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The PEACH2AIR database of air pollution associated with household consumption in Belgium in 2014

Methodological description for the SUSPENS research project funded by the Federal Science Policy Office

March 2018

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Abstract - This report describes the database PEACH2AIR, which calculates air pollution linked to consumer expenditures in Belgium in 2014. The considered pollutants are greenhouse and acidifying gases, gases contributing to tropospheric ozone formation and particulate matter. This air pollution is calculated at the consumption stage, i.e. the use of energy products by households, and at the production stage, i.e. the air pollution caused by the production of the goods and services purchased by households. To do this, PEACH2AIR relies on internationally standardized air pollution data (including air emissions accounts of the Federal Planning Bureau), input-output tables and the House-hold Budget Survey. Analyses for 2014 show that energy products, as well as food and non-alcoholic beverages, were the most air polluting expenditure categories.

Jel Classification - C67, C81, D12, Q53, Q56
Keywords - sustainable development, household consumption, environmental economic accounts

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Executive summary

This report describes a method for linking the demographic and socio-economic characteristics of Belgian households with air pollution caused by their consumption. The database created is named PEACH2AIR, where PEACH stands for 'Profiling the Environmental Accountability of the Consumption of Households'. AIR refers to the pollution considered: greenhouse gases, acidifying gases, gases contributing to tropospheric ozone formation and particulate matter. The air pollution data used here are related to Belgium only. Therefore, it is assumed that imported goods and services generate the same air pollution as those produced in Belgium, which is obviously a simplification.

PEACH2AIR links the following data for 2014:

– the Belgian household budget survey (HBS), which contains representative data on household expenditure on goods and services, with more precise information on energy expenditure compared to the previous HBSs;

– data on air pollution caused during the production of goods and services, calculated on the basis of the air emissions accounts of the Federal Planning Bureau and the input-output tables, including a more detailed estimate for food products and public goods and services;

– data from Belgian inventories or international sources concerning air pollution caused by fuels used by households at home (heating, cooking, hot water) and for their personal means of transport.

PEACH2AIR calculates VAT and excise duties paid on the goods and services recorded in the HBS. This is necessary, because the coefficients regarding air pollution caused during the production of 1 euro of a particular product correspond with 1 euro worth of expenditure at basic prices, so exclusive of taxes on products. However, the data in the HBS are expressed at purchaser's prices, inclusive of those taxes. To avoid an overestimation of air emissions caused by household consumption, the air pollution coefficients also have to be calculated per euro at purchaser's prices, by applying a tax correction factor. Furthermore, the calculation of VAT and excise duties allows us to model the socio-economic impact on households of changes in these taxes.

A provisional analysis of PEACH2AIR shows that food and non-alcoholic beverages and energy products were by far the most air polluting expenditure categories in the 2014 budgets of the households. They accounted for 55 to 60% of air pollution caused by household consumption, while only representing just over 20% of total household expenditure. Food and non-alcoholic beverages are more important in the context of acidification, energy products in the context of climate change.

This report is part of the SUSPENS research project funded by the Federal Science Policy Office. The Centre for Social Policy of the University of Antwerp is coordinating this research work. Besides the Federal Planning Bureau, the IGEAT-CEDD of the Université libre de Bruxelles also takes part in the project. SUSPENS aims to support the preparation of policies that promote the transition towards less polluting consumption patterns. To this end, it plans to further finetune PEACH2AIR and integrate it into the EUROMOD microsimulation model.

Synthèse

Le présent rapport décrit une méthode visant à relier les caractéristiques démographiques et socioéconomiques des ménages belges à la pollution de l'air causée par leur consommation. La base de données créée a été baptisée PEACH2AIR, pour 'Profiling the Environmental Accountability of the Consumption of Households'. AIR renvoie à la pollution prise en compte : les gaz à effet de serre, les gaz acidifiants, les gaz favorisant la formation d'ozone troposphérique et enfin les particules fines. Les données relatives à la pollution de l'air utilisées ici se rapportent exclusivement à la Belgique. Par conséquent, on suppose que les biens et services importés génèrent la même pollution de l'air que ceux produits en Belgique, ce qui constitue naturellement une simplification.

PEACH2AIR relie les données suivantes pour l'année 2014 :

- l'enquête belge sur le budget des ménages (EBM) contenant des données représentatives sur les dépenses des ménages en biens et en services, avec des informations plus précises sur les dépenses énergétiques que dans les EBM précédentes ;
- les données sur la pollution de l'air causée pendant la production de biens et de services, calculées sur la base des comptes des émissions atmosphériques du Bureau fédéral du Plan, à l'aide de tableaux entrées-sorties, avec une estimation plus fine pour les produits alimentaires et les biens et services publics ;
- les données d'inventaires belges ou de sources internationales concernant la pollution de l'air causée par les combustibles utilisés par les ménages dans leur habitation (chauffage, cuisine, eau chaude) et pour leurs moyens de transport personnels.

PEACH2AIR calcule la TVA et les droits d'accise grevant les produits et services enregistrés dans l'EBM. Ce calcul est nécessaire car les coefficients relatifs à la pollution de l'air causée par la production d'un euro d'un produit donné, correspondent à 1 euro de dépenses en prix de base, hors taxes sur les produits. Toutefois, les données de l'EBM sont exprimées au prix d'achat, toutes taxes comprises. Afin d'éviter une surestimation des émissions atmosphériques dues à la consommation des ménages, les coefficients de pollution atmosphérique doivent également être calculés par euro au prix d'achat, en appliquant un facteur de correction fiscale. En outre, le calcul de la TVA et des droits d'accises permet de modéliser les effets socioéconomiques sur les ménages des changements de ces taxes.

Une analyse préliminaire de PEACH2AIR indique que les aliments, les boissons non alcoolisées et les produits énergétiques étaient de loin les dépenses ménagères les plus polluantes en 2014. Ensemble, ils représentent entre 55 % et 60 % de la pollution atmosphérique causée par la consommation des ménages, alors qu'ils représentent un peu plus de 20 % des dépenses totales des ménages. Les aliments et les boissons non alcoolisées sont plus importants dans le contexte des émissions de gaz acidifiants, les produits énergétiques dans le contexte du changement climatique.

Le présent rapport fait partie du projet de recherche SUSPENS financé par le Service public de programmation de la Politique scientifique fédérale. Le Centre de politique sociale de l'Université d'Anvers coordonne ces travaux de recherche. Outre le Bureau fédéral du Plan, l'IGEAT-CEDD de l'Université

libre de Bruxelles participe également au projet. SUSPENS vise à soutenir le processus de préparation de la politique qui accompagne la transition de la société vers des modes de consommation moins polluants. À cette fin, elle prévoit d'affiner le développement de PEACH2AIR et de l'intégrer dans le modèle de microsimulation EUROMOD.

Synthese

Dit rapport beschrijft een methode om demografische en socio-economische kenmerken van Belgische huishoudens te koppelen aan de luchtvervuiling veroorzaakt door hun consumptie. Het opgebouwde databestand kreeg de naam PEACH2AIR, wat staat voor 'Profiling the Environmental Accountability of the Consumption of Households'. AIR verwijst naar de in rekening genomen vervuiling: broeikasgassen, verzurende gassen, gassen die troposferische ozonvorming bevorderen en fijn stof. De hier gebruikte luchtvervuilingsgegevens hebben uitsluitend betrekking op België. Er wordt bijgevolg verondersteld dat de geïmporteerde goederen en diensten dezelfde luchtvervuiling veroorzaken als die geproduceerd in België, wat vanzelfsprekend een vereenvoudiging is.

PEACH2AIR koppelt voor het jaar 2014 volgende gegevens aan elkaar:

- het Belgische Huishoudbudgetonderzoek (HBO) met representatieve gegevens over de huishoudelijke uitgaven voor goederen en diensten, met in vergelijking met de vorige HBO's preciezere informatie over energie-uitgaven;
- op basis van de luchtemissierekeningen van het Federaal Planbureau met input-outputtabellen berekende gegevens over de luchtvervuiling veroorzaakt tijdens de productie van goederen en diensten, waaronder een fijnere raming voor voedingsproducten en publieke goederen en diensten;
- gegevens uit Belgische inventarissen of internationale bronnen over luchtvervuiling veroorzaakt door brandstoffen gebruikt door huishoudens in hun woning (verwarming, koken, warm water) en voor hun persoonlijke vervoermiddelen.

PEACH2AIR berekent de btw en de accijnzen betaald op de producten en diensten geregistreerd in het HBO. Dit is noodzakelijk omdat de coëfficiënten met betrekking tot de luchtvervuiling veroorzaakt tijdens de productie van 1 euro van een bepaald product, overeenstemmen met 1 euro uitgedrukt in basisprijzen, dus zonder die belastingen op producten. Het HBO is evenwel uitgedrukt in consumptieprijzen, dus inclusief die belastingen. Om een overschatting van de door de huishoudelijke consumptie veroorzaakte luchtvervuiling te vermijden, dienen de luchtvervuilingscoëfficiënten eveneens te worden berekend per euro in consumptieprijzen, door ze te corrigeren met de betaalde btw en accijnzen. Bovendien laat de berekening van de btw en accijnzen toe om de socio-economische gevolgen voor huishoudens te modelleren van veranderingen in die belastingen.

Een voorlopige analyse van PEACH2AIR geeft aan dat voeding en niet-alcoholische dranken en energieproducten veruit de meest luchtvervuilende huishoudelijke uitgaven waren in 2014. Ze namen samen tussen 55 % en 60 % van de door de huishoudelijke consumptie veroorzaakte luchtvervuiling voor hun rekening, terwijl ze slechts iets meer dan 20 % van de totale huishoudelijke uitgaven vormden. Voeding en niet-alcoholische dranken zijn belangrijker in de context van de uitstoot van verzurende gassen, energieproducten in de context van klimaatverandering.

Dit rapport maakt deel uit van het onderzoeksproject SUSPENS gefinancierd door de Programmatorische federale Overheidsdienst Wetenschapsbeleid. Het Centrum voor Sociaal Beleid van de Universiteit Antwerpen coördineert dit onderzoek. Naast het Federaal Planbureau neemt het IGEAT-CEDD van de

Université libre de Bruxelles eraan deel. SUSPENS wil de beleidsvoorbereiding ondersteunen, die de maatschappelijke transitie naar minder vervuilende consumptiepatronen begeleidt. Daartoe plant het o.m. een verdere verfijning van PEACH2AIR, en de integratie ervan in het micro-simulatiemodel EUROMOD.

1. Introduction

Our climate has warmed up at a rapid pace over recent decades. "*Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. (IPCC, 2014: 2)"*. Climate change leads to an increased probability of serious, profound and irreversible consequences for human beings and various ecosystems. The main reason is most likely the increasing emissions of gases – called greenhouse gases, such as carbon dioxide – caused by human activities, i.e. the production and use of specific goods and services, for example cars with combustion engines (IPCC, 2014: 4, 8). The higher atmospheric concentration of these gases causes the greenhouse effect: atmospheric greenhouse gases partially reflect thermal radiation from the Earth, leading to a rise in the Earth's surface temperature. To limit climate change, current production and consumption patterns should emit fewer greenhouse gases.

Belgium is aware of this challenge, as is reflected in the Federal Long-Term Strategic Vision for Sustainable Development adopted in 2013, among other measures. It states that Belgian greenhouse gas emissions within the country should decrease by at least 80 to 95% by 2050 compared to their 1990 level (Royal Decree of 18 July 2013: Objective 31). This objective is in line with the internationally approved commitments resulting from the United Nations Framework Convention on Climate Change of 1992 and the Paris Convention of 2015. The internationally approved objective is to limit global warming to 1.5 or 2°C above pre-industrial levels.

This report is drafted within this context and focuses on the interaction between climate and social objectives. Lower-carbon production and consumption patterns are not only a climatological concern. They are also a social issue because not all citizens contribute equally to greenhouse gas emissions when buying and using goods and services. It all depends on their consumption pattern. Moreover, the impact of climate change can lead to new social inequalities, possibly coming on top of existing social inequalities. For example, wealthy owners can decrease their energy expenditure by investing in environmentally-friendly high-efficiency heating and glazing, unlike less affluent tenants.

This report presents a method for identifying air pollution produced by different categories of the Belgian population according to the goods and services they buy and consume. It makes it possible to describe the ecological and social aspects of air pollution caused by current patterns of both production and consumption. The method described below links air pollution data with the Household Budget Survey (HBS) of 2014, which lists the expenditure on goods and services bought by Belgian households. The database produced, named PEACH2AIR, uses data on expenditure and air pollution that are more precise than those used in a Working Paper drafted by the Federal Planning Bureau on the same topic in 2010 using data for 2002.[1]

This report is the tangible output of task 2.2. '*Build an up-to-date database with consumption and the environmental impact of consumption at the household level'* of the research project SUSPENS. In 2014, the

[1] PEACH stands for 'Profiling the Environmental Accountability of the Consumption of Households'. It is the second database of the Federal Planning Bureau that links household expenses with environmental data. PEACH2AIR specifically focuses on air pollution. Next to air pollution data, the first database 'PEACH,' with data for 2002, also contained data on non-renewable energy sources (Frère and Quertinmont, 2010).

Federal Public Planning Service Science Policy assigned this research project to a consortium led by the Herman Deleeck Centre for Social Policy (Centrum voor Sociaal Beleid - CSB) of the University of Antwerp. The Federal Planning Bureau (FPB) and the Institute for Environmental Management and Land-use Planning (Institut de Gestion de l'Environnement et d'Aménagement du Territoire - IGEAT) - Center for Studies on Sustainable Development (Centre d'Etudes du Développement durable - CEDD) of the Université libre de Bruxelles (ULB) are members of the consortium.[2]

This report is divided into the following chapters.

- Chapter 2 describes the structure of the PEACH2AIR database and how the databases on household expenditure and air pollution are linked. It also gives a brief introduction to the air pollutants considered, 13 in total, and the three air pollution indexes that are calculated based on these pollutants (greenhouse gas index, acidification index and an index on tropospheric ozone).
- Chapter 3 explains the method for calculating the so-called direct air pollution of households i.e. the air pollution caused by consumers burning fossil fuels, for example the air pollution caused by the fuel oil burned by a heating system or the emissions of a car running on petrol.
- Chapter 4 details how the so-called indirect air pollution of households is calculated. Indirect air pollution is caused during the production process of goods and services bought by consumers, for example the air pollution caused during the production of fuel oil for a heating system, or of a loaf of bread or a chair.
- Based on the information detailed in the previous chapters, chapter 5 presents a set of summary results using the PEACH2AIR database. It also reports the advantages and drawbacks of the methodology used to calculate the air pollution associated with the consumption of households in 2014 based on the household expenditures listed in the Household Budget Survey.

The methodology outlined in this report provides a basis for future, more detailed, in-depth analysis. For example, the demographic, socioeconomic and air pollution profile of the consumption of Belgian households of 2014 will be analysed using PEACH2AIR. Also, PEACH2AIR will be linked with tax revenue data, as contractually stipulated. A more thematic analysis of these data is also planned. This future analysis will focus on air pollution caused by household energy use, transport and finally food and on its connection with the socioeconomic profile of consumers.

Statbel, the Commission for the Protection of Privacy, the international experts invited within the framework of SUSPENS by the CSB to a technical seminar held on 26 and 27 June 2017 and finally all those who have worked in the SUSPENS consortium contributed to this report. The authors would like to thank these organisations and take responsibility for all possible mistakes and inconsistencies.

[2] SUSPENS stands for 'Sustainable Policy for Environmental and Social Aims'. This research project runs from 1 January 2015 to 31 March 2019. The following websites give more information: https://www.belspo.be/belspo/brain-be/projects/SUSPENS_en.pdf and https://suspens.net/ (last consulted on January 31, 2018).

2. PEACH2AIR

The PEACH2AIR database provides detailed data on air pollution caused by the consumption expenditure of households in Belgium for 2014. The novelty of PEACH2AIR is that it is used to describe the socio-economic characteristics of the households that are responsible for a certain type of air pollution through their consumption expenditure.

It brings together various databases and types of information in one coherent framework. Section 2.1 explains the structure of PEACH2AIR and section 2.2 presents, for non-specialists, the pollutants considered in PEACH2AIR.

2.1. Structure of PEACH2AIR

The structure of PEACH2AIR is described schematically in the box below. The grey shaded boxes are the primary sources used. The uppermost box represents the expenditure data on goods and services listed in the COICOP[3] nomenclature of the 2014 Household Budget Survey (HBS) and the socio-economic characteristics of the households that made these expenditures.

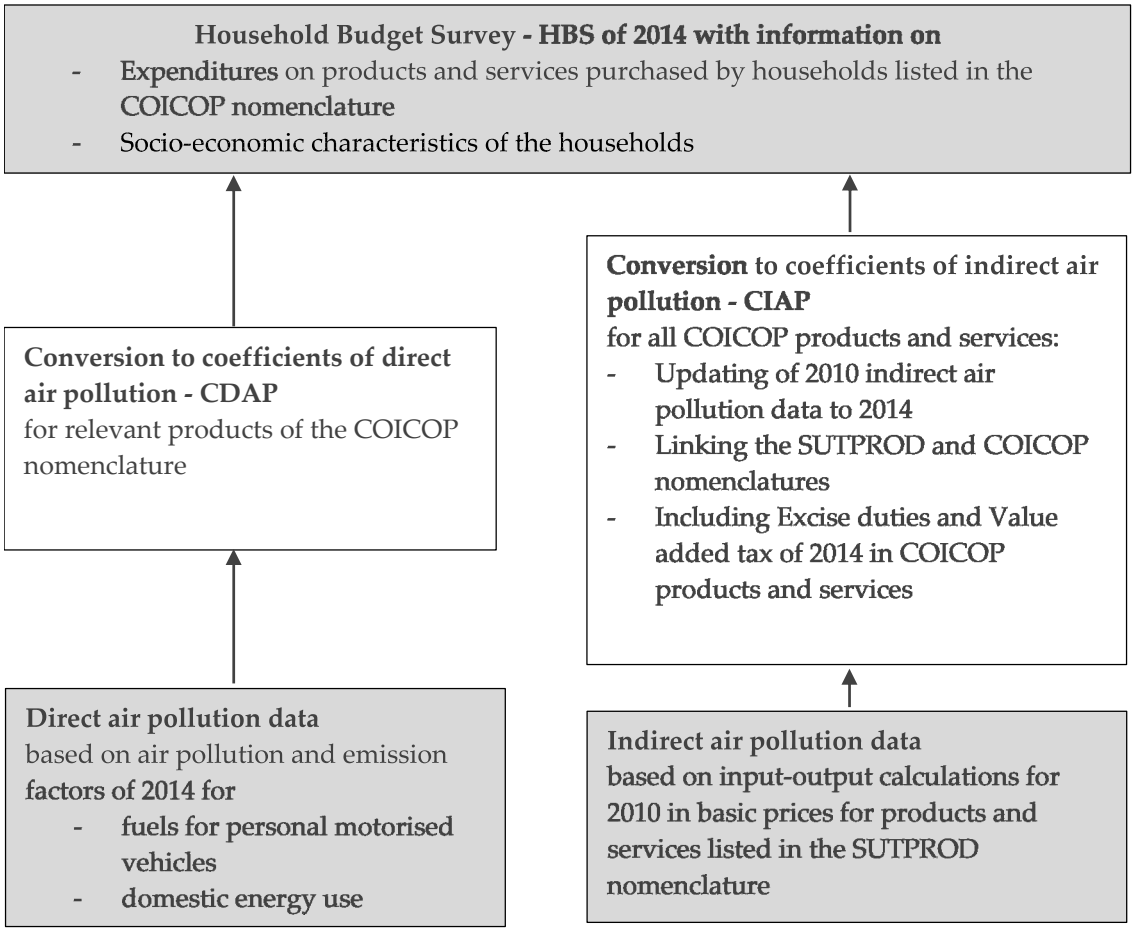
The box on the lower left-hand side stands for the data on air pollution and emission factors for fuels used for heating, cooking and personal motorised vehicles. They are used to calculate coefficients of direct air pollution (CDAP) for the fuels listed in the HBS. The box on the bottom right-hand side refers to the input-output data on air pollution for 2010 that were used to calculate coefficients of indirect air pollution (CIAP) of goods and services listed in the SUTPROD nomenclature, which is the product nomenclature used in the Belgian input-output tables. This indirect pollution is caused during the production process of these items. These data are converted into CIAP data on goods and services of the COICOP nomenclature of the Household Budget Survey.

The calculation of the CDAP and CIAP following the COICOP nomenclature is represented respectively by the left and right hand transparent boxes. The total air pollution of the COICOP items of the HBS can be calculated by adding up the total direct and indirect air pollution, which itself is obtained by multiplying respectively the CDAP and CIAP with the expenses of the relevant COICOP items.

Sections 2.1.1 to 2.1.4 introduce each building block of PEACH2AIR further. Chapters 3, 4 and 5 give the details of the calculations.

[3] Classification of Individual Consumption According to Purpose

Box: Schematic structure of PEACH2AIR



2.1.1. Household Budget Survey of 2014 for Belgium

The starting point of PEACH2AIR is the Belgian Household Budget Survey (HBS) of 2014. It is presented in the top part of the scheme. This national survey is conducted by Statbel. The HBS includes a detailed description of household consumption expenditure in Belgium. The survey also provides demographic and socio-economic information on households and household members.[4] Designed to carry out certain statutory tasks, such as calculating weights for the Consumer Price Index, it can be used for scientific research purposes.

[4] Until 2010, Statistics Belgium organised the HBS annually. From 2010 onwards, the survey has taken place every two years and a larger sample has been used. For more information see http://statbel.fgov.be/nl/statistieken/gegevensinzameling/enquetes/huishoudbudget/

The HBS records the final consumption expenditure of Belgian households at a very detailed level. All such expenditures are listed in the 12 general categories of the Classification of Individual Consumption According to Purpose, the so-called COICOP nomenclature. These categories are as follows.

1. Food and non-alcoholic beverages
2. Alcoholic beverages, tobacco and narcotics
3. Clothing and footwear
4. Housing, water, electricity, gas and other fuels
5. Furnishings, household equipment and routine household maintenance
6. Health
7. Transport
8. Communication
9. Recreation and culture
10. Education
11. Restaurants and hotels
12. Miscellaneous goods and services

Each category is further subdivided. At the most detailed level, the COICOP nomenclature of the 2014 HBS distinguishes about 1 200 goods and services. For each of these goods and services, the HBS indicates the household expenditure per year. It is possible, while complying with the usual statistical precautions related to the extrapolation of survey findings, to describe the demographic and socio-economic profile of households that have bought these goods and services.

For the development of PEACH2AIR, it was important to calculate air pollution caused by each good or service listed in the COICOP nomenclature of the 2014 HBS. Consequently, for each pollutant considered, coefficients of air emissions had to be calculated for each good and service. Such a coefficient represents the air pollution caused during the production and consumption of one monetary unit of a specific good or service. It is expressed in grams of pollutant per euro spent. The multiplication of this coefficient, which is specific for each pollutant and each good or service, with the yearly expenses on the goods or services considered, gives the total pollution caused by household consumption of that good or service.

An important distinction should be made here between direct and indirect air pollution caused by household consumption. Both types of pollution are calculated separately.

2.1.2. Direct air pollution

Direct air pollution refers to emissions by households using certain goods i.e. fuels for personal motorised vehicles and fuels burned at home for heating and cooking purposes. The coefficients of direct air pollution (CDAP) for the following COICOP products (fuels) are calculated directly in PEACH2AIR for the year 2014, using external sources:

– Fuels for heating and cooking: natural gas, natural gas for second residence, butane gas (deposit not included), propane gas (deposit not included), heating oil, other liquid fuels, coal, firewood, and other solid fuels (wood charcoal, wood pellets, etc.);

– Fuels used for personal motorised vehicles: diesel, gasoline, LPG, moped gasoline, and other fuels.

