	Manufacture of fu	501,79
C33	Repair and instal	39,86
D35	Electricity, gas, s	991,61
E36	Water collection,	0,23
E37T39	Sewerage, waste	26,53
F	Construction	34,04
G45	Wholesale and re	16,01
G46	Wholesale trade,	494,30
G47	Retail trade, exce	437,22
H49	Land transport an	796,09
H50	Water transport	302,76
H51	Air transport	321,39
H52	Warehousing and	19,54
H53	Postal and courie	0,52
I	Accommodation	4,30
J58	Publishing activiti	147,47
J59_60	Motion picture, vi	3,90
J61	Telecommunicati	4,46
J62_63	Computer progra	357,98
K64	Financial service	4.599,99
K65	Insurance, reinsu	30,16
K66	Activities auxiliary	1,68
L	Real estate activi	5,18
M69_70	Legal and accoun	100,88
M71	Architectural and	143,72
M72	Scientific researc	42,70
M73	Advertising and m	2,83
M74_75	Other profession	3,16
N77	Rental and leasin	3,56
N78	Employment acti	1,74
N79	Travel agency, to	0,13
N80T82	Security and inve	9,24
O84	Public administra	35,52
P85	Education	9,90
Q86	Human health ac	1,55
Q87_88	Residential care	0,42
R90T92	Creative, arts and	0,81
R93	Sports activities a	0,21
S94	Activities of mem	0,38
S95	Repair of comput	0,15
S96	Other personal s	23,29
T	Activities of hous	0,00
U	Activities of extra	0,00

Table 4 : CO_2e linked to final demand in imports

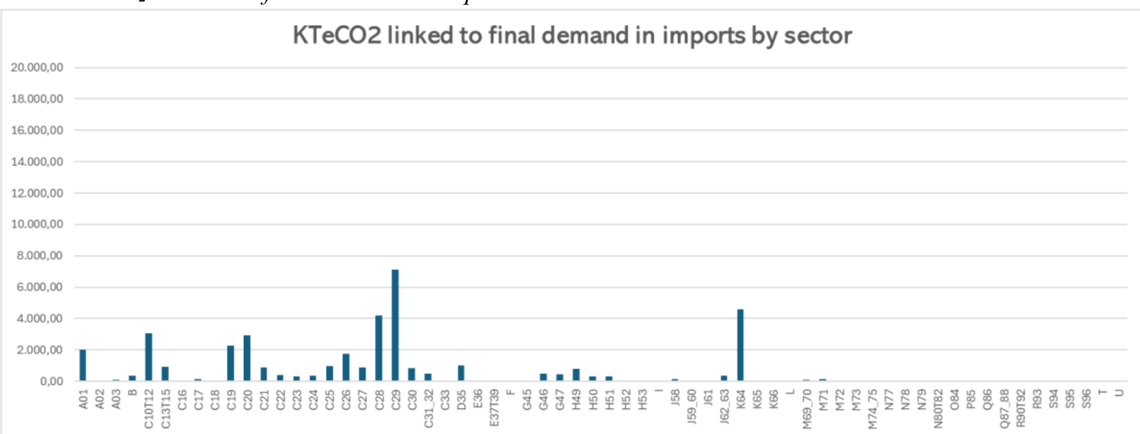

Figure 20 : CO_2e linked to final demand in imports

Domestic production		38.751,17 KTeCO2
A01	Crop and animal	5.167,88
A02	Forestry and log	21,08
A03	Fishing and aqua	99,86
B	Mining and quarr	212,33
C10T12	Manufacture of f	1.039,73
C13T15	Manufacture of t	39,29
C16	Manufacture of v	24,72
C17	Manufacture of p	106,04
C18	Printing and repr	108,96
C19	Manufacture of c	1.689,48
C20	Manufacture of c	1.300,73
C21	Manufacture of b	60,02
C22	Manufacture of r	32,80
C23	Manufacture of c	3.905,11
C24	Manufacture of b	493,15
C25	Manufacture of f	87,73
C26	Manufacture of c	27,29
C27	Manufacture of e	14,48
C28	Manufacture of r	161,06
C29	Manufacture of r	19,33
C30	Manufacture of c	4,85
C31_32	Manufacture of f	39,08
C33	Repair and insta	75,40
D35	Electricity, gas, s	10.136,86
E36	Water collection	74,08
E37T39	Sewerage, wast	1.380,29
F	Construction	2.460,82
G45	Wholesale and r	258,67
G46	Wholesale trade	456,69
G47	Retail trade, exc	923,55
H49	Land transport a	1.043,30
H50	Water transport	199,52
H51	Air transport	995,75
H52	Warehousing an	62,92
H53	Postal and couri	45,71
I	Accommodation	608,20
J58	Publishing activi	15,74
J59_60	Motion picture, v	45,55
J61	Telecommunica	19,87
J62_63	Computer progra	87,39
K64	Financial service	76,37
K65	Insurance, reins	20,13
K66	Activities auxiliar	33,55
L	Real estate activ	39,88
M69_70	Legal and accou	309,41
M71	Architectural and	79,57
M72	Scientific resear	64,77
M73	Advertising and r	12,15
M74_75	Other professior	41,98
N77	Rental and leasi	887,06
N78	Employment act	108,52
N79	Travel agency, t	9,84
N80T82	Security and inve	223,96
O84	Public administra	979,39
P85	Education	384,12
Q86	Human health ac	563,03
Q87_88	Residential care	318,88
R90T92	Creative, arts an	165,49
R93	Sports activities	152,11
S94	Activities of mem	108,82
S95	Repair of compu	24,13
S96	Other personal s	436,29
T	Activities of hous	166,39
U	Activities of extra	0,00

