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Carbon taxation, carbon subsidies and ETS payments in Luxembourg (integrated report)

An Environmentally Extended Input-Output Analysis

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Abstract

This study is an analysis of current energy and transport taxation and carbon relevant subsidies in Luxemburg, utilizing an Environmentally Extended Input-Output model. The method allows to not only calculate direct taxation and emissions that are produced and paid by a sector, but also indirect emissions and taxation that is paid and produced indirectly because of the interconnectedness of the value chains. Besides current carbon-related taxation, we also ran the model for four fictional taxation scenarios, with further versions including a sensitivity analysis for selected scenarios with a varying ETS price. The analysis is based on Eurostat data on greenhouse gas emissions, taxation and sectoral connections of international economies (FIGARO-tables). Descriptive statistics show that Luxembourg had the highest GHG emissions per capita of all EU countries in 2019, while a relatively large share of energy and transport taxes was paid by non-residents. Therefore, we extended the model and introduced non-resident corporations and non-resident households in addition to the usual units, such as (resident) households and industries, in the model. In one of the fictional scenarios, we analyzed the effects of the planned carbon tax in Luxembourg in 2023 (30 Euros per ton of CO_2). In the short run, this tax would generate almost 295 million Euros of revenues, in addition to already existing carbon-related taxation (1 billion Euros in 2019) if emissions stayed at their 2019 levels. In all scenarios, non-resident corporations would bear the brunt of carbon taxation, as these produced around one third of greenhouse gas emissions in Luxembourg in 2019. Energy and transport taxation in 2019 was very unevenly distributed in Luxembourg, when considering the emissions of the respective economic unit. While sectors such as agriculture paid only one Euro per emitted ton of CO_2, construction and mining paid around 300 Euros for the same pollution. Moreover, we found that a selected list of carbon subsidies in Luxembourg amount to 417 million Euros, whereas entities not located in Luxembourg (foreign households and corporations) profit the most of these, while households located in Luxembourg profit the least. We suggest that policy makers in Luxembourg should come up with a taxation scheme that is stronger connected to GHG and CO_2 emissions and carbon-related subsidies should be abolished to a large extent.

Key words: carbon price, carbon subsidies, energy, taxes, greenhouse gas emissions, FIGARO.

Table of Contents

List of Figures

List of Tables

Introductory note

The study at hand is an integrated report, extending and building upon a study by Schnabl et al. (2022). Large text passages, tables, graphs, data and the underlying model are directly taken over from this study, without further citations.

1 Introduction

According to Eurostat (2021a) Air Emissions Accounts, Luxembourg's residential industry and households produced 9.75 million tons of carbon dioxide (CO_2) in 2019, which is the most well-known greenhouse gas (GHG[1]) that contributes to global warming. The country by far shows the highest GHG emissions per capita of all EU member states. Because Luxembourg has a relatively small number of residents and the highest gross domestic product (GDP) per capita in the EU, this observation is no surprise. Research suggests that growth in GDP and GHG emissions are connected (Ansuategi & Escapa, 2002; Parrique, et al., 2019).

As part of the "European Green Deal", all EU member states, including Luxembourg, have agreed to cut their GHG emissions by at least 55% until 2030, compared to the level of emissions in 1990 (European Commission, 2021). Eurostat's Air Emissions Database shows that so far Luxembourg has not managed to reach the EU's 20% reduction goal for 2020 (European Commission, 2009), on the contrary, its emissions were still at 92.7% of 1990's emissions in 2019. To reach the 55% reduction goal, national governments will very likely have to implement policy measures such as carbon taxes or alternative carbon pricing schemes. In 2021, a carbon tax amounting to 20 Euros per emitted ton of CO_2 was introduced in Luxembourg. This amount will be increased stepwise to 30 Euros by 2023. The World Bank (2020) estimates that a minimum price ranging between 40 and 80 USD per emitted ton will very likely be necessary to reach the 1.5 degrees Celsius reduction goal of the Paris Agreement. The Intergovernmental Panel on Climate Change (2019) suggests that the price for reaching the goal is noticeably higher and will be located somewhere between 135 and 6,050 USD[2] in 2030. This means that the carbon tax will very likely have to be increased in the future if policy makers are determined to reach the 1.5-degree goal.

This study consists of two parts, which are strongly intertwined. Part one is an analysis of selected subsidies that benefit the use, consumption and incineration of carbon-based energy products, such as diesel and gasoline. The second part is an analysis of current

[1] Eurostat (2015) calculates total GHG emissions by weighting different types of pollutants by their global warming potentials. The potential is expressed in CO_2 equivalents (CO_2e), meaning that CO_2 has a weighting factor of 1, while methane (CH_4) or nitrous oxide (N_2O) for example have factors of 25 and 298, respectively.

[2] At 2010 price levels.

carbon-related subsidies and taxation in Luxembourg (and indirectly also in the EU). The study not only includes the proposed carbon tax, but also already existing energy and transport taxes, as these are closely connected to CO_2 and other GHG emissions. Additionally, four fictional emissions-taxation scenarios were calculated and further sensitivity analysis with higher ETS prices[3] were conducted. Methodologically, an Environmentally Extended Input-Output Analysis (EE-IOA) based on FIGARO tables from 2017 was used in both modules. The method allows to connect the value chains of all EU 27 countries, the UK and the US at a detailed level of 64 industries (hereafter often referred to as "sectors" and used interchangeably).[4] Moreover, data on 16 partner countries and the rest of the world based on 30 industries is included in the tables. 2019 was used as a reference year for pollution and taxation data, as it was the most recent information available. The EE-IOA allows for a calculation of direct and indirect effects. Direct effects refer to taxes which are paid directly by the respective economic unit. Indirect effects are taxes which are paid indirectly by taking the respective value chains into account and can be calculated on a domestic and an international level. The analysis was conducted on a partly aggregated NACE[5] Rev. 2 industry level and includes (1) resident households, (2) non-resident households, such as cross-border workers, foreign tourists and "fuel tourists", and (3) non-resident companies, such as transportation enterprises, as separate units. For the calculation of the indirect effects, government consumption and exports were included as additional units of analysis. Therefore, it was possible to analyze how much carbon-related subsidies and taxes households, or individual industries received and paid both directly and indirectly on either a domestic or an international level in 2019. We could not only analyze the effects of fictive new taxation schemes in Luxembourg on households or individual industries, but also the impact of new taxation schemes on other countries.

The analysis of direct and indirect carbon-related subsidies is based on Eurostat (2022b) Physical Energy Flow Accounts data and information on excise duties in EU-member states by the European Commission (2022). We found that the selected carbon-related subsidies analyzed in this study amount to 418 million Euros. Entities not located in Luxembourg

[3] ETS stands for *European Union Emissions Trading System*.

[4] Only air emissions that are related to economic activities are considered in this data set, including the combustion of energy sources in private households. The pollution generated along the supply chains during production processes is captured by the EE-IOA. It does not include any activities that precede production and only indirectly lead to a deterioration in the air emissions balance. The methane and CO_2 emissions from beef production including the emissions along the supply chains, for instance, are considered. However, if rainforests were cleared beforehand to produce animal feed, only the emissions produced during the clearing (e.g., from the operation of chainsaws) is included in the data. It does not account for the reduced capacity of the forest to absorb CO_2. Furthermore, the air pollution is assigned to the respective producing industry, regardless of legal ownership. If the finance and banking sector would own high shares of the manufacturing industry, for example, the emissions would still be assigned to the manufacturing industry.

[5] NACE stands for *Nomenclature statistique des activités économiques dans la Communauté européenne* and is a statistical classification system of economic activities used in the European Union. For an overview of the NACE sectors used in this study, see Table 27 in the Appendix.

(foreign households and corporations) profit the most from these subsidies, while households located in Luxembourg profit least.

The analysis of direct and indirect effects of current carbon-related taxes is based on industry level data from the Eurostat (2021b) Environmental Taxes Database for 2019. We found that non-resident corporations paid 44% of the total revenues generated by these taxes in 2019. Results of the direct and indirect effects of the four fictive carbon taxation scenarios based on Eurostat (2021a) Air Emissions Accounts show that also here non-resident corporations would pay the brunt of planned carbon taxation. In the short run, the planned carbon-tax (30 Euros per ton of CO_2 in 2023) would generate revenues of almost 295 million Euros, in addition to 1 billion of already existing carbon-related taxation in 2019.

Note that the analysis of fictive taxation scenarios was restricted to short-term effects due to the nature of the method used. Consequently, no price effects stemming from changed behavior on both the corporate and consumer side could be considered.

We conclude that Luxembourg's economy is highly interconnected with its neighbors and the entire European Union. A large share of emissions in Luxembourg is produced by non-residents. Consequently, these non-domestic corporations and households already pay a large share of carbon-related taxation and would pay a large part of any planned tax. At the same time, non-domestic entities profit the most from carbon subsidies in Luxembourg. We suggest that policy makers in Luxembourg should develop a taxation scheme that is strongly linked to actual GHG and CO_2 emissions produced by the taxed unit, as this is currently not the case. Moreover, we highly recommend that most carbon subsidies should be abolished, as they have the potential to undermine any future decarbonization attempts.

2 Preceding study (Austria)

In 2020, the IHS research group Regional Science and Environmental Research (formerly Companies, Industries and Regions) conducted a commissioned study (Schnabl, et al., 2021) for the Austrian Arbeiterkammer, which is an institution that officially represents all Austrian workers and employees. The purpose of this study was the examination of the Austrian system of taxes and duties relating to CO_2 emissions, especially regarding tax exemptions and subsidies. Methodologically, an EE-IOA was utilized. The study was structured into three parts. First, direct taxes and duties aimed at reducing CO_2 emissions as well as (partial) exemptions and subsidies relating to these were evaluated. Particular attention was paid to the distribution of burdens and benefits between companies and households. Secondly, by looking at CO_2 emissions along the respective value chains, the resulting indirect effects in Austria and abroad were assessed. Finally, indirect taxes and duties relating to CO_2 were calculated for Austria as well. For the first two parts, the results demonstrated an uneven distribution of the tax burden in favor of companies, placing households at a disadvantage. While in 2018 companies paid taxes and duties directly related to CO_2 emissions in the amount of approximately 3.5 bn. Euros, households paid 5.3 bn. Euros. Moreover, tax exemptions and subsidies were mainly tailored to benefit businesses (2.67 bn. Euros for companies; 0.65 bn. Euros for households). On average, households paid 127 Euros per directly generated ton of CO_2 emissions while companies were charged with only 41 Euros. An inclusion of the indirect effects lead to a slightly more balanced distribution. Moreover, both direct and indirect effects of three hypothetical carbon taxes on economic sectors and selected components of the final demand were calculated. Based on all CO_2 emissions in 2018, in the three scenarios the direct total tax burden would have increased by 2.2 bn, 5.2 bn and 6.9 bn Euros compared to the current energy taxes in 2018, respectively. The households would have once again carried the main burden of the considered taxes, which also holds true if the indirect effects were considered as well. When considering only CO_2 emissions which are harmful to the climate[6], the overall tax burden would have decreased considerably in all three scenarios.

It is important to stress the country-specific differences between Luxembourg and Austria when comparing the results of the studies. According to Eurostat (2021d), Luxembourg was populated by 602,005 people on January 1st, 2018, whereas Austria was populated by 8,822,267 people (same date). At current prices, Luxembourg had a GDP of 60.4 billion Euros, while Austria's GDP amounted to 385.42 billion Euros in 2018 (Eurostat, 2021e). Luxembourg's residents emitted 9.75 (10.72) million tons of CO_2 (GHG), Austria's residents 63 (75) tons in 2018, respectively (Eurostat, 2021a).

[6] Emissions that are not harmful to the climate make up a relatively large share in Austria. These mostly include CO_2 emissions from the incineration of wood.

3 Data

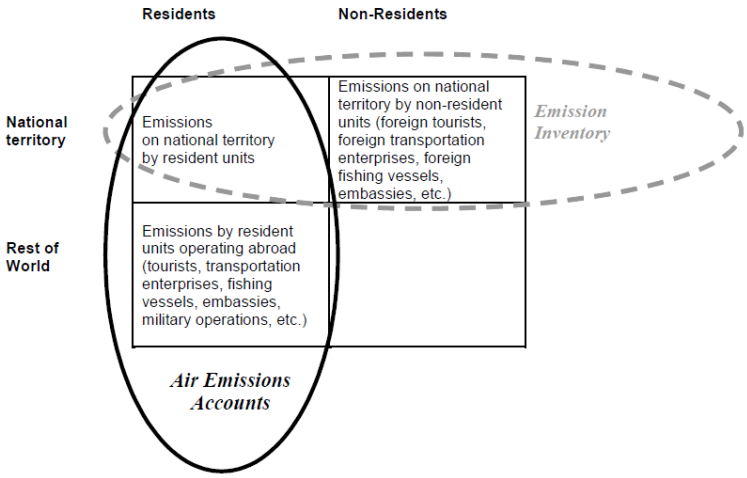
The inputs for the empirical model of this study were data on CO_2 and GHG emissions and physical energy flows as well as energy and transport taxes by Eurostat. Moreover, additional data sources were used when further refinements were necessary. The following section describe these datasets in detail.

3.1 Emissions

Data on CO_2 emissions for 2019 (without emissions from biomass used as fuel) came from the Eurostat (2021a) Air Emissions Database. This database covers a wide range of GHGs and air pollutants. For our analysis, we were mainly interested in the Air Emissions Accounts by NACE Rev. 2 activity, as this format fits the FIGARO tables used in this study. Moreover, we used Eurostat Air Emissions Inventories and the corresponding bridging tables as a complementary data source. We utilized the datasets for calculating the fictive carbon taxation scenarios and in the analysis of current taxation schemes in Luxembourg.

There are different international reporting standards for air emissions. The main data source used in this study builds on the Air Emissions Accounts principle, which means that all emissions by residents (in this case from Luxembourg) are covered. This not only includes emissions on national territory, but also abroad, for example by Luxembourgian tourists, transportation enterprises and military operations (Eurostat, 2015). In contrast, the emissions in a specific territory are recorded in the Air Emission Inventories, for instance, of Luxembourg residents, but also of foreign tourists, freight companies, etc. on Luxembourgian territory. This main difference between these two concepts is depicted in the following figure. Another difference lies in the different classifications of the emissions. While in the Air Emissions Accounts the emissions are assigned to economic activities, in the Air Emission Inventories they are distributed according to technical processes.

Figure 1: Geographic and economic (resident) definition of a country



Source: Eurostat (2015): Manual for air emissions accounts, 2015 edition: page 17.

In 2019, all CO_2 emissions by Luxembourg's residential industries and households summed up to 9.75 million tons, whereas the households produced 1.53 million tons. If all GHG emissions are considered, these numbers amount to 10.72 and 1.58 million tons, respectively. According to the European Environmental Agency (2022), 1.76 million tons of these GHG emissions were so called "verified emissions" covered by the EU Emissions Trading Scheme (EU-ETS, see Section 3.2.1) in 2019.

Besides industries and households, we introduced additional units of analysis in our study, using data from the Eurostat (2021a) bridging tables: non-resident households and non-resident corporations. We have information on the emissions from non-residents in total but not separate for households and corporations. Therefore, we calculated the distribution of these emissions by estimating the shares of foreign private and foreign companies' fuel consumption. An estimation of foreign fuel consumption split between cars and other road vehicles can be found in Ewringmann (2016: 26). Due to the fact that passenger cars can be either private or company cars, we utilize a corresponding estimation from Roy (2014: 23) using the neighboring countries as a basis (Germany, France, Germany, the Netherlands). We used the resulting proportions for the foreign (non-Luxembourgian) households and foreign corporations, respectively, as a distribution key for the emissions by non-resident units. These emissions can be assigned to the use of fuel purchased on national territory, as shown in the bridging tables. We are aware that this distribution key probably does not perfectly reflect the true distribution of emissions between the concerned units, but it was arguably the best information available at the time this study was produced. A disaggregation of non-resident households into foreign cross-border workers, foreign tourists and "fuel tourists" was not feasible.

Moreover, we made certain assumptions for the emissions produced by the aviation sector using information from the Air Emissions Inventories and the corresponding bridging tables. In the Air Emissions Accounts, the aviation sector (H51) showed emissions of 5,110,900 tons of CO_2 and 5,155,597 tons of GHG in 2019. A large proportion of these very likely came from Luxembourgian airlines operating abroad. Instead of using these amounts of emissions, we used the amount of aviation emissions that were assigned to Luxembourg's territory according to the Inventories data[7] in 2019, summing up to 1,798,590 tons of CO_2 and 1,814,510 tons of GHG. The reason for this is that the changes in the Luxembourg taxation system examined in this study can only have an impact on its own territory. Therefore, only pollution on Luxembourgian territory can be taken into account. For our analyses, we need the spatial delimitation of the Air Emission Inventories, but with a classification of the emissions according to economic activities (Figure 1).

Eurostat's database shows that Luxembourg had the highest per capita emissions[8] of GHGs in the EU, amounting to 20.3 tons in 2019. Second and third in place were Iceland and Ireland, with 15.8 and 12.8 tons, respectively. The average of the EU-27 countries was 8.4 tons in the same year. As discussed in the introduction of this study, this is no surprise due to the high GDP per capita in Luxembourg.

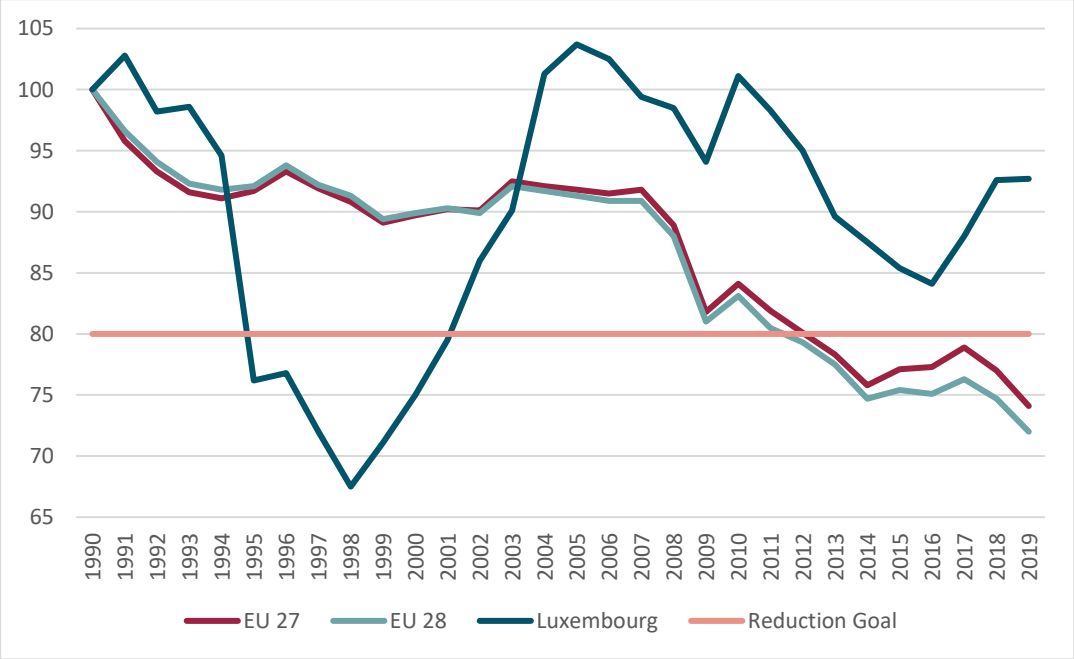
Figure 2 shows the development of GHG emissions in Luxembourg and the EU since 1990, according to the Eurostat (2021a) Air Emissions Database. One can see that it is very unlikely that Luxembourg will fulfil the EU's reduction goal for 2020[9]. In this scheme, which was part of the EU's "2020 Climate & Energy Package", countries agreed to reduce GHG emissions by 20% compared to 1990 (European Commission, 2009). Luxembourg's emissions where still at 92.7% of the GHG emissions level of the base year 1990 in 2019, whereas the EU as a total already reached the 20% reduction goal at the same time. As can be seen in Figure 2, Luxembourg was on a solid reduction path between 1993 and 1998, until emissions began to increase again sharply until 2005.

[7] Sum of fuel combustion in domestic and international aviation.

[8] Note that these numbers are reported under the United Nations Framework Convention on Climate Change (UNFCCC) and that totals might differ from numbers reported under the Air Emissions Accounts principle, as also some indirect emissions are included in these numbers.

[9] Data for 2020 was not available when this study was completed.

Figure 2: Development of net GHG emissions ('Kyoto basket') in Luxembourg and the EU (1990=100) between 1990 and 2019.



Note: The figure is based on data reported to the EEA and might differ from emissions reported in the Air Emissions Accounts. Data Source: Eurostat (2021a).

3.2 Current Taxation

In this study, we analyzed already existing taxation that is closely connected to CO_2 emissions. The utilized datasets came from the Eurostat (2021b) Environmental Taxes Database. They contain statistics about revenue collected through taxation of energy, transport, pollution and resources in every EU country on the NACE Rev. 2 level. For information on value-added tax (VAT), see Section 3.4.

According to the Eurostat (2013, S. 9) Environmental taxes statistical guide, an environmental tax is *"[a] tax whose tax base is a physical unit (or a proxy of a physical unit) of something that has a proven, specific negative impact on the environment, and which is identified in ESA[10] as a tax."* We argue that in the case of activities targeted by energy and transport taxes one of these negative impacts is the contribution to global warming. Therefore, these two types of taxation are very closely connected to a carbon tax and both were included in our analysis of current taxation.

The database not only shows taxes paid by industries and households, but also those that are paid by non-resident households and other non-residents as a separate unit, such as

[10] ESA stands for European System of Accounts.

corporations and foreign governments. According to the manual, transport fuels, more specifically taxes on petrol and diesel, by far make up the largest share of taxes paid by non-residents. In almost all countries, the share of taxes paid by non-residents was relatively small (3.48% of cumulated energy and transport taxes in the EU-27 in 2018[11]) and nearly negligible when running a similar analysis as in this study. Luxembourg is virtually the only EU country where this is not the case. More than 55% of relevant taxes were paid by non-residents in 2019. For this reason, we further decomposed the non-residents unit into taxes paid by non-resident households and non-resident corporations. To achieve this, we used the same distribution key as described for emissions of non-resident corporations and households (see Section 3.1).

Especially in small countries where only few corporations operate in single industries, confidentiality can lead to difficulties for conducting research. This issue also applies to Luxembourg, where many sectors do not show a value for the taxation due to confidentiality reasons. Of the 67 units (households, industries, non-residents, excluding aggregates) where values can be reported, 27 showed the confidential flag. As a result, certain assumptions and aggregations had to be made. For the energy taxes (see Section 3.2.1), we used the average energy taxes in all EU countries for each individual confidential sector in Luxembourg. We then distributed them via the emissions in the concerned sectors and adjusted them to sectoral aggregates if necessary (which are not as detailed as NACE-2 but are available for all sectors). For transport taxes (see Section 3.2.2), we basically applied the same procedure with minor adjustments.

Table 26 in the Appendix shows taxes for all countries where data is available. Table 28 in the Appendix depicts the original tax data for Luxembourg, also showing gaps in the data due to confidentiality, as reported by Eurostat. The following subsections describe the different types of environmental taxes in detail.

3.2.1 Energy taxes and EU-ETS

According to the Eurostat (2013) statistical guide, energy taxes include taxation of energy production for both transport and stationary purposes. The most important energy products for transport are petrol and diesel. Stationary purposes mainly use products such as light and heavy fuel oil, natural gas, coal, coke and electricity. Moreover, revenues from carbon taxation and GHG emissions-allowances through the EU-ETS are included in this category. Energy taxes in Luxembourg summed up to 1,012.59 million Euros in 2019, excluding VAT.

According to data from the European Energy Exchange (2022), prices for one ton of CO_2e in EU-ETS emissions allowances showed a steady increase between mid-2017 and the

[11] Data on cumulated taxes paid by non-residents in 2019 not available.

beginning of 2021. While prices did not climb above 10 Euros between the end of 2011 and mid-2018, the price steadily increased to 30 Euros until the beginning of 2021, with a temporary plunge to around 15 Euros during the beginning of the Coronavirus crisis. In 2021, another sharp increase followed, and the price almost reached 100 Euros in January 2022 (see Figure 3).