Chapter 3 presents the CDAP calculation method in detail. These CDAP can be used to calculate total direct air pollution (TDAP). Indeed, the TDAP for pollutant 'i' associated with fuel product 'j' is obtained by multiplying the expenses on this product, as listed in the HBS, by the coefficient of direct air pollution (CDAP) of pollutant i and product j.

This corresponds to the following formula.

$$\text{TDAP}_{i,j} = CDAP_{i,j} * HBS_{j} \quad (1)$$

2.1.3. Indirect air pollution

Indirect air pollution from household consumption stems from emissions released during the production process of goods and services bought by households. Chapter 4 explains in detail the calculation method of the coefficients of indirect air pollution (CIAP). The CIAP are calculated using air pollution data processed by an input-output model developed at the Federal Planning Bureau. Section 4.1. explains the details of the input-output calculations.

The data that the input-output model generates cannot be linked directly to the COICOP nomenclature of the 2014 HBS. There are three reasons for this.

– The CIAP of the input-output model relate to the year 2010 because this is the most recent year for which detailed supply and use tables are available. The CIAP of the input-output model thus must be recalculated for the year 2014, using inflation data for goods and services listed in the so-called SUTPROD nomenclature.

– The input-output model does not use the COICOP nomenclature, but the SUTPROD nomenclature, which is less detailed. The input-output model thus only calculates CIAP for goods and services listed in the SUTPROD nomenclature, which must thereafter be linked to the COICOP nomenclature used in the HBS 2014. This is done using a correspondence table that links each COICOP good or service to one or several SUTPROD goods or services.

– Finally, the CIAP of the input-output model are expressed in basic prices i.e. the price of a product excluding indirect taxes and excise duties. However, HBS only registers consumption expenditure on goods and services at purchaser prices to final customers, i.e. the actual prices paid by households. To avoid allocating a certain amount of indirect air pollution to indirect taxes and excise duties paid, the CIAP of the goods and services listed in the COICOP nomenclature need to be expressed in purchaser prices. Therefore, it is necessary to determine the excise duties and indirect taxes paid on each COICOP good or service in 2014.

Section 4.2 explains how the 2010 input-output data were updated to 2014, explains the correspondence table between the SUTPROD and COICOP nomenclature and details the VAT and excise duty calculations.

The CIAP can be used to calculate the total indirect air pollution (TIAP) using the following formula, for pollutant 'i' and product 'j'.

$$\mathrm{TIAP}_{i,j} = CIAP_{i,j} * HBS_{\,j} \quad (2)$$

It should be noted that the indirect air pollution calculations are based only on Belgian air pollution data and Belgian input-output tables. The production technology in foreign countries is thus assumed to be the same as the one used in Belgium. This simplification inevitably biases the air pollution profile calculations for Belgian households made by PEACH2AIR.

2.1.4. Total air pollution

The sum of total direct (where relevant) and indirect air pollution gives the total air pollution that can be can be allocated to each COICOP good or service in 2014. Expressed more formally, for each pollutant 'i' and for each product of the COICOP nomenclature 'j', total air pollution (TAP) of 2014 equals the sum of total direct air pollution (TDAP) and total indirect air pollution (TIAP).

$$\mathrm{TAP}_{i,j} = \mathrm{TDAP}_{\,i,j} + \mathrm{TIAP}_{i,j} \quad (3)$$

PEACH2AIR allocates this total air pollution to the households that are responsible for it, since their consumption expenditures are listed in the HBS. The HBS also lists the socio-economic characteristics of the households that bought certain goods or services. The air pollution profile of certain categories of households can consequently be described and analysed, as well as the influence of different consumption patterns on air pollution.

In total, PEACH2AIR contains information on 13 pollutants and three indexes: the greenhouse gas index, the acidification index and an index on tropospheric ozone. The next section gives more information on the nature of these types of air pollution.

2.2. Air pollution considered in PEACH2AIR

The interpretation of air pollution data is not obvious. To improve the understanding of the described methodology and preliminary results, especially for readers not familiar with air pollution, all air pollutants contained in PEACH2AIR are briefly described in the next table. This table also lists whether the air pollution is direct (caused during the consumption of fuels by households)[5] or indirect (caused during production).

Table 1 Air pollution considered in PEACH2AIR

Abbreviation	Brief description	Direct air pollution*	Indirect air pollution
CO_2	Carbon dioxide is a naturally occurring gas and a by-product of burning fossil fuels, such as oil, gas and coal, of burning biomass, of land use changes and of industrial processes (e.g. cement production). It is the main anthropogenic greenhouse gas.	yes	yes
N_2O	Nitrous oxide is a by-product of microbiological activity in the soil. The main anthropogenic sources of nitrous oxide are agriculture (soil and animal manure management), sewage treatment and chemical industrial processes. Nitrous oxide is a greenhouse gas.	yes	yes
CH_4	Methane is a natural gas and a by-product of using fossil fuels, of animal husbandry and of agriculture. Methane is a greenhouse gas.	yes	yes
HFCs	Hydrofluorocarbons are a group of synthetic compounds introduced as alternatives to ozone depleting substances (mainly chlorofluorocarbons or CFCs). When released into the atmosphere, they contribute to global warming.	no	yes
PFCs	Perfluorocarbons are a group of synthetic chemicals. They were introduced as alternatives to ozone depleting substances. They are used as solvents in the electronics industry and as refrigerants and are emitted as a by-product during aluminium production. Perfluorocarbons are greenhouse gases.	no	yes
SF_6	Sulphur hexafluoride is a synthetic gas used extensively in various electronic components and systems, in the production of magnesium and aluminium and for insulated double-glazed windows. Sulphur hexafluoride is a greenhouse gas.	no	yes
NO_x	Nitrogen oxides are gases formed whenever combustion occurs in the presence of nitrogen (e.g. car engines). Nitrogen oxides affect the respiratory system. They react to form smog as well as acid rain and contribute to the formation of particulate matter (PM) and tropospheric ozone, both associated with adverse health effects, especially respiratory dysfunctions.	yes	yes
SO_x	Sulphur oxides are a group of air pollutants consisting of gaseous and particulate chemical species. They derive mainly from the combustion of fossil fuels containing sulphur (coal, diesel). Sulphur oxides and particulates can lead to different health complications, such as respiratory related problems. They contribute to the formation of acid rain.	yes	yes
NH_3	Ammonia is a naturally occurring gas. It is also manufactured for use in the production of fertilizers, chemicals, synthetic fibres, foods and beverages, etc. Ammonia has toxic effects and causes burns and irritation. It contributes to the acidification and eutrophication of natural ecosystems, leading to biodiversity changes and reduced plant species richness.	yes	yes
NMVOC	Non-methane volatile organic compounds are a collection of organic compounds emitted into the atmosphere by different sources, including combustion activities, solvent use and production processes. NMVOCs contribute to the formation of tropospheric ozone, which has adverse effects on human health, in particular on the respiratory system. Certain NMVOCs are themselves hazardous to human health.	yes	yes
CO	Carbon monoxide is a naturally occurring gas found in the air produced by combustion processes. The main sources of additional carbon monoxide are motor vehicle exhaust and some industrial activities. High levels of carbon monoxide reduce the amount of oxygen carried around the body in red blood cells.	yes	yes
$PM_{2.5}$ PM_{10}	Particulate matter pollution is a mixture of solid and liquid particles suspended in the air. The numbers in "$PM_{2.5}$"and "PM_{10}"refer to the aerodynamic diameter of the matter considered, i.e. 2.5 and 10 µm. Finer particles may remain in the atmosphere for some time (from days to weeks). Motor vehicles, wood burning stoves and fireplaces, dust from construction, landfills, agriculture, waste burning, industrial sources and, finally, windblown dust from open land are some important sources of PM. Exposure to PM is linked to respiratory problems and lung diseases.	yes	yes

* Only for fuels used for heating and cooking and personal motorised vehicles.

[5] HFCs, PFCs and SF_6 are not emitted during the consumption of fuels, and therefore are not associated direct air pollution in PEACH2AIR. HFCs and SF_6 are emitted during the use of other products by the households, though. HFC emissions are primarily linked to cooling and air-conditioning, SF_6 to noise insulating windows.

To assess different kinds of environmental impacts, specific indexes can be built based on these air pollutants. The air pollutants used in these indexes are weighted according to their potential effect on the environmental impact concerned. PEACH2AIR calculates the following indexes:

– The greenhouse gas index, hereafter referred to as GHG index, measures the global warming potential of six air pollutants. It is expressed in CO_2 equivalents, according to the following formula:

$$\text{GHG index} = CO_2 + 298\ N_2O + 25\ CH_4 + PFC + SF_6 + HFC$$

– The acidification index, hereafter referred to as ACID index, is an index calculating the impact of three air pollutants on rain acidity. Acid rain consists of water with an elevated level of hydrogen ions. The index is therefore expressed in hydrogen ions according to the following formula:

$$\text{ACID index} = 0.03125\ SOx + 0.021739\ NOx + 0.058824\ NH_3$$

– The tropospheric ozone forming potential index, hereafter referred to as TOFP index, calculates the impact on tropospheric ozone formation of the release of four air pollutants. Tropospheric ozone formation is a very complex chemical process. The extent to which ozone is actually formed will depend on the cocktail, the relative amounts of the different air pollutants at a particular moment in time and on climatic circumstances. Tropospheric ozone is a respiratory hazard. The TOFP index is expressed in NMVOC equivalents according to the following formula:

$$\text{TOFP index} = 1.22\ NOx + NMVOC + 0.11\ CO + 0.014\ CH_4$$

3. Direct air pollution related to the use of fuels by households

This chapter explains how the direct air pollution related to the use of fuels by households is calculated. This is done by calculating coefficients of direct air pollution (CDAP) for 10 types of air pollution caused by the use of fuels by households to heat their dwelling, cook food and drive vehicles. The air pollution considered here relates to the emissions of CO_2, N_2O, CH_4, NO_x, SO_x, NH_3, NMVOC, CO, $PM_{2.5}$ and PM_{10}. These CDAPs express, for each type of pollutant, the amount of air pollution per euro spent on these fuels. Multiplying the CDAPs with the yearly household expenses on the fuel considered gives the total direct pollution caused by the burning of this fuel by households. For pollutant 'i' and product 'j', this corresponds to the following formula:

$$\mathrm{TDAP}_{i,j} = CDAP_{i,j} * HBS_{\,j} \tag{4}$$

Several sources and methods were used to obtain these CDAP. Section 3.1 discusses the sources and methods used to calculate the CDAP related to heating and cooking. Section 3.2 does the same for fuels used in personal motorised vehicles.

3.1. Fuels used for heating and cooking

The HBS considers nine types of expenses related to heating and cooking fuels: natural gas, natural gas for second residence, butane gas (deposit not included), propane gas (deposit not included), heating oil, other liquid fuels, coal, firewood and other solid fuels (wood charcoal, wood pellets, etc.). The HBS does not provide any information on home appliance technologies used by the HBS respondents.

3.1.1. Data sources

To estimate the CDAP for 2014 for fuels for heating and cooking, three sources are used.

– The National Greenhouse Gas Emissions Inventory includes all greenhouse gas emissions emanating from the final consumption of fuels. The category to which we refer for household residential consumption in Belgium is category '1.A.4.b.i.: Stationary combustion in the residential sector'. This source covers the emissions of CO_2, N_2O and CH_4 for all types of fuels mentioned in the HBS (National Climate Commission, 2017).

– The EMEP/EEA air pollutant emissions inventory guidebook provides guidelines to the national reporters (LRTAP – EEA, 2016). It summarises guidelines and benchmarks identifying the tools to elaborate national inventories. This source is used for emissions of NO_x, SO_x, NMVOC, CO, $PM_{2.5}$ and PM_{10}. It is also used for emissions of NH_3 but only those caused by burning of coal, firewood and other solid fuels (wood charcoal, wood pellets, etc.).

  These guidelines provide two types of methods when real emission data are not available. The first method considers the equipment technology (for instance, fireplaces and wood boilers do not emit the same number of particulates, although they both burn wood). The second method is only fuel specific, without regard to the technology of the burning or consumption equipment. To remain as close as possible to real emissions caused by Belgian households, the second method is used when

no data on emissions are available or are detailed enough in the national inventory. We refer more precisely to the data on the small combustion installations mainly intended for heating and provision of hot water in residential and commercial/institutional sectors. We especially consider typical Belgian residential heating appliances, such as fireplaces, stoves, cookers, small boilers (> 50kW).

– Regarding the NH_3 emitted during the combustion of gaseous and liquid heating fuels, regional measurements and emission factors are used (IRCEL-CELINE, 2012).

3.1.2. Conversion of air pollution data to air pollution per euro spent

The above-mentioned sources give mainly pollutant emissions per quantity of energy. For instance, the amount of CO_2 released when burning natural gas, as given by the national inventory, is 56.10 t CO_2/TJ (National Climate Commission, 2017). This information has to be converted per euro spent, so that they can be linked to households' expenditure reported in the HBS.

Depending on the unit used, data were subject to different conversions based on commonly shared standards:

– First, data were converted from pollutant emissions per quantity of released energy to pollutant emissions per quantity (weight or volume). For example, NOx emissions from heating fuel, expressed in the national inventory as 34 g/GJ, were converted to 0.828 g/l. We used conversion coefficients from the *Energy Statistics Manual* published by the International Energy Agency (International Energy Agency - OECD - Eurostat, 2005).

– A second conversion was then made to express pollution per euro of expenditure. To simulate prices for 2014, 2012 prices were updated according to the average CPI variation per category of products.

For each pollutant, the following table presents the CDAP for the nine types of fuels used for heating and cooking.

Table 2 Coefficients of direct air pollution - CDAP for 2014 for fuels used for heating and cooking
Grams per EUR

COICOP code	COICOP Category name	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SOx	CH_4	$PM_{2.5}$	PM_{10}
04521A	Natural gas	2,785	0.248	0.005	2.084	1.092	0.089	0.015	0.030	0.010	0.010
04521B	Natural gas for second residence	2,785	0.248	0.005	2.084	1.092	0.089	0.015	0.030	0.010	0.010
04522A	Butane gas (deposit not included)	1,486	0.132	0.003	1.113	0.583	0.048	0.008	0.016	0.005	0.005
04522B	Propane gas (deposit not included)	1,502	0.134	0.003	1.125	0.589	0.048	0.008	0.016	0.005	0.005
04530A	Heating oil	3,745	0.498	0.030	1.729	5.643	0.061	3.051	0.007	0.112	0.112
04530B	Other liquid fuels	3,652	0.486	0.029	2.528	2.825	0.034	3.470	0.005	0.094	0.094
04541A	Coal	6,275	19.901	0.100	9.951	132.674	19.901	29.852	0.020	14.594	15.921
04549A	Firewood	9,666	25.891	0.345	6.473	287.674	34.521	0.949	4.143	34.607	35.528
04549B	Other solid fuels (wood charcoal, wood pellets, etc.)	5,938	18.829	0.094	5.021	18.830	0.628	0.690	0.753	1.820	1.820

Source: FPB calculations

These CDAP can be interpreted as follows: a consumer who bought one euro worth of natural gas will, when using this gas domestically for heating or cooking, emit 2.785 kilograms of CO_2 or carbon dioxide into the air. The CDAP of the other fuels and pollutants can be interpreted in a similar manner.

3.2. Fuels used for personal motorised vehicles

The HBS considers five types of expenses related to fuels used for personal motorised vehicles: diesel, gasoline, LPG, moped gasoline and other fuels. The HBS does not provide technical information on personal motorised vehicles used by HBS respondents, such as the cylinder capacity of the motor or the weight of the vehicle which influence, among others, the fuel consumption of the vehicle.

3.2.1. Data source

The EMEP/EEA air pollutant emission inventory guidebook provides a detailed method for estimating transport emission factors, which considers the different elements influencing fuel consumption of personal motorised vehicles and its subsequent air pollution. It suggests using vehicle activity-based models, when only vehicle mean distances and mean travelling speed are available per mode and vehicle technology (based on certain assumptions regarding e.g. vehicle efficiency, vehicle and road maintenance, meteorological conditions, weight of people and luggage carried and driving habits) (LRTAP – EEA, 2016).

The COPERT 5 program is a vehicle activity-based program. It is used in Belgium by the regional administrations to calculate air emissions from transport. The Federal Planning Bureau uses these calculations to build air emissions accounts. COPERT is the abbreviation of 'Computer Program to calculate Emissions from Road Transport' (Ntziachristos *et al.*, 2009).[6] It calculates transport emissions based on burned quantities of fuel, for each fuel according to its specifications and for each type of vehicle used (motorbike, private cars, trucks, etc.). The results of COPERT5 were used to calculate the CDAP for all fuels. Note that, in Belgium, refiners must add 10% of ethanol to gasoline and of biodiesel to diesel. Emissions from biomass (in this case, ethanol or vegetal oils) are estimated independently from those from fossil energy.

3.2.2. Conversion of air pollution data to air pollution per euro spent

The transport emissions data reported in COPERT5 are expressed in grams per unit of energy. Consequently, a conversion to grams per euro was computed.

– Firstly, data were converted from pollutant emissions per quantity of energy to emissions per unit of volume. The coefficients used for this conversion come from the *Energy Statistics Manual* published by the International Energy Agency (International Energy Agency - OECD - Eurostat, 2005).

– Secondly, volumes were converted to euros using average purchaser prices. Prices come from the Consumer Price Index, as calculated by the FPB and updated for 2014 with the indexation ratios from Statbel.[7]

For each pollutant, the following table presents the CDAP for the five types of fuels used for personal motorised vehicles.

[6] For more information, see http://emisia.com/products/copert/copert-5 (last consulted on January 31, 2018).
[7] http://statbel.fgov.be/en/statistics/figures/economy/consumer_price_index/ (accessed on 18 December 2017).

Table 3 **Coefficients of direct air pollution - CDAP for 2014 for fuels used for personal motorised vehicles**
Grams per EUR

COICOP code	COICOP category name	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SOx	NH_3	$PM_{2.5}$	PM_{10}
07221A	Diesel	1,873.204	0.006	0.075	7.553	0.671	0.156	0.010	0.019	0.347	0.465
07222A	Gasoline	1,438.274	0.143	0.015	1.170	12.683	1.722	0.004	0.261	0.106	0.187
07223A	LPG	2,544.538	0.287	0.059	2.941	27.728	2.411	-	0.625	0.186	0.328
07223B	Moped gasoline	1,386.203	0.143	0.015	3.369	87.009	14.141	0.004	0.025	0.222	0.283
07223C	Other fuels	1,438.274	0.143	0.015	1.170	12.683	1.722	0.004	0.261	0.106	0.187

Note: CO_2 emissions exclude emissions related to biomass, CH_4 and N_2O include emissions related to biomass. The category 'Other fuels' include biofuels, alcohol-based fuels, mixed fuels and fuels other than diesel, gasoline and LPG. Due to the heterogeneity of this category, no CDAP could be calculated. They are here assumed to be equal to those of gasoline.

Source: FPB calculations

These CDAP can be interpreted in the following way: a consumer who bought one euro worth of diesel will, when using his car, emit 1,873 grams of CO_2 into the air. The same logic applies to the other fuels and pollutants.

4. Indirect air pollution from household consumption

This chapter explains how indirect air pollution from household consumption is calculated. A crucial parameter in this calculation are the coefficients of indirect air emissions (CIAP). They express for a specific type of pollutant, per euro spent on each type of good or service of the COICOP, the amount of air pollution generated during production.

The CIAP are calculated for 13 types of air pollution for each good and service listed in the COICOP nomenclature of the 2014 Household Budget Survey. The considered air pollutants are CO_2, N_2O, CH_4, NO_x, SO_x, NH_3, NMVOC, CO, $PM_{2.5}$, PM_{10}, HFCs, PFCs and SF_6. Multiplying these CIAP of each pollutant with the expenses of the goods or services listed in the COICOP nomenclature results in the total indirect pollution TIAP) that can be allocated to each COICOP good or service. Expressed more formally, for pollutant 'i' and product 'j', this corresponds to the following formula:

$$\mathrm{TIAP}_{i,j} = CIAP_{i,j} * HBS_{j} \quad (5)$$

The CIAP are based on an input-output model developed at the Federal Planning Bureau using data for the year 2010. Section 4.1 explains the calculations made by means of this model. They result in a set of indirect air pollution coefficients, expressed at basic prices at the SUTPROD product aggregation level (CIAP_IO_2010_BP). The results of these calculations must then be adjusted so that they can be linked to the 2014 HBS expenditures. These adjustments are explained in section 4.2. Section 4.3. gives an overview of the calculated CIAP for the goods and services of the COICOP nomenclature.

4.1. The input-output calculation of coefficients of indirect air pollution by households

As explained in section 2.1, consumption by households not only causes pollution during the consumption stage itself (direct pollution), the details of which were presented in chapter 3, but also during the production process of the consumer goods and services (indirect pollution). This indirect pollution generated by consumption is twofold.

– The production process of consumer products generates pollution directly both in Belgium (domestic consumer products), and abroad (imported consumer products). In the remainder of the text, the former will be called domestic direct production pollution, while the latter will be called foreign direct production pollution.[8]

– In addition, many intermediate goods and services are used in this production process. The production of these intermediate products also generates pollution, both in Belgium and abroad. This is the indirect production pollution[9], which can also be domestic or foreign.

[8] The direct production pollution is not to be confused with the direct pollution during the consumption of the products, which is the subject of chapter 3.

[9] The indirect production pollution is not to be confused with the indirect pollution caused by consumption. The latter consists of the sum of the direct production pollution and the indirect production pollution.

The following sections describe how basic price coefficients of indirect air pollution or CIAP_IO_2010_BP $_{i,k}$ have been calculated for each pollutant 'i' and for the goods and services listed in the SUTPROD nomenclature referred to here by 'k', which is less detailed than the COICOP nomenclature of the HBS. This calculation uses air pollution data from the 2010 Air Emissions Accounts. The indirect production pollution is calculated by means of an input-output model developed at the Federal Planning Bureau.

The calculation of the CIAP_IO_2010_BP consists of six steps:

1. The direct production pollution coefficients are determined at the industry level.
2. These industry coefficients are transformed into product coefficients, using the SUTPROD nomenclature.
3. The direct production pollution is determined.
4. The indirect production pollution is determined. It consists of three parts:
    a. domestic indirect production pollution
    b. foreign indirect production pollution for domestic final consumption products
    c. foreign indirect production pollution for imported final consumption products
5. Indirect pollution caused by household consumption is calculated.
6. The CIAP_IO_2010_BP are determined.

4.1.1. Coefficients of direct pollution from production by industry

The coefficients of direct pollution from production are obtained by combining the air emissions data for 63 industries[10] found in the air emissions accounts (AEA) for Belgium (Instituut voor de Nationale Rekeningen, 2016) with economic data for the same industries obtained from the supply and use tables for Belgium[11]. The direct production pollution coefficients by industry were calculated for the year 2010 because this is the most recent year for which a thorough study was made of the supply and use relationships in the Belgian economy.

The supply table shows the output of all products supplied to the Belgian economy by source, both domestic (domestic industries) and foreign (imports). The supply table also contains trade and transport margins, as well as taxes and subsidies on products, in order to make the transition from basic prices to purchaser's prices for each product. The basic price is the price received by the seller[12], the purchaser's price is the price paid by the buyer[13].