Table 5 : CO_2e linked to domestic production

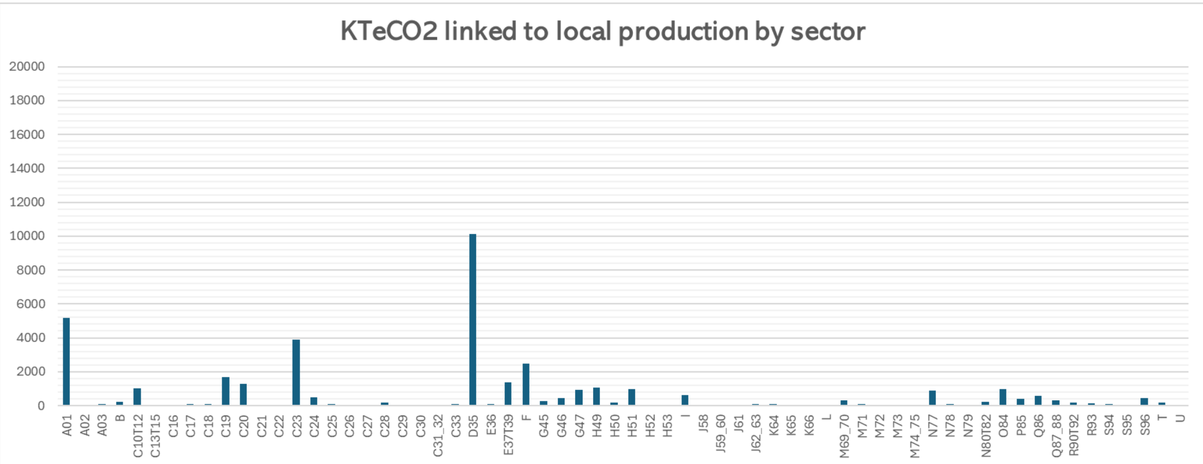

Figure 21 : CO_2e linked to domestic production

Average carbon content of imports by product	
A01	1,84
A02	0,20
A03	0,49
B	2,61
C10T12	0,45
C13T15	0,20
C16	0,17
C17	0,40
C18	0,11
C19	1,71
C20	1,41
C21	0,10
C22	0,32
C23	1,86
C24	1,34
C25	0,37
C26	0,21
C27	0,20
C28	0,29
C29	0,20
C30	0,14
C31_32	0,09
C33	0,24
D35	4,78
E36	0,18
E37T39	4,36
F	0,49
G45	0,31
G46	1,40
G47	0,57
H49	1,17
H50	1,65
H51	1,10
H52	0,80
H53	0,14
I	0,21
J58	0,06
J59_60	0,06
J61	0,19
J62_63	0,31
K64	0,62
K65	0,15
K66	0,13
L	0,40
M69_70	0,53
M71	0,22
M72	0,05
M73	0,13
M74_75	0,14
N77	0,37
N78	0,24
N79	0,11
N80T82	0,42
O84	0,18
P85	0,06
Q86	0,10
Q87_88	0,05
R90T92	0,04
R93	0,05
S94	0,08
S95	0,08
S96	0,08
T	0,04
U	0,00