Figure 3: Development of EEX emissions market primary auction price in Euros for one ton of CO_2e between 29.1.2021 and 24.02.2021.

Data Source: European Energy Exchange AG (2022).

Data from the European Energy Exchange (2022) shows that revenues from primary market auctions for Luxembourg's treasury decreased from 17 million in 2019 to 8 million Euros in 2021. Even though emissions data for 2021 is not available yet, it is highly unlikely that this decrease is caused by a similar drastic decrease in GHG emissions. Data from the European Environmental Agency (2022) shows that Luxembourg constantly allocated more emissions allowances than its verified emissions targeted by these. We assume that companies in Luxembourg used these excess allowances instead of paying high prices at the primary auctions. For our calculations we used the 2019 emissions revenues of 17.06 million Euros, which are reported together with the other energy taxes by Eurostat. The average price for one ton of CO_2e in EU-ETS emissions allowances was 24.65 Euros in that year, according to the European Energy Exchange (2022).

Data on revenues for the proposed carbon tax is not available yet. Usually, the most recent data is information on taxation from 2 to 3 years ago. For this reason, we treated the new

carbon tax of 30 euros per emitted ton (see Section 5.2) as a fictive scenario and calculated the sectoral impacts using different assumptions.

3.2.2 Transport taxes

The Eurostat (2013) guide defines transport taxes as taxation that mainly targets the ownership of motor vehicles and other transport equipment, such as planes or ships. Examples are one-off taxes on imports and sales of motor vehicles and (regular) registration taxes for these, road-use taxes, congestion charges, tolls and taxes on vehicle insurance. Also, taxes that are directly connected to the CO_2 emissions of a vehicle (e. g. using emissions or average fuel consumption per 100 km as a benchmark) are covered here rather than in the category "energy taxes". Transport taxes include taxation of all means of transport, including, for example, public transport, trains, or electric vehicles. We argue that this is not a problem in the context of our analysis, as policy makers usually take the relatively higher environmental friendliness into account when designing tax policies, resulting in a low share of taxes paid through the use of these means of transport. Luxembourg's tax office received 68.27 million Euros in transport taxes in 2019, excluding VAT.

3.2.3 Pollution and resource taxes

The other two categories are taxation of (1) pollution and (2) resources. The first covers taxation of nitrogen oxide[12], sulfur oxide and ozone-emissions, effluents to water, pesticides, fertilizers, waste management and noise. The latter covers taxes on water abstraction, harvesting of biological resources, extraction of raw materials and landscape changes, such as cutting trees. We argue that these taxes do not show a direct connection to CO_2 emissions and are thus not relevant to our analysis.

We are aware that one could argue that taxation of resources and pollution does have an indirect connection to CO_2 emissions and should therefore be included in our analysis. We decided not to follow this line of argumentation, as in this case most or all taxes (also outside the environmental taxes) would have to be included in the analysis. Nearly all taxes do have a certain negative or restrictive effect on economic activities and consequently on GHG and CO_2 emissions, as these are connected.

3.3 Physical energy flows

For distributing most subsidies (see Section 6) among the economic entities we mainly relied on Eurostat (2022b) Physical Energy Flow Accounts (PEFA), more specifically the energy supply and use by NACE Rev. 2 activity. These show the amount of energy in

[12] The chemical formula is NO_X, which should not be confused with nitrous oxide (N_2O) in footnote 1.

terajoule (TJ) supplied and used for every economic entity and for every common energy product.

3.4 Value-added tax

For all calculations concerning energy and carbon taxation and subsidies, we also took VAT into account for the final demand (households). VAT is not included in the tables of Eurostat's (2021b) Environmental Taxes Database. Moreover, we also had to consider VAT in the calculations in the fictional taxation scenarios and the subsidies (see Section 5).

Like other European countries, Luxembourg has several VAT rates for different products and services (European Commission, 2021b). While products such as petrol and diesel are taxed with the standard maximum rate (17%), natural gas and heating oil are taxed with reduced rates of 8% and 14%, respectively. For domestic households, we assumed a weighted average VAT rate of 16.05%, using Eurostat (2022b) Physical Flow Accounts data as a distribution key for the different rates on different energy products in the base scenario. As in the fictional scenarios GHG and CO_2 emissions form the basis for the taxation, the distribution keys changes from scenario to scenario resulting in sometimes lower weighted average VAT rates. For the non-domestic households, we assumed the maximum rate of 17%, as the physical flows show that only petrol and diesel are exported.

We argue that VAT should be considered when looking at the sectoral distribution of taxation and subsides. Only final demand components (households) have to pay VAT, while non-final demand components (companies) usually get a full refund. In our calculations, VAT connected to transport taxation was assumed to amount to 17%, which is the rate for motor vehicle sales.

4 Method

For our analysis, we utilized the Environmentally Extended Input-Output-Analysis (EE-IOA). Literature on this method was first published by Nobel-laureate Wassily W. Leontief (1970), who also issued the original version (Leontief, 1936) of the Input-Output Analysis (IOA).

Note that in the remainder of this chapter paragraphs that require knowledge of linear algebra and matrix notation are highlighted in pink. These paragraphs might be skipped by the reader, as the remaining text provides an applied example which allows to understand the most important aspects of the method.

The emissions and carbon (-related) taxes and subsidies reported for each industry, households and other economic unit (non-resident households and non-resident companies) in the tables described in Section 3 are taxes that are paid, subsidies that are received and emissions that are produced directly by the respective economic unit. From an economic point of view, it is often interesting to not only calculate the direct but also the indirect effects of the production and consumption of goods and services. In the case of our analysis this also includes emissions produced and carbon (-related) taxes (subsidies) paid (received) outside of Luxembourg. On top of the economic units mentioned above the analysis of indirect effects includes government consumption and exports as additional entities.

In the following example, assume that we want to determine the CO_2 emissions produced and the carbon taxes paid directly and indirectly if a car is produced in a national economy. In a first step, we will consider the *direct effects*. These are simply the emissions and taxes of the unit C29 "Manufacture of motor vehicles, trailers and semi-trailers", whereas taxes and emissions from this part of the value chain must also be considered. In a next step we will consider the suppliers of the car industry, for example manufacturers of fabricated metal products (C25). These suppliers buy machinery (C26), which in turn consumes energy (E36), and so forth. This process goes on indefinitely. We end up with an infinite sum[13] of taxes and CO_2 emissions paid and produced by (very likely) all sectors of our economy. All these links describe the *indirect effects*.

We can now generalize and formally write down this interconnectedness of our economy. Assume that we have some matrix $\boldsymbol{A}$ of coefficients a_{ij} that connect all units of our economy, which has n sectors. Thus, our matrix $\boldsymbol{A}$ has dimensions $n \times n$. The rows are the inputs, the columns are the outputs of our economy, whereas the columns sum up to 1

[13] In this specific case, this does not mean that the value of the sum itself is infinite.

and single coefficients mustn't be equal to or exceed the value of 1. The information stored in this matrix enables us to write

$$x_i = a_{i1}x_1 + a_{i2}x_2 + \cdots + a_{in}x_n + d_i$$

, where $\boldsymbol{x}$ and $\boldsymbol{d}$ are the vectors of final total output and final demand, respectively. In the equation above, sector j produces one unit of goods or services and needs a_{ij} inputs from sector i. What this equation tells us is that total outputs $\boldsymbol{x}$ equal intermediate outputs plus outputs to final demand $\boldsymbol{d}$, i. e., goods and services are not only produced for final consumption (for example by households) but also for further use in other sectors.

Using matrix and vector notation, we can write this down as

$$\boldsymbol{x} = \boldsymbol{A}\boldsymbol{x} + \boldsymbol{d}$$

or

$$\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{d}$$

, whereas $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ is the *Leontief Inverse*. If $(\boldsymbol{I} - \boldsymbol{A})$ is invertible, then a unique solution for the system of equations can be found. Assuming $|\boldsymbol{A}| < 1$ (the matrix' determinant is smaller than 1), which holds for each input coefficient matrix, we can decompose $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ into a geometric series of matrices.

Thus, the series

$$\boldsymbol{x} = \boldsymbol{d} + \boldsymbol{A}\boldsymbol{d} + \boldsymbol{A}^2\boldsymbol{d} + \boldsymbol{A}^3\boldsymbol{d} + \cdots + \boldsymbol{A}^{k+1}\boldsymbol{d}$$

converges to $\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{d}$ with $\lim_{k\to\infty} \boldsymbol{A}^{k+1} = 0$.

This decomposition enables us to see the crucial property of the IOA. Given a final demand vector $\boldsymbol{d}$, we can find the output that is required to satisfy this demand. Like in the practical example stated in the beginning of this chapter, this is done by adding up the vector of final demand $\boldsymbol{d}$ with the intermediate inputs required for its production, which is $\boldsymbol{A}\boldsymbol{d}$. To produce $\boldsymbol{A}\boldsymbol{d}$ we need $\boldsymbol{A}^2\boldsymbol{d}$, and for its production we need $\boldsymbol{A}^3\boldsymbol{d}$. This process goes on indefinitely, whereas $|\boldsymbol{A}| < 1$ ensures that $\boldsymbol{A}^q\boldsymbol{d}$ diminishes steadily and converges to 0 instead of exploding.

In its original application, scholars mainly used the IOA as a method to calculate the direct and indirect effects of spending and investment on value-added, employment or tax income in an economy. Later, undesirable outputs, such as emissions to the environment, were also analyzed.

For our calculations, we used Eurostat's (2021c) "*Full International and Global Accounts for Research in Input-Output analysis*" tables (FIGARO-tables) to compute the coefficients matrix $\boldsymbol{A}$. These show the monetary connections of all EU-27 countries, the UK and the US at a detailed level of 64 industries. Moreover, data on 16 partner countries and the rest of the world based on 30 industries is included in the tables. From the tables one can for example read the monetary value of inputs that Luxembourg's agricultural sector received from the German chemicals-manufacturing sector (5.39 million Euros) or the value-added of the Hungarian energy sector (1.88 billion Euros). The monetary values are then converted column-wise to fractions, i. e., the input coefficients (a_{ij}). As the FIGARO tables not only cover the sectoral connections within Luxembourg, but also include connections to the rest of the world, it is possible to calculate the effects of existing or planned (carbon) taxation of other countries in Luxembourg. This is especially interesting when looking at large trading partners, such as Germany or France. In general, this method enables the analysis of the amount economic units pay both directly and indirectly on either a domestic or an international level.

Note that the direct and indirect effects calculated in this study must be interpreted as short-term effects. Changes in consumption behavior and value chains (input coefficients), induced by changes in (relative) prices, cannot be considered. This implies that long-term revenues of the fictive taxation scenarios (see Section 5) would most likely be lower than the calculated short-term revenue (sum of direct effects), as rational consumers and corporations would probably try to substitute products that are targeted by the new taxation with products that are less or not affected by it. After all, long-term changes in consumption behavior resulting in reduced emissions are the purpose of any CO_2-related taxation.

Assumption of tax incidence of 1

Moreover, we want to stress that analyzing taxes with the IOA implies that a tax incidence of 1 is assumed. With this method it is presumed that each economic unit (except final consumption, i. e. households, exports, non-residents etc.) passes on the tax burden to the next unit in the value chain. This presumption also holds for emissions and subsidies. Therefore, domestic corporations do not pay any energy or transport taxes, as they get the "money back" from the next economic unit, passing on the tax burden on to the last units in the chain, which are usually the entities of the final consumption.

Domestic households, for example, pay taxes and produce emissions directly by buying and burning mineral oils for transport and heating purposes. But they also pay taxes and produce emissions indirectly through the products and services they buy, as these contain indirect taxation and emissions through the interconnectedness of the economic sectors via the value chain. Domestic corporations (represented by the industry sectors) hand over the tax burden and emissions accumulated along the value chain to the next entity in the

value chain. To better show the taxation and emissions contained in the different goods and services, the tables in the sections 7 to 9 of this study show values for the industry sectors before handing over to the next entity.

The assumption of a tax incidence of 1 is valid for the calculation of short-term effects (in a non-crisis environment). This does not allow any mid- to long-term predictions. In addition, the current situation with sharply rising production costs does not enable the companies to pass the tax burden to the final consumers entirely.

5 Taxation Scenarios

In addition to the analysis of current carbon-related energy and transport taxes, direct and indirect effects of four fictive taxation scenarios were calculated. For each except the first scenario we calculated two versions: (1) one solely based on CO_2 emissions and (2) one based on all GHG emissions, measured in CO_2 equivalents (see Footnote 1). Calculations were based on Eurostat (2021a; 2021b) data (see Section 3.1). We assumed that sectors targeted by the EU-ETS were excluded from the fictive taxation in all scenarios, as a double taxation would very likely not be feasible from both a political and a legal perspective.

The different scenarios are described in detail in the following subsections.

5.1 Base scenario – 2019

This scenario includes all existing energy and transport taxation as of 2019. Luxembourg's planned carbon tax was not included in the calculations.

Note that this and all following scenarios not only include direct carbon-related taxes paid in Luxembourg, but also carbon-related taxes paid in all European countries when considering the indirect effects[14].

5.2 Scenario 1 – 2023

This scenario includes a tax that targets all emissions (excluding ETS sectors) with 30 Euros per ton of CO_2 on top of the existing energy and transport taxation. This level of taxation targeting only CO_2 emissions is equivalent to the currently planned carbon tax in Luxembourg. As data on tax revenues was not available at the time of conducting this analysis, we treated this already existing taxation like a fictive scenario.

The design of the carbon tax in Luxembourg was first outlined in the national energy and climate plan for 2021 to 2030 by the Luxembourgian Ministry of Energy and Spatial Planning, as well as the Ministry of Environment, Climate and Sustainable Development (2019). The tax is planned to increase stepwise from 20 Euros in 2021 to 25 Euros in 2022 and 30 Euros per ton of CO_2 in 2023 (International Energy Agency, 2020; World Bank, 2022). Afterwards, a dynamic carbon price is being considered. In our first scenario we are only analyzing the planned tax rate for 2023 (30 Euros per ton of CO_2).

[14] Scenario 3 also takes planned carbon taxes of neighboring countries as of 2023 (in fact only Germany) into account.

5.3 Scenario 2 – redistribution

In this scenario, we assumed that current energy and transport taxation (not taking the planned carbon tax and ETS revenues into account) was abolished and replaced by a revenue-neutral carbon tax targeting all non-ETS emissions in Luxembourg. To be revenue-neutral, this tax amounted to 108.67 Euros per ton of CO_2 and 98.54 Euros per ton of GHG emission.

5.4 Scenario 3 – neighboring countries

In this scenario, we assumed that Luxembourg introduced a carbon tax that amounts to the average level of taxation in all neighboring countries and the Netherlands. The average tax was calculated by cumulating all relevant energy, transport and carbon taxes of the neighboring countries and the Netherlands and dividing them by the total amount of relevant CO_2 and GHG emissions. For the relevant countries, we assumed that the carbon taxation schemes shown in Table 1 apply in addition to already existing energy and transport taxes. If available, we used information on taxation plans for 2023. Otherwise, we used the most recent information or data available.

In 2019, Luxembourg's verified emissions covered by ETS only made up 16.4% of total GHG emissions on its national territory. At the same time, the sum of verified ETS emissions produced by its neighboring countries made up 36.1% of all emissions on their national territory. In contrast, 64.6% of all ETS allowances in Luxembourg are freely allocated and only 55.9% Europe-wide. Because of this highly different sectoral pollution distribution, it was reasonable to include, but also to exclude both ETS emissions and ETS revenues when calculating the average emissions taxation for the neighboring countries. Thus, we calculated two averages. Using data from Eurostat and the European Energy Exchange (see Section 3), we calculated average prices of 229.36 and 171.49 Euros per ton of CO_2 and GHG emissions, when excluding ETS. If ETS is included, these values are 125.78 and 107.46 Euros (see Table 30 in the Appendix).

Table 1: Carbon taxation and pricing schemes in selected European countries.

Country	Year of implementation	Description
Germany	2021	The German carbon price will be 35 Euros per ton of non-ETS emission in 2023 (German Federal Ministry for the Environment, 2020).
France	2014	France's carbon tax is already included in the Eurostat (2021b) tables, amounting to 44.6 Euros per ton of CO_2 for non-ETS emissions (World Bank, 2022). The tax was originally planned to increase to 86.2 Euros in 2022, but plans were discarded, and the new trajectory was yet to be determined (World Bank, 2022). Because of these uncertainties, no assumptions were made for 2023 in our calculations.
Netherlands	2021	The Dutch carbon tax acts as a carbon floor price in the EU-ETS system, mainly targeting ETS emissions. As the Dutch government (World Bank, 2020) and legal experts (Dentons, 2020) expected that the tax would not generate revenues due to the high ETS prices during the next years, we did not take this tax into account in our calculations.
Belgium	Pending	According to the World Bank (2022), there were no plans on the implementation of a carbon tax, carbon price or a similar policy instrument in Belgium in 2021 and before.

5.5 Scenario 4 – pricing the damage

This scenario included a carbon tax that targets all emissions (excluding ETS) with 203.14 Euros per ton of CO_2 or GHG emission on top of the existing energy and transport taxation. In contrast to all other scenarios, we also calculated an alternative version of this scenario that additionally targets (and thus double-taxes) ETS emissions.

There are several scientific methods to put a price tag on a ton of GHG emission. In our analysis, we relied on calculations by the German Environmental Agency (2019)[15]. In its so-called Methodological Convention, the agency uses a calculation-principle which is very closely related to the Social Cost of Carbon – the SCC (Intergovernmental Panel on Climate Change, 2019, S. 150). The idea behind SCC is to find a value that corresponds to the monetary amount of (net) damage caused by one ton of CO_2e emissions for all present and future generations worldwide.

There are several crucial modelling assumptions which can change outcomes when trying to determine the SCC. The German Environmental Agency uses the so-called FUND damage cost model version 3[16] under the assumption of equity weighting for Western Europe.

[15] We use the updated cost rates of the Methodological Convention 3.1, which is only available in German language: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2020-12-21_methodenkonvention_3_1_kostensaetze.pdf.

[16] See http://www.fund-model.org/publications/ for all related publications.

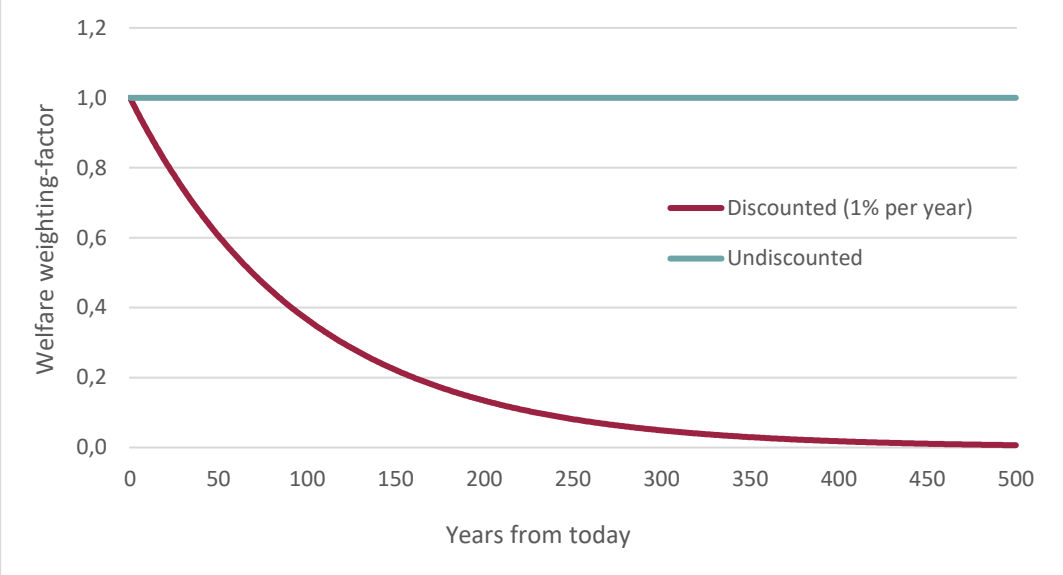
Damages from GHG emissions occur globally, independently of where they have been emitted. On the one hand, it is difficult to compare these damages due to different income levels. If a building in Luxembourg is destroyed, it is more expensive to rebuild it than in almost any other country in the world, as the price and income level in Luxembourg is very high. On the other hand, negative utility from a building being destroyed is very likely higher in poorer than in wealthier countries, because insurances and governmental aid are scarce or completely absent. For its cost calculation, the agency treats each monetary amount of damage as if it occurred in Western Europe. This is done by dividing the damage by the average income in Western Europe, resulting in a conservative estimate for the damage cost, as the following example shows: Assume that a ton of emissions causes 1 Euro of damage in region A and 1 Euro of damage in region B. The average income in region A is assumed to be 1,000 Euros, the average income in region B 50 Euros. The weighted damage in region A is 1/1,000, for region B it is 1/50. The damage in region B is weighted 20 times higher than the damage in region A.

The second crucial assumption is that a pure rate of 1% time preference per year is used when weighting future damages. This is done because people usually tend to value the future less than the present, whereas the discount rate for the future for a specific society is generally unknown and determining it includes subjective judgements. This makes it necessary to introduce assumptions. The German Environmental Agency chooses a discount rate of 1%. As can be seen in Figure 4, the welfare of the next generation (30 years from today) is weighted with 74% of today's welfare. In economics, welfare is a generic concept which can be applied in many situations. Individuals and societies can for example receive utility and thus generate welfare from consumption of goods and services, spending time with friends or looking at a piece of art. The same is true for negative utility and negative welfare. Individuals might receive negative utility from a car crash, a pandemic or events that are caused by GHGs and climate change. Especially for CO_2, which stays in the atmosphere for several hundred years and thus warms up the earth over a long period of time, this is true for the far future. Assume that a ton of CO_2 that is emitted today together with other emissions contributes to an extreme weather event in 30 years. It is calculated that this specific ton's contribution to the damage of the weather event is 1 Euro.[17] Using a discount rate of 1%, this damage is discounted to 0,74 Euros when determining the SCC for today. If no discount rate is used, the damage is just 1 Euro.

It is important to stress that neither a discount rate of 0% nor of 1% allows the model to produce a monetary value that is equivalent to the "real" SCC, as the real discount rate is generally unknown.

[17] This monetary amount of damage just serves as an example.

Figure 4: Welfare weighting-factor over time.



Source: Own depiction (IHS).

Taking the assumptions above into account, the German Environmental Agency suggests a price of 203.14 Euros[18] per ton of CO_2e emission in 2021. If future damages are not discounted, this amount equals 709.97 Euros[19].

Another method for putting a price tag on GHG emissions is finding a value that allows to reach a given (political) emissions reduction goal. The Intergovernmental Panel on Climate Change (2019, S. 152) calculates a price range for reaching the goal of keeping the temperature increase below 1.5°C in the 21st century. It ranges between 135-6,050 USD for 2030 and 690-30,100 USD for 2100.[20] These price ranges have a probability of 50 to 66% to reach this goal and are basically estimates of marginal abatement costs (World Bank, 2020).[21] To reach a given goal, the price for one unit of emissions must be marginally above the cost of abatement for the same unit of emissions. Rational individuals (in this case mostly companies) will then prefer to abate emission rather than pay the price, which is economically more attractive. It is important to mention that this approach and the SSC approach do not exclude each other. Especially for the next years, chances are rather high that the price calculated with SCC is similar or higher than the price calculated with the

[18] To arrive at this amount, we take the damage price for 2020 (195 Euros) and apply some further calculation steps as recommended by the agency. First, we calculate the value for 2021 by interpolating between 2020 and 2030 (215 Euros), which results in 197 Euros. Finally, we apply a price adjustment factor (Destatis, 2022), which gives us a price of 203.14 Euros per ton of CO_2e.

[19] Same procedure as in footnote 18, starting at 680 Euros in 2020.