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10 NACE Rev.2.2 A64 classification, a combination of NACE sections and divisions, minus section U (Activities of extraterritorial organisations and bodies). Part of NACE 68, namely the imputed rents of owner occupied dwellings, was deducted as well, because the use and the supply regarding this activity does not generate the air emissions attributed to NACE 68. All emissions linked to owner occupied dwellings are reported as emissions by the households in the AEA, and are part of the direct pollution generated by household consumption, as presented in chapter 3.

11 A detailed study of the supply and use relationships in the Belgian economy is undertaken every five years to build input-output tables (Instituut voor de Nationale Rekeningen, 2015).

12 The basic price is the price receivable by the producers from the purchaser, minus any taxes on products payable on the product sold as a consequence of its production or sale, plus any subsidies on products receivable on that product as a consequence of its production or sale. It excludes any transport charges invoiced separately by the producer.

13 The purchaser price includes taxes less subsidies on the products (though excluding deductible taxes such as VAT), transport charges paid separately by the purchaser to take delivery at the required time and place, deductions for any discounts for bulk or off-peak purchases from standard prices or charges. It excludes interest or service charges added under credit arrangements, as well as extra charges incurred as a result of late payment.

The use table shows how the supply of the different products is used both domestically and abroad, for intermediate consumption by the industries, for final consumption by the government, households and non-profit institutions serving households, for gross fixed capital formation and for exports. The use table also shows the changes in inventories for the products, with a positive value if inventories increase. The use table is expressed in basic prices.

To take better account of the differences in the environmental impact of various types of agriculture, the latter industry was split into three subindustries, namely arable farming, horticulture and livestock farming. The same split has been introduced in the agricultural air emissions data.

To consider the environmental impact of domestic trade, trade margins were allocated to the corresponding products[14] in the supply and use tables.

The direct production pollution coefficients by industry are obtained by dividing the pollution (in physical units, mostly tonnes) by total output (in monetary units, millions of euros) for each industry. This has been done for 13 pollutants (total CO_2, N_2O, CH_4, HFC, PFC, SF_6, NO_x, SO_x, NH_3, NMVOC, CO, PM_{10}, $PM_{2.5}$) and three indexes (greenhouse gases, acidification and photochemical pollution). The coefficients form a 16 x 65 matrix, thus including 1040 coefficients. These coefficients of direct production pollution by industry show the physical amount of pollution generated by an industry per monetary unit of its output.

4.1.2. Coefficients of direct pollution from production by product

From the direct production pollution coefficients by industry, it is possible to derive the coefficients by product. To avoid negative coefficients, we made use of the industry technology assumption.[15] In other words, we assume all products made by the same industry to be produced with an identical input mix. Consequently, the coefficient of direct production pollution of a product can be calculated as a weighted average of the direct production pollution coefficients by industry of all industries that produce that particular product (as primary or secondary output). The weights are equal to the market shares of the different industries in total domestic output of the product.

The supply and use tables for the year 2010 contain 354 products, the so-called SUTPROD nomenclature[16]. For each of these products, we calculated the direct production pollution coefficient for the 13 individual pollutants and the 3 indexes. The direct production pollution coefficient matrix thus is a 16 x 354 matrix. This implies that we obtain a total of 5664 direct production pollution coefficients by product. The coefficients of direct pollution from production by product show the physical amount of pollution generated during the production of a monetary unit of that particular product in Belgium.

14 Margins on trade of motor vehicles were added to product 45A01 (trade in motor vehicles and motorcycles), wholesale trade margins to product 46A01 (wholesale trade) and retail trade margins to product 47A01 (retail trade).

15 A formal explanation of the industry technology assumption can be found in Eurostat, 2008: p 312 and following.

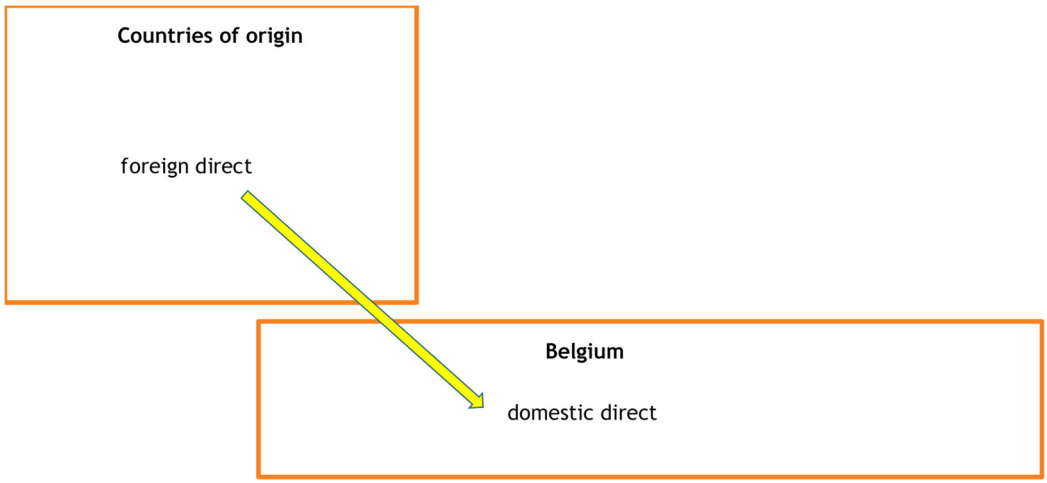
16 After removal of product 68B01, imputed rents of owner occupied dwellings.

Some of the 354 products are not made in Belgium, however. To calculate pollution coefficients for these products as well, we assumed them to be produced by one NACE A64 level industry.[17]

4.1.3. Direct pollution from production

When the product coefficients of direct pollution from production are multiplied by final demand for domestic products by Belgian households, this results in the **domestic direct pollution from production** generated by Belgian consumer demand. Final household demand can be found in the use table of domestic products under the heading P31/S14. There are a number of services, however, which we know are consumed by households, but primarily paid for by the government. These concern education, human health and social services.[18] For these services we added P31/S13, government individual consumption, to obtain a more complete view on the environmental impact of the consumption of these services.

Graph 1 Direct pollution from production



Consumers of course also buy foreign products. Final demand for imported products by the households can be found in the use table of imports under the heading P31/S14. In graph 1, this flow of goods and services is shown by means of the arrow starting in the countries of origin of Belgium's imports and ending in Belgium.

When final demand for imported products by the Belgian households is multiplied by the coefficients of direct pollution from production by product, this results in the **foreign direct production pollution** generated by Belgian consumer demand. It should be noted that we also use the Belgian coefficients of direct pollution from production to estimate the environmental impact abroad. Identical emissions per unit of output of a specific product in different countries are linked to the use of identical production technologies. This is called the domestic technology assumption.[19] This simplifying assumption, namely

[17] Products 05A01, 06A01 and 24B05 were allocated to industry 05-09, product 12A02 to industry 21, product 23B02 to industry 23, product 26C04 to industry 26, product 30D01 to industry 30, product 37A91 to industry 37-39, and product 52A93 to industry 52.

[18] In the Belgian SUT, this concerns products 85A93, 86A01+02, 86B01, 86C01, 86D01+02, 87A01+02 and 88A01+02.

[19] Applying the domestic technology assumption to imports implies that one calculates the emissions that are avoided in the importing country by not having to produce the products which are imported rather than the emissions caused by the

that the environmental impact of production of a product abroad is identical to the impact in Belgium, has been chosen because our calculations are not embedded in a multi-regional input-output model.[20]

4.1.4. Indirect pollution from production

As indicated above, products consumed by the households also generate production pollution indirectly, as many foreign and domestic intermediate goods and services are necessary to produce the products consumed by the Belgian households. We will therefore also calculate this indirect pollution from production. The indirect pollution from production is calculated on the basis of the direct production pollution coefficients of the intermediate products used during a production process.

The indirect production pollution consists of three parts:
a. domestic indirect production pollution
b. foreign indirect production pollution for domestic final consumption products
c. foreign indirect production pollution for imported final consumption products

a. Domestic indirect production pollution for domestic final consumption products

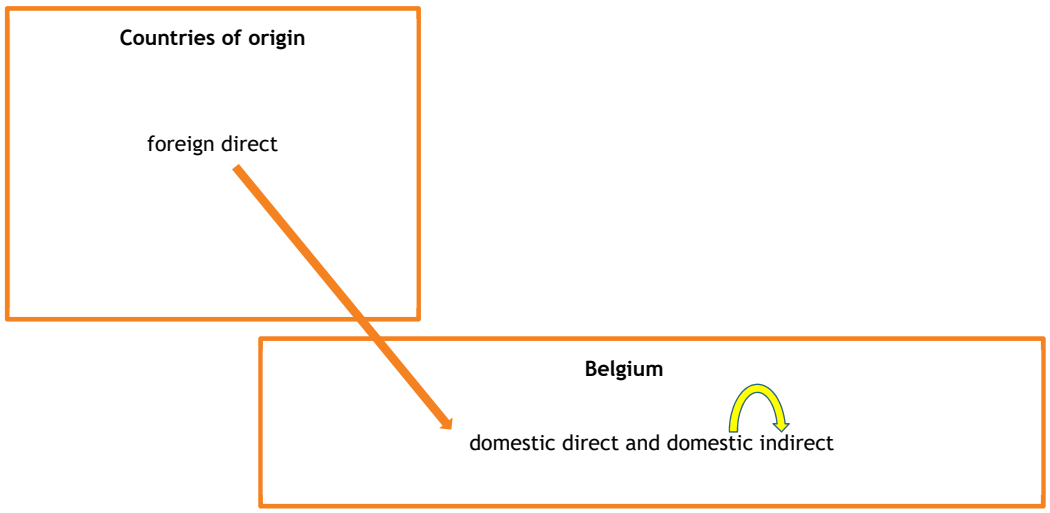
The Belgian supply and use tables contain among others the use table of domestic intermediates. For 2010, it consists of 354 products produced by 137 industries. When the 137 columns of this domestic intermediate use table are divided by the total domestic output of each of the 137 industries, we obtain a matrix showing the direct domestic product requirements (of 354 products) per unit of output of each one of the 137 industries. Multiplying this matrix with the market share matrix, showing for each of the 354 products which industries are producing them, one obtains the domestic technical coefficients matrix. This matrix shows the domestic intermediary product requirements (of 354 products) per unit of output of each one of the 354 products.

When the domestic technical coefficients matrix is multiplied with the final household demand for domestic products, we obtain all domestic intermediates needed to produce all these final demand products. But of course, these intermediates have to be produced as well. So, other domestic intermediate products will need to be made. The amount of each of these products can be obtained by pre-multiplying the domestic intermediates matrix just obtained, by the domestic technical coefficients matrix. Alternatively, one can pre-multiply final household demand for domestic products with the square of the domestic technical coefficients matrix. In order to make the intermediate products obtained by means of the previous calculation, yet more domestic intermediates are necessary. This loop goes on infinitely, but since the elements of the domestic technical coefficients matrix are smaller than one, the elements tend to zero the more the domestic technical coefficients matrix is multiplied by itself. When all the matrices obtained in the course of the infinite loop are added, one obtains the total domestic intermediates necessary to satisfy final household demand for domestic products. This flow of goods and services in the Belgian economy is represented by the curved arrow in the shape representing Belgium in graph 2.

production of these products abroad. However, to simplify the narrative, we will interpret the emissions calculated for imports as emissions caused by the production of the products abroad.

[20] In order to assess the environmental impact abroad in a more precise way, one needs to be able to split imports according to the origin, to have separate pollution data by industry or product for the different countries/regions of origin, and to have separate supply and use tables or input-output tables for each country/region of origin.

Graph 2 Adding domestic indirect production pollution

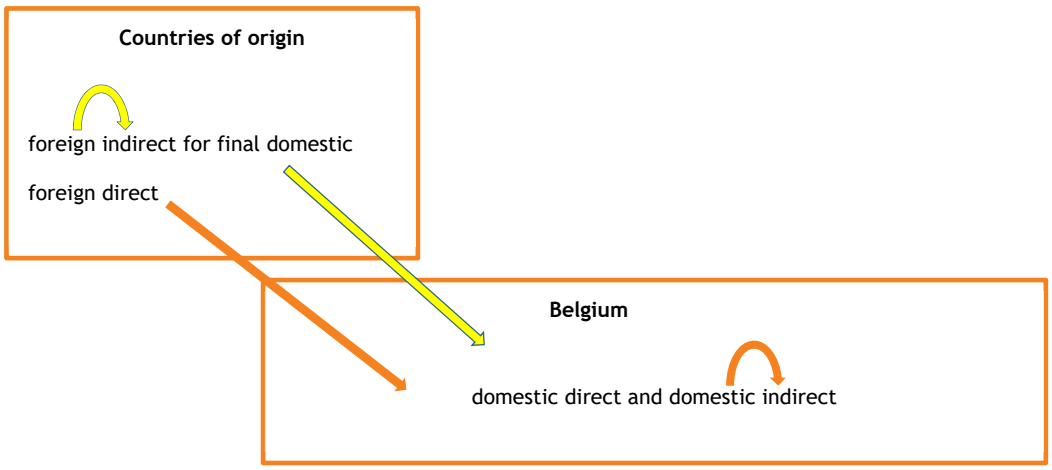


By multiplying the total domestic intermediates necessary to satisfy final household demand for the 354 domestic products with the coefficients of direct pollution from production, one obtains the domestic indirect pollution from production. This is the pollution generated in Belgium by the production of all the intermediate products used during the production process of the domestic goods and services consumed by the households.

b. Foreign indirect pollution from production for domestic final consumption products

The Belgian supply and use tables also contain the use table of imported intermediates. This concerns foreign products which are necessary to feed the production processes in Belgium. Just as in the case of the domestic intermediates, we will consider the use of 354 products by 137 industries. When the 137 columns of this imported intermediates use table are divided by the total domestic output of each of the 137 industries, we obtain a matrix showing the direct imported product requirements (of 354 products) per unit of output of each one of the 137 industries. By multiplying this matrix with the market share matrix, showing for each of the 354 products which industries are producing them, one obtains the technical import coefficients matrix. This matrix shows the imported intermediary product requirements (of 354 products) per unit of output of each one of the 354 products.

Graph 3 **Adding foreign indirect production pollution generated in the countries of origin for domestic consumer products**



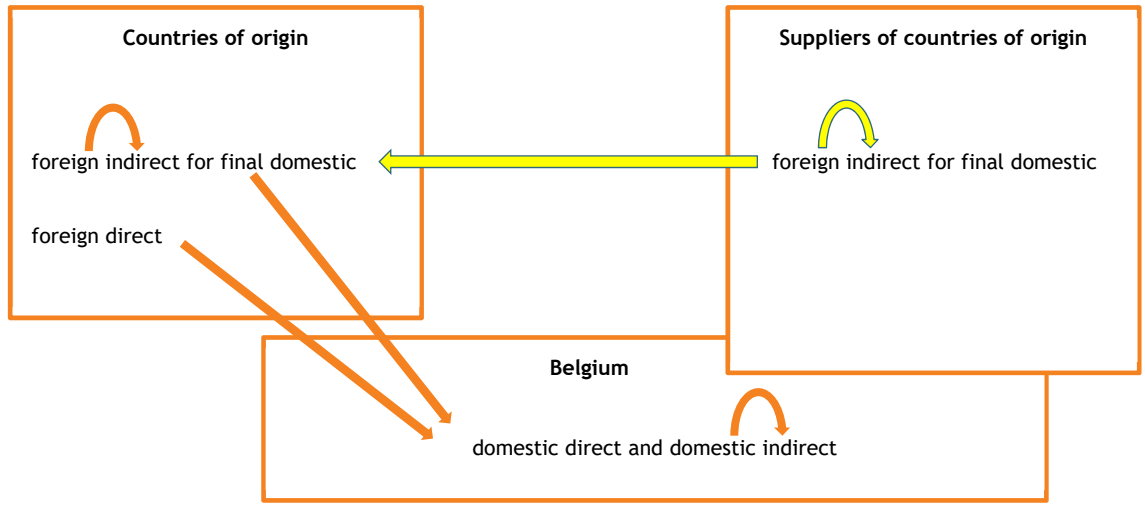
When the technical import coefficients matrix is multiplied with the total domestic production (both of final products and intermediates) needed to satisfy final demand for domestic products by the households, one obtains all imported intermediates needed to produce all these final demand products. But of course, these imported intermediates have to be produced as well. So, in the countries of origin of the imported intermediates, other intermediate products will need to be made. The amount of each of these products can be obtained by pre-multiplying the imported intermediates matrix just obtained, by the domestic[21] technical coefficients matrix. To make the intermediate products needed to manufacture the imported intermediates required to produce final demand for domestic products by the Belgian households, yet more domestic intermediates are necessary in the countries of origin of the intermediate Belgian imports. This loop goes on infinitely, but since the elements of the domestic technical coefficients matrix are smaller than one, the elements tend to zero the more the domestic technical coefficients matrix is multiplied by itself. When all the matrices obtained in the course of the infinite loop are added, one obtains the total domestic intermediates that are necessary, in the countries of origin, to produce the intermediates imported in Belgium in order to satisfy the household final demand for domestic products. Adding these domestic intermediates produced in the countries of origin of Belgium's imported intermediates (the internal flow of goods and services in the countries of origin, represented by the curved arrow in graph 3) to Belgium's imported intermediates themselves (the flow of goods and services from the countries of origin to Belgium, represented by the straight arrow from foreign indirect for final domestic to Belgium in graph 3), one obtains all products needed, in the countries of origin of Belgium's imported intermediates, to produce the Belgian domestic products consumed by the Belgian households.

Multiplying these totals for the 354 products with the coefficients of direct pollution from production, one obtains the foreign indirect pollution from production in the countries of origin of imported intermediates for the domestic production of consumer goods. This is all the pollution generated in the

[21] Logically, this ought to be the domestic technical coefficients matrix of the country of origin of the Belgian intermediate imports. Again, we assume the production process abroad to be identical to the production process in Belgium.

countries of origin of imported intermediates needed to produce all the Belgian products necessary to satisfy household consumption demand for Belgian products.

Graph 4 **Adding foreign indirect production pollution generated in the supplier countries for domestic consumer products**



We further assume that the countries of origin of Belgium's imported intermediates also have the same import product requirements per unit of industry output as Belgium. Since we also assume them to share the same market share matrix, this implies that we can apply the Belgian technical import coefficients to the total production in the countries of origin, that is necessary to create the intermediate imports needed to produce domestic consumer goods in Belgium (in graph 4 this corresponds to foreign indirect for final domestic in the countries of origin). This gives the total amount of imported intermediates needed, in the countries of origin of Belgium's imported intermediates, to produce domestic consumer goods in Belgium. This flow of goods and services is represented by the horizontal arrow from the suppliers of the countries of origin to those countries of origin in graph 4. And considering that the production of these imported intermediates also requires the use of domestic intermediates in the countries supplying them to the countries of origin of Belgium's imported intermediates, we can apply the domestic technical coefficients infinite loop to the total amount of imported intermediates (the straight yellow arrow in graph 4) needed in the countries of origin of Belgium's imported intermediates. This gives the total amount of domestic intermediates used in the countries supplying intermediates to the countries of origin of Belgium's imported intermediates (this internal flow of goods and services is represented by the curved arrow in the supplier countries in graph 4). That amount is necessary to produce the foreign intermediates used by the producers in the countries of origin of the foreign intermediates used by the Belgian producers to satisfy household consumer demand. Adding this to the foreign intermediates imported by the countries of origin of intermediates imported in Belgium themselves, we obtain total output in the suppliers of the countries of origin of Belgium's imported intermediates, necessary to satisfy Belgian consumer demand for Belgian products.

If we apply the coefficients of direct pollution from production to this matrix, we obtain the total pollution generated, as a consequence of Belgian household demand for domestic products, in the countries

that provide intermediate products to the producers of Belgium's imported intermediates.[22] This is the foreign indirect pollution from production in the countries supplying intermediates to the countries of origin of imported intermediates for the domestic production of consumer goods in Belgium.

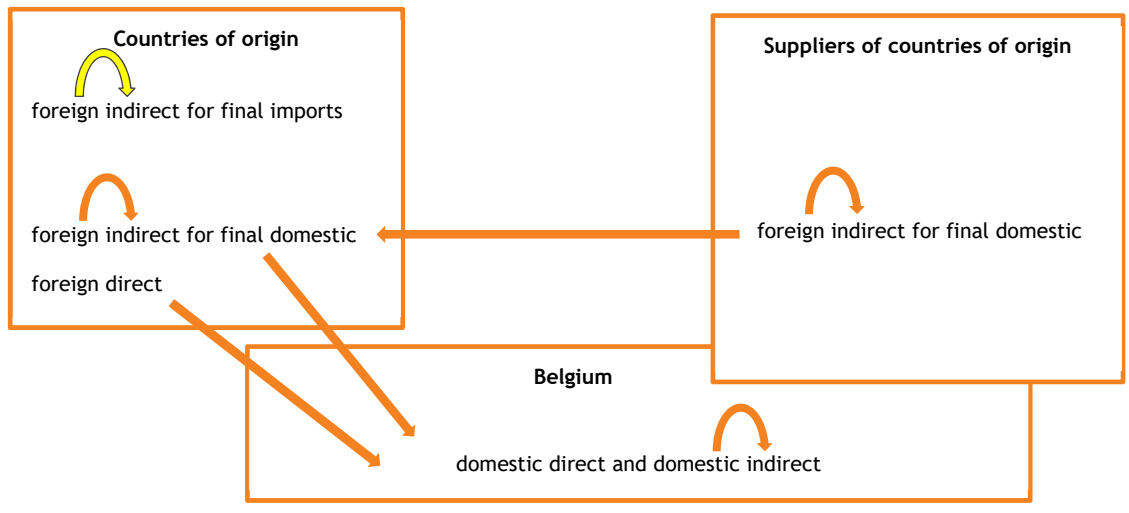
Adding the former to the foreign indirect pollution from production in the countries of origin of imported intermediates needed for the domestic production of consumer goods in Belgium, we obtain the total foreign indirect production pollution for domestic production of consumer products purchased by the Belgian households. This boils down to the total foreign[23] pollution from production generated by the Belgian household demand for Belgian products.

c. Foreign indirect pollution from production for imported final consumption products

As already mentioned above, the products that are imported in Belgium do not only serve as intermediates. Part of imports consists of consumer products (foreign direct in graphs 2 to 5). Evidently, the production of these products requires the use of both domestic and imported intermediates in the countries of origin. Applying the infinite loop of the domestic technical coefficients matrix to the amount of imported consumer products, we obtain the total amount of domestic intermediates needed in the countries of origin of Belgium's imported consumer products to produce these products. This is an internal flow of goods and services in the countries of origin of the consumer products imported into Belgium. In graph 5 this flow is represented by the curved yellow arrow above "foreign indirect for final imports" in the box representing the countries of origin of Belgium's imports.

Multiplying the resulting values with the coefficients of direct pollution from production by product, we obtain the foreign indirect production pollution generated for Belgium's imported consumer products in the countries of origin of these products.