Table 6 : Average carbon content of import by sector

CO2 linked to import demand by sector	
Crop and animal proc	5.523,82
Forestry and logging	16,15
Fishing and aquacult	103,43
Mining and quarrying	7.893,54
Manufacture of food	5.684,78
Manufacture of textil	1.039,92
Manufacture of wood	322,20
Manufacture of pape	731,88
Printing and reprodu	12,77
Manufacture of coke	6.526,80
Manufacture of chem	10.815,15
Manufacture of basic	2.045,28
Manufacture of rubbe	1.340,13
Manufacture of other	2.262,65
Manufacture of basic	5.317,60
Manufacture of fabric	1.869,63
Manufacture of comp	2.136,58
Manufacture of elect	1.498,55
Manufacture of mach	5.825,34
Manufacture of moto	8.047,49
Manufacture of other	958,44
Manufacture of furnit	677,17
Repair and installatio	226,18
Electricity, gas, stean	2.212,09
Water collection, trea	6,76
Sewerage, waste mai	3.108,14
Construction	1.380,11
Wholesale and retail	400,70
Wholesale trade, exc	14.786,97
Retail trade, except c	3.388,09
Land transport and tr	4.285,26
Water transport	1.875,54
Air transport	1.659,97
Warehousing and su	4.472,47
Postal and courier ac	97,35
Accommodation and	2.393,41
Publishing activities	211,82
Motion picture, videc	87,26
Telecommunications	398,59
Computer programmi	2.310,33
Financial service acti	5.965,38
Insurance, reinsuran	244,67
Activities auxiliary to	450,56
Real estate activities	56,41
Legal and accounting	5.260,50
Architectural and eng	1.428,36
Scientific research ai	68,45
Advertising and mark	259,64
Other professional, s	51,12
Rental and leasing ac	676,60
Employment activitie	32,85
Travel agency, tour c	347,60
Security and investig	1.693,61
Public administration	155,98
Education	200,65
Human health activiti	7,54
Residential care acti	2,48
Creative, arts and en	10,31
Sports activities and	8,68
Activities of member	2,63
Repair of computers	1,62
Other personal servi	29,62
Activities of househo	0,60
Activities of extraterr	0,00

Table 7 : CO_2e linked to import demand by sector

Appendix 7 : Final results by exporting country for Belgium

Average carbon content of imports by country	
Bulgaria	0,56
Czechia	0,47
Denmark	0,26
Germany	0,75
Estonia	0,47
Ireland	0,30
Greece	0,42
Spain	0,43
France	0,45
Croatia	0,42
Italy	0,48
Cyprus	0,33
Latvia	0,27
Lithuania	0,30
Luxembourg	0,17
Hungary	0,37
Malta	0,18
Netherlands	0,39
Austria	0,32
Poland	0,67
Portugal	0,34
Romania	0,46
Slovenia	0,32
Slovakia	0,33
Finland	0,31
Sweden	0,25
Norway	0,27
Switzerland	0,21
United Kingdom	0,48
Türkiye	0,46
Russia	1,57
South Africa	1,09
Canada	0,56
United States	1,04
Mexico	1,55
Argentina	0,62
Brazil	0,69
China	1,44
Japan	0,44
South Korea	0,54
India	1,20
Indonesia	1,80
Saudi Arabia	1,02
Australia	0,51
Rest of the world	2,03

Table 8 : Average carbon content of import by country

KTeCO2 linked to final demand in imports by country	
Bulgaria	82,10
Czechia	441,63
Denmark	103,24
Germany	9.797,24
Estonia	16,27
Ireland	882,02
Greece	33,01
Spain	710,31
France	3.021,51
Croatia	12,44
Italy	1.492,89
Cyprus	1,37
Latvia	8,68
Lithuania	36,07
Luxembourg	840,04
Hungary	211,42
Malta	1,00
Netherlands	3.245,41
Austria	146,28
Poland	742,47
Portugal	85,50
Romania	126,34
Slovenia	19,92
Slovakia	74,99
Finland	109,54
Sweden	406,77
Norway	62,47
Switzerland	446,99
United Kingdom	1.473,61
Türkiye	164,01
Russia	1.234,52
South Africa	82,37
Canada	127,38
United States	3.560,32
Mexico	238,63
Argentina	46,36
Brazil	92,05
China	2.165,72
Japan	1.215,86
South Korea	176,74
India	448,47
Indonesia	52,07
Saudi Arabia	320,62
Australia	68,76
Rest of the world	4.416,17

Table 9 : CO_2e linked to intermediate demand in imports by country

KTeCO2 linked to intermediate demand in imports by country	
Bulgaria	326,68
Czechia	362,72
Denmark	350,60
Germany	11.312,86
Estonia	63,93
Ireland	1.817,09
Greece	120,24
Spain	1.375,88
France	8.132,79
Croatia	46,21
Italy	1.804,01
Cyprus	4,26
Latvia	45,08
Lithuania	155,46
Luxembourg	1.047,16
Hungary	206,20
Malta	9,48
Netherlands	7.695,27
Austria	291,47
Poland	1.988,33
Portugal	236,13
Romania	445,01
Slovenia	54,19
Slovakia	125,82
Finland	200,61
Sweden	356,85
Norway	1.767,63
Switzerland	1.194,71
United Kingdom	3.788,10
Türkiye	258,87
Russia	8.620,73
South Africa	803,89
Canada	1.090,73
United States	10.699,79
Mexico	1.020,66
Argentina	361,20
Brazil	324,12
China	2.326,22
Japan	797,01
South Korea	158,22
India	988,09
Indonesia	97,44
Saudi Arabia	627,78
Australia	288,85
Rest of the world	13.239,03