[20] All USD values are 2010 prices.

[21] Marginal abatement costs are defined by a carbon price at which emitters prefer to abate carbon emissions, because the cost of emitting an additional ton of carbon is higher than the cost of abating it. (World Bank, 2020, page 22)

abatement-cost approach, which means that using SCC can also contribute to reaching the 1.5°C goal.

We argue that the existing taxation had to be included in this scenario, as the 203.14 or 709.97 Euros solely serve the purpose of damage pricing. While the other tax revenues can be used for their usual purposes (such as building roads, maintaining infrastructure or budget consolidation), the additional tax revenues should be bound to climate related projects or repairing damages caused by climate change. In this line of argument, it would not have made sense to additionally include the planned carbon tax of 30 Euros, as this would imply a double taxation of emissions.

5.6 Sensitivity analyses for ETS prices

In the scenarios above, payments of Luxembourgian firms for ETS allowances are included in the Eurostat tax data for 2019. As already mentioned in Section 3.2.1, the average spot market price in 2019 was 24.65 Euros per ton of CO_2e emissions, which corresponds to the price in the Eurostat data. According to data from the European Energy Exchange (2022), prices saw a strong increase after 2019, with an average price of 52.63 Euros in 2021.

This module is a ceteris paribus analysis, using the average ETS price for 2021 instead of the average price for 2019. In other words, the base scenario, scenario 1 and scenario 4 of this study were recalculated, using the same data on emissions and taxation and producing the same graphs, but assuming a different ETS price in the tax data. As an additional sensitivity analysis, an ETS price of 100 Euros per ton of CO_2e emissions was used as a sensitivity check.

6 Subsidies

Like many other countries (see, e. g. Schnabl et al., 2021, for the Austrian case) Luxembourg has a series of subsidies that benefit the consumption and incineration of carbon-based energy products, such as diesel and gasoline. There already exist studies that identify some of these subsidies (OECD, 2020a; Trinomics, 2020), where the total amount of subsidies identified varies substantially between 14 and 140 million Euros in 2018. One study, which was commissioned by the Luxembourgian government but was not publicly available yet[22], even estimated the cost of these kind of subsidies between 750 million and one billion Euros (Ewringmann & Deloitte Tax & Consulting, 2018)[23]. A closed list of all carbon subsidies in Luxembourg remained absent until mid-2022. Thus, this study is an analysis of selected carbon subsidies in Luxembourg and does not claim to analyze all subsidies that existed in Luxembourg at the time of publication.

For the identification of subsidies that benefit the use, consumption and incineration of carbon-based energy products in Luxembourg, we followed the approach of Schnabl et al. (2021). This means that all subsidies that were considered here directly increase the use of carbon-based energy products and/or produce an incentive for households and companies to change their behavior in such a way that they use more carbon-based energy products. As stressed in a report by the OECD (2020a, S. 100) on Luxembourg, *"such subsidies […] distort competition, lock in inefficient technology, lead to inefficient allocation of resources and weigh on public finances."* Moreover, in the same paragraph the report stresses that *"these exemptions undermine the carbon-price signal and discourage an efficient use of energy resources"* in Luxembourg. According to the report, recommendations by the organization made in 2010 to identify and consequently remove some of these subsidies have only resulted in little progress.

We want to emphasize two things: 1) For a political measure to be identified and treated as a subsidy within the context of this study, it is of no consequence if the measure of interest was named or defined as such by the legislator. In fact, most subsidies which were identified are tax exemptions and privileges and not explicitly defined as carbon subsidies by the Luxembourgian lawmakers. 2) We only took subsidies into account that can be directly linked to an increase in the use of carbon based-energy products. Despite major efforts for decarbonization, virtually every national economy is still largely dependent on fossil fuels. This, in turn, means that almost every subsidy has the potential to indirectly increase the use of these energy products, as subsidies usually increase economic activity.

[22] As of August 5th, 2022.

[23] The existence of this study and the estimated cost of subsidies is only known to the authors of the study at hand because it is mentioned in a report by the OECD (2020a).

The subsidies that were analyzed are listed in the following sub chapters.

6.1.1 Diesel privilege

Analogous to Schnabl et al. (2021) and OECD (2020a), we defined the difference in taxation between diesel and gasoline as a subsidy. According to the European Commission (2022), the excise duty on gasoline in Luxembourg for one liter of gasoline is 0.516 Euros, while it is only 0.404 Euros for diesel. Therefore, we defined the difference of 0.112 Euros per liter as the subsidy per liter. Virtually all sectors and economic entities in Luxembourg profit from this subsidy, as all of them consume diesel. We used Eurostat (2022b) PEFA tables to distribute the subsidy among the sectors. In 2019, Luxembourgian corporations used transport diesel equivalent to 9943 terajoules (TJ), while households used 3964.3 and economic activities in the rest of the world used 57181.2 TJ. The high share of use by foreign entities is an indicator that diesel (and energy products in general) are highly subsidized compared to adjacent regions. The OECD (2020a) suggests adjusting the excise taxation of diesel to the taxation of gasoline, because diesel has a higher carbon content than gasoline.

6.1.2 Electricity privilege for businesses

According to the European Commission (2022), business consumers in Luxembourg pay 0.5 Euros of excise duties per megawatt hour (MWh), while household consumers pay 1 Euro per MWh. As Luxembourg is highly dependent on electricity imports (86% in 2018 according to the IEA (2020)) and electricity production in Europe is still largely based on combustible fuels (41% in 2020; see Eurostat (2022a)), we defined the difference in taxation of 0.5 Euros as a subsidy for the corporate sectors. This approach follows Schnabl et al. (2021). We distributed the subsidy according to the Eurostat (2022b) PEFA tables, according to which households used 3296.2 TJ and businesses used 24743.5 TJ in 2019.

6.1.3 Diesel used in agriculture and for trains

In Luxembourg, diesel consumed in the agricultural sector and used for the operation of trains is exempt from excise duties, according to the European Commission (2022). We defined the amount of tax that would have to be paid without this exemption (0.404 Euros per liter) as a subsidy and assigned it to the agricultural and the transport sector, using Eurostat (2022b; Eurostat, 2021a) PEFA tables and Air Emissions data.

6.1.4 Gas oil for heating purposes

Gas oil for heating purposes, which has similar physiochemical properties as diesel, is subject to substantially lower excise duties in Luxembourg (0.064 Euros per liter according to the European Commission (2022)), while producing almost the same amount of GHG emissions. Once again, we defined the difference of 0.453 Euros per liter compared

to the taxation of gasoline as a subsidy and distributed it to the business sectors (6413.9 TJ in 2019), households (4831.8 TJ) and economic activities of the rest of the world (15.7 TJ).

6.1.5 Non-business use of coal

Coal, coke and similar products, which are by far the most polluting energy products in terms of emitted GHG emissions per unit output of energy, are exempt from excise duties for non-business users in Luxembourg, according to the European Commission (2022). The subsidy was 158 Euros per TJ (i. e. the difference to the amount that business consumers would have to pay) and was assigned to the households, which consumed 10.4 TJ of coal products in 2019.

6.1.6 Free ETS allowances allocation

Companies in countries that participate in EU-ETS usually have to buy emissions certificates in order to be allowed to produce GHG emissions. However, a large share of these emission certificates is freely allocated (especially in the manufacturing sector) to the polluters. While this may make sense from an economic and juridical point of view (security of investment), this measure is nevertheless a subsidy for the production of GHG emissions and a direct transfer of money, which is positively correlated with the amount of pollution. We defined the average amount that would have to be paid in 2021 for one emissions certificate (52.56 Euros per ton of CO_2e) as a subsidy and distributed it among the economic sectors in Luxembourg according to their respective free allocation in 2019 (European Environmental Agency, 2022). In total, 1.26 million certificates (i. e. 1.26 million tons of CO_2e) have been freely allocated in Luxembourg in 2019, which was one of the lowest figures relative to total emissions compared to other participating counties.

6.1.7 Not considered

A thorough review of excise duty tables, existing studies and Eurostat data revealed that to the knowledge of the authors of this study, it was not possible to include any further subsidies in the analysis, as the required data was not available, confidential, or not collected at all.

One of these subsidies, which could not be considered due to limited data availability about the amount (and sectoral distribution), was the favorable tax treatment of company cars for personal use. In a report, the OECD (2020a) stresses that this subsidy is one of the reasons for the relatively high car-ownership rate and carbon-intensity of cars registered in Luxembourg. Despite recent changes to legislation, this favorable treatment persists until today and in-kind-benefits in the form of company cars are still relatively lower taxed than the equivalent monetary income, making company cars especially attractive for high-income taxpayers. According to the OECD, fuel costs are also deductible, while not

increasing the employee's taxable incomes. Both measures would have been defined as subsidies that benefit the consumption and incineration of carbon-based energy products in the context of this study if data were available.

Another measure which could not be quantified but would fall under our definition of subsidies was the deductibility of commuting expenses from employee's taxable income in Luxembourg. According to the OECD (2020a), the deductible amount increases with the travel distance to the place of work and does not distinguish between types of transport. This provides a strong incentive to live far away from the working place and use private cars to go there.

According to the OECD (2020a), energy tax rates in Luxembourg are among the lowest in the EU and the fourth lowest in the OECD in 2018. Consequently, around 70% of fuels used for road transport are sold to motor vehicles not registered in Luxembourg. Theoretically, one could define this lower taxation of gasoline and diesel compared to other countries as a subsidy in the context of this study. As it was not clear which price per liter of gasoline and diesel (for example, which country) should serve as a benchmark to calculate the subsidy (what is the true unsubsidized price? – to give an example, which country charges the true unsubsidized price?) this measure was not considered. In general, taxation of diesel and gasoline have been chosen by the authors to serve as a benchmark for the calculation of several subsidies considered in this study.

7 Results and Discussion

The following subsections describe the results of this study calculated with the EE-IO model (see Section 4). All calculations are based on data described in Section 3. Subsection 7.1 focusses on emissions and subsection 7.2 on current taxation, while the remaining subsections are fictional carbon taxation scenarios, which are described in section 5. Table 35 to Table 38 in the Appendix show the results for economic sectors on a more disaggregated level (NACE-2).

Cumulated direct and indirect effects in the figures in this section always refer to all effects in the EU27, the United Kingdom, Switzerland and Norway. All tables also show government consumption ("Government"), non-governmental organizations ("NGOs") and investment activities ("Investment") as separate entities for the indirect effects. Exports also include non-resident households and non-resident corporations. For the indirect effects, the exports-column also includes typical export activities in addition to the non-resident units.

7.1 Emissions

Table 2 shows Luxembourg's direct and indirect emissions. The first column depicts the respective economic unit and the second column the direct effects. The economic units A to S always refer to domestic (resident) companies grouped as economic sectors, as opposed to the single category "Non-Resident Corporations". Columns three and four show the direct plus the indirect effects in Luxembourg (column 3) and the 27 EU countries plus the additional four countries Norway, Switzerland, the UK and Turkey (column 4).[24]

First, we look at the sector level. The table reveals transportation to be the most polluting single economic sector within Luxembourg with around 2.1 million (million) directly and indirectly emitted tons of CO_2 in 2019 (within Luxembourgian borders). The direct effects alone (1.97 million) account for almost 31% of direct emissions from businesses and resident households[25]. In this case, almost the entirety of emissions can be attributed to direct effects, indicating that most inputs transport companies obtain from other

[24] Only air emissions that are directly related to economic activities are considered in this data, including the combustion of energy sources in private households. It does not include any activities that precede production and only indirectly lead to a deterioration in the air emissions balance. The methane emissions from beef production, for instance, are considered. However, if rainforests were cleared beforehand for the production of animal feed, only the CO_2 produced during the clearing (e.g., from the operation of chainsaws) is included in the data. It does not account for the reduced capacity of the forest to absorb CO_2.
Furthermore, in our analyzes the air pollution is assigned to the respective producing economic sector, but not to the owners. For example, the finance and banking sector could have a high share of the manufacturing industry at home and abroad, but this is not assigned to the finance and banking sector, but to the manufacturing industry.

[25] Note that unlike direct emissions indirect effects and therefore columns 3 and 4 should not be summed up, as double counting cannot be ruled out.

businesses were emitting comparatively little CO_2. That is hardly surprising, as emissions attributed to the transport sector mostly result from fuel consumption while driving (or flying) a vehicle. If we include emissions in the European Union (plus Norway, Switzerland, the UK and Turkey), the Luxembourgian transport sector triggered the emission of approximately 2.7 million tons of CO_2 across Europe. It should be kept in mind that the analysis is based on data from 2019. The current sum of emissions from the transport sector may have somewhat decreased as a result of the introduction of a carbon tax in 2021.

If we take the European effects as the starting point of the analysis, manufacturing surpassed the emissions of the transport sector as well as any other single industry with 4.2 million emitted tons of CO_2. Over 50% (2.4 million tons) of those emissions were emitted outside of Luxembourg, thus illustrating the importance of taking effects outside of the national territory into account. The direct effects of the transport and manufacturing sector combined emitted almost 55% (3.5 million tons) of the direct effects of industries and households in Luxembourg.

In comparison to transport and manufacturing, the direct and indirect effects in Luxembourg of all remaining sectors are relatively small. Here, again, it is worth looking at the effects outside the national borders. Despite moderate effects within Luxembourg, construction led to the emission of 1.4 million tons and wholesale to around 1.2 million tons of CO_2 in 2019 if we include the European Union and the aforementioned countries. The direct emissions of resident households were about as high as those of the manufacturing sector (1.5 million tons)[26] and amounted to the emission of 4.1 million tons of CO_2 across Europe.

The aggregated direct emissions of all sectors and resident households amounted to 6.4 million tons of CO_2, adding exports (4.9 million tons), we get a total of 11.4 million tons of CO_2. Here, exports are the sum of emissions by non-resident households and non-resident corporations.[27] The bulk of these direct emissions is associated with non-resident corporations (3.9 million tons of CO_2), while non-resident households account for 1 million tons of CO_2. Due to limited data availability, the values for non-resident households and corporations represent an estimate based on estimations of foreign fuel consumption and of the share of company cars (see chapter 3.1).

[26] Around 60.1% stem from heating/cooling, 38.3% from transport activities, the rest from other activities.

[27] The purchase of goods and services without using them does not generate any emissions, but the production of these goods and services does. Thus, we get zero direct emissions, but a lot of indirect pollution, especially in Asia (which is not reported here). The direct emissions of resident household stem mainly from the combustion of fuel for their cars and heating, other polluting consumption effects are part of the indirect effects. The same holds for the other categories of the final demand. For instance, the direct emissions from exports stem mainly from the combustion of fuel for transport by non-residents. The pollution generated by exported goods and services produced by resident companies are part of the indirect pollution. That is why the direct pollution of exports include only emissions by non-residents.

Table 2: Luxembourg's direct and indirect CO_2 emissions in thousand tons CO_2, 2019.

Economic Unit	Direct	Direct and indirect (LU)	Direct and indirect (Europe)
A – Agriculture	70.1	74.4	117.8
B – Mining	6.8	8.2	17.0
C – Manufacturing	1 526.9	1 810.7	4 166.5
D – Energy	256.7	276.2	533.1
E – Water and waste	17.5	43.1	145.4
F - Construction	153.6	490.6	1 422.5
G – Wholesale	224.7	365.9	1 195.4
H - Transport	1 971.5	2 062.0	2 650.7
I – Hospitality	39.5	68.1	191.4
J-N – Other sectors	438.1	782.9	3 685.0
O – Public administration	52.7	78.1	206.6
P – Education	19.3	29.8	72.6
Q – Health	70.2	96.7	236.9
R – Arts and recreation	28.8	38.8	97.0
S – Other services	12.4	20.6	51.4
Households	1 532.2	2 053.7	4 118.7
Sum of domestic entities	6 421.0	-	-
Government	-	203.1	646.0
NGOs	-	23.5	61.1
Investments	-	379.7	1 532.5
Exports	4 944.7	8 703.2	14 139.6
Non-Resident Households	1 042.7	1 050.4	1 436.6
Non-Resident Corporations	3 902.0	3 931.2	5 376.5
Sum of domestic entities and exports	11 365.7	-	-

Source: Eurostat (2021a); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland, and Norway. Results are presented before handing over to the next element of the production process.

Table 3 exhibits the same structure as Table 2, but for all GHG emissions, using CO_2 equivalents (CO_2e) as standardized unit. For more information on CO_2 equivalents see Footnote 1. If we consider all relevant pollutants on a direct and indirect European scale, manufacturing stands out as the by far most polluting single sector with almost 5 million emitted tons of CO_2e. In contrast to the approach in Table 2 based solely on CO_2, manufacturing already slightly exceeds construction if we only consider direct and indirect emissions within Luxembourg (both around 2.1 million ton). Based only on direct emissions in Luxembourg, the most polluting sector remains transportation with 2 million emitted tons of CO_2e. Another interesting sector is agriculture. Though small compared to manufacturing and transport, its environmental impact grows significantly when taking other GHGs into account. In Table 2, agriculture is only responsible for 70 thousand directly emitted tons of CO_2. In Table 3, this value increased tenfold (769 thousand tons of CO_2e). The sharp increase can mainly be traced back to the inclusion of methane emissions, which are around 25 times more harmful to the climate than CO_2. The concept of CO_2e is designed to reflect this relative harmfulness. The direct emissions of all domestic entities (business sectors and resident households) combined sum up to 7.4 million tons of CO_2e. If we include non-resident households and corporations, we arrive at 12.4 million tons of CO_2e in 2019.

Looking at direct emission only, domestic households produce 12.8%, domestic corporations 46.7% and non-residents 40.5% of the emissions in Luxembourg, while exports minus non-residents produce no emissions. Considering the indirect effects too, domestic households are responsible for 19.6%, non-residents for 40.9% and exports minus non-residents for 33.9% of emissions.

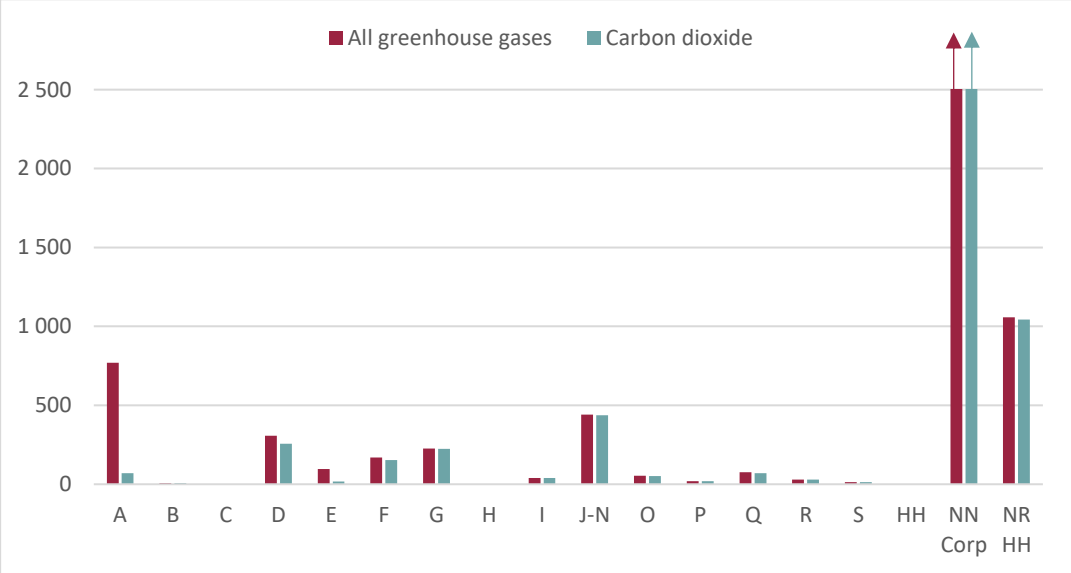
Table 3: Luxembourg's direct and indirect GHG emissions in thousand tons of CO_2e, 2019.

Economic Unit	Direct	Direct and indirect (LU)	Direct and indirect (Europe)
A – Agriculture	768.8	776.0	874.1
B – Mining	6.9	8.5	18.5
C – Manufacturing	1 533.7	2 148.1	4 953.7
D – Energy	306.5	329.0	605.8
E – Water and waste	95.8	126.3	260.8
F - Construction	169.9	573.1	1 661.5
G – Wholesale	226.4	398.0	1 379.7
H - Transport	2 004.8	2 115.5	2 765.2
I – Hospitality	39.7	131.3	340.2
J-N – Other sectors	441.4	858.1	4 153.5
O – Public administration	53.0	84.2	233.7
P – Education	19.4	32.2	80.1
Q – Health	75.8	113.1	285.7
R – Arts and recreation	29.0	41.5	107.3
S – Other services	12.5	22.6	59.2
Households	1 578.8	2 425.8	5 099.2
Sum of domestic entities	7 362.4	-	-
Government	-	233.0	744.1
NGOs	-	27.8	74.6
Investments	-	441.8	1 767.7
Exports	5 019.3	9 250.8	15 483.2
Non-Resident Households	1 058.4	1 066.8	1 471.3
Non-Resident Corporations	3 960.9	3 992.3	5 506.0
Sum of domestic entities and exports	12 381.8	-	-

Source: Eurostat (2021a); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

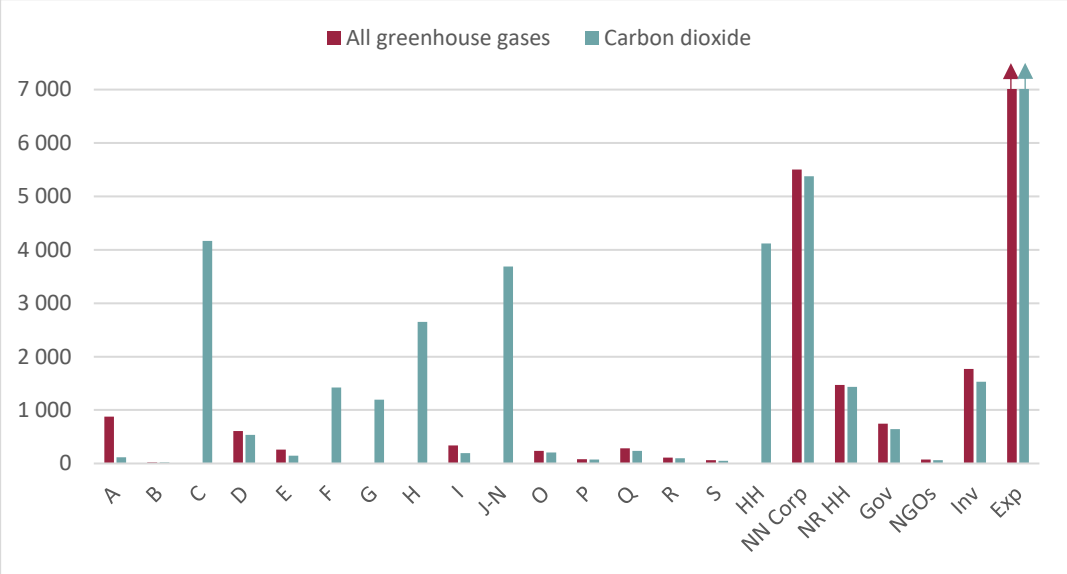
Figure 5 shows Luxembourg's direct CO_2 and GHG emissions in relation to each other. Figure 6 shows Luxembourg's direct plus indirect emissions for CO_2 and GHG. In most cases, both approaches arrive at fairly similar results. Taking only direct effects into account, most sectors show almost no difference between CO_2 and GHG emissions. As already mentioned, agriculture is an exception mainly due to the production of methane.

Figure 5: Luxembourg's direct CO_2 and GHG emission on the sectoral level in thousand tons of CO_2e, 2019.



Source: Eurostat (2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations.

Figure 6: Luxembourg's direct and indirect CO_2 and GHG emissions on the sectoral level in thousand tons of CO_2e, 2019.



Source: Eurostat (2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households.