Graph 5 Adding foreign indirect production pollution in the countries of origin of consumer imports



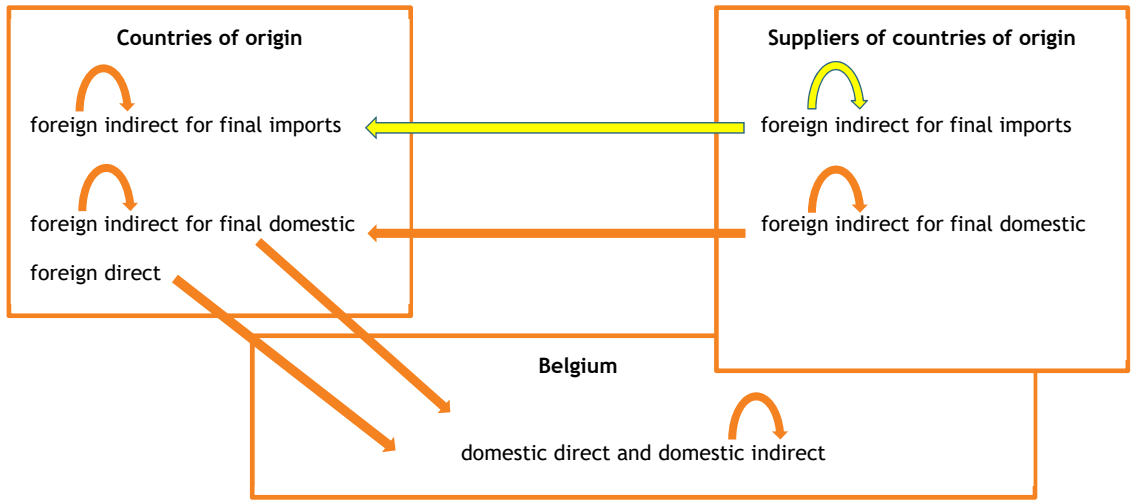
[22] Part of this pollution will probably be generated in Belgium, since Belgium also exports intermediate products which are used in production processes of the countries of origin of its own imported intermediates and of countries providing intermediates to these countries of origin of Belgium's imported intermediates. In Graph 4, this is indicated by the overlap between Belgium and the suppliers of the countries of origin.

[23] Due to Belgian exports, it most probably contains a small Belgian component.

Just like the imported intermediates, the imported consumer products also require the use of imported intermediates in the countries of origin of Belgium's imported consumer products. This flow of goods and services is represented by the horizontal yellow arrow starting from "foreign indirect for final imports" in the suppliers of the countries of origin and finishing at "foreign indirect for final imports" in the countries of origin in graph 6. The number of imported intermediates necessary in the countries of origin of Belgium's imported consumer products is obtained by multiplying the sum of the direct and indirect domestic production (foreign direct and foreign indirect for final imports) in the countries of origin of these products with the technical import coefficients matrix.

In the countries supplying these intermediates to the producers of Belgium's imported consumer products, once again a certain number of domestic intermediates will be necessary to produce them. This internal flow of goods and services in the suppliers of the countries of origin is represented by the curved yellow arrow above "foreign indirect for final imports" in graph 6. This amount is calculated by applying the infinite loop of the domestic technical coefficients to the number of imported intermediates necessary in the countries of origin of Belgium's imported consumer products.

Graph 6 **Adding foreign indirect pollution from production generated in the suppliers of the countries of origin of consumer imports**



The sum of the intermediate products imported into the countries of origin of Belgium's imported consumer products and the number of domestic intermediates needed to produce these intermediate products, in the countries supplying them, results in the total amount of intermediate products produced in the countries providing intermediates to the countries of origin of Belgium's imported consumer products. Multiplying the resulting values with the coefficients of direct pollution from production by product, we obtain the foreign indirect pollution from production for Belgium's imported consumer products in the countries providing intermediates to the countries of origin of Belgium's imported consumer products.

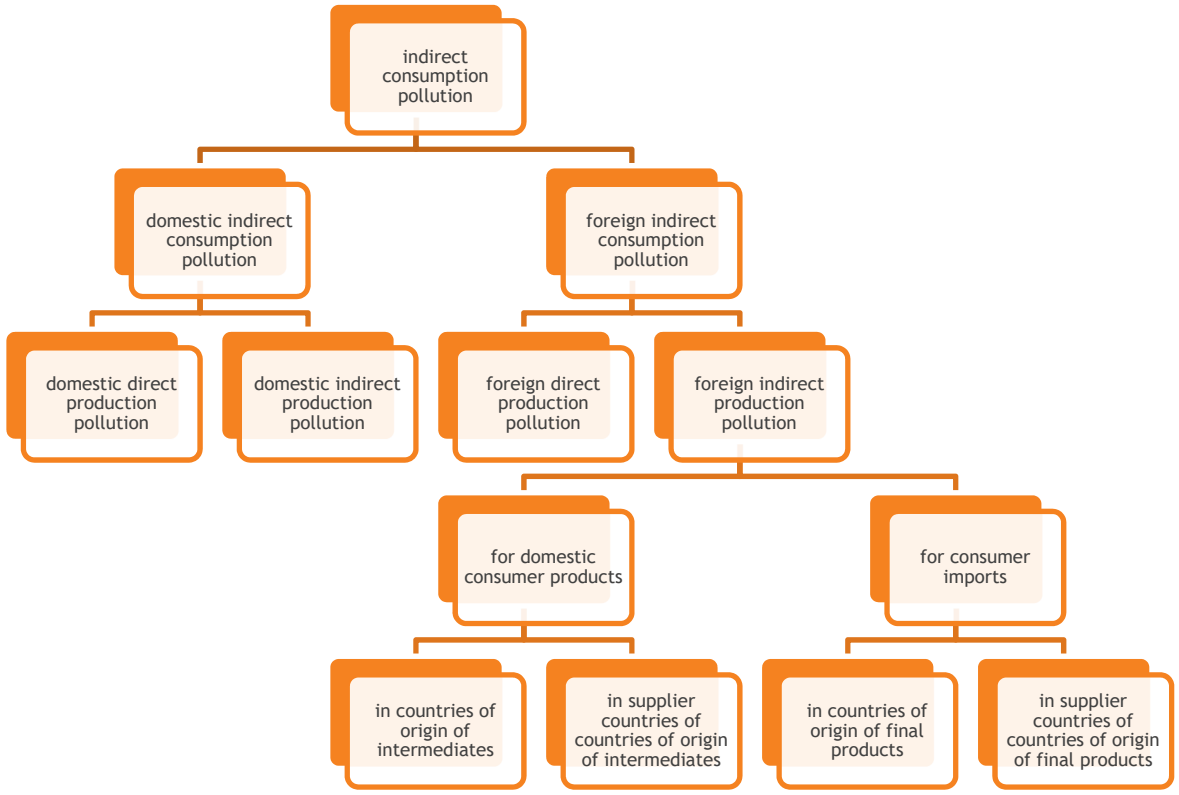
The sum of the foreign indirect pollution from production for Belgium's imported consumer products in the countries of origin of these products and the foreign indirect pollution from production for Belgium's imported consumer products in the countries providing intermediates to the countries of origin

of Belgium's imported consumer products gives total foreign indirect production pollution for the imports of consumer products for the Belgian households.

4.1.5. Indirect pollution caused by consumption

Graph 7 shows all the building blocks that together form the indirect pollution caused by consumption, in other words all pollution caused during the production of the consumer products. The sum of the domestic direct production pollution and the domestic indirect production pollution results in the domestic indirect consumption pollution.[24] This is all the pollution generated in Belgium to produce all the Belgian products necessary to satisfy household consumption demand for Belgian consumer products. It should be noted that this is not equal to all the pollution generated in Belgium to satisfy household consumption demand for Belgian products, because Belgian export products are used abroad to produce intermediate and final Belgian imports.

Graph 7 Indirect pollution from consumption and its constituent parts



Adding foreign indirect production pollution for domestic production of consumer products, on the one hand, and for imports of consumer products, on the other hand, to foreign direct production pollution, results in the foreign indirect consumption pollution.[25] This is all the pollution generated to

[24] For carbon dioxide, the most important greenhouse gas, the domestic indirect consumption pollution accounts for 48% of total indirect consumption pollution.

[25] As far as carbon dioxide is concerned, the foreign indirect consumption pollution accounts for 52% of the total indirect consumption pollution. Of this 52%, 39% is generated in the countries of origin of Belgian imports and 13% in the supplier countries of these countries of origin. In the supplier countries 8% is generated for intermediate Belgian imports and 5% for final Belgian imports. In the countries of origin 25% is generated for intermediate imports and 13% for final imports.

produce all the foreign products necessary to satisfy household consumption demand in Belgium for both imports and domestic products. It should be noted that this is not exactly equal to all the pollution generated abroad to satisfy household consumption demand, because Belgian export products are used abroad to produce intermediate and final Belgian imports.

The sum of the domestic and the foreign indirect consumption pollution gives the total indirect consumption pollution. This is all the pollution generated in Belgium and abroad to produce all the products consumed by Belgian households in one year.[26]

4.1.6. Coefficients of indirect air emissions caused by consumption

After all the calculations presented in sections 4.1.3 to 4.1.5, the indirect pollution from consumption is now available by SUTPROD product. Dividing this pollution by household demand by product, we obtain for each SUTPROD product the 2010 coefficients of indirect air pollution expressed in physical units of pollution per monetary unit of household expenditure at basic prices (CIAP_IO_2010_BP).

Since these coefficients will be applied to HBS expenditure data, the indirect pollution from consumption is divided only by the values for household consumption in the use table.[27] For the products of which the household use cannot be assessed properly on the basis of their private expenditure, we thus exclude individual government consumption.[28] These products concern education, human health and social services. As a consequence, these coefficients will be a lot higher than expected. The CIAP_IO_2010_BP for these products should be excluded if one wants to assess which products generate most pollution per unit of output during their production phase. The total pollution generated by a particular level of household consumption of education, human health and social services can nevertheless be compared to the pollution generated by the consumption of other products.

The way in which the CIAP_IO_2010_BP are calculated implies that the consumption of each product consists of domestic and imported components according to a fixed ratio. One could relax this assumption by calculating separate CIAP_IO_2010_BP for domestic products on the one hand, and imports on the other. Coefficients of indirect pollution from consumption for domestic products are obtained by adding the foreign indirect production pollution for domestic production to the domestic indirect consumption pollution and dividing this sum by household demand for domestic products. CIAP_IO_2010_BP for imports are obtained by adding the foreign indirect production pollution for imports to the foreign direct production pollution and dividing this sum by household demand for imports.

When identical parts of the supply chain of a particular product are considered, the coefficient of indirect pollution from consumption should be the same whether that product is produced domestically or imported, since we assume the production technology and the environmental impact per unit of output to be identical in Belgium and abroad. However, this is not true in the case of this study, because for domestic products consumed by the Belgian households, we take into account an extra step in the

[26] The total indirect consumption pollution of carbon dioxide is 79% higher than the direct consumption pollution by the households as measured in the Belgian AEA. The indirect consumption pollution is higher than the direct consumption pollution for most of the air pollutants. PFC, CO and the two types of PM are exceptions.

[27] The value for P31/S14 in the national accounts use table.

[28] P31/S13 in the national accounts use table.

supply chain, namely the foreign suppliers of intermediate products used in the countries of origin to produce Belgium's intermediate imports. As far as imported consumer products are concerned, we only take into account the intermediate products which are imported into the countries of origin of Belgium's imported consumer products, and not the imports needed to produce these intermediate products. The domestically produced products will therefore have a larger CIAP_IO_2010_BP than the imported version. In other words, the calculations made for PEACH2AIR are not to be used to compare the environmental impact of domestic products to the impact of imports. Their purpose is solely to compare the environmental impact of different consumption patterns with a fixed share of domestic and imported products for each product.

4.2. Linking the goods and services listed in the 2014 Household Budget Survey to the input-output calculations

The coefficients of indirect air pollution or CIAP_IO_2010_BP of the input-output model described in section 4.1. need to be adjusted so that they can be linked to the 2014 HBS. Three adjustments must be made.[29]

Firstly, the CIAP_IO_2010_BP need to be updated to 2014 because they are based on 2010 data. They thus need to be adapted to price inflation. Secondly, the CIAP_IO_2010_BP of goods and services listed in the SUTPROD nomenclature used by the input-output model need to be linked to the more detailed COICOP nomenclature of the 2014 HBS. And finally, the CIAP_IO_2010_BP need to be converted from basic prices into purchaser's prices, taking into account the excise duties and value added tax on COICOP goods and services in 2014.

The following paragraphs explain these adjustments.

4.2.1. Adapting the coefficients of indirect air pollution of the input-output model to price inflation

The CIAP_IO_2010_BP, i.e. the amount of air pollution of a product of the SUTPROD nomenclature per euro, have been calculated by means of an input-output model for the year 2010. These coefficients need to be corrected for inflation so that they can be linked to the HBS expenditures, which refer to the year 2014. This was done with a deflator using inflation rate data for the period 2010-2014 (*Infl_R*), which was calculated by the National Bank of Belgium (NBB) per item 'k' of the SUTPROD nomenclature. The deflator unfortunately is gross of VAT, while the data we apply it to are net of VAT. In as far as VAT rates changed between 2010 and 2014, this introduces a bias.

The following formula was used:

$$Deflator\ {}^{2014}_{2010,k} = (1 + Infl\_R\ {}^{2011}_{k}) * (1 + Inf\_R\ {}^{2012}_{k}) * (1 + Infl\_R\ {}^{2013}_{k}) * (1 + Inf\_R\ {}^{2014}_{k}) \quad (6)$$

The coefficients of indirect air pollution at basic prices or CIAP_IO_BP for 2014 are corrected for inflation between 2010 and 2014 by dividing the CIAP_IO_2010_ BP by the deflator.

[29] Assuming that the production process for each product is identical in 2010 and 2014.

$$CIAP\_IO\_BP_{i,k} = \frac{CIAP\_IO\_2010\_BP_{i,k}}{Deflator\ {}^{2014}_{2010,k}} \quad (7)$$

This implies that the coefficients of indirect air pollution of a product of which the price increased between 2010 and 2014, will be lower in 2014 than in 2010. As a consequence, the indirect air pollution caused by the consumption of 1 euro of that product will be lower. This is normal, as the volume of the product one can obtain for 1 euro is now smaller. For a product of which the price decreased between 2010 and 2014, the opposite will be true.

4.2.2. Linking goods and services of the SUTPROD nomenclature to the COICOP nomenclature

The CIAP_IO_BP calculated in the previous paragraph cannot be applied directly to the goods and services mentioned in the 2014 HBS. The reason is that the CIAP_IO_BP follow the SUTPROD nomenclature, whereas the expenses listed in the HBS are classified according to the more detailed COICOP nomenclature. To link both nomenclatures, a correspondence table had to be build. The correspondence table used in PEACH2AIR is based on a correspondence table provided by the NBB, considering some adjustments.

These adjustments are largely an appreciation issue. They relate to the specific composition or property of some COICOP products and the extent to which they can reasonably be linked to a SUTPROD category, for which the product definition is broader. A simple example can illustrate this. COICOP product 'Speculoos based spreads' was originally linked to the SUTPROD item 'Chocolate'. Since this spread contains no chocolate, it was linked to the product 'Sugar confectionery (excluding cocoa) and fruits, nuts and similar candied with sugar', which is more compatible with the characteristics of the COICOP product referred to here, although not completely.

In the correspondence table, some HBS categories were linked to several SUTPROD categories. For example, the HBS category ’various types of meat‘ refers to a purchase of a bundle of unspecified meat products (chicken, pork, etc.) that each correspond to a specific SUTPROD-category. In these cases, the weight of each of the associated SUTPRODs is proportional to the production value of each SUTPROD in the whole set of SUTPRODs associated with the COICOP category. If this information was not available, the weights of the associated SUTPRODs were considered equal. For example, the HBS category ‘Various household chemicals (white spirit, liquid drain unblocker, air neutralizer for all bad smells, incense, etc.)‘ is linked to the SUTPRODs ‘Soaps, detergents and cleaning products’ and ‘Etheric oils’, with each a weight of 0.5.

Some expenses listed in the 2014 HBS could not be linked to a SUTPROD category. Consequently, PEACH2AIR does not allocate any air pollution to these expenses. This is the case for the following expenses.

– Taxes and penalties paid by households and reported in the 2014 HBS i.e. traffic charges for cars, traffic fee for motorcycles, traffic tax for caravans, mobile home or trailer, traffic tax for other vehicles, unspecified taxes (province, region, municipality, etc.), inheritance taxes and gift duties and finally criminal penalties and fines, court fees or bailiff's fees.

– Household expenditure for which it is not clear which goods or services have been purchased: pocket money to children under 14 years of age, pocket money to children between 14 and 18 years, pocket money to children over 18 years, contributions to trade unions or political parties, gifts without description, gift voucher, unspecified grouped purchases, unspecified repairs and finally expenses in the HBS with no clear description.

The fact that there are less SUTPROD than COICOP products also means that several COICOP products are linked to one and the same SUTPROD. In most cases this is not a problem. But some COICOP products are inevitably mixed with products with a different emission profile. An example are eggs and honey, two products which had to be linked to the SUTPROD livestock farming. As a consequence, the air pollution linked to these products will be severely biased.

Based on the correspondence table between SUTPROD items 'k' and COICOP products 'j', referred to in the following formula as the matrix 'Coupling', the coefficients of indirect pollution for 2014 expressed in basic prices, called CIAP_BP were calculated for each pollutant 'i' and COICOP product 'j' using the following formula:

$$CIAP\_BP_{i,j} = \sum_k Coupling_j^k * CIAP\_IO\_BP_{i,k} \quad (8)$$

4.2.3. Incorporating excise duties and VAT in coefficients of indirect air pollution

The expenditure reported in the HBS is expressed in purchaser's prices. They cannot be multiplied with the relevant CIAP_BP presented in the previous paragraph as such, because the CIAP_BP are expressed in basic prices. Therefore, these CIAP_BP need, for each pollutant 'i' and for each product of the COICOP nomenclature 'j', to be corrected for excise duties and VAT paid by the consumers for each product 'j'[30]. This is done using the following formula.

$$CIAP_{i,j} = \frac{CIAP\_BP_{i,j}}{(1+VAT\_R_j)*(1+Excise\_Duty\_R_j)} \quad (9)$$

The following two subsections focus respectively on excise duties and VAT. They explain how the excise duty and VAT per euro for the goods and services of the COICOP nomenclature are calculated.

a. Excise duties

Excise duties are levied on fuels, alcohol, tobacco products and drinks and coffee. The sources used to calculate these duties are explained in the next point. Subsequently some assumptions are detailed so that the excise duty rate applicable to some specific COICOP products can be determined. The calculation of the excise duty per euro spent on the relevant products listed in the COICOP nomenclature and used in PEACH2AIR are presented hereafter.

[30] In fact, subsidies on products should also be added, but no attempt has been undertaken to do as such in the context of this paper.

Excise duties: origin, sources and rates

Regulations related to excise duties are spread among European and Belgian tax laws. Three legal sources include provisions relating to the collection of excise duties:

- The EU directives concerning specific products (alcoholic beverages, tobacco and energy).[31]
- The Belgium-Luxembourg Economic Union: some provisions on excise duties of the 1921 Treaty are still in force. Consequently, only the special excise duty tax can be modified on a standalone basis by Belgium, excluding any modification to the normal duty.
- Belgian law: the main Acts are the following:
  - Alcohol and alcoholic beverages: Act of 7 January 1998 on the structure and rates of excise duties on alcohol and alcoholic beverages;[32]
  - Non-alcoholic beverages: Act of 21 December 2009 on the excise duty regime for non-alcoholic beverages and coffee;[33]
  - Tobacco Act of 3 April 1997 on the tax regime for manufactured tobacco products;[34]
  - Energy products and rates are listed in the Programme Law of 27 December 2004.[35]

Excise duties have frequently been modified since the adoption of the acts. To reach an adequate level of time matching, changes in excise acts were assessed daily, which means that the average rates in 2014 were computed considering changes occurring on a day-to-day basis. Only Acts as published in the Belgian Official Gazette were used, without considering the summary tables published by the European Union. Time series were built to allow further comparative analysis of the fiscal impact.

Several taxes are levied on COICOP products by Belgian federal and regional governments. In this respect, excise duties are composed of two different levies:

- (Regular) excise duties: the amount of excise duty is harmonised at the level of the Belgium-Luxembourg Economic Union, with a minimum imposed by the EU Energy Taxation Directive[36];
- Special excise duties: the amount of special excise duty is also considered for complying with the minimum level of taxation imposed by the Energy Taxation Directive, but Belgian authorities can modify its burden on a standalone basis.

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31 Council Directive 2008/118 of 16 December concerning the general arrangements for excise duty and repealing Directive 92/12/EEC, OJ L 9 of 14 January 2009, p. 12-30, www.eur-lex.europa.eu (accessed on June 12th, 2017); Council Directive 92/83/EEC of 19 October 1992 on the harmonisation of the structures of excises duties on alcohol and alcoholic beverages, OJ L 316 of 31 October 1992, 21-27, www.eur-lex.europa.eu (accessed on June 12th, 2017); Council Directive 92/84/EEC of 19 October 1992 on the application of the rates of excise duty on alcohol and alcoholic beverages, OJ L 316 of 31 October 1992, 29, www.eur-lex.europa.eu (accessed on June 12th, 2017); Council Directive 2011/64/EU on the structure and rates of excuse duty applied to manufactured tobacco, OJ L 176 of 5 July 2011, 24, www.eur-lex.europa.eu (accessed on June 12th, 2017).

32 Loi du 7 janvier 1998 concernant la structure et les taux des droits d'accise sur l'alcool et les boissons alcoolisées / Wet van 7 januari 1998 betreffende de structuur en de accijnstarieven op alcohol en alcoholhoudende dranken, Belgian Gazette, 14 February 1998, 3122.

33 Loi du 21 décembre 2009 relative au régime d'accise des boissons non alcoolisées et du café / Wet van de 21 december 2009 betreffende het accijnsstelsel van alcoholvrije dranken en koffie, Belgian Gazette, 1 April 2010, 1649.

34 Loi du 3 avril 1997 relative au régime fiscal des tabacs manufacturés / Wet van de 3 april 1997 betreffende het fiscaal stelsel van gefabriceerde tabak, Belgian Gazette, 16 May 1997, 12105.

35 Loi-programme du 27 décembre 2004 / Programma-wet van 24 december 2004, Belgian Gazette, 31 December 2004, 87006.

36 Council Directive 2003/96/EC of 27 October 2003 restructuring the Community for the taxation of energy products and electricity, OJ L 283 of 31 October 2003, 51.

Several specific taxes are levied on energy products, both at the producer and consumer level. In the context of PEACH2AIR, only the taxes levied per unit of quantity purchased by the final consumer were assessed. They can be described as follows:

– Energy contribution[37]: the energy contribution is a special levy calculated by the federal government and charged on residential energy consumption. As with excise duties, the energy contribution is included in the VAT base.

– Monitoring fee[38]: the monitoring fee is levied on liquid fuels: gasoline, diesel, heating oil and heavy heating oil. The receipts are allocated to a Fund in charge of monitoring fuel quality.[39]

Average rates on fuels for 2014 are presented in the next table.