Table 10 : CO_2e linked to intermediate demand in imports by country

Appendix 8 : Final results by consumption category

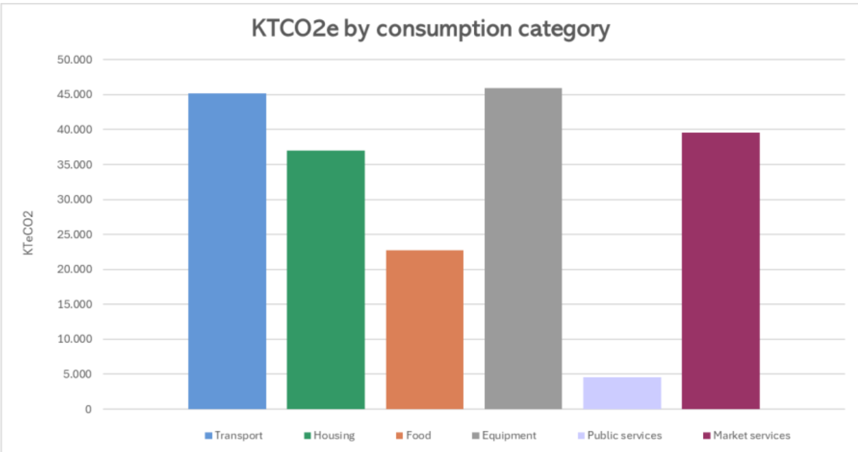

Figure 21 : CO_2e by consumption category

Appendix 9 : Results activities by household

Total activities by households	29.757,70 ***KTeCO2***
Heating/cooling activities by households	15.597,85
Transport activities by households	13.626,52
Other activities by households	533,35

Table 11 : Activities by households

Appendix 10 : French results with Belgium's method

Domestic production	253.398,62	KTeCO2
Total activities by household	117.797,47	KTeCO2
Import for intermediate dem	244.502,63	KTeCO2
Import for final demand	154.548,23	KTeCO2
Total	770.246,95	KTeCO2
French population	66.978	Thousands inhabitants
Emission per capita	11,50	TeCO2 per capita

Table 12 : French results with Belgium's method

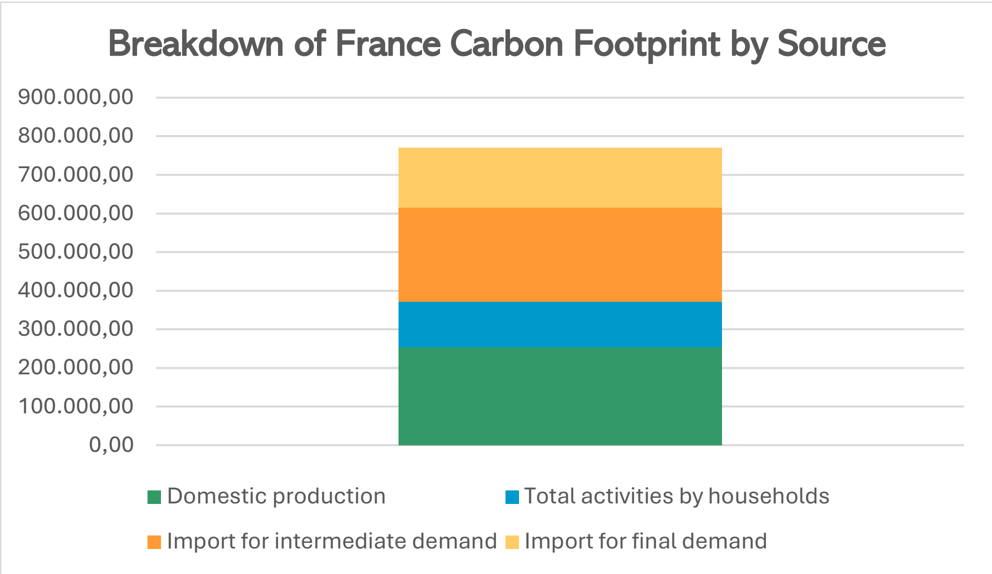

Figure 22 : Breakdown of French results