7.2 Base scenario

Table 4 depicts all direct and indirect energy and transport taxes paid in Luxembourg in 2019 as well as the energy and transport taxes they triggered along the value chains which were paid in the rest of the analyzed group of European countries. Between the two groups of taxes, energy taxes represent the lion's share. As a reminder, the base scenario does not include Luxembourg's proposed carbon tax, as it is based on the taxation in 2019. The represented values for these taxes are the actually paid taxes. If the subsidies mentioned in chapter 6 would be added to these values, we would get the taxes which should have to be paid – these values would be higher.

The economic units are mostly structured analogous to Table 1 and Table 2 in the previous section. Additionally, this table covers value-added taxes paid by residents and non-residents in 2019 to Luxembourg's treasury. As the table shows, the transport sector (sector "H") paid the largest share of direct energy (158.6 million Euros) and transport (14.2 million Euros) taxation among the individual sectors. Along the value chains, the transport sector led to 194.9 million Euros of energy and 19.7 million Euros of transport taxes within the EU (+3 countries). Interestingly enough, manufacturing (sector "C") paid a rather small share of the overall taxes, although it directly and indirectly (combined) emitted the most emissions of all sectors considered. Resident households paid 77.3 million Euros of direct

energy taxes, which was only surpassed by the transport sectors among the group of domestic entities, and 40.2 million Euros of transport taxes and therefore the biggest share within that group.

Notably, non-resident companies paid the largest overall share of direct energy taxes (470.2 million Euros). The prominence of non-resident corporations in Luxembourg becomes apparent, as they paid 39% more in energy taxes than the combined resident companies. Non-resident households (125.6 million Euros) paid more direct energy taxes than resident households (77.3 million Euros).

Looking at the direct effects only, domestic households pay 10.9% of energy and transportation taxes in Luxembourg, while domestic corporations pay 34% and non-residents pay 55.1%. Exported goods minus non-residents do not pay taxes when only considering the direct effects. Considering indirect effects too, domestic households pay 15.2%, non-residents 55.4% and exports minus non-residents 21.9% of the total taxation. The energy and transportation taxes are not distributed proportionally to the emissions, as can be seen in Table 4.

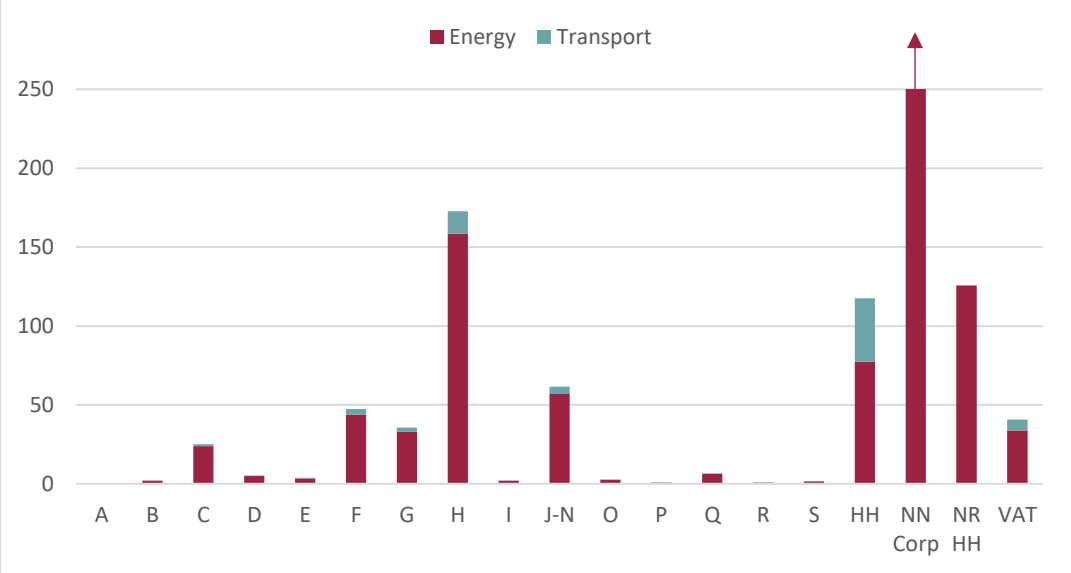
Table 4: Luxembourg's direct and indirect energy and transport taxation in million Euros, 2019.

	Energy Taxation			Transport Taxation		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	0.07	0.38	3.08	0.00	0.02	0.32
B	1.84	1.94	2.32	0.16	0.17	0.22
C	23.83	83.86	192.87	1.30	6.37	22.10
D	5.00	6.53	14.58	0.09	0.21	0.75
E	3.37	6.26	11.22	0.28	0.56	1.36
F	43.61	54.47	90.55	3.69	4.42	9.01
G	32.92	53.48	100.80	2.66	4.40	12.56
H	158.60	166.37	194.88	14.15	14.88	19.71
I	1.88	3.53	10.94	0.15	0.27	1.24
J-N	56.83	85.06	289.50	4.70	7.05	70.03
O	2.47	4.71	10.37	0.19	0.36	1.24
P	0.67	1.35	3.18	0.05	0.10	0.35
Q	6.14	8.00	14.85	0.51	0.65	1.68
R	0.77	1.43	3.79	0.06	0.11	0.40
S	1.42	2.08	3.47	0.12	0.17	0.37
Househ.	77.32	121.25	214.52	40.16	43.29	57.10
Sum of domestic entities	416.74	-	-	68.27	-	-
Govern.	-	32.15	58.53	-	2.68	6.61
NGOs	-	1.65	3.52	-	0.13	0.42
Invest.	-	40.31	94.74	-	3.30	12.62
Exports	595.85	817.14	1 148.91	0.00	18.86	103.60
Non-Res. Househ.	125.64	126.30	137.59	0	0.05	0.85
Non-Resi. Corp.	470.21	472.66	514.91	0	0.20	3.17
Sum of domestic entities plus exports	1 012.59	-	-	68.27	-	-
VAT Res.	12.41	19.45	25.57	6.83	7.36	8.32
VAT Non-Res.	21.36	21.47	23.39	0	0.01	0.14

Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 7 offers a graphic depiction of Luxembourg's direct energy and transport taxes in 2019. The figure clearly shows the dominance of energy in comparison to transport taxation. Unsurprisingly, the transport sector by far paid the largest share of both energy and transport taxes among the individual industries.

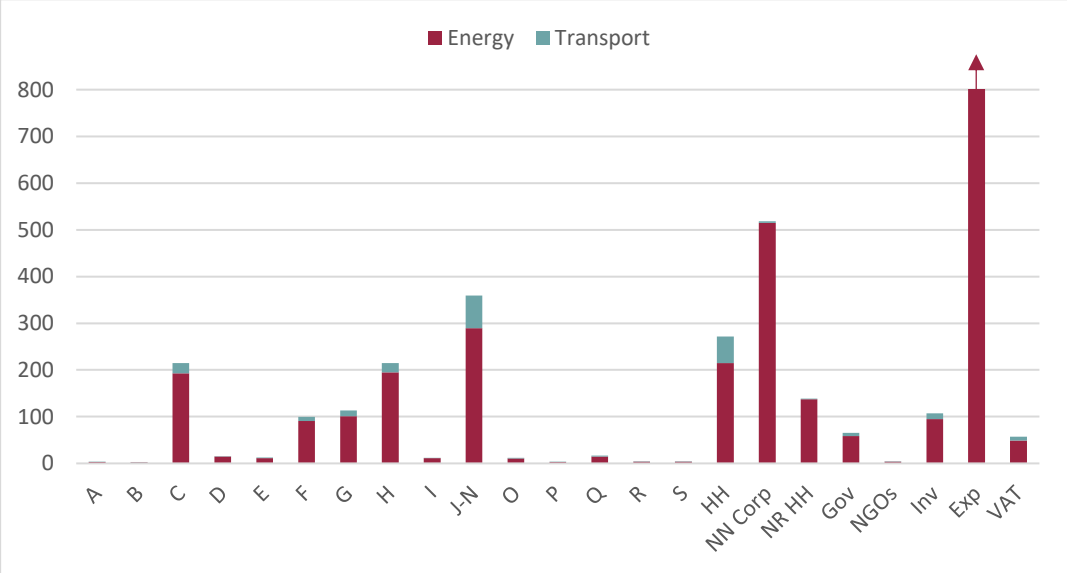
Figure 7: Luxembourg's direct energy and transport taxation in million Euros, 2019.



Source: Eurostat (2021b); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, VAT: Value-added tax.

In contrast to Figure 7, Figure 8 also includes indirect taxes that emerged along the value chains. This approach brings the group of sectors "J-N" to the fore, which includes a range of industries, such as information and communication, scientific and technical activities as well as financial and administrative activities. The full list can be seen in Table 27 in the Appendix.

Figure 8: Luxembourg's direct and indirect energy and transport taxation in million Euros, 2019.



Source: Eurostat (2021b); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households.

Table 5 shows current energy and transport taxes paid per unit of GHG and CO_2 emissions for the economic entities. Once again, we not only calculate the direct, but also the indirect effects. The table was constituted by dividing the cumulated energy and transport taxes from Table 4 with the results from Table 2 and Table 3, respectively. The data reveals a certain imbalance between households and companies. In 2019, resident households paid 17.1% more per emitted ton of GHG or 2% more per ton of CO_2 than the average resident corporation.

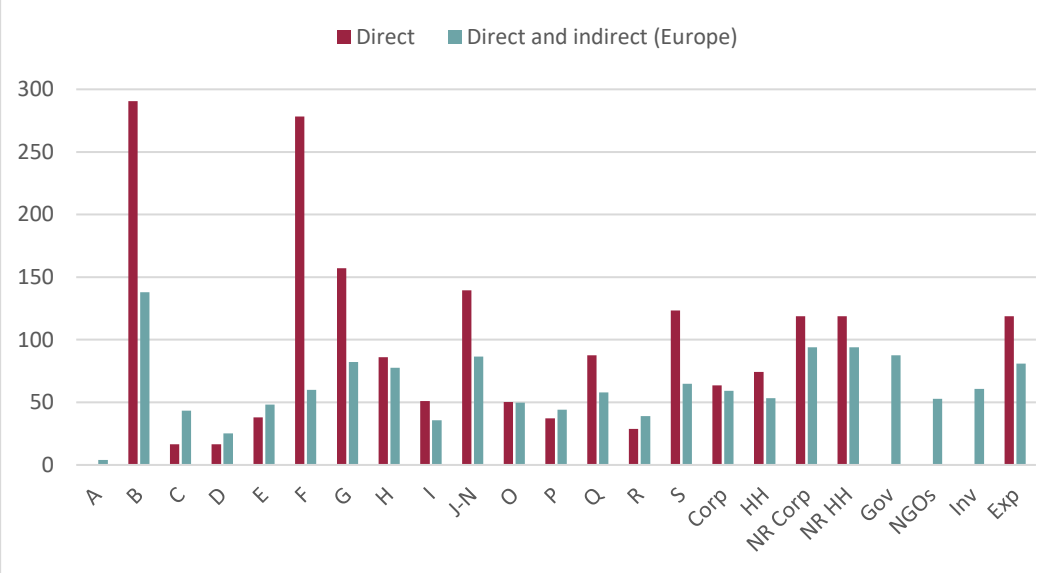
Table 5: Energy and transport taxes directly and indirectly paid per unit of GHG and CO_2 emission in Euros, 2019.

	Euros per ton of GHG			Euros per ton of CO_2		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A – Agriculture	0.09	0.52	3.90	1.00	5.44	28.92
B – Mining	290.45	247.87	137.97	294.12	256.15	149.42
C – Manufacturing	16.39	42.01	43.39	16.46	49.83	51.59
D – Energy	16.61	20.47	25.29	19.83	24.39	28.74
E – Water and waste	38.09	54.00	48.24	208.57	158.31	86.56
F - Construction	278.35	102.77	59.92	307.94	120.03	69.99
G – Wholesale	157.18	145.43	82.16	158.34	158.19	94.83
H - Transport	86.17	85.68	77.60	87.63	87.90	80.95
I – Hospitality	51.11	28.91	35.79	51.39	55.78	63.62
J-N – Other sectors	139.41	107.34	86.56	140.45	117.66	97.56
O – Public administration	50.16	60.22	49.71	50.47	64.90	56.24
P – Education	37.10	45.15	44.13	37.31	48.79	48.71
Q – Health	87.67	76.42	57.87	94.73	89.43	69.80
R – Arts and recreation	28.66	37.00	39.07	28.82	39.58	43.19
S – Other services	123.35	99.60	64.73	124.19	109.34	74.58
Resident Corporations	63.55	63.55	59.23	75.18	75.18	69.69
Households	74.41	67.83	53.27	76.67	80.12	65.95
Sum of domestic entities	65.88	-	-	75.54	-	-
Government	-	149.51	87.55	-	171.56	100.84
NGOs	-	63.98	52.76	-	75.84	64.44
Investments	-	98.72	60.73	-	114.87	70.06
Exports	118.71	90.37	80.90	120.50	96.06	88.58
Non-Resident Households	118.71	118.43	94.07	120.50	120.28	96.35
Non-Resident Corporations	118.71	118.43	94.07	120.50	120.28	96.35
Sum of domestic entities plus exports	87.29	-	-	95.10	-	-

Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 9 shows directly and indirectly generated energy and transport taxes per unit of CO_2e that can also be seen in Table 5. If we only consider direct effects, two sectors stand out clearly: mining ("B") and construction ("F"). Once we include indirect effects, the individual values vary to a lesser extent. Mining still paid more energy and transport taxes per ton of GHG, but construction is surpassed by several other sectors, including wholesale ("G") and transport ("H").

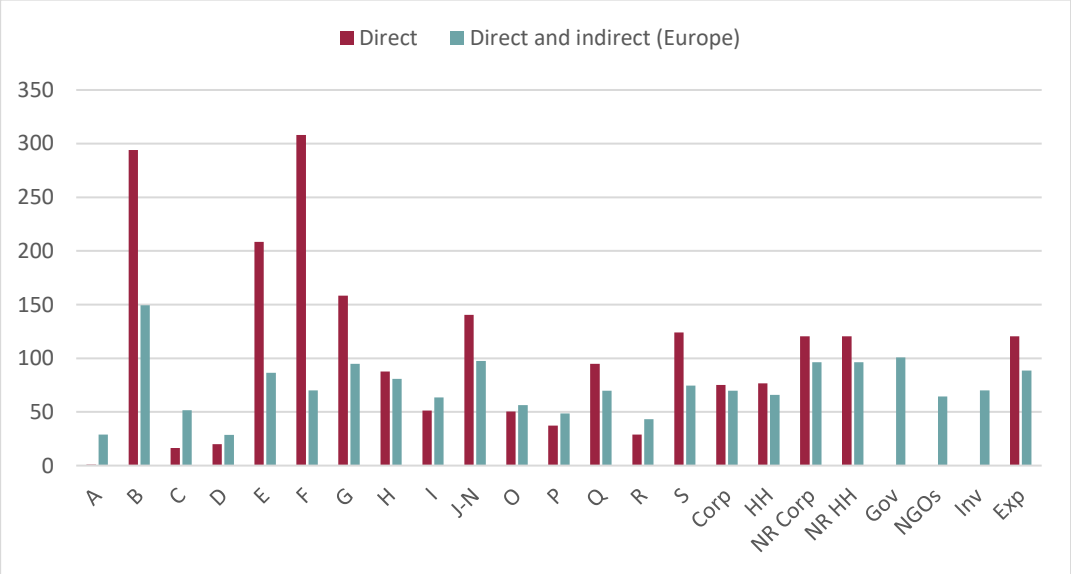
Figure 9: Energy and transport taxes directly and indirectly paid per unit of GHG emission in Euros, 2019.



Source: Eurostat (2021b; 2021a); own calculations. Corp: corporations, HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up. As this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Figure 9 illustrates the amount of energy and transport taxes that were paid per unit of CO_2. Now, construction paid the highest amount per emitted ton of CO_2, followed by mining and then water and waste ("E"). If we include indirect effects, mining once again takes the lead.

Figure 10: Energy and transport taxes directly and indirectly paid per unit of CO_2 emission in Euros, 2019.



Source: Eurostat (2021b; 2021a); own calculations. Corp: corporations, HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up. As this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

7.3 Scenario 1

Scenario 1 calculated the effect of the existing energy and transport taxation plus the extra 30 Euros per ton of CO_2, which targets all emissions except for those sectors already taxed through the ETS.

Table 6 shows energy and transport taxes combined, with the additional 30 Euros carbon tax on top. Comparing this scenario with the base scenario, we see that the carbon tax would generate additional revenues of around 290 million Euros in the short run.

Just like in the base scenario, transport triggers the largest share of direct and indirect taxation of all industries in Luxembourg, with 234.4 million Euros paid in taxes, 224 million of which can be attributed to the direct effects. Within that group of industries, the ratios of directly paid taxes remained roughly the same as in the base scenario. All sectors combined add up to approximately 462.9 million Euros directly paid taxes. If we take directly and indirectly paid taxes outside the national territory into account, the group of sectors “J-N” take the lead with 380.5 million Euros in 2019.

As in the base scenario, non-resident corporations pay a larger share of the overall direct taxes (587 million Euros). Non-resident households (157 million Euros), however, pay almost the same direct taxes than resident households (163 million Euros).

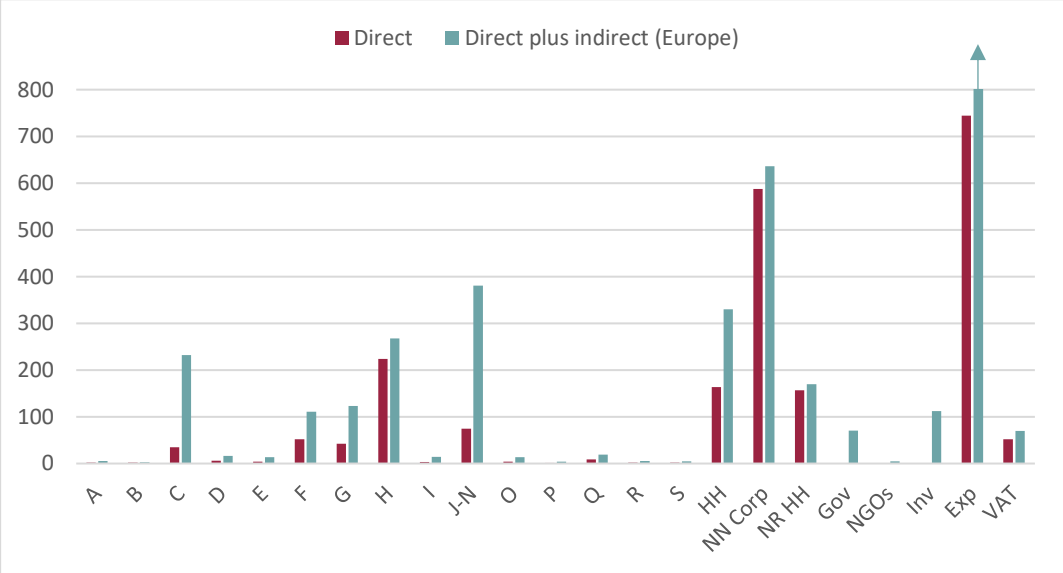
Table 6: Direct and indirect effects of taxation scenario 1 in million Euros.

Economic Unit	Direct	Direct and indirect (LU)	Direct and indirect (Europe)
A – Agriculture	2.17	2.61	5.61
B – Mining	2.20	2.34	2.78
C – Manufacturing	34.58	107.11	231.83
D – Energy	5.78	7.84	16.42
E – Water and waste	4.18	7.86	13.62
F - Construction	51.91	70.12	110.78
G – Wholesale	42.32	67.89	123.36
H - Transport	224.01	234.36	267.70
I – Hospitality	3.22	5.69	14.07
J-N – Other sectors	74.67	113.10	380.51
O – Public administration	4.24	7.20	13.75
P – Education	1.30	2.23	4.32
Q – Health	8.76	11.32	19.21
R – Arts and recreation	1.69	2.60	5.26
S – Other services	1.91	2.81	4.39
Households	163.45	223.24	330.31
Sum of domestic entities	626.38	-	-
Government	-	40.33	70.64
NGOs	-	2.42	4.57
Investments	-	48.64	112.39
Exports	744.19	1 055.82	1 472.34
Non-Resident Households	156.92	157.85	169.93
Non-Resident Corporations	587.27	590.71	635.95
Sum of domestic entities plus exports	1 370.57	-	-
VAT Residents	25.15	34.34	41.08
VAT Non-Residents	26.68	26.83	28.89

Source: Eurostat (2021a. 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 11 contrasts direct effects with the sum of direct and indirect effects paid in the group of European countries analyzed in this study. It illustrates the large share paid by non-resident companies compared to any other economic unit analyzed here. If we add the effects of non-resident households ("Exports"), we receive 744.2 million Euros direct effects in Luxembourg and 1.5 billion Euros overall effects in the analyzed group of European countries.

Figure 11: Direct and indirect effects of taxation scenario 1 in million Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Table 7 shows taxes paid per unit CO_2 emissions for the economic entities in scenario 1. Like in the base scenario, resident households would pay more per emitted ton of CO_2 (106.67 Euros) than resident corporations (94.69 Euros). The construction sector (F) would pay most (337.94 Euros per ton), while the energy sector (D) would only pay 22.52 Euros per ton, mainly because most of its emissions are already covered by ETS and would not be subject to new taxation.

Table 7: Energy and transport taxes of scenario 1 directly and indirectly paid per unit of CO_2 in Euros.

	Euros per ton of CO_2		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A – Agriculture	31.00	35.07	47.62
B – Mining	324.12	284.49	163.10
C – Manufacturing	22.64	59.15	55.64
D – Energy	22.52	28.38	30.81
E – Water and waste	238.57	182.47	93.71
F - Construction	337.94	142.90	77.88
G – Wholesale	188.34	185.53	103.20
H - Transport	113.63	113.66	100.99
I – Hospitality	81.39	83.59	73.51
J-N – Other sectors	170.45	144.47	103.26
O – Public administration	80.47	92.25	66.58
P – Education	67.31	75.08	59.49
Q – Health	124.73	117.09	81.09
R – Arts and recreation	58.82	67.12	54.21
S – Other services	154.19	136.50	85.46
Resident Corporations	94.69	94.69	76.79
Households	106.67	108.70	80.20
Sum of domestic entities	97.55	-	-
Government	-	198.62	109.34
NGOs	-	103.11	74.92
Investments	-	128.12	73.34
Exports	150.50	121.31	104.13
Non-Resident Households	150.50	150.26	118.26
Non-Resident Corporations	150.50	150.26	118.26
Sum of domestic entities plus exports	120.59	-	-

Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

7.4 Scenario 2

In this scenario, current energy and transport taxation is replaced by a revenue-neutral[28] carbon tax. while removing all energy and transport taxes besides ETS, the planned carbon tax was not considered when calculating the new average tax. Table 8 shows the direct and indirect effects of this scenario for the economic units already used in the previous sections. The table contrasts the effects of CO_2 emissions with the effects of all relevant GHGs. The most apparent variance appears in the agricultural sector "A". If we only look at CO_2, agriculture would only pay 7.6 million Euros in direct taxes. This value increases tenfold (75.8 million Euros) if CO_2 equivalents are used as measurement units.

[28] Note the taxes are not exactly revenue-neutral because of confidentiality gaps in ETS data.