Table 4 Excise duty rates on fuels in 2014
Duty in € per unit of quantity

Product	Quantity	Normal duty	Special duty	Energy fee	Con-trol fee
Gasoline with lead	1000 l	245.415	363.624	28.632	0.000
Unleaded petrol with high sulphur content	1000 l	245.415	354.524	28.632	0.000
Unleaded gasoline with low sulphur content RON > 95	1000 l	245.415	339.524	28.632	0.000
Unleaded petrol with low S content with ethanol RON > 95	1000 l	245.415	296.574	28.632	0.000
Unleaded petrol RON < 98	1000 l	245.415	339.524	28.632	0.000
Unleaded petrol RON < 98 with ethanol	1000 l	245.415	296.574	28.632	0.000
Lamp oil used as propellant	1000 l	294.993	303.253	28.632	0.000
Lamp oil used as fuel for non-professional consumption	1000 l	0.000	0.000	19.383	0.000
Gasoil with sulphur content > 10 used as fuel	1000 l	198.315	229.500	14.874	0.000
Gasoil with sulphur content > 10 used as fuel for non-professional consumption	1000 l	0.000	0.000	8.485	10.000
Gasoil with sulphur content < 10 used as unmixed propellant fuel	1000 l	198.315	214.500	14.874	0.000
Gasoil with sulphur content < 10 used as mixed propellant fuel	1000 l	198.315	193.115	14.874	0.000
Gasoil with sulphur content < 10 used as fuel for non-professional purposes	1000 l	0.000	0.000	7.102	10.000
Heavy fuel oil used for non-professional purpose	1000 kg	13.000	3.200	0.000	0.000
LPG used as propellant fuel	1000 kg	0.000	0.000	0.000	0.000
LPG used as fuel for non-professional purposes – butane	1000 kg	0.000	0.000	18.473	0.000
LPG used as fuel for non-professional purposes – Propane	1000 kg	0.000	0.000	18.741	0.000
Natural gas used as propellant fuel	MWh	0.000	0.000	0.000	0.000
Natural gas used as fuel for non-professional purposes	MWh	0.000	0.000	0.989	0.000
Coal, coke and lignite	1000 kg	0.000	8.653	3.000	0.000
Electricity for non-professional use		0.000	0.000	1.909	0.000

Source: FPB calculations

37 In French: "cotisation énergétique" and in Dutch: "federale bijdrage".

38 In French: "redevance de contrôle" and in Dutch: "controleheffing".

39 This is the so-called 'Fonds d'Analyse des Produits pétroliers/Fonds voor de Analyse van Aardolieprodukten'. A.R. du 8 février 1995 fixant les modalités de fonctionnement du Fonds d'Analyse des Produits pétroliers, M.B., 26 mars 1995 / K.B. van 8 februari 1995 tot vaststelling van de modaliteiten voor de werking van het Fonds voor de Analyse van Aardolieprodukten, B.S., 26 maart 1995

The following table summarises the excise rates on alcohol.

Table 5 Excise rates on alcoholic products in 2014
Duty in € per unit of quantity

Excise duty category	Quantity	Normal duty	Special duty
Beer	hl-Plato degree	0.793 €	0.973 €
Still wine	hl	0	54.484 €
Sparkling wine	hl	0	186.434 €
Unspecified fermented beverages – non-sparkling	hl	0	54.484 €
Unspecified fermented beverages – sparkling	hl	0	186.434 €
Unspecified fermented beverages – non-sparkling with less than 8.5% alcohol	hl	0	17.249 €
Ethyl alcohol	hl	223.104 €	1803.4 €

Source: FPB calculations

Similarly, both normal and special duties are levied on tobacco products. However, tax rates are computed according to two different methods: a percentage of the resale price and a fixed duty per unit of quantity. The next table gives the rates for 2014.

Table 6 Excise rates on tobacco products in 2014
Percentage of price or duty in € per unit of quantity

Product	Tax base	Normal duty	Special duty
Cigars	Resale price established by Federal Public Service Finance	5.00%	5.00%
Cigarettes	Resale price established by Federal Public Service Finance	45.84%	0.00%
	For 1000 units	6.891 €	16.7 €
Tobacco	Resale price established by Federal Public Service Finance	31.50%	0.00%
	Kg	0 €	14.5 €

Source: FPB calculations

Finally, the next table presents the excise duty rates for drinks and coffee, for which only a normal rate applies.

Table 7 Excise duty rates on coffee products and drinks in 2014
Duty in € per unit of quantity

Excise duty category	Quantity	Normal duty
Waters, including natural or artificial mineral waters and sparkling waters, not containing added sugar or other sweetening matter or flavour, and ice falling under CN code 2201	hl	0
Waters, including mineral waters and sparkling waters, containing added sugar or other sweetening matter or flavouring, and other non-alcoholic beverages falling under CN code 2202, except milk, soya beverages	hl	3.7184 €
Beers with an alcoholic strength not exceeding 0.5% vol.	hl	3.7184 €
Wines falling under CN codes 2204 and 2205, with an alcoholic strength not exceeding 1.2% vol.	hl	3.7184 €
Fermented beverages falling under CN codes 2204 and 2205 and those falling under CN code 2206, with an alcoholic strength not exceeding 1.2% vol.	hl	3.7184 €
Drinks falling under CN code 2208, with an alcoholic strength not exceeding 1.2% vol.	hl	3.7184 €
Unfermented fruit or vegetable juices, not containing added spirit, containing added sugar or other sweeteners or not – falling under CN code 2009	hl	0
All substances, in any form whatsoever, expressly intended for the manufacture of non-alcoholic beverages referred to in (b), put in retail packaging or in packages for use in the manufacture of ready-to-use liquid beverages – liquid	100 kg	22.3706 €
All substances, in any form whatsoever, expressly intended for the manufacture of non-alcoholic beverages referred to in (b), put in retail packaging or in packages for use in the manufacture of ready-to-use liquid beverages – solid	100 kg	37.2844 €
Unroasted coffee	kg	0.1983 €
Roasted coffee	kg	0.2479 €
Extracts, essences and concentrates of coffee, solid or liquid, and preparations based on coffee	kg	0.6941 €

Source: FPB calculations

Assumptions on some COICOP products subject to excise levies

Some assumptions had to be made to determine the level of the applicable excise duty on several products of the COICOP nomenclature. In total, three types of assumptions were necessary.

a. General product categories of the COICOP nomenclature

Some categories of the COICOP nomenclature, mainly charges or collective bills for a house, include products subject to different excise duties. In this case, an average ratio was used, calculated according to the following assumption: when all the products and/or services included in these categories are subject to excise duties, an arithmetical mean of non-bundled products of the category was used as excise rate (for instance, for collective heating, an arithmetical mean of all heating fuel excise rates was calculated to obtain a tax rate for this product). If the COICOP category includes both products and/or services subject to excise and products and/or services not subject to excise, the arithmetical mean was applied to only 50% of the amount spent by the household[40].

b. Specific assumptions for certain products of the COICOP nomenclature

For some COICOP products, specific assumptions are made to determine the exact excise levy.

– '02129A other wine-based beverages (including non-alcoholic)' are considered as alcoholic wine for excise calculation.
– '02111E Unspecified alcoholic beverages' include leftover alcoholic beverages and are granted the same level of excise levy as ethylic alcohols.
– '07221A Diesel' is considered low-sulphur.
– '07222A Gasoline' is considered low-sulphur and with a 95 RON index.
– '01221C Flavoured waters (fruit flavour)' are considered as containing sugar and consequently are subject to excise duties on sodas.
– '01211D Coffee for Senseo machines' is subject to the same excise as roasted and ground coffee.
– '01221D Unspecified water' is subject to the tax regime for mineral and sparkling water. For pricing, an average price based on all water products was applied, due to the lack of product description.

c. Assumptions on the conversion of excise duties in their original formulation to a percentage per euro

Given the final objective of expressing all taxes per euro spent, excise duties were converted from their original formulation (mainly euros per quantity) to a percentage per euro. To proceed to the conversion, we used prices as collected for the computation of the Consumer Price Index – CPI. Based on these quantities, an excise duty percentage was calculated for every product.

[40] This is the case for the following COICOP products: collective bills for a main residence (electricity + other), charges for a second residence (including water, gas, electricity, heating if not separable), collective invoice for a second residence, rental charges (including water, gas, electricity, heating if not separable), charges for the owner (main house) (including water, gas electricity, heating if not separable), collective heating, collective bills for a main residence (electricity + other).

However, some assumptions were required for a selection of excise products:

– For coffee pads (01211D Coffee for Senseo machines), the price in the CPI is for 18 pads. Consequently, an average weight of 7 grams per pad was used to estimate the excise duty per euro.

$$\frac{Excise\ duty\ (euro\ per\ kg)}{Purchaser\ price\ \text{for}\ 18\ pads} * (0.007 * 18) = excise\ duty\ per\ \text{euro}$$

– For whisky (02111A), cognac (02111B) and liquors (02123A Liquors and spirits + 23° (calvados, gin, grand marnier, pastis, vodka, rum, etc.)) and alcohol without further specification (02111E), the average strength in alcohol was approximated at 40% of total volume; for genever (02111C), at 30%.

– For mixers including alcohol, the alcohol content was estimated at 7% of the total volume. No excise duties are charged on the remaining part of the recipe, although it should be seen as a soda.

– The product "02129A other wine-based beverages (including non-alcoholic)" is taxed as wine without regard to its alcoholic content.

– For beers, different categories are proposed for households in the HBS i.e. beer, table beer, strong beers, non-alcoholic beers or low-alcoholic beers and beer-soda mixes (panachés, shandy etc.). Excise duties refer to a special grading system for fermented drinks: the Plato scale, which is a measurement of the concentration of dissolved solids in a brewery wort. All COICOP products related to beer were linked to a certain alcohol degree and then converted by means of the Plato scaling.

– For cigarettes, two different taxes are levied as excise duty: first, a duty per 1 000 cigarettes and second, a percentage of the resale price. The first duty was calculated by applying the following formula:

$$\frac{Price\ for\ a\ pack}{20} * \frac{(Excise\ rate\ for\ 1\,000\ cigarettes + special\ excise\ rate\ for\ 1\,000\ cigarettes)}{1\,000} = \%\ of\ excise\ for\ 1\ euro$$

The second rate is proportional to the purchase price, averaging at 31.5% for 2012 and 2014. It corresponds to a tax of EUR 0.315 per euro spent.

Excise duty percentage per euro of the products of the COICOP nomenclature as used in PEACH2AIR

The next table presents the excise duty per euro spent on all targeted COICOP products as used in PEACH2AIR, given the previously made assumptions. Because they are expressed per euro spent, they can also be interpreted as a percentage.

Table 8 **Final excise duty per euro spent on COICOP products for 2014**
Per euro of COICOP product

COICOP code	COICOP category name	per EUR
01211A	Beans or ground coffee (including filters)	0.023
01211B	Soluble coffee and coffee essence	0.065
01211D	Coffee for Senseo machines	0.141
01221A	Non-sparkling mineral waters	0.000
01221B	Sparkling waters	0.000
01221C	Flavoured water (fruit flavour)	0.048
01221D	Unspecified water	0.000
01222A	Other non-alcoholic drinks (cola, lemonades, schweppes etc.) except sport drinks	0.024

COICOP code	COICOP category name	per EUR
01222B	Energy drinks for sportsmen and sportswomen (Aquarius, Extran, Isostar, Gatorade, etc.) + Red Bull	0.024
01223A	Vegetable juices	0.000
01223B	Fruit juices	0.000
01223C	Fruit syrup (grenadine, blackcurrant, mint, strawberry, etc.) and fruit-based dessert sauces	0.165
02111A	Whisky	0.479
02111B	Cognac	0.663
02111C	Genever	0.497
02111D	Liqueurs and spirits + 23° (calvados, gin, grand marnier, pastis, vodka, rum, etc.)	0.291
02111E	Unspecified alcoholic beverages	0.427
02112A	Soft drinks containing alcohol (alcopops, premixes, Bacardi Breezers, Vodka Red Bull, etc.)	0.096
02121A	Wines	0.079
02121B	Champagne and sparkling wines, sparkling wines	0.051
02122A	Cider, perry, sake (rice alcohol)	0.291
02123A	Sweet wines, aperitifs and alcoholic beverages from 15 to 23° C (vermouth, sherry, port, Pineau des Charentes, martini, etc.)	0.554
02129A	Other wine-based beverages (including non-alcoholic)	0.055
02131A	Blond beer and unspecified beer	0.135
02131B	Table beer	0.108
02132A	Strong beers	0.093
02133A	Non-alcoholic or low-alcohol beer	0.017
02134A	Mix of beer and soda (variegated, shandy, etc.)	0.059
02201A	Cigarettes	0.471
02202A	Cigars, cigarillos	0.100
02209A	Tobacco (smoking, snuff or chewing)	0.466
04441A	Rental charges (except water, gas, electricity, heating): lift, concierge, common lighting, etc.	0.000
04441B	Charges for a second residence (except water, gas, electricity, heating): lift, concierge, common lighting, etc.	0.000
04441C	Charges for a second residence (including water, gas electricity, heating if not separable)	0.006
04441E	Collective invoice for a second residence	0.006
04441F	Rental charges (including water, gas electricity, heating if not separable)	0.006
04441G	Charges for owner (main house) (including water, gas electricity, heating if not separable)	0.006
04449A	Collective heating	0.006
04510A	Electricity for a main residence	0.000
04510B	Electricity for a second residence	0.000
04510C	Collective bills for a main residence (electricity + other)	0.000
04521A	Natural gas	0.012
04521B	Natural gas for a second residence	0.016
04522A	Butane gas (deposit not included)	0.009
04522B	Propane gas (deposit not included)	0.009
04530A	Heating oil	0.019
04530B	Other liquid fuels	0.019
04541A	Coal	0.027
07221A	Diesel	0.304
07222A	Petrol	0.374
07223A	LPG	0.000
07223B	Two stroke engine oil	0.365
07223C	Other fuels	0.270

Source: FPB calculations

b. VAT

VAT is an indirect tax levied on goods and services bought by the final consumer. The sources used to calculate the VAT rates are explained in the next paragraph. Subsequently, some assumptions necessary to calculate the VAT rate applicable to some COICOP products, are detailed.

VAT: origin, sources and rates

An important part of household expenses is subject to VAT. The first sales taxes were adopted at the national level during the late 19th century. Modern VAT was developed during the European integration, in the framework of the Common Market. Consequently, its main legal provisions were included in successive European Directives. The last reform came in 2006, including new localisation criteria for services.[41]

Changes introduced by EU Directives are transposed into the Belgian VAT code on an ongoing basis. However, although the tax basis, the localisation and the collection method were harmonised at the European level, tax rates remain a national competence. Consequently, member states can discriminate goods and services if they respect a minimum level of taxation. In Belgium, four tax rates are currently in force: 0% (for daily newspapers), 6%, 12% and 21%. The ordinary tax rate is 21%. All exceptions are included in two Annexes to the Royal Decree n° 20 of 20 July 1970 establishing VAT rates.[42] The next table summarises the main categories of goods and services subject to reduced rates.

Table 9 Summary of categories of services or products subject to reduced VAT rates
Percentage of pre-tax purchaser price

Rate	Main categories
0%	Daily newspapers
6%	Living animals; meat; fish and seashells; milk and dairy products; fruits; vegetables; seeds and flowers; oils and greases; other food products; animals food; tap water; medicines and medical devices; non-daily newspapers, magazines and books; art and collection objects and antiques; automotive vehicles for disabled peoples; goods delivered by social bodies; Agricultural services; transports; culture, sport and entertainment installations; author fees, concerts and performances; hotels and camping places; renovation works to private buildings; private housing for disable people; disabled people institutions; services delivered by social bodies; housing through social programs; demolition and rebuilding in urban areas; repairing and rebuilding of private houses; small repairing services; school buildings.
12%	Restaurants; Phyto-pharmacy; margarine; tyres and air chambers; fuels; housing through social programs.

Source: Royal Decree n° 20 of 20 July 1970, annexes.

Exemptions of VAT are also authorised and encompassed by the Title IX of the Directive. Belgian exemptions are listed in article 44 and 44*bis* of the VAT Code and include e.g. services related to human health, bank services, and real estate transactions related to old buildings.

41 Council Directive 2006/112/EC of 28 November 2006 on the common system of value added tax, OJ L 347, 11 December 2006, 1-118.

42 Informal translation from: Arrêté royal n° 20 du 20 juillet 1970 fixant les taux de la taxe sur la valeur ajoutée et déterminant la répartition des biens et des services selon ces taux / Koninklijk besluit nr. 20 van 20 juli 1970 met betrekking tot de jaarlijkse lijst van de btw-belastingplichtige afnemers, www.fisconet.be (accessed on October 17th, 2017).

Assumptions regarding COICOP products subject to VAT

Four types of assumptions had to be made to determine the VAT rate for some COICOP products, mainly for "composed products" consisting of different products and/or services. These assumptions are the following.

a. Expenditures related to private houses

   Expenditure incurred for renovating and rebuilding houses older than 15 years can benefit from a VAT rate of 6%. However, for several COICOP goods and services, it was not possible to identify whether the expenditure was related to a building older than 15 years. Consequently, a ratio for refurbishing and rebuilding services and materials was used in the model. Houses are considered to be used by their owners for 100 years. The average VAT rate was calculated according to this occupation ratio, based on the following formula:

$$\text{Average Tax Rate}_{\,Expenditures\ related\ to\ private\ houses} = (0.15 * 0.21\ ) + (0.85 * 0.06) = 0.0825$$

b. Goods and services provided by profit-oriented organisations and non-profit entities

   Some COICOP products (mainly products related to cultural activities like tickets to a festival, theatre or museum) can be provided by profit-oriented organisations (with a VAT rate of 6%) as well as by non-profit entities, where no VAT is applicable. Since HBS data do not include an identification of the service or product provider, an average rate was calculated for these COICOP expenditures, i.e. 3%.

c. Goods and services depending on the professional status of the provider

   For the COICOP products related to the purchase of domestic animals, the VAT rate will be different if provided by a professional provider or by a private citizen. In the first case, the VAT is equal to 21%, in the latter case the transaction will not be subjected to VAT. Again, an average rate was used i.e. 10.5%.

d. Expenditures related to COICOP categories including goods or services with different VAT rates

   Some COICOP categories include goods or services that are subject to different VAT rates. For instance, a meal taken in a restaurant includes food (taxed at the rate of 12%) and drinks (taxed at the rate of 21%). Different tax regimes may also apply to goods and services included in a travel package involving transport, accommodation and meals. For categories including several goods and services sold as a package, two different tax treatments were applied. For COICOP products listed in the CPI, we used the VAT rate observed and reported in the CPI. When no data was available for the specified product, an arithmetic average, based on rates applying to different goods and/or services composing the package was calculated.

4.3. Coefficients of indirect air pollution

Based on the calculations described in sections 4.1 and 4.2, the coefficients of indirect air pollution CIAP can be calculated for each pollutant and each good and service of the COICOP nomenclature. The following formula synthetizes all calculations into one equation.

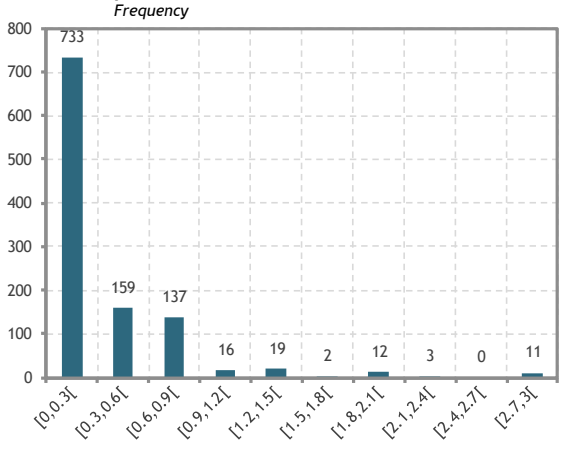
$$CIAP_{i,j} = \frac{\sum_k Coupling_j^k * \frac{CIAP\_IO\_2010\_BP_{i,k}}{\left(1+Infl\_R_k^{2011}\right)*\left(1+Infl\_R_k^{2012}\right)*\left(1+Infl\_R_k^{2013}\right)*\left(1+Infl\_R_k^{2014}\right)}}{\left(1+VAT\_R_j\right)*\left(1+Excise\_Duty\_R_j\right)} \quad (10)$$

The CIAP express, in grams of emitted pollutant per euro spent on goods or services (at purchaser's prices), the pollution generated by the production of the goods and services of the 2014 COICOP nomenclature. PEACH2AIR calculates, for each pollutant or index, 267 different CIAP and attributes these to the 1092 goods or services listed in the COICOP nomenclature of the 2014 HBS[43]. The histogram of these CIAP informs about their distribution. Annex 1 lists these histograms for all pollutants considered. They all point in the same direction: the histograms are highly right skewed, indicating that only a few COICOP goods or services have a high to very high CIAP. For most products, the indirect air emissions are low.

This is further illustrated for the air pollutant nitrous oxide or N_2O. This greenhouse gas is a by-product of microbiological activity in the soil. The main anthropogenic sources of nitrous oxide are agriculture, sewage treatment and chemical industrial processes.

Graph 8 **Histogram of coefficients of indirect air pollution of N_20 for goods or services listed in the COICOP nomenclature of 2014, in grams per euro**

Frequency



Source: FPB calculations

The histogram of the CIAP of N_2O is highly right skewed. Approximately 70% of all COICOP products belong to the bottom decile of the CIAP, which express the grams of N_2O emitted into the air during the production process of these products, per euro spent on these products. In other words, a clear majority of goods or services listed in the HBS emit in grams per euro spent low levels of N_2O into the air during the production process.

The tail of the histogram represents the few products with the highest CIAP. The following table lists all goods or services belonging to the top five categories of most polluting products. Practically all relate to agricultural products.

[43] Here we used the list of goods and services as reported by Statistics Belgium in its summary expenditure tables of the Household Budget Survey 2014, as presented on its website (see https://statbel.fgov.be/nl/themas/huishoudens/huishoudbudget#figures)

Table 10 Goods or services in the top 5 highest coefficients of indirect air pollution for N_2O or nitrous oxide

Rank	CIAP in grams per euro	COICOP product
1	2.97	Various types of vegetable fats and oils (11 COICOP codes)
2	2.35	Various types of margarine (3 COICOP codes)
3	2.03	Honey (2 COICOP codes)
4	1.94	Pets (3 COICOP codes)
5	1.87	Eggs (4 COICOP codes)

Source: FPB calculations

Various types of vegetable fats and oils listed in the HBS – 11 in total – have the highest N_2O CIAP, i.e. 2.97 grams per euro. This means that spending one euro in 2014 on vegetable oils, represents 2.97 grams of N_2O emitted in the air during the production process of these oils. The other CIAP can be interpreted likewise. However, one should take heed of the fact that the high coefficients for honey and eggs are caused by the calculation method. The CIAP by product are based on pollution data for 65 industries. As already mentioned, direct pollution from production of these products is biased, because they are part of the livestock farming subsector of agriculture. The direct pollution from production per euro of output of honey and eggs is to a large extent determined by the direct pollution from production per euro of output of cattle and pigs. And since the direct pollution from production forms the basis of the CIAP, this is also the case for the CIAP of honey and eggs.

Annex 2 details which specific COICOP products are in the top 5 for N_2O, as well as for the other pollutants considered in PEACH2AIR.

5. Results and outlook

This report describes a methodology to construct a database, called PEACH2AIR, which allocates different air pollutants, 13 in total, to the consumption expenditures of households in Belgium for 2014. The considered air pollutants are greenhouse gases, acidifying gases, gases that contribute to tropospheric ozone and particulate matter. This methodological report and PEACH2AIR itself constitute the tangible results of task 2.2. '*Build an up-to-date database with consumption and the environmental impact of consumption at the household level*' of the research project SUSPENS funded by the Federal Science Policy Office.

Section 5.1. describes some summary results based on calculations with PEACH2AIR. Section 5.2. looks beyond these results: it situates the limits and possibilities of the proposed approach and how the method can be used in the context of the SUSPENS research project.

5.1. Summary results based on PEACH2AIR

The calculations of coefficients of direct (CDAP) and indirect (CIAP) air pollution were presented and analyzed in chapters 3 and 4, respectively. The CDAP express in grams per euro spent the air pollution generated by the fuels used by households (for heating and cooking or transport purposes). The CIAP express in grams per euro spent the air pollution associated with the production process of the products bought by households. These coefficients are necessary to calculate the total air pollution (TAP) associated with the expenditures of households, as reported in the Household Budget Survey (HBS) according to the COICOP nomenclature.