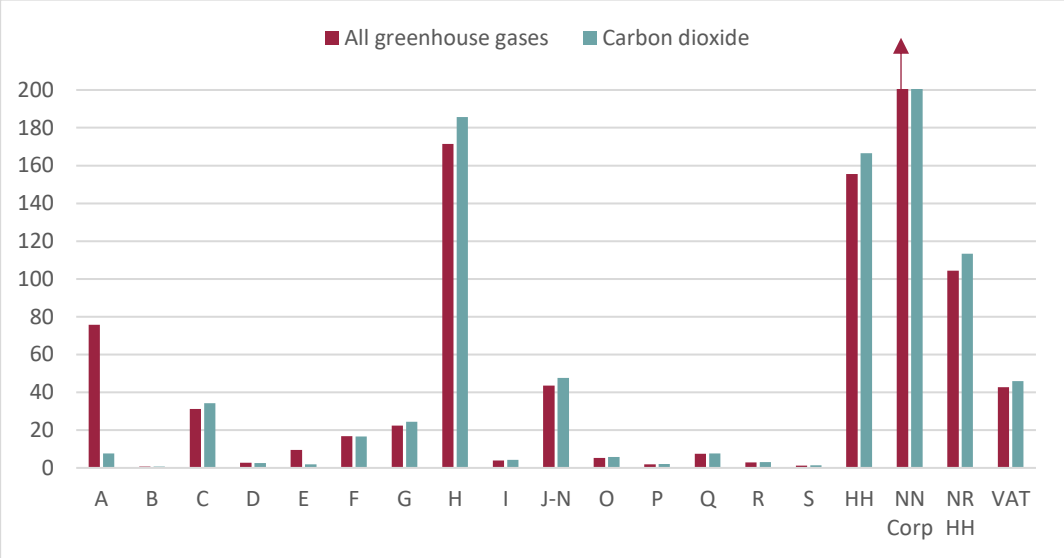
Table 8: Direct and indirect effects of taxation scenario 2 in million Euros.

	All GHGs (98.54 Euros per ton of CO_2e)			CO_2 (108.67 Euros per ton)		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	75.76	76.37	79.37	7.62	7.98	10.98
B	0.68	0.79	1.23	0.74	0.84	1.28
C	31.17	87.66	212.39	34.21	61.11	185.83
D	2.71	4.36	12.94	2.51	3.99	12.57
E	9.44	11.59	17.35	1.90	3.77	9.53
F	16.74	44.80	85.47	16.69	40.65	81.32
G	22.31	35.90	91.37	24.42	36.24	91.71
H	171.43	179.39	212.73	185.68	192.40	225.74
I	3.91	12.41	20.79	4.29	6.86	15.24
J-N	43.49	75.99	343.41	47.61	76.02	343.43
O	5.23	7.56	14.11	5.73	7.73	14.28
P	1.91	2.77	4.85	2.10	2.83	4.92
Q	7.47	10.33	18.22	7.63	9.69	17.58
R	2.85	3.74	6.39	3.13	3.87	6.53
S	1.23	2.02	3.60	1.35	2.03	3.61
Househ.	155.58	228.62	335.70	166.50	212.64	319.71
Sum of domestic entities	551.93	-	-	512.10	-	-
Govern.	-	20.84	51.15	-	19.90	50.21
NGOs	-	2.51	4.67	-	2.32	4.47
Invest.	-	21.99	85.74	-	18.22	81.97
Exports	494.60	772.48	1 189.00	537.34	796.27	1 212.79
Non-Resident Househ.	104.29	105.05	117.14	113.31	114.08	126.16
Non-Resident Corporat.	390.31	393.14	438.36	424.03	426.92	472.15
Sum of domestic entities + exports	1 046.53	-	-	1 049.44	-	-
VAT Res.	24.97	36.68	43.70	26.72	34.11	41.14
VAT Non-Res.	17.73	17.86	19.91	19.26	19.39	21.45

Source: Eurostat (2021a. 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

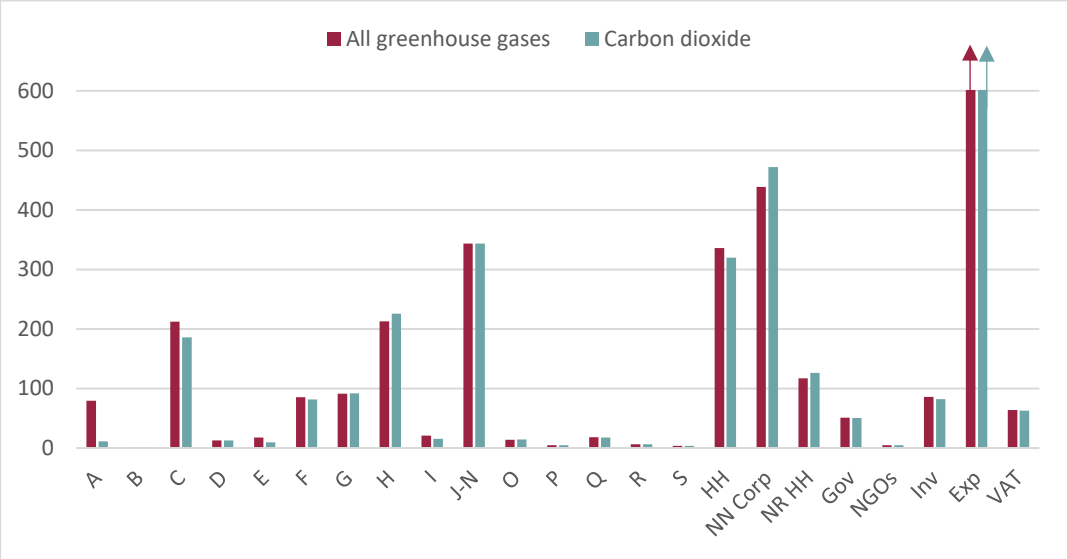
Figure 12 illustrates the direct effects that can also be taken from Table 8, while Figure 13 depicts direct as well as indirect effects of that table. As in previous scenarios, the sector that stands out most when only considering direct effects is transportation. Another large position are the resident households and non-resident corporations. If we consider indirect effects as well, the service sectors "J-N", again, take the lead.

Figure 12: Direct effects of taxation scenario 2 in million Euros.



Source: Eurostat (2021b; Eurostat, 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, VAT: Value-added tax.

Figure 13: Direct and indirect effects of taxation scenario 2 in million Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households.

Table 9 shows taxes paid per unit of GHG and CO_2 emissions for the economic entities in scenario 2. Most sectors and households just pay the average tax of 98.54 (108.67) Euros per emitted unit. As part of the emissions in some sectors are already covered by ETS and thus not targeted by the new taxation, the average tax per unit in these sectors and for corporations as a whole compared to households is lower.

Table 9: Energy and transport taxes of scenario 2 directly and indirectly paid per unit of GHG and CO_2 emission in Euros.

	Euros per ton of GHG			Euros per ton of CO_2		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A – Agriculture	98.54	98.41	90.80	108.67	107.33	93.24
B – Mining	98.54	93.06	66.67	108.67	102.66	75.34
C – Manufacturing	20.33	40.81	42.87	22.41	33.75	44.60
D – Energy	8.85	13.24	21.36	9.76	14.43	23.58
E – Water and waste	98.54	91.77	66.53	108.67	87.52	65.58
F - Construction	98.54	78.17	51.44	108.67	82.85	57.16
G – Wholesale	98.54	90.19	66.23	108.67	99.03	76.72
H - Transport	85.51	84.80	76.93	94.18	93.31	85.16
I – Hospitality	98.54	94.49	61.11	108.67	100.74	79.61
J-N – Other sectors	98.54	88.56	82.68	108.67	97.10	93.20
O – Public administration	98.54	89.87	60.39	108.67	99.05	69.15
P – Education	98.54	86.00	60.53	108.67	95.21	67.75
Q – Health	98.54	91.31	63.77	108.67	100.23	74.20
R – Arts and recreation	98.54	90.08	59.61	108.67	99.76	67.26
S – Other services	98.54	89.36	60.82	108.67	98.36	70.18
Resident Corporations	68.53	68.53	61.05	70.69	70.69	68.06
Households	98.54	94.25	65.83	108.67	103.54	77.62
Sum of domestic entities	74.97	-	-	79.75	-	-
Government	-	89.45	68.74	-	98.02	77.72
NGOs	-	90.33	62.60	-	98.76	73.25
Investments	-	49.77	48.50	-	47.98	53.49
Exports	98.54	83.50	76.79	108.67	91.49	85.77
Non-Resident Househ.	98.54	98.47	79.61	108.67	108.60	87.82
Non-Resident Corp.	98.54	98.47	79.61	108.67	108.60	87.82
Sum of domestic entities plus exports	84.52	-	-	92.33	-	-

Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

7.5 Scenario 3

The results depicted here use average carbon-related taxation from Luxembourg's neighboring countries and the Netherlands that exclude ETS emissions and revenues. Results for the scenario including ETS emissions and revenues can be found in Table 31, Figure 34 and Figure 35 in the Appendix. Further information on the calculation is described in chapter 5.4.

Similar to previous tables, Table 10 depicts both direct and indirect taxes of this fictive scenario for Luxembourg and the analyzed group of European countries. The effects stemming from taxation based on CO_2 mostly exceed those based on all GHG emissions. This divergence from the scenarios above is rooted in different averages prices, which are lower when considering all GHG because of the larger number in the divisor. Notable exceptions are the sectors agriculture ("A") as well as water and waste ("E"). Overall, direct taxation arising from emitted CO_2 amounts to 1.1 billion Euros for resident households and companies. This value increases to almost 2.2 billion once we include non-resident households and corporations. In comparison, the cumulated taxes based on GHG emissions amount to 960.5 million Euros for domestic entities and 1.8 billion Euros if we include exports. In the short run, tax revenues would increase by 1.1 (CO_2 scenario) or 0.7 (GHG scenario) billion Euros compared to the base scenario.

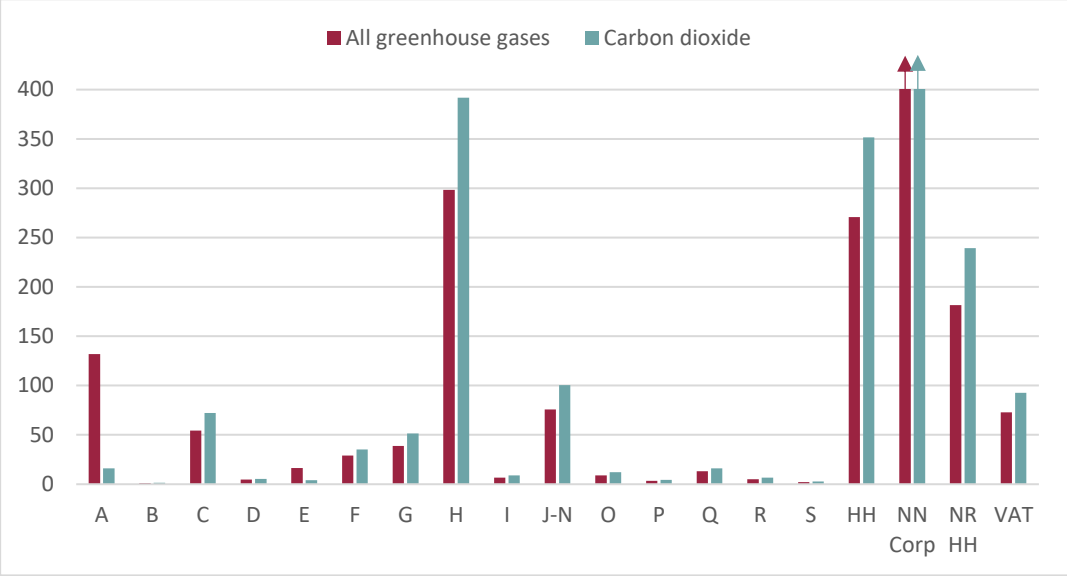
Table 10: Direct and indirect effects of taxation scenario 3 in million Euros, excluding ETS.

	All GHGs (171.49 Euros per ton)			CO_2 (229.36 Euros per ton)		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	131.85	132.91	135.91	16.08	16.84	19.84
B	1.18	1.38	1.82	1.56	1.78	2.22
C	54.25	152.56	277.29	72.21	128.98	253.70
D	4.72	7.58	16.16	5.29	8.41	17.00
E	16.44	20.16	25.93	4.01	7.96	13.72
F	29.14	77.97	118.63	35.23	85.80	126.46
G	38.82	62.47	117.95	51.54	76.48	131.96
H	298.33	312.20	345.53	391.89	406.08	439.42
I	6.81	21.59	29.97	9.06	14.47	22.85
J-N	75.69	132.25	399.66	100.48	160.45	427.86
O	9.09	13.16	19.71	12.09	16.33	22.87
P	3.33	4.81	6.90	4.43	5.98	8.07
Q	13.01	17.98	25.87	16.10	20.45	28.34
R	4.97	6.51	9.16	6.61	8.17	10.82
S	2.14	3.52	5.10	2.84	4.28	5.86
Househ.	270.75	397.88	504.95	351.43	448.79	555.86
Sum of domestic entities	960.52	-	-	1 080.84	-	-
Govern.	-	36.27	66.58	-	42.01	72.32
NGOs	-	4.37	6.53	-	4.89	7.05
Invest.	-	38.27	102.01	-	38.45	102.20
Exports	860.76	1 344.36	1 760.88	1 134.12	1 680.62	2 097.14
Non-Resident Househ.	181.51	182.82	194.91	239.14	240.77	252.86
Non-Resident Corp.	679.26	684.18	729.40	894.97	901.06	946.29
Sum of domestic entities plus exports	1 821.29	-	-	2 214.96	-	-
VAT Residents	41.91	61.57	68.34	52.06	66.47	72.95
VAT Non-Residents	30.86	31.08	33.13	40.65	40.93	42.99

Source: Eurostat (2021a. 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

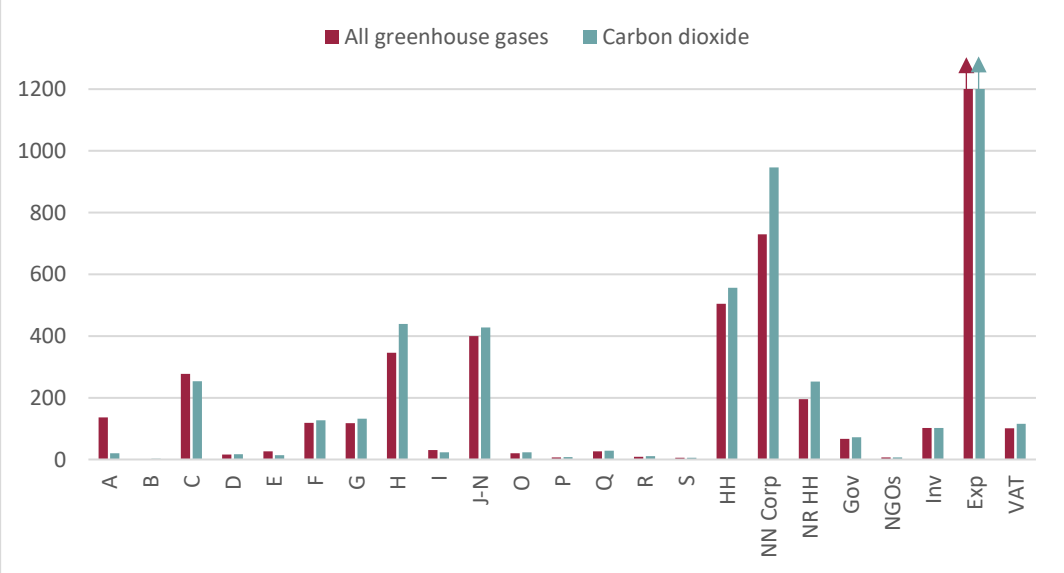
Figure 14 graphically illustrates the direct effects of the third scenario, while Figure 15 includes both direct and indirect effects. The depiction of direct and indirect effects includes all EU countries and the additional four countries that are part of this analysis.

Figure 14: Direct effects of taxation scenario 3 in million Euros, excluding ETS.



Source: Eurostat (2021b; Eurostat, 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, VAT: Value-added tax.

Figure 15: Direct and indirect effects of taxation scenario 3 in million Euros, excluding ETS.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports. Values that include indirect effects must not be added up. as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households.

Table 11 shows taxes paid per unit of GHG and CO_2 emissions for the economic entities in scenario 3. We see a similar pattern as in scenario 2 (Table 9) with sectors that are partly subject to ETS paying a lower average tax per ton of emissions and the rest of the sectors just paying the assumed average tax.

Table 11: Energy and transport taxes of scenario 3 directly and indirectly paid per unit of GHG and CO_2 emission in Euros.

	Euros per ton of GHG			Euros per ton of CO_2		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A – Agriculture	171.49	171.27	155.48	229.36	226.52	168.48
B – Mining	171.49	161.96	98.40	229.36	216.68	130.37
C – Manufacturing	35.37	71.02	55.98	47.29	71.23	60.89
D – Energy	15.41	23.04	26.69	20.61	30.46	31.89
E – Water and waste	171.49	159.71	99.41	229.36	184.72	94.38
F - Construction	171.49	136.05	71.40	229.36	174.87	88.90
G – Wholesale	171.49	156.95	85.49	229.36	209.02	110.39
H - Transport	148.81	147.58	124.96	198.78	196.94	165.78
I – Hospitality	171.49	164.44	88.11	229.36	212.63	119.40
J-N – Other sectors	171.49	154.12	96.22	229.36	204.95	116.11
O – Public administration	171.49	156.40	84.35	229.36	209.06	110.74
P – Education	171.49	149.67	86.09	229.36	200.96	111.12
Q – Health	171.49	158.91	90.54	229.36	211.54	119.64
R – Arts and recreation	171.49	156.76	85.42	229.36	210.55	111.56
S – Other services	171.49	155.51	86.08	229.36	207.59	113.95
Resident Corporations	119.26	119.26	79.62	149.20	149.20	96.63
Households	171.49	164.02	99.02	229.36	218.53	134.96
Sum of domestic entities	130.46	-	-	168.33	-	-
Government	-	155.67	89.48	-	206.88	111.94
NGOs	-	157.20	87.56	-	208.44	115.43
Investments	-	86.62	57.71	-	101.27	66.69
Exports	171.49	145.32	113.73	229.36	193.10	148.32
Non-Resident Households	171.49	171.37	132.44	229.36	229.21	175.96
Non-Resident Corporations	171.49	171.37	132.44	229.36	229.21	175.96
Sum of domestic entities plus exports	147.09	-	-	194.88	-	-

Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

7.6 Scenario 4

Finally, scenario 4 calculates the effects of another fictive carbon tax that charges 203.14 Euros per emitted ton of CO_2 or GHG emission while keeping the already existing energy and transport taxes. This scenario constitutes the most ambitious carbon taxation scheme analyzed in this study. Although it can be assumed that scenario 4 would be politically difficult to implement, the idea to put a price tag on the net damage caused by these emissions is certainly interesting to deliberate. Chapter 5.5 offers more information on the theoretical background. Results for the same scenario where ETS emissions are also part of the analyzed taxes can be found in Table 32, Figure 36 and Figure 37 in the Appendix. Moreover, Table 33 and Table 34 show the direct and total effects when using no discount factor (709,97 instead of 203.14 Euros per ton of emissions).

Table 12 provides an overview of the effects such a carbon tax might have. The ratios between the individual units of analysis remain roughly the same when comparing this scenario to the redistribution scenario (scenario 2), but in absolute terms, the amount of taxes rises accordingly. If we only consider direct effects, resident households and corporations pay 1.4 billion Euros (CO_2) or 1.6 billion Euros (GHG), depending on the emissions that are taxed. Once we add exports, we arrive at 3 billion Euros (CO_2) or 3.2 billion Euros (GHG). Compared to the base scenario, short term revenues in this scenario would rise massively. Taxing only CO_2 would generate 2 billion Euros, taxing all GHG would generate 2.2 billion Euros of additional revenues for Luxembourg's treasury.

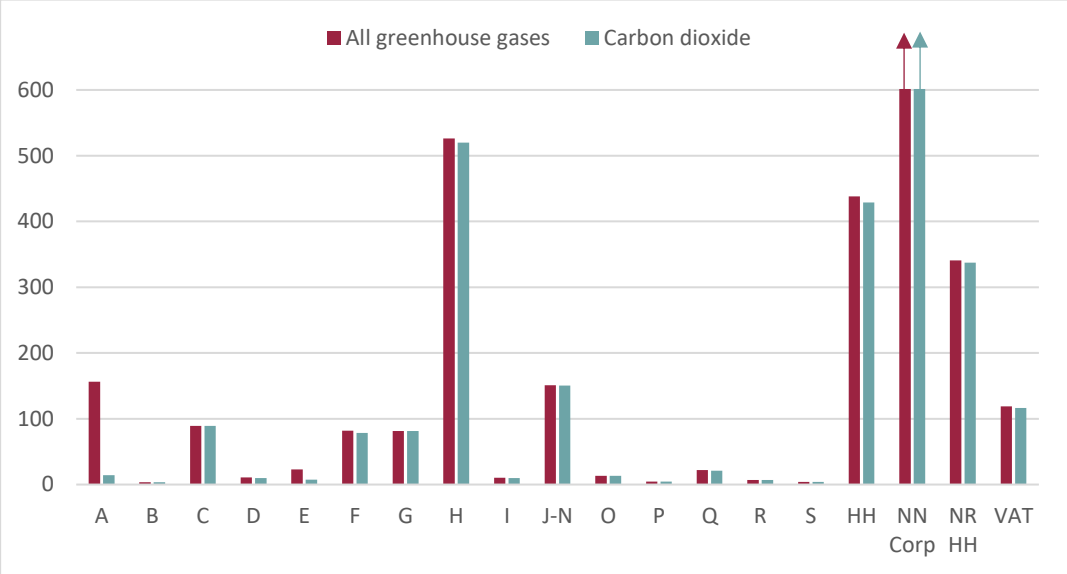
Table 12: Direct and indirect effects of taxation scenario 4 in million Euros, excluding ETS.

	All GHGs			CO_2		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	156.25	157.85	160.85	14.31	15.32	18.32
B	3.40	3.74	4.18	3.38	3.69	4.12
C	89.39	270.95	395.68	89.09	204.47	329.20
D	10.68	15.72	24.30	9.77	14.19	22.77
E	23.12	30.70	36.47	7.20	13.86	19.63
F	81.82	151.25	191.92	78.50	134.88	175.55
G	81.56	131.88	187.36	81.23	125.62	181.10
H	526.14	551.06	584.40	519.84	540.90	574.24
I	10.10	29.37	37.75	10.05	16.61	24.99
J-N	151.19	248.77	516.18	150.53	234.21	501.63
O	13.43	20.66	27.21	13.37	19.53	26.08
P	4.66	7.16	9.24	4.64	6.75	8.83
Q	22.06	29.94	37.83	20.91	26.76	34.65
R	6.71	9.24	11.90	6.68	8.77	11.43
S	4.08	6.42	8.00	4.06	6.04	7.62
Househ.	438.20	635.85	742.92	428.73	562.03	669.10
Sum of domestic entities	1 622.81	-	-	1 442.29	-	-
Govern.	-	77.81	108.11	-	72.05	102.35
NGOs	-	6.96	9.12	-	6.11	8.27
Invest.	-	88.94	152.69	-	77.67	141.41
Exports	1 615.48	2 428.47	2 844.99	1 600.32	2 324.49	2 741.01
Non-Resident Househ.	340.65	342.91	367.08	337.45	339.60	363.77
Non-Resident Corp.	1 274.82	1 283.30	1 373.76	1 262.87	1 270.91	1 361.37
Sum of domestic entities plus exports	3 238.28	-	-	3 042.61	-	-
VAT Residents	60.79	88.18	94.26	59.29	77.71	83.77
VAT Non-Residents	57.91	58.29	62.40	57.37	57.73	61.84

Source: Eurostat (2021a. 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

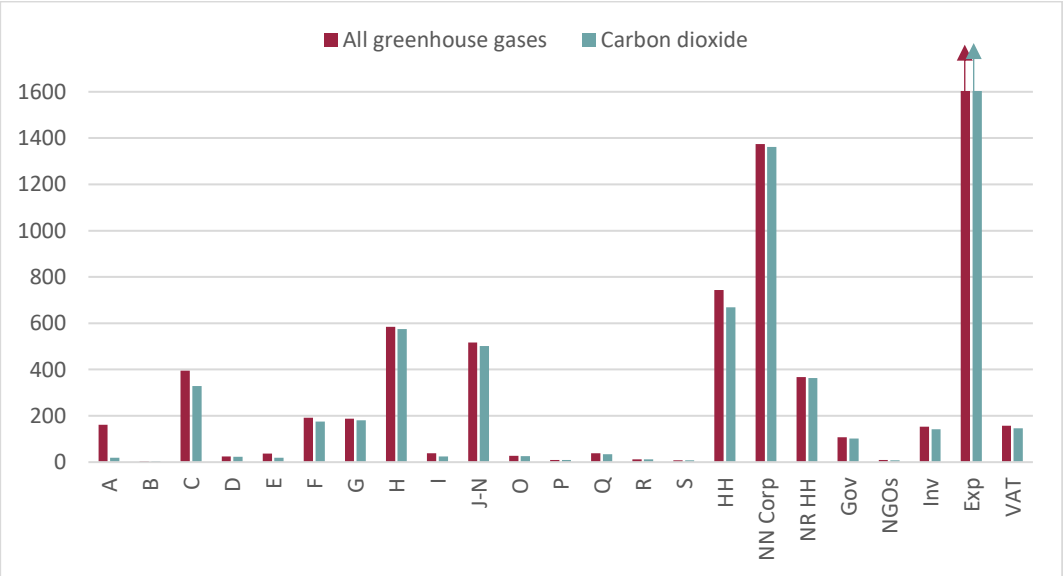
Once again, the two sets of figures present the direct effects of this scenario (Figure 16) and the cumulated direct and indirect (Figure 17) effects.

Figure 16: Direct effects of taxation scenario 4 in million Euros, excluding ETS.



Source: Eurostat (2021b; Eurostat, 2021a); own calculations. HH: Households. NR HH: Non-resident households. NR Corp: Non-resident corporations. VAT: Value-added tax.

Figure 17: Direct and indirect effects of taxation scenario 4 in million Euros, excluding ETS.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households.

Table 13 shows taxes paid per unit of GHG and CO_2 emissions for the economic entities in scenario 4. Both for the GHG (34.86 Euros) and CO_2 (38.08 Euros) case, the energy sector (D) would pay the lowest taxes per unit due to being largely covered by ETS. The mining (B) and construction sector (F) would pay around 500 Euros per unit of emissions, which is a manyfold of the amount of the energy sector. Once again, resident households would pay more taxes per emitted unit (277.55 or 279.81 Euros per ton of GHG or CO_2) than resident corporations (204.82 or 207.33 Euros per ton of GHG or CO_2).

Table 13: Energy and transport taxes of scenario 4 directly and indirectly paid per unit of GHG and CO_2 emission in Euros.

	Euros per ton of GHG			Euros per ton of CO_2		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A – Agriculture	203.23	203.40	184.01	204.14	206.07	155.57
B – Mining	493.59	439.72	226.33	497.26	448.06	242.05
C – Manufacturing	58.29	126.14	79.88	58.34	112.92	79.01
D – Energy	34.86	47.76	40.12	38.08	51.37	42.72
E – Water and waste	241.23	243.19	139.83	411.71	321.91	135.03
F - Construction	481.49	263.92	115.51	511.08	274.91	123.41
G – Wholesale	360.32	331.34	135.80	361.48	343.31	151.50
H - Transport	262.44	260.49	211.34	263.68	262.32	216.64
I – Hospitality	254.25	223.70	110.98	254.53	244.10	130.59
J-N – Other sectors	342.55	289.91	124.28	343.59	299.18	136.13
O – Public administration	253.30	245.48	116.43	253.61	250.07	126.24
P – Education	240.24	222.44	115.31	240.45	226.78	121.70
Q – Health	290.81	264.65	132.42	297.87	276.78	146.27
R – Arts and recreation	231.80	222.69	110.93	231.96	226.06	117.76
S – Other services	326.49	283.81	135.07	327.33	293.21	148.26
Resident Corporations	204.82	204.82	110.92	207.33	207.33	117.79
Households	277.55	262.12	145.69	279.81	273.67	162.45
Sum of domestic entities	220.42	-		224.62	-	-
Government	-	333.91	145.30	-	354.79	158.43
NGOs	-	250.19	122.27	-	260.45	135.43
Investments	-	201.32	86.38	-	204.57	92.28
Exports	321.85	262.51	183.75	323.64	267.09	193.85
Non-Resident Households	321.85	321.43	249.43	323.64	323.28	253.16
Non-Resident Corporations	321.85	321.43	249.43	323.64	323.30	253.16
Sum of domestic entities plus exports	261.54	-	-	267.70	-	-

Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

8 Subsidies

Table 14 shows all direct and indirect carbon-related subsidies in Luxembourg in 2019, as described in Section 6. As this study solely focusses on subsidies in Luxembourg, no indirect effects along the values chains in foreign countries are presented. Besides this deviation, Table 14 is structured as the tables in Section 7. Moreover, the logic behind the value added tax shown in the tables in this section differs compared to the results in Section 7. Table 14 covers value-added taxes which are not paid (directly and in total) by residents and non-residents in 2019 to Luxembourg's treasury due to the subsidies.

As can be seen in Table 14, the manufacturing sector (C) received[29] the largest share of direct subsidies (68.5 million Euros) among the individual industry sectors in Luxembourg. Along the value chains in Luxembourg the manufacturing sector gets another 14.6 million Euros indirectly. All resident corporations together received 182.8 million Euros subsidies directly (43.8% of all direct subsidies). Resident households received 68.2 million Euros of direct subsidies (16.4% of all direct subsidies) and 97 million Euros subsidies in total.

Notably, non-resident entities (households and companies) received an overall share of 165.9 million Euros, 39.8% of all direct subsidies and in total (285.3 million Euros). This is largely a result of the very low taxes for car fuel (especially diesel), attracting many so-called "fuel tourists" to Luxembourg, which visit the country to refuel and leave. In a sense, this tax competition is mainly financed by Luxembourgian companies and households, as they have to provide the missing financial contribution for a balanced treasury budget.

Among the sectors which profit the least (in absolute terms) from carbon-related subsidies in Luxembourg is mining (B) with 0.5 directly and in total (including indirect effects) followed by other service activities (S) with 1 and 1.3 million Euros directly and in total.

[29] Note that in this chapter, „receive" and similar phrases do not necessarily mean that actual transfer of money took place (see Section 6).

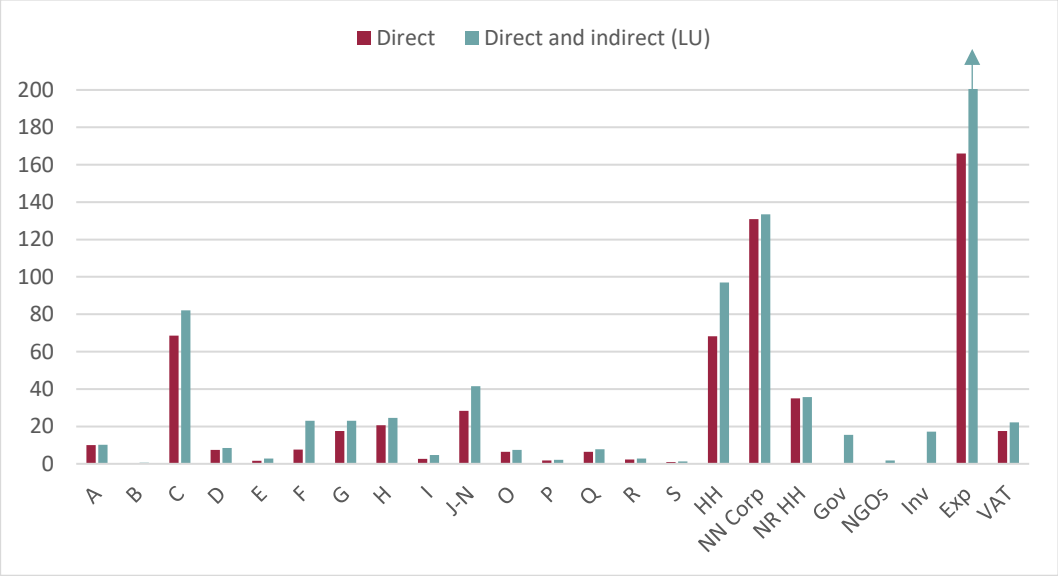
Table 14: Direct and indirect carbon related subsidies in Luxembourg in million Euros, 2019 (2021)

Economic Unit	Direct	Direct and indirect (LU)
A – Agriculture	10.04	10.25
B – Mining	0.48	0.54
C – Manufacturing	68.53	82.09
D – Energy	7.48	8.41
E – Water and waste	1.60	2.76
F - Construction	7.57	22.96
G – Wholesale	17.53	22.95
H - Transport	20.56	24.61
I – Hospitality	2.63	4.69
J-N – Other sectors	28.33	41.47
O – Public administration	6.38	7.52
P – Education	1.79	2.22
Q – Health	6.50	7.73
R – Arts and recreation	2.38	2.77
S – Other services	0.95	1.28
Households	68.17	97.01
Sum of domestic entities	250.93	-
Government	-	15.48
NGOs	-	1.74
Investment	-	17.16
Exports	165.94	285.30
Non-Resident Households	34.99	35.65
Non-Resident Corporations	130.95	133.40
Sum of domestic entities plus exports	416.88	-
VAT Residents	11.59	16.19
VAT Non-Residents	5.95	6.06

Source: European Commission (2022); Eurostat (2022b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 18 depicts the results in Table 14 in a bar chart. The figure once again clearly shows the imbalance in the distribution of subsidies in favor of domestic and foreign companies.

Figure 18: Direct and indirect carbon related subsidies in Luxembourg in million Euros.



Source: European Commission (2022); Eurostat (2022b); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Table 15 shows subsidies per unit of GHG and CO_2 emissions received by the economic entities. Once again, we not only calculate the direct, but also the indirect (total) effects. The table is constituted by dividing the cumulated subsidies from Table 14 with the results from Table 2 and Table 3, respectively. Figure 19 and Figure 20 depict the same results in a bar chart.

Of all entities, the public administration and defense sector; compulsory social security (O) received by far the highest subsidies per emitted unit, while the transport sector received the lowest. For most sectors, calculations based on CO_2 and GHG show rather similar results. For the agricultural sector, the only sector where other GHG emissions than CO_2 play a very important role, this is not the case and per unit subsidies higher by a tenfold for CO_2 than for GHG. The same is true for sector E on a smaller magnitude.

The data reveals that households receive more subsidies per unit of GHG and CO_2 emissions than any other entity (when treating domestic industry sectors as an average). This is mainly caused by the subsidies for gas oil for heating from which primarily domestic households benefit.

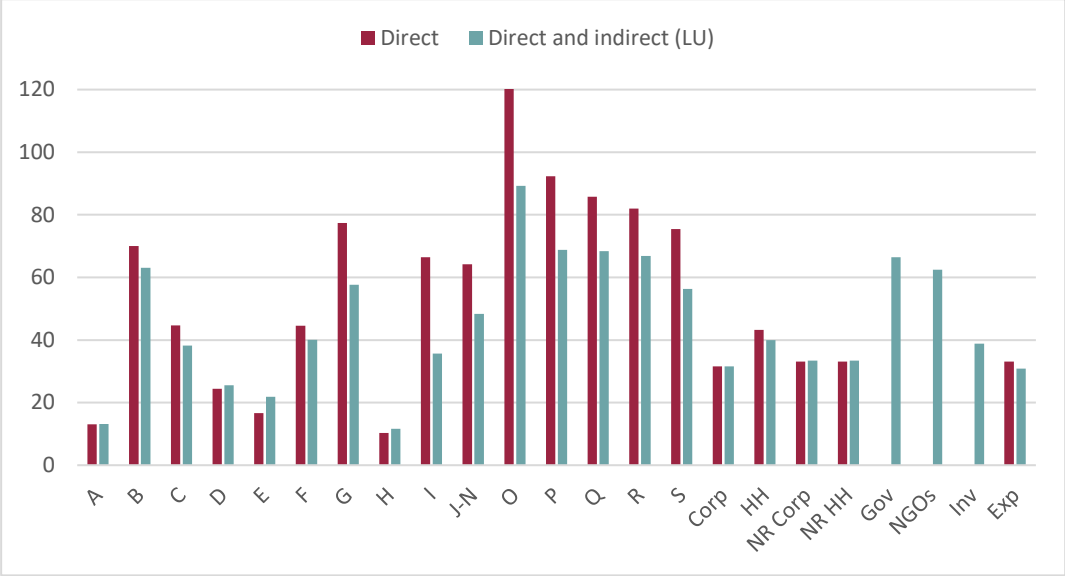
With a few exceptions (e. g. sector E with GHG), total subsidies per emitted unit are always noticeably lower than just the direct ones. On average, 33.7 or 36.7 Euros of subsidies are received per unit of emitted GHG or CO_2 in Luxembourg, respectively.

Table 15: Direct and indirect carbon related subsidies per ton of CO_2/GHG in Luxembourg in Euros, 2019 (2021).

	Euros per ton of GHG		Euros per ton of CO_2	
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct**	**Direct and indirect (LU)**
A – Agriculture	13.06	13.20	143.28	137.70
B – Mining	70.05	63.08	71.07	65.39
C – Manufacturing	44.69	38.21	44.88	45.34
D – Energy	24.41	25.55	29.14	30.43
E – Water and waste	16.65	21.89	91.18	64.14
F - Construction	44.58	40.06	49.31	46.78
G – Wholesale	77.42	57.68	78.02	62.74
H - Transport	10.26	11.63	10.42	11.93
I – Hospitality	66.40	35.69	66.73	68.80
J-N – Other sectors	64.19	48.33	64.68	52.97
O – Public administration	120.40	89.27	121.08	96.24
P – Education	92.31	68.80	92.80	74.34
Q – Health	85.80	68.40	92.65	80.00
R – Arts and recreation	81.99	66.85	82.56	71.50
S – Other services	75.42	56.32	76.03	61.80
Resident Corporations	31.60	31.60	37.38	37.38
Households	43.18	40.00	44.49	47.24
Sum of domestic entities	34.09	-	39.08	-
Government	-	66.46	-	76.24
NGOs	-	62.48	-	73.91
Investments	-	38.83	-	45.18
Exports	33.06	30.84	33.56	32.78
Non-Resident Households	33.06	33.40	33.56	33.92
Non-Resident Corporations	33.06	33.40	33.56	33.92
Sum of domestic entities plus exports	33.67	-	36.68	-

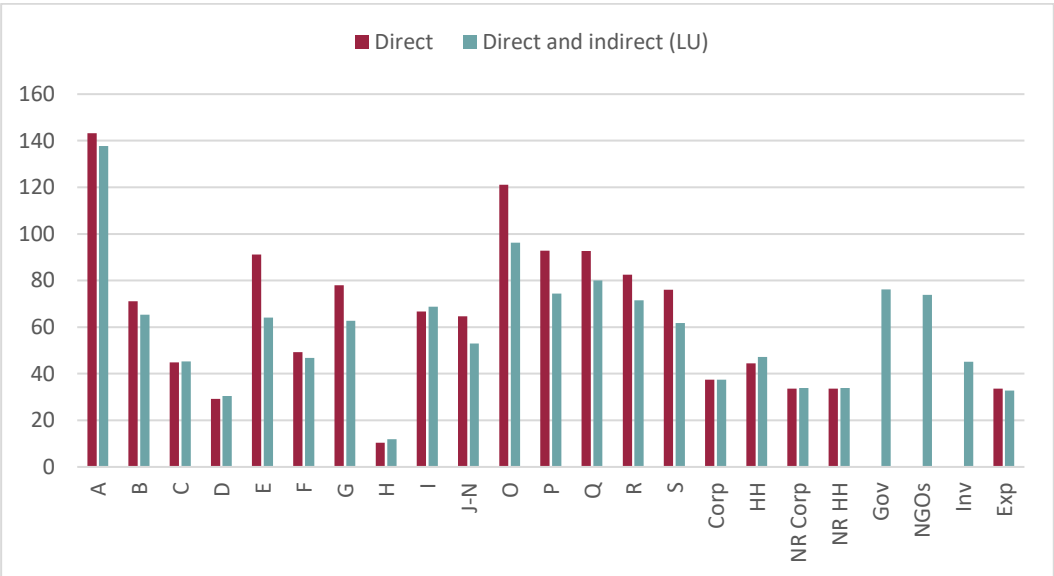
Source: European Commission (2022); Eurostat (2022b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 19: Direct and indirect carbon related subsidies per ton of GHG in Luxembourg in Euros.



Source: European Commission (2022); Eurostat (2022b); own calculations. Corp: corporations, HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Figure 20: Direct and indirect carbon related subsidies per ton of CO_2 in Luxembourg in Euros.



Source: European Commission (2022); Eurostat (2022b); own calculations. Corp: corporations, HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

If the carbon-related taxes and levies actually paid by the sectors and the respective subsidies and exemptions are added up to the theoretically payable carbon-related taxes and levies, a sectoral subsidy rate can be calculated. This results from the ratio of subsidies and exemptions to the carbon-related taxes and levies that must theoretically be paid in total. Table 16 shows the results of this theoretical consideration. While the agricultural sector (A) almost shows a nearly 100% direct subsidy ratio, it is around 33% for the resident corporations in total, 37% for resident households and 22% for non-residents. With only 11% direct effects, the transport sector (H) shows the lowest ratio.

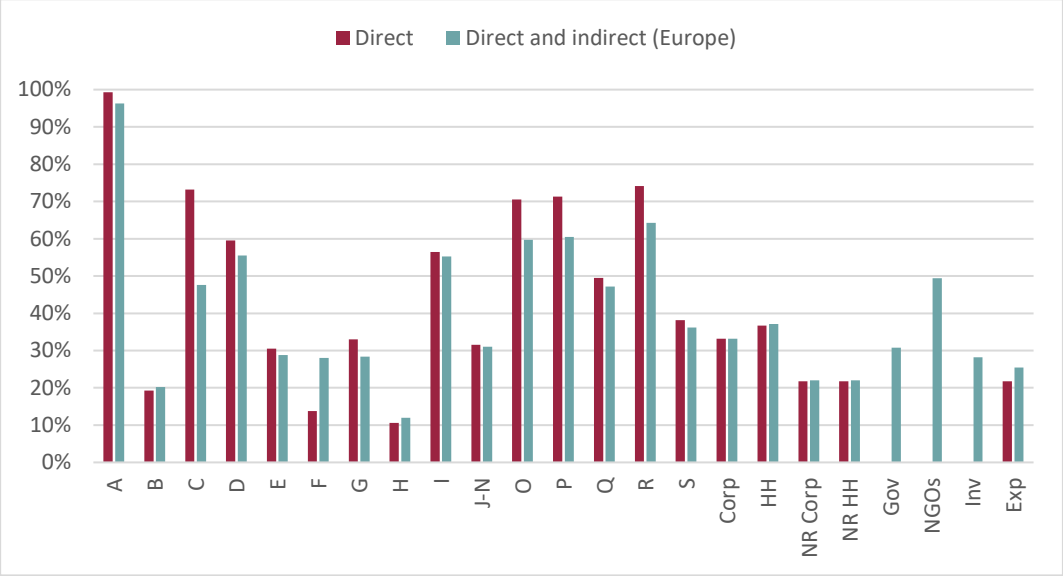
Table 16: Share of subsidies in energy and transport taxes theoretically directly and indirectly paid in Luxembourg, 2019 (2021).

Economic Unit	Direct	Direct and indirect (LU)
A – Agriculture	99.3%	96.2%
B – Mining	19.3%	20.3%
C – Manufacturing	73.2%	47.6%
D – Energy	59.5%	55.5%
E – Water and waste	30.5%	28.8%
F - Construction	13.8%	28.1%
G – Wholesale	33.0%	28.4%
H - Transport	10.6%	12.0%
I – Hospitality	56.5%	55.2%
J-N – Other sectors	31.5%	31.0%
O – Public administration	70.6%	59.7%
P – Education	71.3%	60.4%
Q – Health	49.4%	47.2%
R – Arts and recreation	74.1%	64.3%
S – Other services	38.1%	36.2%
Resident Corporations	33.2%	33.2%
Households	36.7%	37.1%
Sum of domestic entities	34.1%	-
Government	-	30.8%
NGOs	-	49.4%
Investments	-	28.2%
Exports	21.8%	25.4%
Non-Resident Households	21.8%	22.0%
Non-Resident Corporations	21.8%	22.0%
Sum of domestic entities plus exports	27.8%	-

Source: European Commission (2022); Eurostat (2021a, 2021b, 2022b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 21 shows the results in Table 16 in a bar chart. Once again, it is apparent that the agricultural sector (A) has the highest subsidy ratio.

Figure 21: Share of subsidies in energy and transport taxes theoretically directly and indirectly paid in Luxembourg.



Source: European Commission (2022); Eurostat (2021a, 2021b, 2022b); own calculations. Corp: corporations, HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

9 Sensitivity analyses for ETS prices

In the scenarios above, payments of Luxembourgian firms for ETS allowances are included in the Eurostat tax data for 2019. As already mentioned in Section 3.2.1, the average spot market price in 2019 was 24.65 Euros per ton of CO_2e emissions, which matched the price in the Eurostat data. According to data from the European Energy Exchange (2022), prices saw a strong increase after 2019 with an average price of 52.63 Euros in 2021. The supposed increase of the ETS price must be considered not only for Luxembourgian territory, but for the entirety of countries participating in the ETS scheme.

As described in chapter 5.6, this module is a ceteris paribus analysis that uses the average ETS price for 2021 instead of the average price for 2019. In other words, the base scenario, scenario 1 and scenario 4 of this study were recalculated, using the same data on emissions and taxation and producing the same graphs while assuming a different ETS price. As a second version, an ETS price of 100 Euros per ton of CO_2e emissions was used as a sensitivity check.

9.1 Base scenario

In the first ETS version (based on the ETS price of 2021) we assumed that the ETS price increased to 52.63 Euro instead of 24.65 Euro, while in the second ETS version we assumed that the ETS price increased to 100 Euro instead of 24.65 Euros. These two increased ETS prices were used in all scenarios of the sensitivity analysis.

The total direct costs would increase by 19.4 million Euros with an ETS price of 52.63 Euros and by 52.2 million Euros with an ETS price of 100 Euros compared to the results in section 7.2. A look at resident corporations shows that this increase is mainly caused by the sectors manufacturing (C) and energy (D) in Luxembourg. The amount of total carbon-related taxes paid by the resident households would increase by 5.6% in the version with the average price of 2021 and by 15.2% in the 100 Euro version, compared to the results in section 7.2.

Table 17 shows the direct and indirect effects of the base scenario with varying ETS prices. While resident households would still pay still 117.5 million Euros of direct carbon-related taxes, indirectly paid taxes would increase, compared to the base scenario. The totally paid taxes ascend to 168.5 million Euros (average ETS price of 2021) and 175.2 million Euros (ETS price of 100 Euros) considering Luxembourgian value chains.

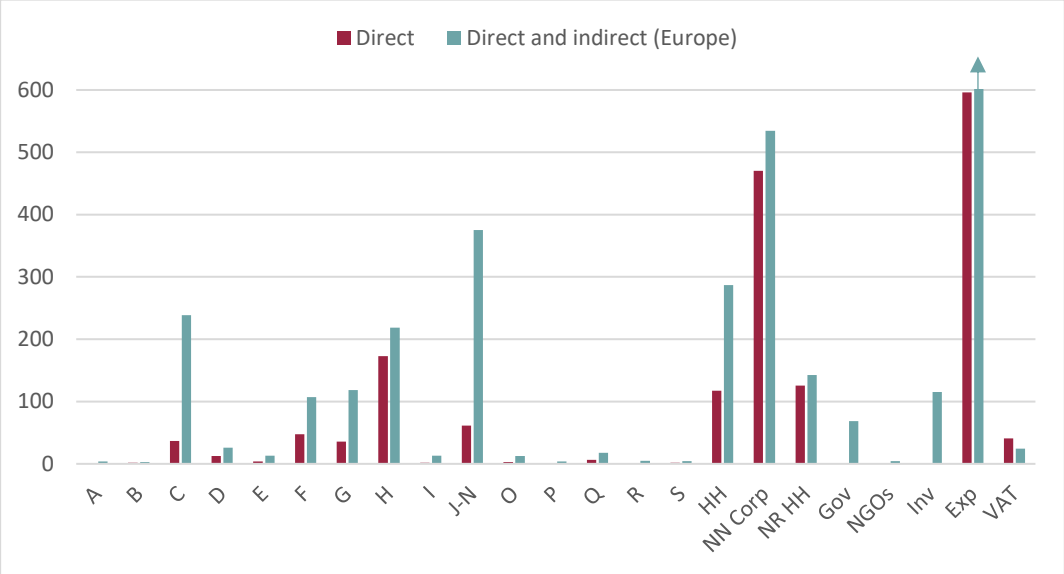
Table 17: Direct and indirect effects of base scenario in million Euros with varying ETS prices, 2019.