The TAP is equal to the sum of total direct air pollution (TDAP) and total indirect air pollution (TIAP). TDAP is equal, for the considered pollutant 'i' and purchased product 'j' (supposing 'j' is a fuel), to the product of the CDAP and the expenditures in the HBS. TIAP can be calculated likewise but here the CIAP are used. This calculation can be rewritten in order to obtain the coefficients of total air pollution (CTAP), as presented in the next equation.

$$TAP_{i,j} = TDAP_{i,j} + TIAP_{i,j}$$

$$= (CDAP_{i,j} * HBS_j) + (CIAP_{i,j} * HBS_j)$$

$$= (CDAP_{i,j} + CIAP_{i,j}) * HBS_j$$

$$= CTAP_{i,j} * HBS_j$$

Indeed, for each pollutant 'i' and product 'j', the CTAP equals the sum of the CDAP and the CIAP. The CTAP inform about the total air pollution in grams per euro spent per product 'j'. Multiplying the CTAP by the expenditures gives the total air pollution, for each pollutant 'i', associated with the purchase of product 'j'.

The next paragraph presents a summary analysis of the coefficients of total air pollution of the goods and services considered in PEACH2AIR. Then the distribution of the total pollution associated with different categories of goods and services of the 2014 Household Budget Survey is discussed.

5.1.1. The coefficients of total air pollution of goods and services of the 2014 Household Budget Survey

The CTAP are analyzed with a focus on three environmental problems monitored by specific indexes: climate change due to greenhouse gas emissions (monitored by the GHG index), acidification (monitored by the ACID index) and tropospheric ozone formation (monitored by the TOFP index)[44]. The histograms of these CTAP are presented in the next graph. Each histogram divides the CTAP into ten categories, with the maximum value equaling the upper value of the tenth category. Keeping this in mind, these categories can also be interpreted as deciles.

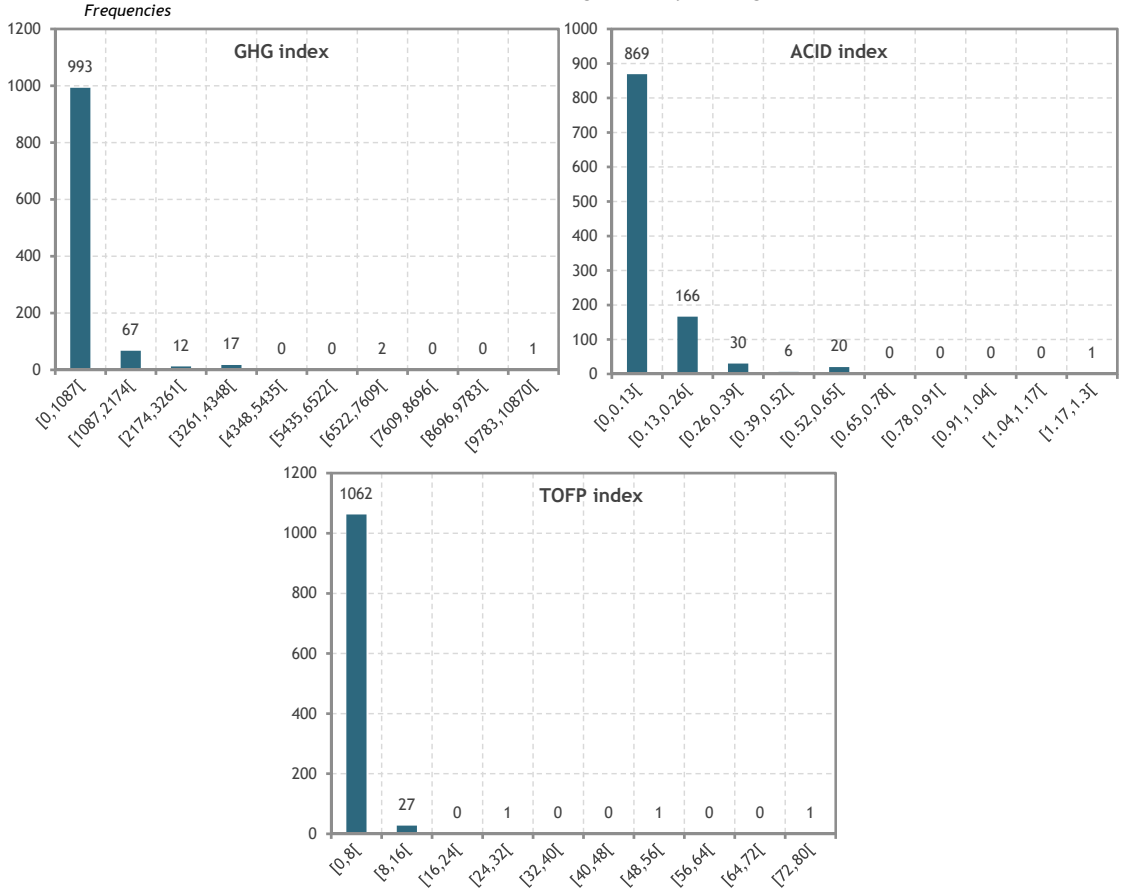
The maximum value of the CTAP for GHG is equal to 10 870 grams of CO_2 equivalents per euro. Those for the ACID index and TOFP index equal 1.3 grams of hydrogen ions per euro and 77 grams of NMVOC equivalents per euro, respectively. For each of the three indexes, it appears that these histograms are highly right skewed.

Of all 1092 considered products listed in the 2014 HBS, 993 (or 91%) have a CTAP for the greenhouse gas index that is situated in the lower quintile or lower than 1.87 grams of CO_2 equivalents per euro. For the ACID index, 902 products listed in the 2014 HBS, or 83% of them have a CTAP lower than 0.13 grams of hydrogen ions per euro. The calculations show that the CTAP for tropospheric ozone formation of 1062 products listed in the 2014 HBS, or 97% of them is lower than 7.7 grams of NMVOC equivalents per euro. So, for these environmental problems, a clear majority of products listed in the HBS emit relatively low levels of grams of pollution per euro spent.

[44] These indexes can be calculated using the following formulas:
ACID index = 0.03125 SOx+0.021739 NOx+0.058824 NH_3
TOFP index = 1.22 NOx+NMVOC+0.11 CO+0.014 CH_4
GHG index = CO_2+298 N_2O+25 CH_4+PFC+SF_6+HFC

Graph 9 **Histogram of coefficients of total air pollution (CTAP) for greenhouse gases (GHG index), acidifying gases (ACID index) and gases that contribute to tropospheric ozone (TOFP index) for products listed in the COICOP nomenclature of the 2014 Household Budget Survey of Belgium**

Frequencies



Source: FPB calculations

The following table lists, for each index, the top five most polluting products expressed in grams of pollution per euro. Not surprisingly, fuels are in the top 5 with regard to greenhouse gas emissions. Regarding acidification, coal contributes the most, in grams of pollution per euro spent, followed by certain food products (honey, eggs and various types of vegetable oils) and purchases of domestic animals. Regarding gases contributing to tropospheric ozone formation, firewood is the most polluting per euro spent, followed by coal, moped gasoline, honey and eggs.

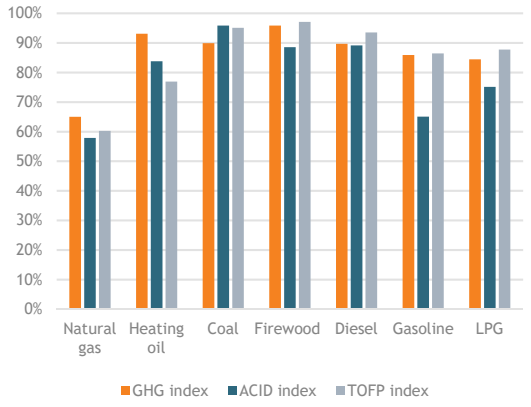
Table 11 **The 5 categories of products listed in the COICOP nomenclature of the Household Budget Survey of Belgium for 2014 with the highest coefficients of total air pollution (CTAP) for greenhouse gases (GHG index), acidifying gases (ACID index) and gases contributing to tropospheric ozone (TOFP index)**

Rank	CTAP of GHG index in grams of CO_2 equivalents per euro	COICOP product	CTAP of ACID index in hydrogenions per euro	COICOP product	CTAP of TOFP index in MVOC equivalents per euro	COICOP product
1	10,867	Firewood	1.200	Coal	76.642	Firewood
2	7,570	Coal	0.592	Honey (2 COICOP codes)	49.352	Coal
3	7,225	Other solid fuels (wood charcoal, wood pellets, etc.)	0.574	Eggs (4 COICOP codes)	28.516	Moped gasoline
4	4,299	Natural gas	0.568	Domestic animals (3 COICOP codes)	12.192	Honey (2 COICOP codes)
5	4,293	Natural gas for second residence	0.532	Various types of vegetable oils (11 COICOP codes)	12.132	Eggs (4 COICOP codes)

Source: FPB calculations

The observation that honey and eggs are so high in the ranking is a consequence of the fact that the emissions due to their production cannot be separated from the emissions from livestock farming. This inflates the CIAP of these products artificially. The reason fuels have such a high CTAP is that burning fuels emits pollutant gases directly during their use and indirectly during their production, whereas the CTAP of the non-fuel products is determined by the CIAP only, i.e. the pollution caused during their production. The following graph illustrates this for some fuels.

Graph 10 **Share of the coefficients of direct air pollution in the coefficients of total air pollution associated with some fuels in 2014 for greenhouse gases (GHG index), acidifying gases (ACID index) and gases that contribute to tropospheric ozone (TOFP index)**
Percentages



Source: FPB calculations

For almost all air pollution indexes and for all fuels considered, the share of direct air pollution in total air pollution ranges between approximately 75 to 95%. This means that the burning process of these fuels – when using them for heating or cooking purposes or transport – largely determines their coefficients of total air pollution. This is also valid, but to a lesser degree, for natural gas and for acidifying gases associated with gasoline. For these two fuels, this share is around 60%.

Or expressed more technically, the share of CIAP in the CTAP of natural gas is considerably higher than for other fuels, around 40%. This means that the production process of natural gas determines to a larger extent the total pollution per euro spent than is the case for the other fuels.

If we consider the GHG index, the direct production pollution coefficient of natural gas is 9 times higher than the one for diesel and heating oil. The CIAP is only 5 times higher, implying that the indirect production pollution coefficient (the pollution linked to the production of intermediate goods and services) is lower for natural gas than for diesel.

5.1.2. Total pollution associated with expenses on goods and services of the 2014 Household Budget Survey

The previous analysis does not consider the structure of the consumption expenditures of the Belgian households, as monitored by the 2014 Household Budget Survey (HBS). This can be done by linking the CDAP and CIAP (which both sum up to CTAP) to the original expenditure data of the 2014 HBS[45], thus allowing an integrated and detailed description of the socio-economic and air pollution profile of Belgian households. As such, one could investigate to what extent expenses on food and non-alcoholic

[45] PEACH2AIR is programmed in Python, using the library LArray developed at the Federal Planning Bureau. In its current version PEACH2AIR only uses summary tables at the most detailed level of the COICOP nomenclature expenditures reported in the Household Budget Survey 2014. These tables can be consulted on the website of Statistics Belgium: https://statbel.fgov.be/nl/themas/huishoudens/huishoudbudget#figures (last consulted on 31/01/2018). The results presented here refer to the data run V 133 of PEACH2AIR.

beverages, clothing and footwear or transport for example contribute to the total emissions of air pollutants in 2014, or to which type of households these emissions can be allocated, and finally which socio-economic variables influence these emissions. Such an integrated and detailed description of the socio-economic and air pollution profile of Belgian households is the main advantage of PEACH2AIR.

The next table presents a general overview of the distribution of greenhouse gases, acidifying gases and gases contributing to tropospheric ozone over the goods and services bought by Belgian households in 2014.

Table 12 Distribution of expenditure and three types of air pollution related to goods and services bought by the Belgian population in 2014
Percentage of total expenditure and pollution

		Expend-iture	GHG index	ACID index	TOFP index
1	Food and non-alcoholic beverages	13.12	18.03	41.95	27.83
2	Alcoholic beverages and tobacco	1.95	1.06	3.03	1.56
3	Clothing and footwear	4.57	1.65	1.65	2.12
4.a	Housing: rental, water supply and miscellaneous services	23.69	6.50	7.78	6.94
4.b	Electricity	2.35	7.61	2.08	3.06
4.c	Gas from the natural gas network	1.55	11.71	2.46	4.02
4.d	Butane or propane in bottles	0.02	0.07	0.02	0.03
4.e	Heating oil	1.28	9.25	3.99	2.68
4.f	Other types of solid or liquid fuels for home use (coal, firewood, oil for stoves, pellets...)	0.15	2.33	1.48	3.90
5	Furnishings, household equipment, household maintenance and services	5.83	2.88	2.36	3.41
6	Health	4.61	5.89	4.78	6.55
7.a	Private personal transport: non-motorised vehicles, parts and services	7.81	2.08	1.37	2.99
7.b	Private personal transport: motorised vehicles, parts and services	0.23	0.07	0.06	0.10
7.c	Private personal transport: diesel	1.69	6.38	6.15	9.82
7.d	Private personal transport: gazoline	1.20	3.59	1.47	3.61
7.e	Private personal transport: other fuels	0.04	0.18	0.07	0.16
7.f	Public transport	0.95	2.72	1.45	2.36
8	Communication	2.97	0.73	0.48	0.68
9	Recreation and culture	8.21	7.36	8.41	8.04
10	Education	0.50	3.79	1.98	3.30
11	Restaurants and hotels	6.45	3.60	5.10	4.17
12	Miscellaneous goods and services	10.83	2.50	1.88	2.67
total		100	100	100	100

* Such as coal, firewood, oil for stoves or pellets.
Source: FPB calculations

Table 12 shows that almost a quarter of the 2014 household budget was spent on housing costs, excluding the purchase of energy vectors. Food and non-alcoholic beverages were the second most important item, with a share of 13%. Adding the category 'non-identified miscellaneous goods and services' to the former two categories captures almost half of household expenditure. Spending on food and non-alcoholic beverages clearly had a large impact on air pollution. Almost 42% of all acidifying gases generated to satisfy household consumption were caused by this category, 28% of photochemical pollution and 18% of greenhouse gas emissions. Food and non-alcoholic beverages top the list for each category of household expenditure. Of course, expenditure on energy was disaggregated.

Expenditure on all types of energy vectors (categories 4.b to 4.f plus 7.c to 7.e) accounted for around 8% of household expenditure. These expenditures accounted for over 40% of all greenhouse gases emitted to satisfy household consumption, for 27% of tropospheric ozone forming gases and 18% of acidifying gases. Together with food and non-alcoholic beverages, energy accounted for 55 to 60% of air pollution due to household consumption. With respect to air pollution, these are clearly the two major types of household expenditure, although they only accounted for just over 20% of total expenditure.

A comparison between the shares of the different kinds of categories in total expenditure, on the one hand, and in air pollution, on the other hand, shows the relative pollution intensity of each monetary unit spent on a particular type of product. A value higher than 1 shows that expenditure on that type of product is more air polluting than total expenditure. This comparison is presented in table 13.

Table 13 Relative pollution per unit of expenditure by the Belgian households in 2014
relative to total expenditure

		GHG index	ACID index	TOFP index
1	Food and non-alcoholic beverages	1.37	3.20	2.12
2	Alcoholic beverages and tobacco	0.55	1.55	0.80
3	Clothing and footwear	0.36	0.36	0.47
4.a	Housing: rental, water supply and miscellaneous services	0.27	0.33	0.29
4.b	Electricity	3.23	0.88	1.30
4.c	Gas from the natural gas network	7.58	1.59	2.60
4.d	Butane or propane in bottles	3.51	1.15	1.57
4.e	Heating oil	7.20	3.10	2.09
4.f	Other types of solid or liquid fuels for home use (coal, firewood, oil for stoves, pellets...)	15.50	9.85	25.90
5	Furnishings, household equipment, household maintenance and services	0.49	0.41	0.58
6	Health	1.28	1.04	1.42
7.a	Private personal transport: non-motorised vehicles, parts and services	0.27	0.18	0.38
7.b	Private personal transport: motorised vehicles, parts and services	0.32	0.26	0.42
7.c	Private personal transport: diesel	3.77	3.64	5.80
7.d	Private personal transport: gazoline	3.00	1.23	3.02
7.e	Private personal transport: other fuels	5.07	1.87	4.58
7.f	Public transport	2.88	1.53	2.49
8	Communication	0.25	0.16	0.23
9	Recreation and culture	0.90	1.02	0.98
10	Education	7.59	3.97	6.62
11	Restaurants and hotels	0.56	0.79	0.65
12	Miscellaneous goods and services	0.23	0.17	0.25

* Such as coal, firewood, oil for stoves or pellets.
Source: FPB calculations

Each euro actually spent by households on coal, firewood and the like turns out to generate just over 15 times as much greenhouse gases as a euro spent on the mix of all products, 10 times as many acidifying emissions, and almost 26 times as much tropospheric ozone forming pollution. Natural gas and heating oil are also quite greenhouse gas intensive per euro spent. Surprisingly, this seems also to be the case for education. As explained earlier, this is due to the fact that a large part of expenses linked to education cannot be found in the HBS. The share of education in expenditure shown in table 12 does not take into account expenditure by the government, while the shares in air pollution shown in the same table do. The value for education in table 13 is therefore to be interpreted with care. Spending by the households on education triggers a multiple amount of expenditure by the government, and this leads to much

higher coefficients of air pollution than is to be expected on the basis of expenditure on education reported by households in the HBS.

Next to coal and firewood, other products inducing a relatively high degree of acidification are heating oil, diesel for personal transport, and food and non-alcoholic beverages. These products cause 3 to 4 times as much acidification per euro as total household expenditure. For tropospheric ozone formation, diesel (6 times more), other fuels for personal transport (5 times more) and gasoline (3 times more) are the most pollution intensive products, next to coal and firewood.

5.2. Outlook

The method presented here builds further on the method developed in 2010 by the Federal Planning Bureau (Frère, Quertinmont, 2010), which was at that time presented as experimental, and used data for 2002. The following methodological improvements were made.

- In the calculations of the coefficients of indirect air pollution, PEACH2AIR integrates VAT and excise duties. This was not the case in the study of 2010. In that study, air pollution was associated with VAT and excise duties paid by households, which distorts the air pollution allocation to household consumption. In PEACH2AIR, this is not the case anymore.
- The calculation of direct air pollution was improved using more up-to-date sources and an internationally standardized method, such as the COPERT5 program regarding air pollution associated with fuels for private motorized vehicles.
- The calculation of indirect air pollution is derived from an input-output model developed by the Federal Planning Bureau, which uses environmental economic accounts for this purpose. Similar data for 2002 were also used in the 2010 study. Apart from continuous enhancements to the input-output model, two specific methodological improvements should be reported.
  - Firstly, a clearer distinction is made between the air pollution related to food products from livestock farming and arable farming. This is important because their associated air pollution is known to be different.
  - Secondly, the air pollution calculations for goods and services that are mainly financed by the public authorities (e. g. education, health care) are now more precisely allocated to household expenses.

When interpreting the results of PEACH2AIR in its current version, the following limitations need to be considered.

- The CIAP by product are based on pollution data by industry. This implies that for products produced by the same industry the direct pollution from production per euro of output will be identical. As a consequence, the CIAP of products constituting only a small share of output of a particular industry, will be biased by the pollution pattern of products constituting the largest share of that industry's output, whenever the production processes of the two products are different. This is the case for example for honey, which is linked to livestock farming.

- The coefficients of indirect air pollution are based on air pollution data and input-output tables for 2010. These were adjusted to 2014, considering price inflation between 2010 and 2014. This means that PEACH2AIR assumes that the structure of the production process of goods and services of 2010 and the associated air pollution did not change in 2014. Furthermore, the deflators used to update the coefficients to 2014 include VAT, while the coefficients were determined at basic prices, i.e. excluding VAT. As far as price movements between 2010 and 2014 were influenced by changes in VAT rates, this also biases the results.
- Air pollution data and input-output tables are based on Belgian statistics. The absence of foreign input-output tables and air emissions data entails that the production technology in foreign countries is assumed to be the same as the Belgian production technology. Thus, the air pollution allocated to imported goods and services is presumed to be similar to emissions from Belgian production processes. This inevitably biases the air pollution calculations of PEACH2AIR. Indeed, it has recently been shown for Belgium that emissions linked to imports are not equal to emissions linked to production in Belgium (Brizga et al., 2017; Hambyë et al., 2017; Peters and Hertwich, 2006).
- PEACH2AIR currently uses the expenditure data as recorded in the Household Budget Survey and as reported synthetically by Statbel [46]. So, no transformation of expenditures was made in any way. There are reasons to be cautious about some expenditures, particularly those for fuels, which as shown above have a major impact on air pollution. Indeed, the fuel expenditures recorded in the Household Budget Survey do not include benefits in kind such as the use of a company car with an associated petrol card (Statbel, 2014). Also, taking into account that gas from the natural gas network is regularly invoiced by the distributor, usually on a monthly basis, it can be assumed that it is easier for the respondent to estimate the annual expenditure on this type of energy, as asked in the Household Budget Survey questionnaire, in comparison to fuels that have to be delivered to the house by a truck, such as fuel oil, and of which the purchase is influenced by several factors.

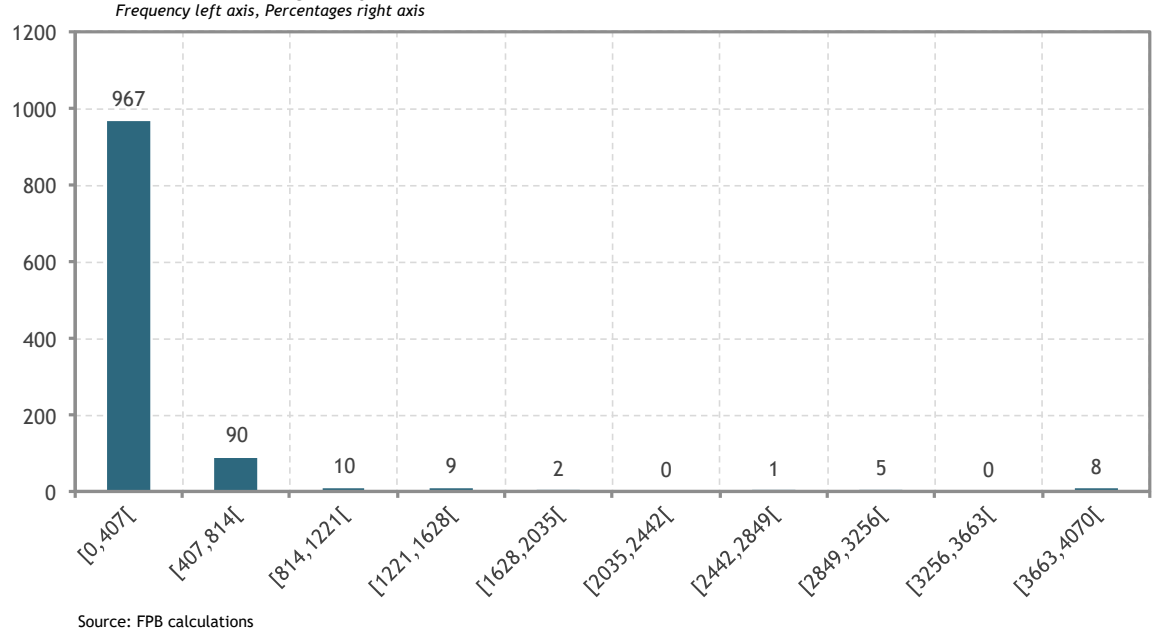
With these considerations in mind, PEACH2AIR will continuously be enhanced so that it can be used for more in-depth analysis of the air pollution for which households can be held accountable, through their consumption patterns. (Barret *et al*., 2006; Birch *et al*., 2014; Dawkins *et al*., 2010; Gough *et al*., 2012; Gough, 2011; Gough, 2013; Ivanova *et al*., 2016; Kerkhof *et al*., 2008; Kerkhof *et al*., 2009; Nijdam and Wilting, 2003; Pey *et al*., 2008; Poom and Ahas, 2014; Wadeskog and Larsson, 2003; Wier *et al*., 2001; Wier *et al*., 2005). In the context of the SUSPENS research project, the air pollution coefficients will be linked to the original data expenses listed in the 2014 HBS but not the synthetic tables presented on the website of Statbel, which were used in this report. A detailed analysis of the influence of consumption patterns on air pollution and its connection to the socioeconomic profile of households will thus be possible. Both a general and a more thematic analysis are planned, the latter focusing on air pollution caused by household energy use, transport use and food consumption. It is also foreseen to complement the HBS data with income tax receipts data and to model the socioeconomic and environmental effects of measures aimed at reducing air pollution, using the EUROMOD microsimulation model.