	Average ETS price of year 2021 (52.63 Euros)			ETS price of 100 Euros		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	0.07	0.44	3.64	0.07	0.51	4.04
B	2.00	2.12	2.61	2.00	2.14	2.71
C	36.55	103.27	238.75	55.89	125.34	279.03
D	12.74	14.50	25.74	25.69	27.65	43.38
E	3.65	7.01	13.27	3.65	7.34	14.45
F	47.30	61.63	106.99	47.30	66.26	119.56
G	35.58	58.69	118.31	35.58	60.04	126.70
H	173.06	182.28	218.66	173.58	184.02	225.56
I	2.03	3.99	12.98	2.03	4.31	14.35
J-N	61.53	94.25	375.42	61.53	97.87	402.33
O	2.66	5.31	12.77	2.66	5.71	14.73
P	0.72	1.62	4.04	0.72	1.89	4.90
Q	6.65	8.97	17.82	6.65	9.52	20.01
R	0.83	1.69	4.85	0.83	1.94	5.97
S	1.54	2.32	4.11	1.54	2.44	4.57
Househ.	117.48	168.52	286.93	117.48	175.25	312.87
Sum of domestic entities	504.39	-	-	537.19	-	-
Govern.	-	35.58	68.63	-	36.85	74.54
NGOs	-	1.86	4.27	-	2.00	4.85
Invest.	-	45.97	115.08	-	49.97	128.16
Exports	595.85	848.19	1 292.25	595.85	868.83	1 359.51
Non-Res. Househ.	125.64	126.50	142.77	125.64	126.74	147.56
Non-Resi. Corp.	470.21	473.39	534.29	470.21	474.30	552.21
Sum of domestic entities plus exports	1 100.24	-	-	1 133.04	-	-
VAT Res.	19.23	27.45	35.27	19.23	28.53	37.61
VAT Non-Res.	21.36	21.50	24.27	21.36	21.55	25.08

Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

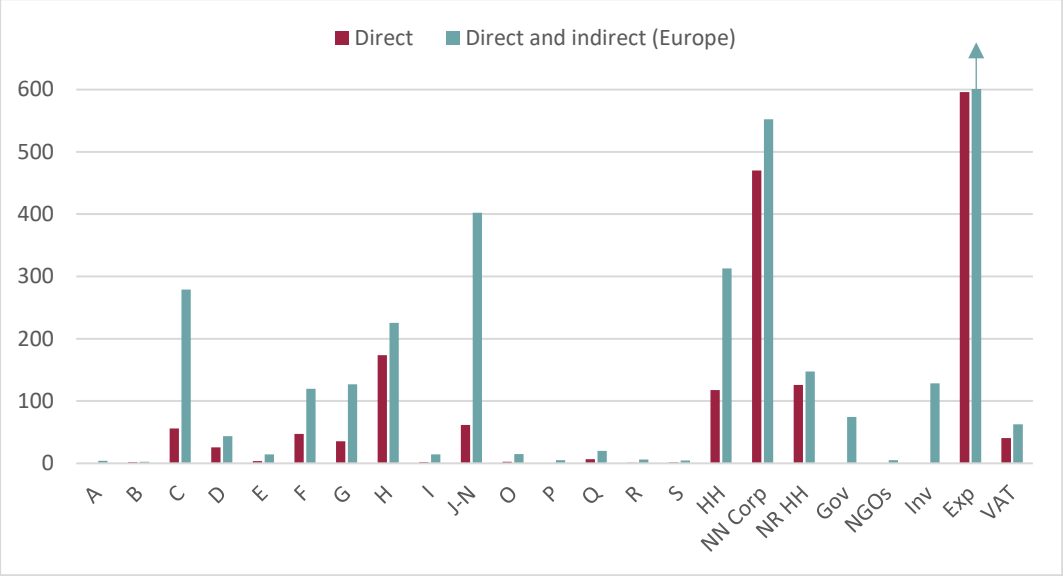
Figure 22 and Figure 23 graphically depict the sectoral distribution of direct and indirect tax effects. Only the ETS sectors C, D and to a much lesser extent H are impacted directly by the higher ETS prices, whereas indirectly all domestic entities as well as exports are affected.

Figure 22: Direct and indirect effects of base scenario in million Euro with ETS price of 52.63 Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up. as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Figure 23: Direct and indirect effects of base scenario in million Euros with ETS price of 100 Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up. as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

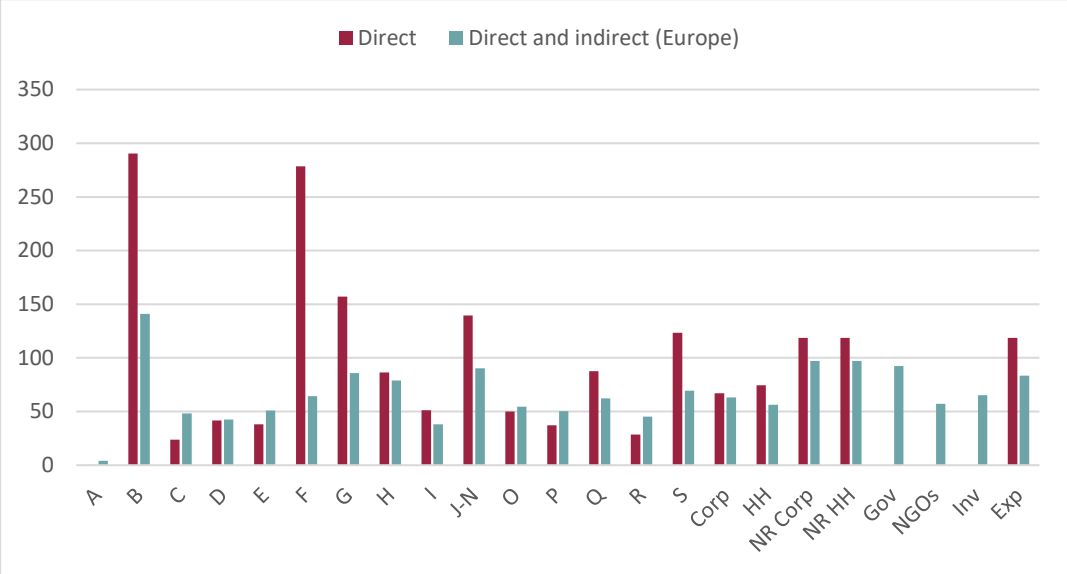
Table 18 shows taxes paid per unit of GHG emissions for the economic entities in the base scenario with varying ETS prices. Once again, resident households would pay more taxes per emitted unit (74.41 Euros per ton of GHG) than resident corporations (66.89 Euros and 72.57 Euros per ton of GHG), but with increasing ETS prices the difference gets smaller. With the average ETS price of 2021, the prices paid per unit of GHG are still considerably lower for the ETS sectors C and D than the average for resident corporations, but with an ETS price of 100 Euros the energy and transport taxes per unit of GHG paid by the energy sector D exceed the resident corporations' average.

Table 18: Energy and transport taxes of base scenario directly and indirectly paid per unit of GHG in Euros with varying ETS prices.

	Average ETS price of year 2021 (52.63 Euros)			ETS price of 100 Euros		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A – Agriculture	0.09	0.57	4.17	0.09	0.65	4.62
B – Mining	290.45	249.28	140.94	290.45	251.70	146.54
C – Manufacturing	23.83	48.08	48.20	36.44	58.35	56.33
D – Energy	41.56	44.08	42.49	83.80	84.05	71.62
E – Water and waste	38.09	55.52	50.90	38.09	58.12	55.40
F - Construction	278.35	107.52	64.38	278.35	115.59	71.95
G – Wholesale	157.18	147.45	85.75	157.18	150.86	91.83
H - Transport	86.32	86.16	79.08	86.58	86.99	81.57
I – Hospitality	51.11	30.36	38.16	51.11	32.84	42.18
J-N – Other sectors	139.41	109.84	90.39	139.41	114.06	96.87
O – Public administration	50.16	63.02	54.66	50.16	67.82	63.04
P – Education	37.10	50.20	50.48	37.10	58.83	61.20
Q – Health	87.67	79.30	62.38	87.67	84.17	70.03
R – Arts and recreation	28.66	40.60	45.21	28.66	46.69	55.61
S – Other services	123.35	102.83	69.38	123.35	108.17	77.19
Resident Corporations	66.89	66.89	63.20	72.56	72.56	69.91
Households	74.41	69.47	56.27	74.41	72.24	61.36
Sum of domestic entities	68.51	-	-	72.96	-	-
Government	-	152.72	92.24	-	158.14	100.18
NGOs	-	67.01	57.30	-	72.03	65.04
Investments	-	104.06	65.10	-	113.11	72.50
Exports	118.71	91.69	83.46	118.71	93.92	87.81
Non-Resident Households	118.71	118.57	97.01	118.71	118.79	100.26
Non-Resident Corporations	118.71	118.57	97.01	118.71	118.79	100.26
Sum of domestic entities plus exports	88.86	-	-	91.51	-	-

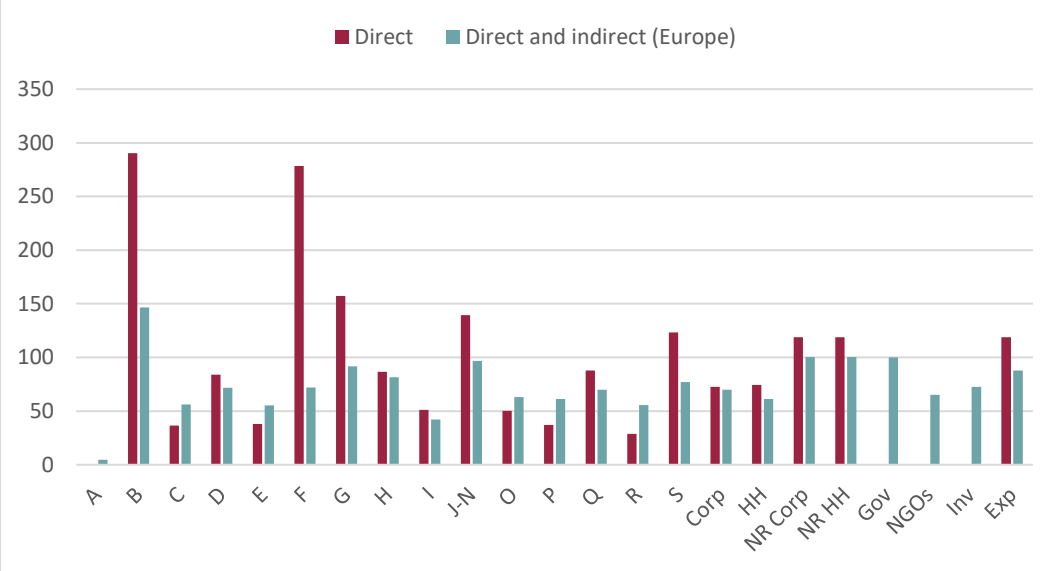
Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 24: Energy and transport taxes of base scenario directly and indirectly paid per unit of GHG in Euros with ETS price of 52.63 Euros.



Source: Eurostat (2021b; 2021a); own calculations. Corp: corporations, HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up. as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Figure 25: Energy and transport taxes of base scenario directly and indirectly paid per unit of GHG in Euros with ETS price of 100 Euros.



Source: Eurostat (2021b; 2021a); own calculations. Corp: corporations, HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up. as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

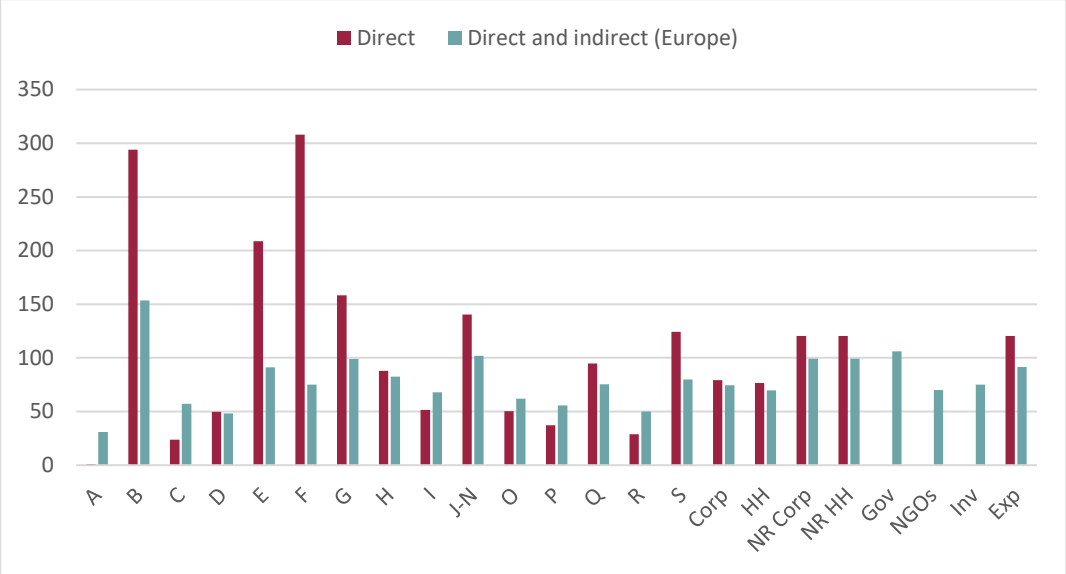
Table 19 shows taxes paid per unit of CO_2 instead of GHG emissions for the economic entities in the base scenario with varying ETS prices. In this case also the direct taxes per emitted unit are higher for the resident corporations than for the resident households. But if the indirect effects in Luxembourg are included it is vice versa.

Table 19: Energy and transport taxes of base scenario directly and indirectly paid per unit of CO_2 in Euros with varying ETS prices.

	Average ETS price of year 2021 (52.63 Euros)			ETS price of 100 Euros		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A – Agriculture	1.00	5.95	30.92	1.00	6.81	34.31
B – Mining	294.12	258.40	153.38	294.12	260.91	159.47
C – Manufacturing	23.94	57.03	57.30	36.60	69.22	66.97
D – Energy	49.62	52.51	48.29	100.06	100.12	81.38
E – Water and waste	208.57	162.69	91.30	208.57	170.31	99.37
F - Construction	307.94	125.62	75.21	307.94	135.06	84.05
G – Wholesale	158.34	160.39	98.98	158.34	164.10	105.99
H - Transport	87.78	88.40	82.49	88.04	89.24	85.09
I – Hospitality	51.39	58.56	67.83	51.39	63.34	74.97
J-N – Other sectors	140.45	120.39	101.88	140.45	125.01	109.18
O – Public administration	50.47	67.95	61.83	50.47	73.13	71.31
P – Education	37.31	54.24	55.69	37.31	63.57	67.53
Q – Health	94.73	92.78	75.24	94.73	98.48	84.47
R – Arts and recreation	28.82	43.43	50.01	28.82	49.94	61.52
S – Other services	124.19	112.82	79.91	124.19	118.67	88.90
Resident Corporations	79.14	79.14	74.36	85.85	85.85	82.27
Households	76.67	82.06	69.67	76.67	85.33	75.96
Sum of domestic entities	78.55	-	-	83.66	-	-
Government	-	175.20	106.25	-	181.42	115.39
NGOs	-	79.27	69.97	-	85.21	79.41
Investments	-	121.08	75.10	-	131.61	83.63
Exports	120.50	97.46	91.39	120.50	99.83	96.15
Non-Resident Households	120.50	120.41	99.36	120.50	120.65	102.69
Non-Resident Corporations	120.50	120.41	99.36	120.50	120.65	102.69
Sum of domestic entities plus exports	96.80	-	-	99.69	-	-

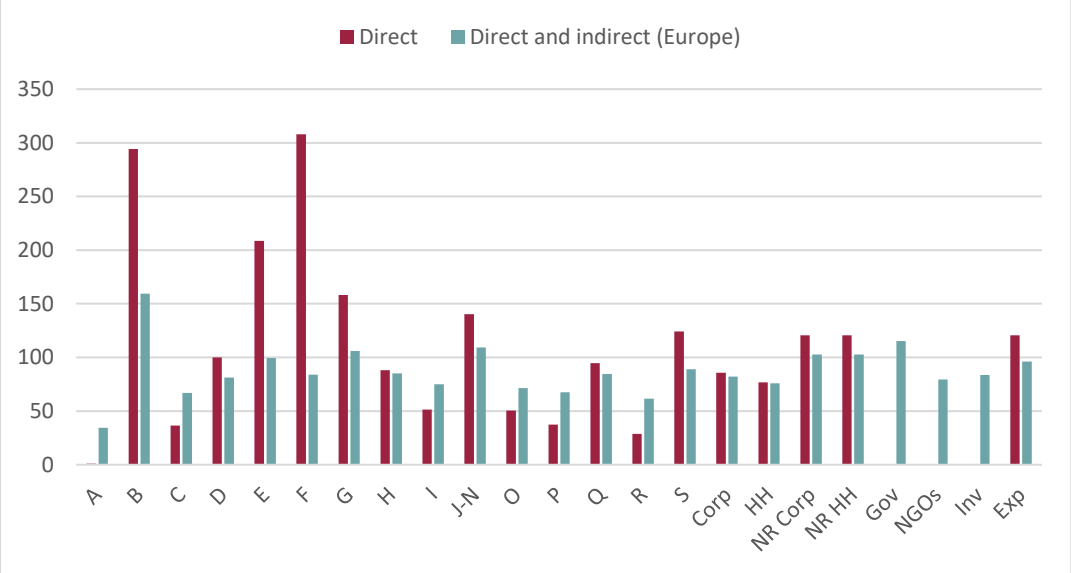
Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 26: Energy and transport taxes of base scenario directly and indirectly paid per unit of CO_2 in Euros with ETS price of 52.63 Euros.



Source: Eurostat (2021b; 2021a); own calculations. Corp: corporations, HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up. as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Figure 27: Energy and transport taxes of base scenario directly and indirectly paid per unit of CO_2 in Euros with ETS price of 100 Euros.



Source: Eurostat (2021b; 2021a); own calculations. Corp: corporations, HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up. as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

9.2 Scenario 1

Scenario 1 is based on the existing energy and transport taxation plus an additional 30 Euros per ton of CO_2 and targets all emissions except for those sectors already taxed by the ETS system.

Table 20 shows the direct and indirect effects of scenario 1 with varying ETS prices. Resident households would still pay 163.4 million Euros of direct carbon-related taxes. In comparison to scenario 1 with the ETS price of 2019, an ETS price of 100 Euros would lead to an increase of indirectly paid taxes.

The directly and indirectly paid taxes increase to 227.2 million Euros (average ETS price of 2021) and 233.9 million Euros (ETS price of 100 Euros) in Luxembourg. When considering the value chains in the group of European countries, taxes amount to 345.6 million Euros (average ETS price 2021) and 371.6 million Euros (ETS price of 100 Euros). The VAT paid by residents increases to 42.5 million Euros (average price 2021) and 44.8 million Euros (higher ETS price). Compared to the original scenario 1 in Section 7.3 (ETS price of 2019), the amount of total carbon-related taxes paid by the resident households would increase by 4.6% when taking the average ETS price of 2021 and by 12.5% with an ETS price of 100 Euros.

Figure 28 and Figure 29 offer graphic depictions of the direct and indirect effects of scenario 1, first with the average ETS price based on GHG emissions and then with the increased ETS price based on CO_2 emissions.

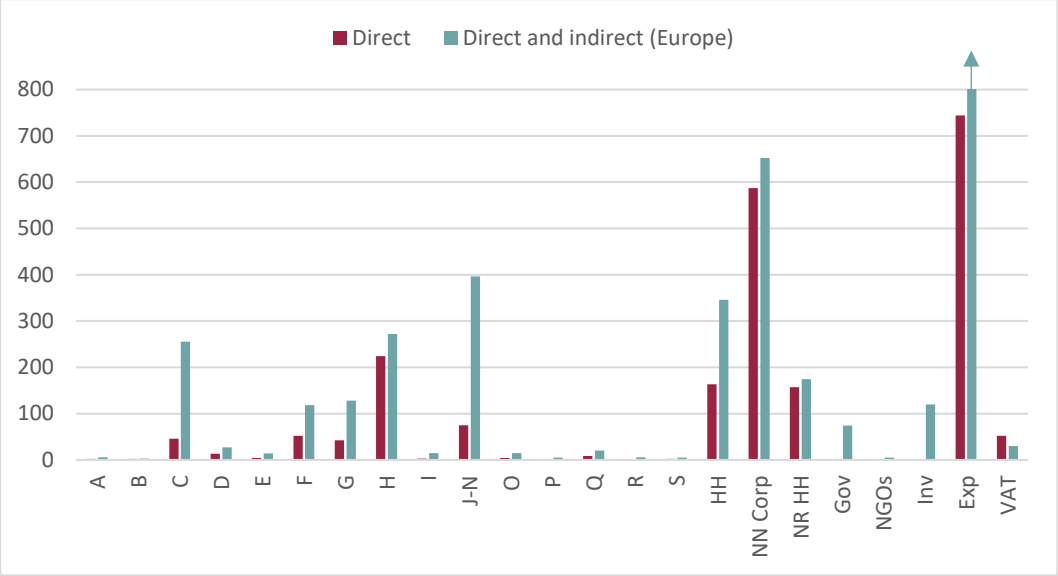
Table 21 shows directly and indirectly paid energy and transport taxes per unit of CO_2 emissions with varying ETS prices for scenario 1. Here, the resident households would pay more taxes per directly emitted ton of CO_2 (106.67 Euros) than resident corporations (98.66 Euros with the lower and 105.37 Euros with the higher ETS price).

Table 20: Direct and indirect effects of scenario 1 in million Euros with varying ETS prices, 2019.