[46] See https://statbel.fgov.be/nl/themas/huishoudens/huishoudbudget#figures

Annexes

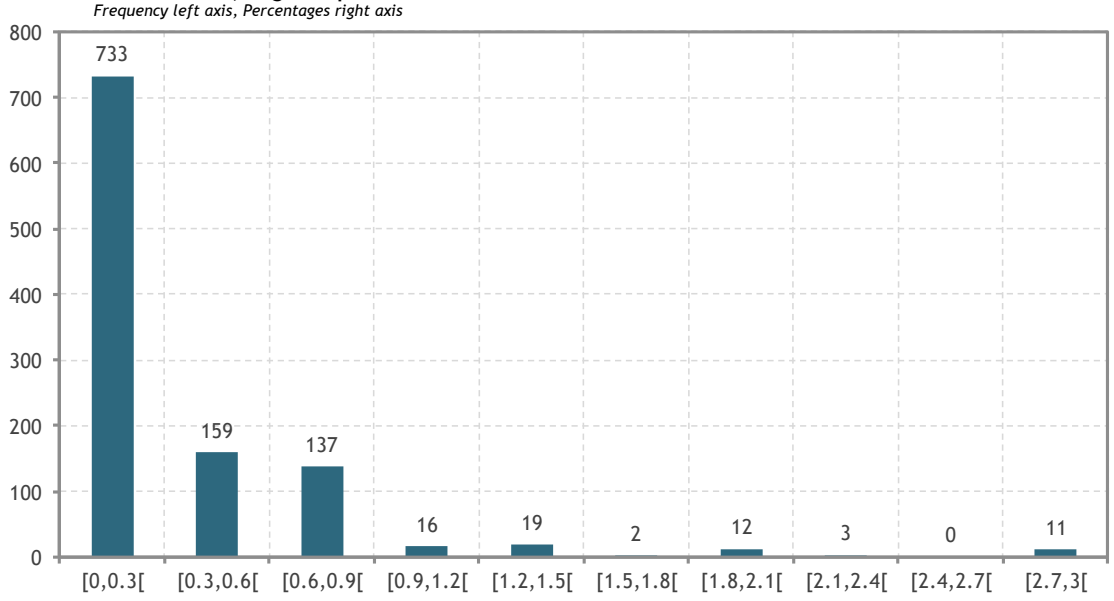
Annex 1: Histograms of coefficients of indirect air pollution (CIAP) for the goods and services listed in the COICOP nomenclature of the 2014 Household Budget Survey of Belgium as calculated in PEACH2AIR

Graph 11 **Histogram of coefficients of indirect air pollution of CO_2 for goods or services listed in the 2014 COICOP nomenclature, in grams per euro**
Frequency left axis, Percentages right axis



Source: FPB calculations

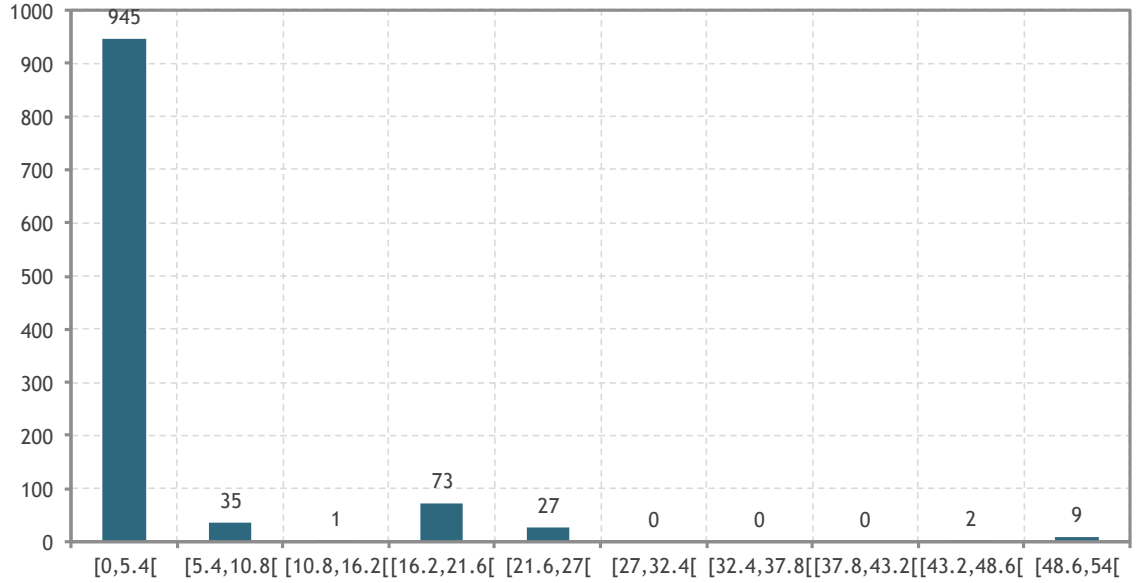
Graph 12 **Histogram of coefficients of indirect air pollution of N_20 for goods or services listed in the 2014 COICOP nomenclature, in grams per euro**
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 13 Histogram of coefficients of indirect air pollution of CH_4 for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

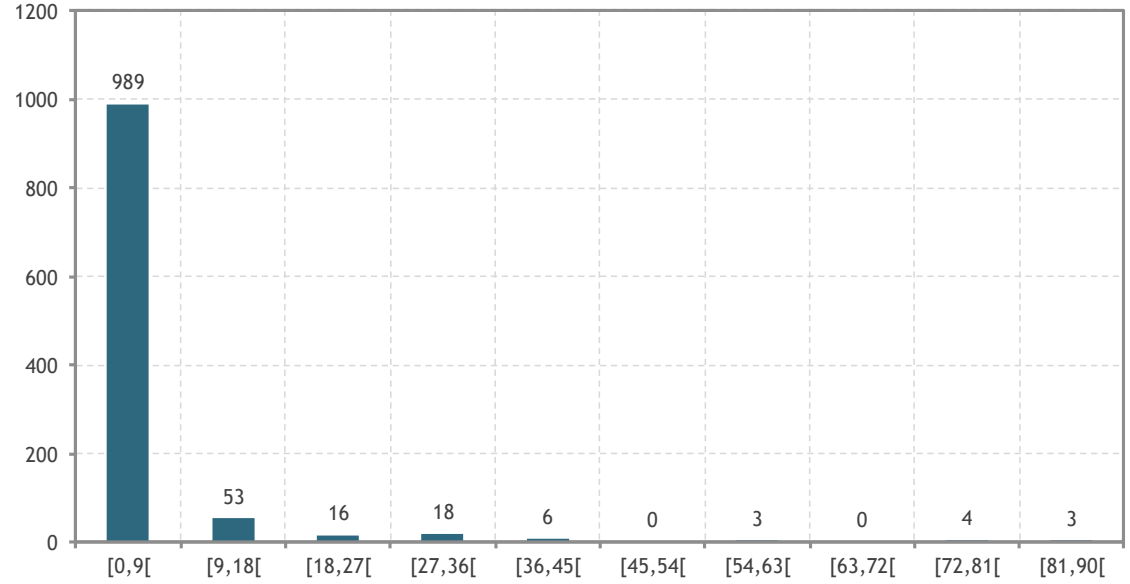
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 14 Histogram of coefficients of indirect air pollution of HFC for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

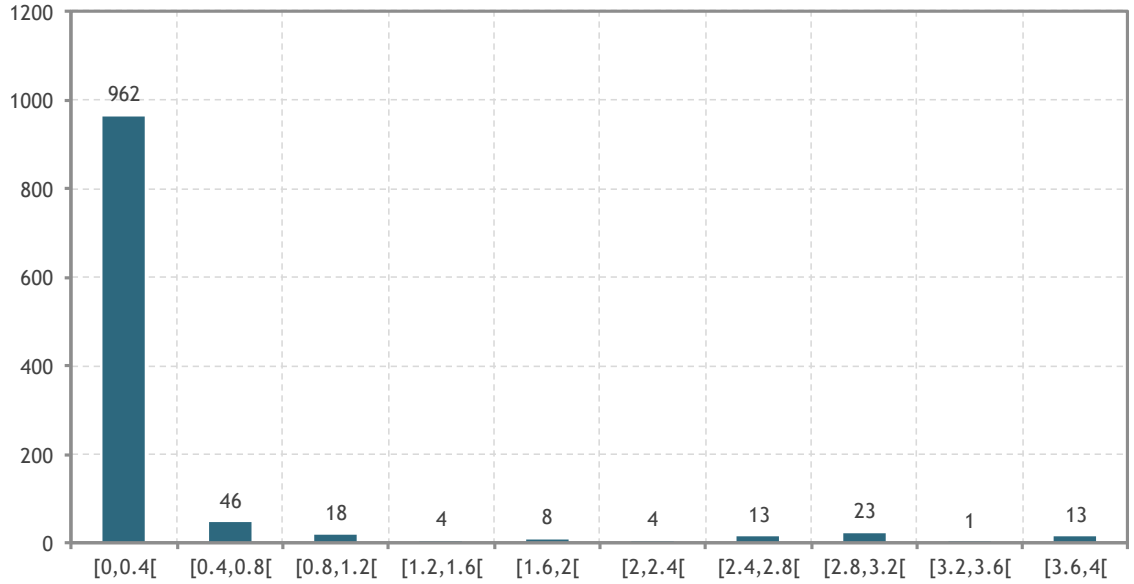
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 15 Histogram of coefficients of indirect air pollution of PFC for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

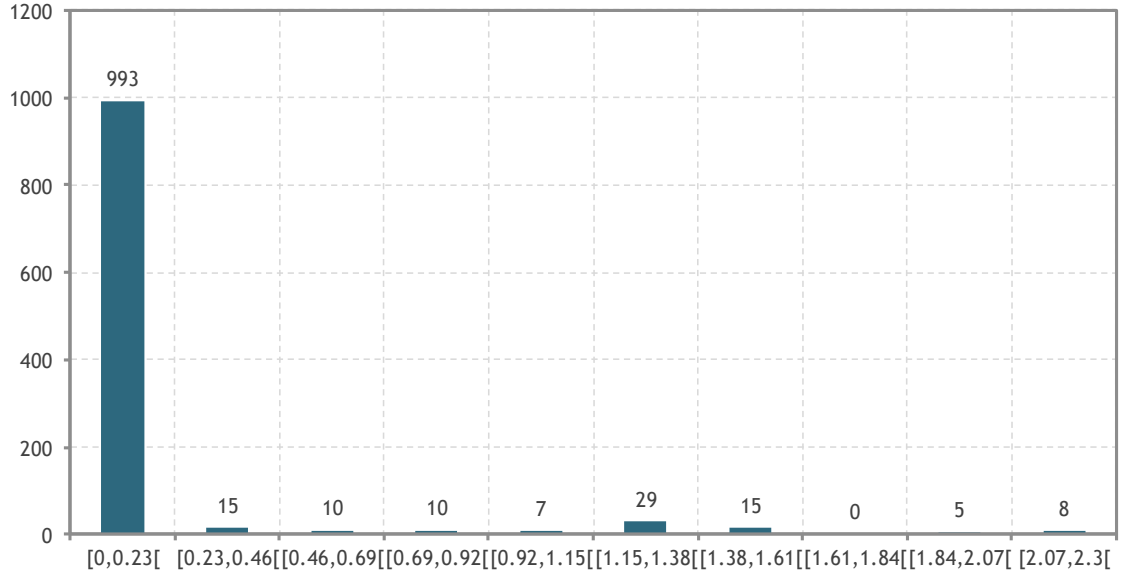
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 16 Histogram of coefficients of indirect air pollution of SF_6 for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

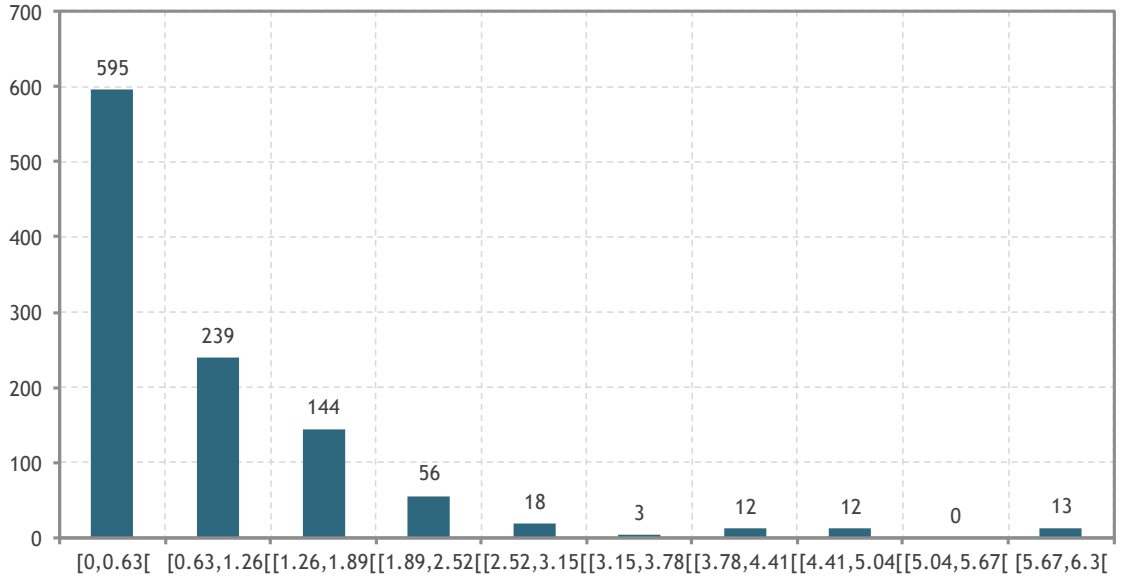
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 17 Histogram of coefficients of indirect air pollution of NOx for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

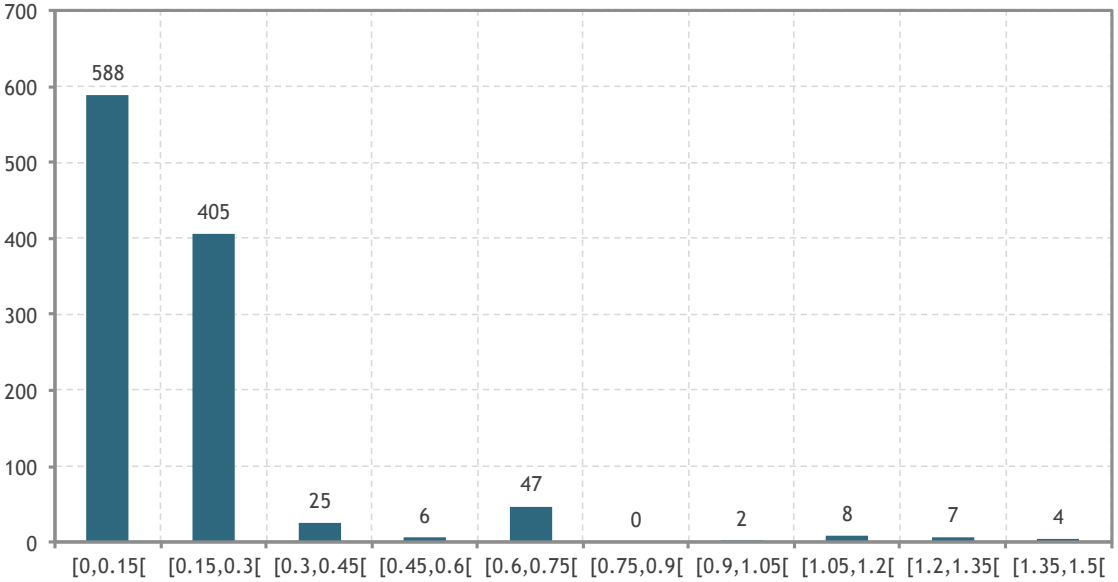
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 18 Histogram of coefficients of indirect air pollution of SOx for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

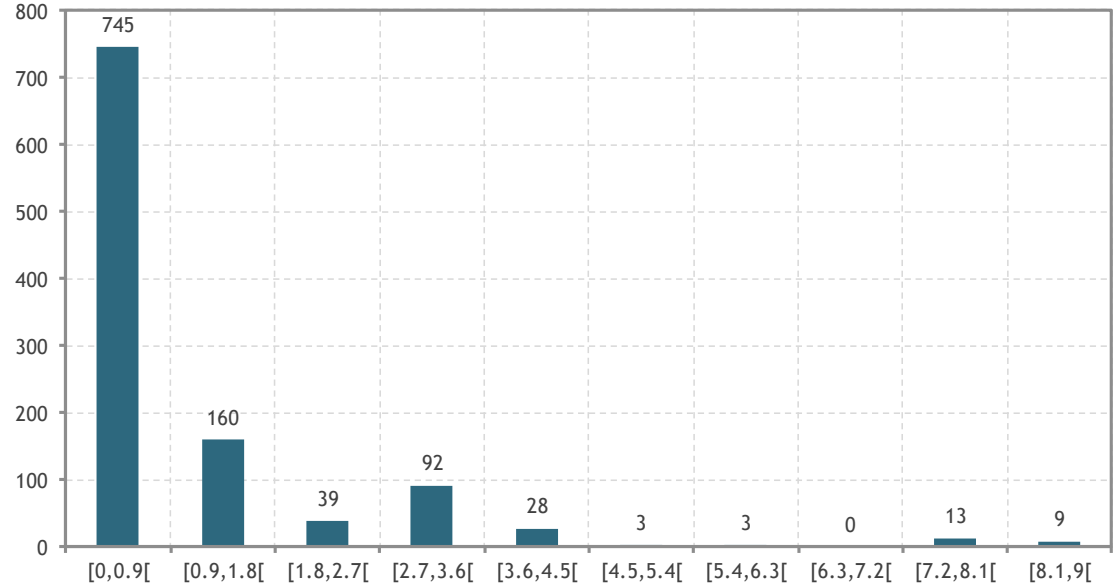
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 19 Histogram of coefficients of indirect air pollution of NH_3 for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

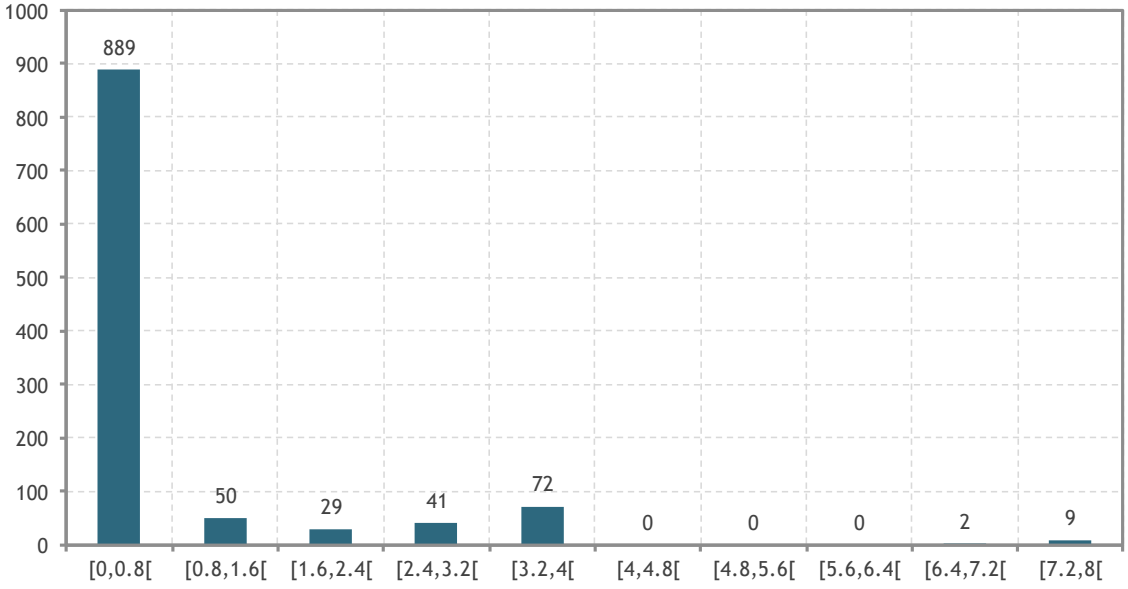
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 20 Histogram of coefficients of indirect air pollution of NMVOC for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

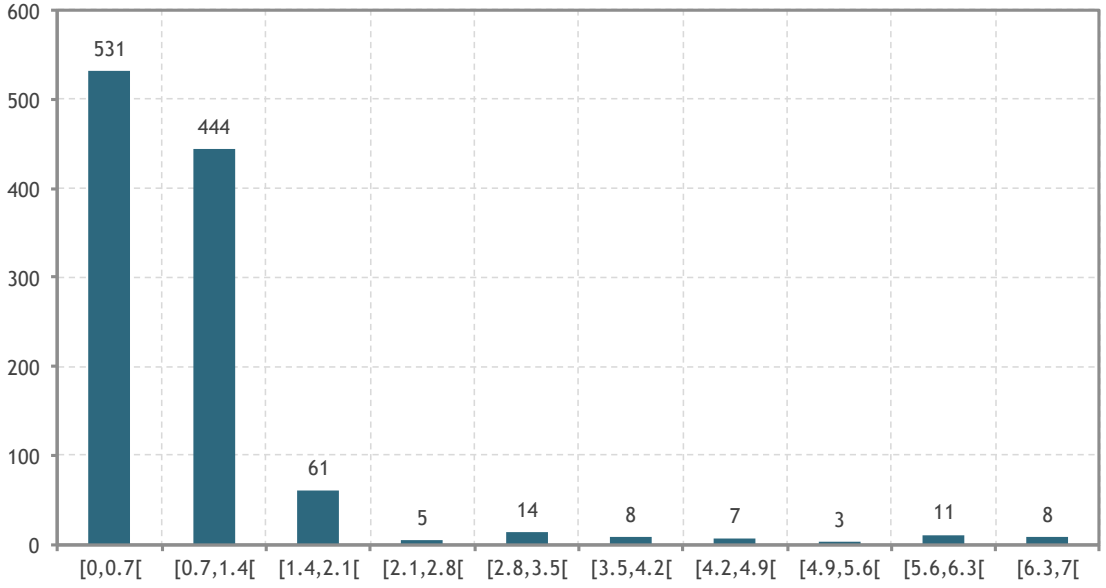
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 21 Histogram of coefficients of indirect air pollution of CO for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

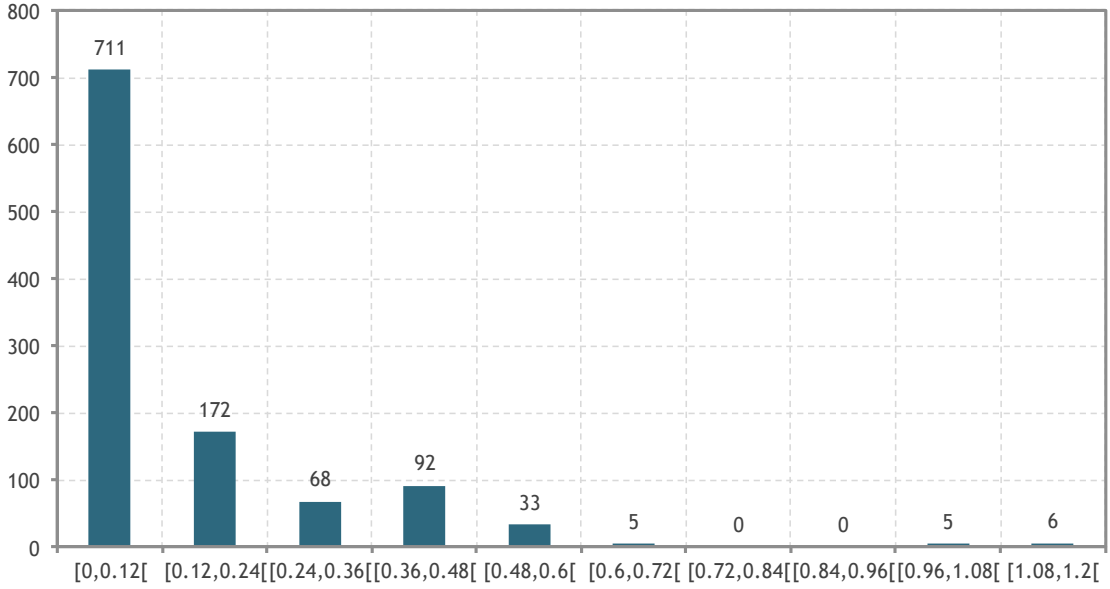
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 22 Histogram of coefficients of indirect air pollution of PM_{10} for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

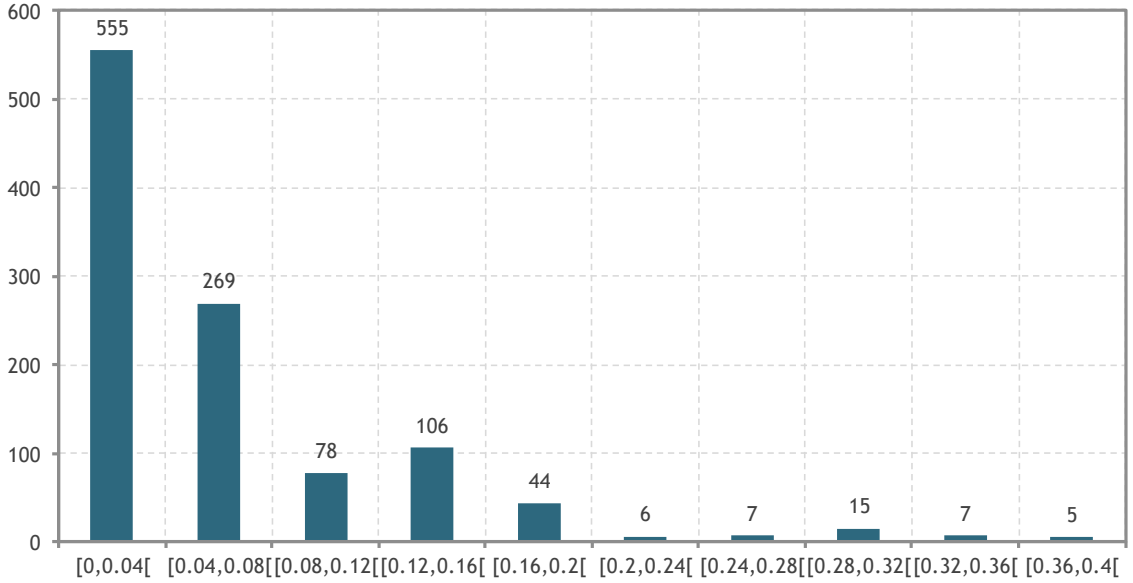
Frequency left axis, Percentages right axis



Source: FPB calculations

Graph 23 Histogram of coefficients of indirect air pollution of $PM_{2.5}$ for goods or services listed in the 2014 COICOP nomenclature, in grams per euro

Frequency left axis, Percentages right axis



Source: FPB calculations

Annex 2: The 5 categories of products listed in the COICOP nomenclature of the 2014 Household Budget Survey of Belgium with the highest coefficients of indirect air pollution (CIAP) for 13 pollutants, as calculated in PEACH2AIR

Rank	Coefficient of indirect air pollution – CIAP in gram per euro	COCIOP code(s) and name(s)
	CO_2	
1	4,068	09512B Lending of books, courses, school periodicals; 10500A Tuition fees, course registration fees, school fees, exam registration fees (day and evening courses); 10500B Distance learning (correspondence courses); 10500C School supervision; 10500D Private lessons for school subjects (languages, maths, computer science...); 11203A Boarding fees; 11203B Student homes fees
2	3,837	11122A Dining hall
3	2,893	06232A Thermal spa, rental of therapeutic equipment; 06232B Ambulance service; 06232C Physiotherapist, corrective gymnastics; 06239A Other outpatient hospital services (dietician, psychologist, logopedist, acupuncturist, chiropractor, osteopath, etc.); 12403A Home care nurse (including midwives)
4	2,673	07332A Passenger air transport
5	1,745	04510A Electricity for main residence; 04510B Electricity for second homes
	N_2O	
1	2.97	01152D Vegetable fats; 01153A Olive oil; 01153B Organic olive oil; 01154A Groundnut oil; 01154B Corn oil; 01154C Other oils (soybean, sunflower, walnut etc.); 01154D Oils w.s.; 01154E Organic groundnut oil; 01154F Organic corn oil; 01154G Other oils (soybean, sunflower, etc.) organic; 01154H Oils w.s. (organic)
2	2.35	01152A Margarine Spread (soft or semi-soft), minarine; 01152B Hard margarine (for baking); 01152C Margarine w.s.
3	2.03	01182B Honey; 01182G Honey (organic)
4	1.94	09341A Purchase of dogs; 09341B Purchase of cats; 09341C Purchase of other domestic animals
5	1.87	01146A Chicken eggs (fresh or hard-boiled); 01146B Other eggs (goose, quail, etc.); 01146C Chicken eggs (organic); 01146D Other eggs (organic)
	CH_4	
1	53.27	01146A Chicken eggs (fresh or hard-boiled); 01146B Other eggs (goose, quail, etc.); 01146C Chicken eggs (organic); 01146D Other eggs (organic)
2	51.14	01182B Honey; 01182G Honey (organic)
3	49.06	09341A Purchase of dogs; 09341B Purchase of cats; 09341C Purchase of other domestic animals
4	44.80	09214A Riding horses; 09215A Other major goods for relaxation and outdoor sports (canoeing, kayaking, sand yacht, sea-diving equipment, golf cart, trampoline, swing, etc.).
5	25.19	01124A Chicken, pieces of chicken (fresh); 01124B Boiling fowl (fresh); 01124C Other poultry (fresh): turkey, pigeon, duck, guinea fowl; 01124D Chicken, pieces of chicken (frozen); 01124E Boiling fowl (frozen); 01124E Other poultry (frozen); 01124G Chicken, chicken pieces (organic); 01124H Boiling fowl (organic); 01124I Other poultry (organic); 01125C Game (fresh): doe, roe deer, caribou, pheasant, young wild boar, partridge, hare, quail, frogs, etc.; 01125F Game (frozen); 01125I Game (organic)
	HFCs	
1	88.00	09134A Typewriter, photocopier; 09134B Calculators; 09134C Other electronic equipment (calendar, diary...)
2	79.28	05319A Sewing and knitting machines
3	75.42	05511B Electric lawnmowers and other electrical garden appliances; 05511C Lawnmowers, tillers and other large non-electric garden equipment; 05511D Agricultural machinery
4	61.89	05403C Scales; 12131E Bathroom scales
5	56.91	05511A Electrical do-it-yourself appliances
	PFC	
1	3.79	06232A Thermal spa, rental of therapeutic equipment; 06232B Ambulance service; 06232C Physiotherapist, corrective gymnastics; 06239A Other outpatient hospital services (dietician, psychologist, logopedist, acupuncturist, chiropractor, osteopath, etc.); 12403A Home care nurse (including midwives)
2	3.68	09131A Desktop computer and hardware; 09131B Laptop computer and hardware; 09132A Computer peripherals (except printer): scanner, external hard drive, numeric keypad; 09132B CD Player for PC; 09132C DVD Player for PC; 09132E DVD writer for PC; 09132F Printer for PC

Rank	Coefficient of indirect air pollution – CIAP in gram per euro	COCIOP code(s) and name(s)
		(including multi-function printer); 09132G Floppy disks, ZIP, mini cassettes for PC, USB stick, etc.
3	3.29	09331A Fertilizers, flower and soil pots
4	3.14	04310A Exterior and interior paints; 07213B Vehicle body paint
5	3.08	12133A Fragranced products: perfume, eau de toilette, aftershave; 12133B Other beauty products (make-up, hair spray, hair gel, deodorant, hair dye, after-shampoo, hair removal cream and wax...)
	SF_6	
1	2.28	09512B Lending of books, courses, school periodicals; 10500A Tuition fees, course registration fees, school fees, exam registration fees (day and evening courses); 10500B Distance learning (correspondence courses); 10500C School supervision; 10500D Private lessons for school subjects (languages, maths, computer science...); 11203A Boarding fees; 11203B Student homes fees
2	2.15	11122A Dining hall
3	2.05	06232A Thermal spa, rental of therapeutic equipment; 06232B Ambulance service; 06232C Physiotherapist, corrective gymnastics; 06239A Other outpatient hospital services (dietician, psychologist, logopedist, acupuncturist, chiropractor, osteopath, etc.); 12403A Home care nurse (including midwives)
4	1.56	09131A Desktop computer and hardware; 09131B Laptop computer and hardware; 09132A Computer peripherals (except printer): scanner, external hard drive, numeric keypad; 09132B CD Player for PC; 09132C DVD Player for PC; 09132E DVD writer for PC; 09132F Printer for PC (including multi-function printer); 09132G Floppy disks, ZIP, mini cassettes for PC, USB stick, etc.
5	1.53	04441A Rental costs (except water, gas, electricity, heating): elevator, caretaker, lighting in the common areas, etc.
	NOx	
1	6.26	06232A Thermal spa, rental of therapeutic equipment; 06232B Ambulance service; 06232C Physiotherapist, corrective gymnastics; 06239A Other outpatient hospital services (dietician, psychologist, logopedist, acupuncturist, chiropractor, osteopath, etc.); 12403A Home care nurse (including midwives)
2	6.15	09512B Lending of books, courses, school periodicals; 10500A Tuition fees, course registration fees, school fees, exam registration fees (day and evening courses); 10500B Distance learning (correspondence courses); 10500C School supervision; 10500D Private lessons for school subjects (languages, maths, computer science...); 11203A Boarding fees; 11203B Student homes fees
3	5.80	11122A Dining hall
4	4.50	01152D Vegetable fats; 01153A Olive oil; 01153B Organic olive oil; 01154A Groundnut oil; 01154B Corn oil; 01154C Other oils (soybean, sunflower, walnut etc.); 01154D Oils w. s.; 01154E Organic groundnut oil; 01154F Organic corn oil; 01154G Other oils (soybean, sunflower, etc.) organic; 01154H Oils w. s. (organic)
5	4.49	07332A Passenger air transport
	SOx	
1	1.45	05401A Drinking glasses (including crystal glasses); 05401B Other glassware (including pyrex and crystal); 05401F Baby dishes (bottles, cups, etc.); 05403D Thermos and spare parts
2	1.30	05401C Dinner set, coffee set; 05401D Porcelain and terracotta tableware
3	1.20	06232A Thermal spa, rental of therapeutic equipment; 06232B Ambulance service; 06232C Physiotherapist, corrective gymnastics; 06239A Other outpatient hospital services (dietician, psychologist, logopedist, acupuncturist, chiropractor, osteopath, etc.); 12403A Home care nurse (including midwives)
4	1.12	09512B Lending of books, courses, school periodicals; 10500A Tuition fees, course registration fees, school fees, exam registration fees (day and evening courses); 10500B Distance learning (correspondence courses); 10500C School supervision; 10500D Private lessons for school subjects (languages, maths, computer science...); 11203A Boarding fees; 11203B Student homes fees
5	1.06	11122A Dining hall
	NH_3	
1	8.85	01182B Honey; 01182G Honey (organic)
2	8.66	01146A Chicken eggs (fresh or hard-boiled); 01146B Other eggs (goose, quail, etc.); 01146C Chicken eggs (organic); 01146D Other eggs (organic)
3	8.49	09341A Purchase of dogs; 09341B Purchase of cats; 09341C Purchase of other domestic animals
4	7.75	09214A Riding horses; 09215A Other major goods for relaxation and outdoor sports (canoeing, kayaking, sand yacht, sea-diving equipment, golf cart, trampoline, swing, etc.).
5	7.26	01152D Vegetable fats; 01153A Olive oil; 01153B Organic olive oil; 01154A Groundnut oil; 01154B

Rank	Coefficient of indirect air pollution – CIAP in gram per euro	COCIOP code(s) and name(s)
		Corn oil; 01154C Other oils (soybean, sunflower, walnut etc.); 01154D Oils w. s.; 01154E Organic groundnut oil; 01154F Organic corn oil; 01154G Other oils (soybean, sunflower, etc.) organic; 01154H Oils w. s. (organic)
	NMVOC	
1	7.96	01146A Chicken eggs (fresh or hard-boiled); 01146B Other eggs (goose, quail, etc.); 01146C Chicken eggs (organic); 01146D Other eggs (organic)
2	7.72	01182B Honey; 01182G Honey (organic)
3	7.40	09341A Purchase of dogs; 09341B Purchase of cats; 09341C Purchase of other domestic animals
4	6.76	09214A Riding horses; 09215A Other major goods for relaxation and outdoor sports (canoeing, kayaking, sand yacht, sea-diving equipment, golf cart, trampoline, swing, etc.).
5	3.97	01124A Chicken, pieces of chicken (fresh) ; 01124B Boiling fowl (fresh) ; 01124C Other poultry (fresh): turkey, pigeon, duck, guinea fowl; 01124D Chicken, pieces of chicken (frozen); 01124E Boiling fowl (frozen); 01124E Other poultry (frozen); 01124G Chicken, chicken pieces (organic); 01124H Boiling fowl (organic); 01124I Other poultry (organic); 01125C Game (fresh): doe, roe deer, caribou, pheasant, young wild boar, partridge, hare, quail, frogs, etc.; 01125F Game (frozen); 01125I Game (organic)
	CO	
1	6.56	04549B Other fuels (charcoal, pellets, etc.)
2	6.54	06232A Thermal spa, rental of therapeutic equipment; 06232B Ambulance service; 06232C Physiotherapist, corrective gymnastics; 06239A Other outpatient hospital services (dietician, psychologist, logopedist, acupuncturist, chiropractor, osteopath, etc.); 12403A Home care nurse (including midwives)
3	6.40	07332A Passenger air transport
4	6.39	04541A Coal
5	5.93	05401A Drinking glasses (including crystal glasses); 05401B Other glassware (including pyrex and crystal); 05401F Baby dishes (bottles, cups, etc.); 05403D Thermos and spare parts
	PM_{10}	
1	1.12	01146A Chicken eggs (fresh or hard-boiled); 01146B Other eggs (goose, quail, etc.); 01146C Chicken eggs (organic); 01146D Other eggs (organic)
2	1.11	01182B Honey; 01182G Honey (organic)
3	1.06	09341A Purchase of dogs; 09341B Purchase of cats; 09341C Purchase of other domestic animals
4	0.97	09214A Riding horses; 09215A Other major goods for relaxation and outdoor sports (canoeing, kayaking, sand yacht, sea-diving equipment, golf cart, trampoline, swing, etc.).
5	0.63	06232A Thermal spa, rental of therapeutic equipment; 06232B Ambulance service; 06232C Physiotherapist, corrective gymnastics; 06239A Other outpatient hospital services (dietician, psychologist, logopedist, acupuncturist, chiropractor, osteopath, etc.); 12403A Home care nurse (including midwives)
	$PM_{2.5}$	
1	0.40	06232A Thermal spa, rental of therapeutic equipment; 06232B Ambulance service; 06232C Physiotherapist, corrective gymnastics; 06239A Other outpatient hospital services (dietician, psychologist, logopedist, acupuncturist, chiropractor, osteopath, etc.); 12403A Home care nurse (including midwives)
2	0.32	09512B Lending of books, courses, school periodicals; 10500A Tuition fees, course registration fees, school fees, exam registration fees (day and evening courses); 10500B Distance learning (correspondence courses); 10500C School supervision; 10500D Private lessons for school subjects (languages, maths, computer science...); 11203A Boarding fees; 11203B Student homes fees
3	0.30	11122A Dining hall
4	0.29	01131A Sole, lemon sole (fresh); 01131B Plaice (fresh); 01131C Cod (fresh); 01131D Salmon (fresh); 01131E Sardines (fresh); 01131E Other sea fish (whiting, redfish, hake, etc.) fresh; 01131G Freshwater fish (trout, eel, pangasius, Nile perch, etc.) - fresh; 01131H Fresh Tuna; 01131I Fish without specification and other seafood products (algae...) fresh; 01131J Fish without specification (organic)
5	0.28	01146A Chicken eggs (fresh or hard-boiled); 01146B Other eggs (goose, quail, etc.); 01146C Chicken eggs (organic); 01146D Other eggs (organic)

Source: FPB calculations

Bibliograpy

Barret, J., Birch, R., Baiocchi, G., and Minx, J. (2006), Environmental impacts of UK consumption – exploring links to wealth, inequality and lifestyle, IABSE Henderson Colloquium, Cambridge, 10-12 July 2006.

Birch, R., Barret, J., and Wiedmann, T. (2014), Exploring the consumption and related environmental impacts of socio-economic groups within the UK, Stockholm Environment Institute – York, University of York Heslington.

Brizga, J., Feng, K., and Hubacek, K. (2017), Household carbon footprints in the Baltic States: A global multi-regional input–output analysis from 1995 to 2011 in Applied Energy, Volume 189, 1 March 2017, Pages 780-788.

Dawkins, E., Roelich, K., and Owen, A. (2010), A Consumption Approach for Emissions Accounting - the REAP Tool and REAP Data for 2006, Stockholm Environment Institute.

Eurostat (2008), Eurostat Manual of Supply, Use and Input-Output Tables, Luxemburg: EC- Eurostat.

Frère, J-M., and Quertinmont, J-C. (2010). De milieudruk van de huishoudelijke consumptie in België in 2002: een sociologische analyse. Working Paper 12-10. Brussels: Federal Planning Bureau.

Gough (2011), Climate change, double injustice and social policy, Paper presented at the UNRISD conference 10-11/10/2011 Geneva.

Gough (2013), Carbon mitigation policies, distributional dilemma's, in Journal of social policy, 42(2). pp. 191-213.

Gough, I., Abdallah, S., Johnson, V., and Ryan, J. (2012), The distribution of total greenhouse gas emissions by households in the UK, and some implications for social policy, Centre for Analysis of Social Exclusion, London School of Economics.

Hambÿe, C., Hertveldt, B., and Michel, B. (2017), Belgium's Carbon Footprint Calculations based on a national accounts consistent global multi-regional input-output table, Brussels: Federal Planning Bureau, 2017.

Instituut voor de Nationale Rekeningen (2016), "Luchtemissierekeningen 2010-2014", Brussel. http://www.plan.be/publications/publication-1620-en-air+emissions+accounts+2010+2014 (last consulted on January 31, 2018).

International Energy Agency - OECD – Eurostat (2005), Energy Statistics Manual 2005, Paris: OECD/IEA.

IPCC (2014), Intergovernmental Panel on Climate Change Climate Change 2014, Synthesis Report, Summary for Policymakers, https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf (last consulted on January 31, 2018).

IRCEL-CELINE (2012), Informative Inventory Report about Belgium's annual submission of air emission data reported in February 2012 under the Convention on Long Range Transboundary Air Pollution CLRTAP, http://cdr.eionet.europa.eu/be/un/UNECE_CLRTAP_BE/ (last consulted on January 31, 2018).

Ivanova, D., Stadler, K., Steen-Olsen, K., Wood, R., Vita, G., Tukker, A., and Hertwich, E. (2016), Environmental Impact Assessment of Household Consumption in Journal of Industrial Ecology. vol. 20 (3).

Kerkhof, A., Molla, H., Drissen, E., and Wilting, H. (2008), Taxation of multiple greenhouse gases and the effects on income distribution, A case study of the Netherlands Ecological Economics in Ecological Economic 67 (2008), 318-326.

Kerkhof, A., Nonhebel, S., and Moll, H. (2009), Relating the environmental impact of consumption to household expenditures: An input–output analysis, in Ecological Economic 68 (2009), 1160-1170.

LRTAP – EEA (2016), EMEP/EEA air pollutant emission inventory, guidebook 2016, Technical guidance to prepare national emission inventories, EEA Report No 21/2016, European Environment Agency, 2016. https://www.eea.europa.eu/publications/emep-eea-guidebook-2016 (last consulted on January 31, 2018).

National Climate Commission (2017), Belgium's greenhouse gas inventory (1990-2015) - National Inventory Report submitted under the United Nations Framework Convention on Climate Change, April 15 2017, http://cdr.eionet.europa.eu/be/eu/mmr/art07_inventory/ghg_inventory (last consulted on January 31, 2018).

Nijdam, D., S., and Wilting, H., C. (2003). Milieudruk consumptie in beeld, dataverwerking en resultaten, Bilthoven: RIVM.

Ntziachristos, L., Gkatzoflias, D., Kouridis, C., and Samaras, Z. (2009), COPERT: a European road transport emission inventory model in Information Technologies in Environmental Engineering (2009), 491-504.

Peters, G. and Hertwich, E. (2006), The Importance of Imports for Household Environmental Impacts in Journal of Industrial Ecology 2006, Volume 10, Number 3.

Poom, A., and Ahas, R. (2014), How Does the Environmental Load of Household Consumption Depend on Residential Location? in Sustainability, 2016, Volume: 46 issue: 10, page(s): 2369-2384

Pye, S., Skinner, I., Meyer - Ohkendorf, N., Leipprand, A., Lucas, K., and Salmons, R. (2008), Addressing the social dimensions of environmental policy: a study on the linkages between environmental and social sustainability in Europe (Manuscript completed in July 2008), Brussels: EC.

Royal Decree of 18 July 2013 laying down the federal long-term strategic vision for sustainable development, Belgian Gazette, 08/10/2013, pp. 70864-70873.

Statbel (2014), Huishoudvragenlijst_Deel 3 HBO 2014, Brussels: Statbel.

Wadeskog, A., and Larsson, M. (2003), Households in the environmental accounts, Statistics Sweden - Eurostat.

Wier, M., Christoffersen, L., B., Jensen, T., Pedersen, O., G., Keiding, H., and Munksgaard, J. (2005), Evaluating the sustainability of household consumption – Using DEA to Assess Environmental Performance in Economic system research, Vol. 17, No. 4, p. 425-447.

Wier, M., Lenzen, M., Munksgaard, J., and Smed, S. (2001), Effects of Household consumption patterns on CO_2 requirements in Economic system research, Vol. 13, No. 3, p. 259-274.