	Average ETS price of year 2021 (52.63 Euros)			ETS price of 100 Euros		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	2.17	2.65	5.84	2.17	2.71	6.24
B	2.20	2.35	2.84	2.20	2.37	2.94
C	46.00	120.14	255.62	65.33	142.21	295.90
D	13.43	15.60	26.84	26.38	28.75	44.49
E	4.18	8.05	14.32	4.18	8.38	15.49
F	51.91	72.85	118.21	51.91	77.48	130.78
G	42.32	68.69	128.32	42.32	70.05	136.71
H	224.32	235.39	271.77	224.84	237.14	278.67
I	3.22	5.88	14.88	3.22	6.21	16.24
J-N	74.67	115.24	396.41	74.67	118.86	423.32
O	4.24	7.44	14.91	4.24	7.85	16.87
P	1.30	2.40	4.83	1.30	2.68	5.68
Q	8.76	11.65	20.50	8.76	12.20	22.69
R	1.69	2.75	5.92	1.69	3.01	7.04
S	1.91	2.88	4.67	1.91	3.00	5.13
Househ.	163.45	227.22	345.63	163.45	233.95	371.57
Sum of domestic entities	645.76	-	-	678.56	-	-
Govern.	-	41.08	74.13	-	42.34	80.04
NGOs	-	2.50	4.91	-	2.64	5.49
Invest.	-	51.00	120.11	-	55.00	133.19
Exports	744.19	1 068.01	1 512.07	744.19	1 088.65	1 579.33
Non-Res. Househ.	156.92	157.99	174.26	156.92	158.23	179.05
Non-Resi. Corp.	587.27	591.25	652.15	587.27	592.17	670.06
Sum of domestic entities plus exports	1 389.95	-	-	1 422.75	-	-
VAT Res.	25.15	34.98	42.46	25.15	36.06	44.80
VAT Non-Res.	26.68	26.86	29.62	26.68	26.90	30.44

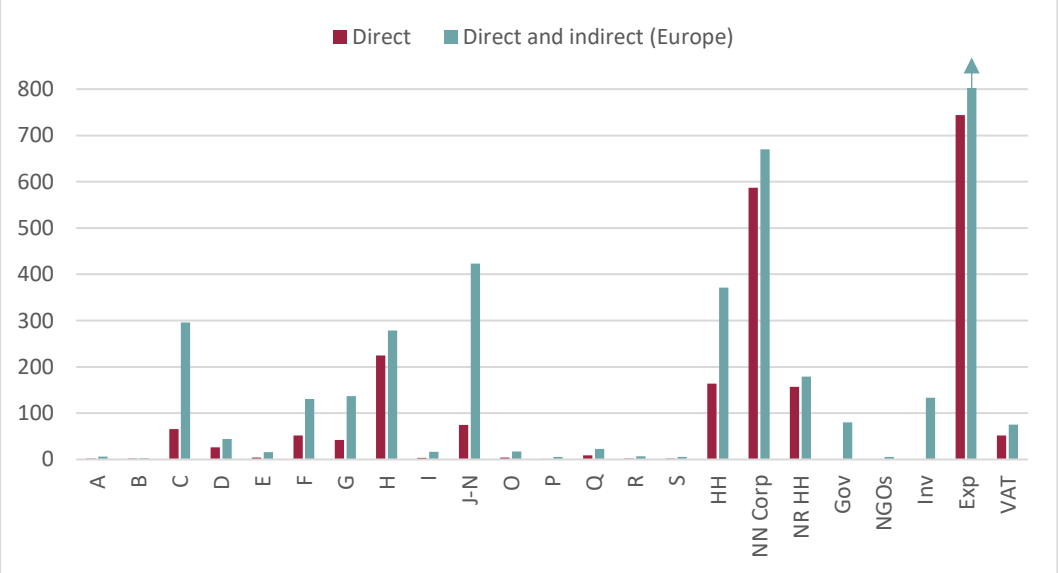
Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 28: Direct and indirect effects of scenario 1 based on GHG in million Euros with ETS price of 52.63 Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Figure 29: Direct and indirect effects of scenario 1 based on CO_2 in million Euros with ETS price of 100 Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Table 21: Energy and transport taxes of scenario 1 directly and indirectly paid per ton of CO_2 in Euros with varying ETS prices, 2019.

	Average ETS price of year 2021 (52.63 Euros)			ETS price of 100 Euros		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A – Agriculture	31.00	35.56	49.62	31.00	36.42	53.01
B – Mining	324.12	286.83	167.09	324.12	289.33	173.19
C – Manufacturing	30.12	66.35	61.35	42.79	78.54	71.02
D – Energy	52.32	56.50	50.35	102.76	104.11	83.45
E – Water and waste	238.57	186.83	98.46	238.57	194.45	106.53
F - Construction	337.94	148.49	83.10	337.94	157.93	91.94
G – Wholesale	188.34	187.73	107.34	188.34	191.44	114.36
H - Transport	113.78	114.16	102.53	114.04	115.00	105.13
I – Hospitality	81.39	86.35	77.72	81.39	91.13	84.86
J-N – Other sectors	170.45	147.19	107.57	170.45	151.82	114.88
O – Public administration	80.47	95.29	72.16	80.47	100.47	81.64
P – Education	67.31	80.50	66.47	67.31	89.83	78.30
Q – Health	124.73	120.45	86.53	124.73	126.15	95.76
R – Arts and recreation	58.82	70.97	61.02	58.82	77.48	72.53
S – Other services	154.19	139.98	90.79	154.19	145.83	99.78
Resident Corporations	98.66	98.66	81.46	105.37	105.37	89.37
Households	106.67	110.64	83.92	106.67	113.92	90.21
Sum of domestic entities	100.57	-	-	105.68	-	-
Government	-	202.26	114.75	-	208.48	123.90
NGOs	-	106.51	80.44	-	112.44	89.88
Investments	-	134.32	78.38	-	144.86	86.91
Exports	150.50	122.71	106.94	150.50	125.09	111.70
Non-Resident Households	150.50	150.40	121.27	150.50	150.63	124.60
Non-Resident Corporations	150.50	150.40	121.27	150.50	150.63	124.60
Sum of domestic entities plus exports	122.29	-	-	125.18	-	-

Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

9.3 Scenario 4 based on GHG

Scenario 4 assumes a carbon tax of 203.14 Euros per emitted ton of CO_2 or GHG emissions while keeping the already existing energy and transport taxes. While this section (9.3) analyzes scenario 4 based on GHG emissions, the subsequent chapter 9.4 focuses on scenario 4 based on CO_2 emissions.

Table 22 shows the direct and indirect effects of scenario 4 based on GHG with varying ETS prices. Direct and indirect taxes paid by the resident household increase to 758.2 million Euros (52.63 Euros, which is the average ETS price of 2021) and 784.2 million Euros (ETS price of 100 Euros) in total. The related VAT paid by residents increases to 95.6 million Euros and 98 million Euros, respectively. Expressed in percentages, the total amount of carbon-related taxes paid by the resident households would increase by 2.1% with the average ETS price and by 5.6% with the higher ETS price compared to scenario 4 in section 7.6., which is based on the 2019 ETS prices.

Analogous to the previous chapters, Figure 30 and Figure 31 offer graphic depictions of the scenario at hand. Both figures show direct and indirect effects of the current scenario based on GHG emissions, with the only difference being the varying ETS price. Figure 30 depicts the effects with the average ETS price of 2021, which is contrasted with the results of an ETS price of 100 Euros, as shown in Figure 31.

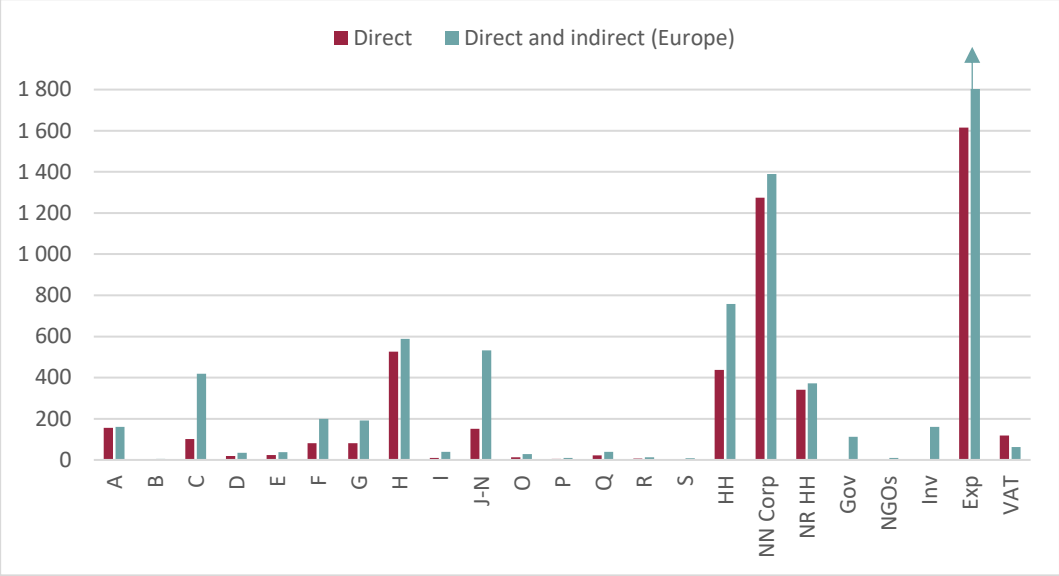
Table 23 shows taxes paid per ton of GHG emissions for the economic entities with varying ETS prices. Once again, resident households would pay more taxes per emitted ton of GHG emissions (277.55 Euros) than resident corporations (208.15 Euros per ton with the lower and Euros 213.82 Euros with the higher ETS price). When including indirect effects, the difference in prices decreases. Notably, the rather high assumed carbon tax leads to an overall minor price gap in this scenario.

Table 22: Direct and indirect effects of scenario 4 based on GHG in million Euros with varying ETS prices, 2019.

	Average ETS price of year 2021 (52.63 Euros)			ETS price of 100 Euros		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	156.25	157.88	161.08	156.25	157.95	161.48
B	3.40	3.75	4.24	3.40	3.77	4.34
C	100.81	283.99	419.47	120.15	306.06	459.74
D	18.33	23.48	34.72	31.28	36.63	52.36
E	23.12	30.90	37.16	23.12	31.23	38.33
F	81.82	153.98	199.34	81.82	158.61	211.91
G	81.56	132.69	192.31	81.56	134.04	200.70
H	526.45	552.09	588.47	526.97	553.84	595.37
I	10.10	29.57	38.56	10.10	29.89	39.93
J-N	151.19	250.91	532.08	151.19	254.53	558.99
O	13.43	20.90	28.36	13.43	21.30	30.32
P	4.66	7.32	9.75	4.66	7.60	10.61
Q	22.06	30.27	39.12	22.06	30.82	41.31
R	6.71	9.39	12.56	6.71	9.65	13.67
S	4.08	6.49	8.27	4.08	6.61	8.74
Househ.	438.20	639.83	758.24	438.20	646.56	784.17
Sum of domestic entities	1 642.18	-	-	1 674.99	-	-
Govern.	-	78.55	111.60	-	79.81	117.51
NGOs	-	7.05	9.46	-	7.18	10.03
Invest.	-	91.30	160.41	-	95.30	173.49
Exports	1 615.48	2 440.66	2 884.72	1 615.48	2 461.30	2 951.98
Non-Res. Househ.	340.65	343.06	371.41	340.65	343.30	376.20
Non-Resi. Corp.	1 274.82	1 283.84	1 389.96	1 274.82	1 284.76	1 407.89
Sum of domestic entities plus exports	3 257.66	-	-	3 290.46	-	-
VAT Res.	60.79	88.82	95.64	60.79	89.90	97.98
VAT Non-Res.	57.91	58.32	63.14	57.91	58.36	63.95

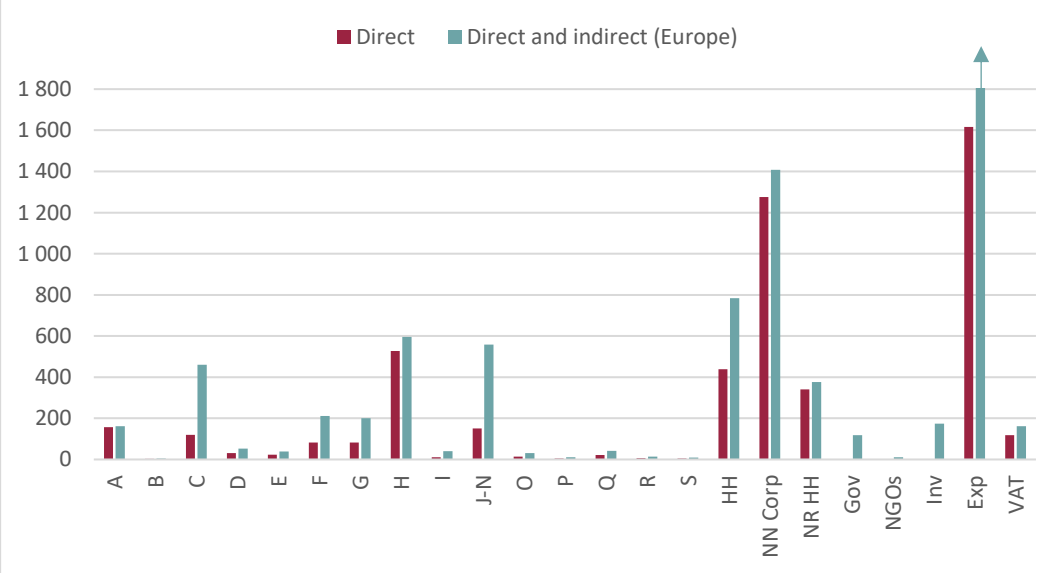
Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 30: Direct and indirect effects of scenario 4 based on GHG in million Euros with ETS price of 52.63 Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Figure 31: Direct and indirect effects of scenario 4 based on GHG in million Euros with ETS price of 100 Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Table 23: Energy and transport taxes of scenario 4 directly and indirectly paid per unit of GHG based on GHG in Euros with varying ETS prices, 2019.

	Average ETS price of year 2021 (52.63 Euros)			ETS price of 100 Euros		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A – Agriculture	203.23	203.46	184.29	203.24	203.54	184.74
B – Mining	493.59	441.12	229.08	493.59	443.54	234.69
C – Manufacturing	65.73	132.20	84.68	78.34	142.48	92.81
D – Energy	59.81	71.38	57.31	102.05	111.34	86.44
E – Water and waste	241.23	244.60	142.47	241.23	247.20	146.97
F - Construction	481.49	268.65	119.96	481.49	276.73	127.52
G – Wholesale	360.32	333.38	139.39	360.32	336.79	145.47
H - Transport	262.60	260.97	212.81	262.86	261.80	215.31
I – Hospitality	254.25	225.11	113.32	254.25	227.59	117.33
J-N – Other sectors	342.55	292.40	128.10	342.55	296.62	134.58
O – Public administration	253.30	248.11	121.33	253.30	252.92	129.71
P – Education	240.24	227.30	121.67	240.24	235.93	132.40
Q – Health	290.89	267.59	136.91	290.89	272.46	144.56
R – Arts and recreation	231.80	226.33	117.04	231.80	232.41	127.44
S – Other services	326.49	287.20	139.76	326.49	292.53	147.57
Resident Corporations	208.15	208.15	114.89	213.82	213.82	121.61
Households	277.55	263.76	148.70	277.55	266.53	153.78
Sum of domestic entities	223.04	-	-	227.50	-	-
Government	-	337.13	149.98	-	342.55	157.92
NGOs	-	253.43	126.77	-	258.44	134.51
Investments	-	206.66	90.75	-	215.71	98.15
Exports	321.85	263.83	186.31	321.85	266.06	190.66
Non-Resident Households	321.85	321.56	252.37	321.85	321.79	255.62
Non-Resident Corporations	321.85	321.56	252.37	321.85	321.79	255.62
Sum of domestic entities plus exports	263.10	-	-	265.75	-	-

Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

9.4 Scenario 4 based on CO_2

Table 24 shows the direct and indirect effects of scenario 4 based on CO_2 emission with, once again, varying ETS prices. The direct and indirect taxes paid by the resident households increase to 684.4 million Euros (ETS price of 52.63 Euros, average of 2021) and 710.4 million Euros (ETS price of 100 Euros) in total. The paid VAT increases to 85.1 million Euros (lower ETS price) and 87.5 million Euros (higher ETS price).

Figure 31 and Figure 32 depict the direct and indirect effects of the current scenario based on CO_2 emissions with varying ETS prices, first with the lower and then with the higher ETS price.

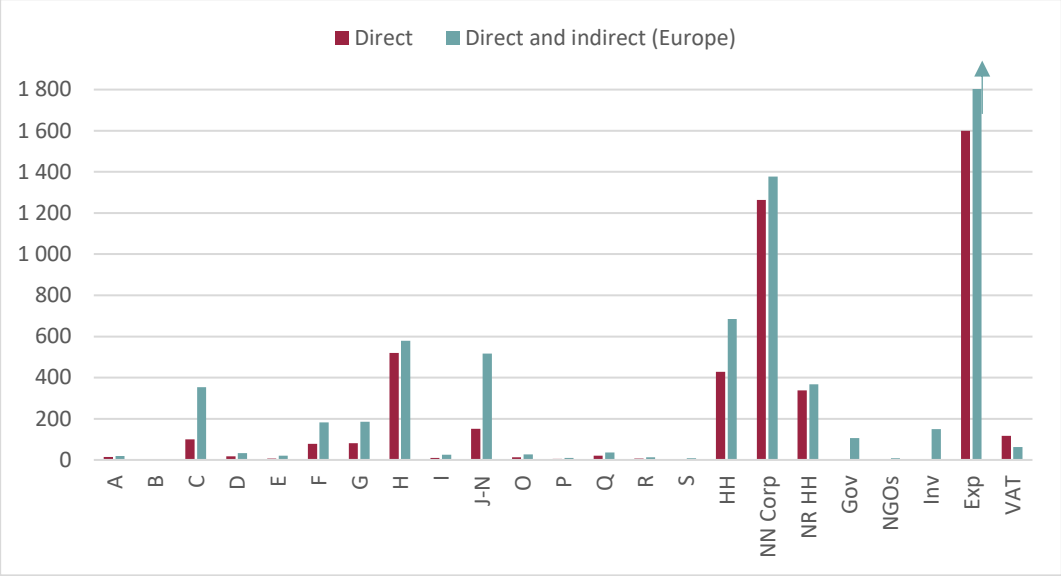
Table 25 shows energy and transport taxes directly and indirectly paid per ton of CO2 emissions for the economic entities with varying ETS prices. Once again, resident households would pay more taxes per emitted ton of CO2 (279.81 Euros) than resident corporations (211.29 Euros per ton of CO2). Considering the indirect effects, the price difference decreases analogous to the previous scenario in section 9.3.

Table 24: Direct and indirect effects of scenario 4 based on CO_2 in million Euros with varying ETS prices, 2019.

	Average ETS price of year 2021 (52.63 Euros)			ETS price of 100 Euros		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	14.31	15.36	18.56	14.31	15.42	18.96
B	3.38	3.70	4.19	3.38	3.72	4.29
C	100.51	217.51	352.99	119.84	239.58	393.26
D	17.42	21.96	33.19	30.37	35.10	50.84
E	7.20	14.06	20.32	7.20	14.39	21.49
F	78.50	137.62	182.98	78.50	142.25	195.55
G	81.23	126.43	186.06	81.23	127.78	194.44
H	520.15	541.94	578.32	520.67	543.68	585.22
I	10.05	16.80	25.80	10.05	17.13	27.17
J-N	150.53	236.35	517.53	150.53	239.98	544.44
O	13.37	19.77	27.23	13.37	20.17	29.19
P	4.64	6.91	9.34	4.64	7.19	10.20
Q	20.91	27.09	35.94	20.91	27.64	38.13
R	6.68	8.92	12.09	6.68	9.17	13.20
S	4.06	6.11	7.90	4.06	6.23	8.36
Househ.	428.73	566.00	684.42	428.73	572.73	710.35
Sum of domestic entities	1 461.67	-	-	1 494.47	-	-
Govern.	-	72.79	105.84	-	74.05	111.75
NGOs	-	6.20	8.61	-	6.34	9.19
Invest.	-	80.03	149.14	-	84.03	162.22
Exports	1 600.32	2 336.69	2 780.74	1 600.32	2 357.32	2 848.01
Non-Res. Househ.	337.45	339.75	368.10	337.45	339.99	372.89
Non-Resi. Corp.	1 262.87	1 271.45	1 377.57	1 262.87	1 272.35	1 395.49
Sum of domestic entities plus exports	3 061.99	-	-	3 094.79	-	-
VAT Res.	59.29	78.35	85.15	59.29	79.43	87.49
VAT Non-Res.	57.37	57.76	62.58	57.37	57.80	63.39

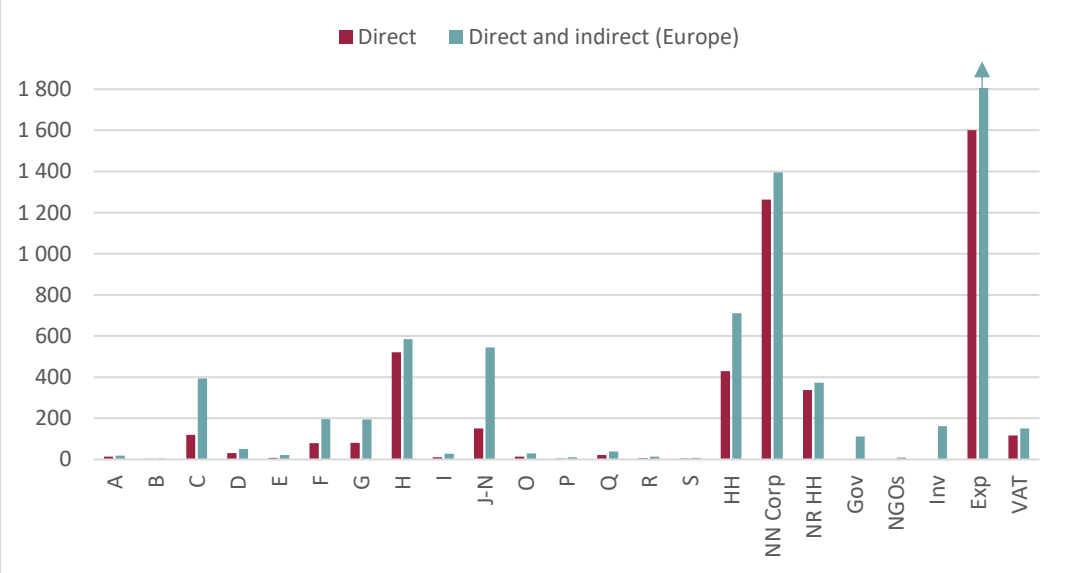
Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 32: Direct and indirect effects of scenario 4 based on CO_2 in million Euros with ETS price of 52.63 Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Figure 33: Direct and indirect effects of scenario 4 based on CO_2 in million Euros with ETS price of 100 Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports, VAT: Value-added tax. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway.

Table 25: Energy and transport taxes of scenario 4 directly and indirectly paid per unit of CO_2 based on CO_2 in Euros with varying ETS prices, 2019.

	Average ETS price of year 2021 (52.63 Euros)			ETS price of 100 Euros		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A – Agriculture	204.14	206.45	157.55	204.14	207.31	160.94
B – Mining	497.26	450.89	246.22	497.26	453.39	252.32
C – Manufacturing	65.82	120.12	84.72	78.49	132.31	94.39
D – Energy	67.87	79.49	62.27	118.31	127.10	95.36
E – Water and waste	411.71	326.17	139.76	411.71	333.79	147.83
F - Construction	511.08	280.51	128.63	511.08	289.95	137.47
G – Wholesale	361.48	345.52	155.64	361.48	349.23	162.66
H - Transport	263.83	262.82	218.18	264.10	263.67	220.78
I – Hospitality	254.53	246.76	134.79	254.53	251.54	141.93
J-N – Other sectors	343.59	301.90	140.44	343.59	306.53	147.74
O – Public administration	253.61	253.08	131.81	253.61	258.27	141.29
P – Education	240.45	232.03	128.66	240.45	241.35	140.50
Q – Health	297.87	280.11	151.71	297.87	285.82	160.93
R – Arts and recreation	231.96	229.91	124.60	231.96	236.42	136.11
S – Other services	327.33	296.71	153.61	327.33	302.56	162.60
Resident Corporations	211.29	211.29	122.46	218.00	218.00	130.36
Households	279.81	275.60	166.17	279.81	278.88	172.47
Sum of domestic entities	227.64	-	-	232.75	-	-
Government	-	358.41	163.84	-	364.62	172.99
NGOs	-	263.71	140.90	-	269.64	150.35
Investments	-	210.77	97.32	-	221.30	105.85
Exports	323.64	268.49	196.66	323.64	270.86	201.42
Non-Resident Households	323.64	323.42	256.17	323.64	323.65	259.50
Non-Resident Corporations	323.64	323.42	256.17	323.64	323.65	259.50
Sum of domestic entities plus exports	269.41	-	-	272.29	-	-

Source: Eurostat (2021a, 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

10 Conclusion

This study is an empirical analysis of current energy and transport taxation and carbon-related subsidies and four fictive carbon taxation schemes in Luxembourg on the sectoral level, utilizing an Environmentally Extended Input-Output Analysis (EE-IOA) and Eurostat data from 2019. These taxes include energy (1 billion Euros) and transport taxation (68 million Euros) from 2019, but also the carbon tax that was introduced in 2021. Besides commonly used units such as (domestic) industries and households, we also introduced additional units, such as foreign households and corporations, in our model.

With regard to GHG taxation and emissions, Eurostat's databases show that Luxembourg is a special case in Europe. While the country had by far the highest GHG emissions per capita in the EU (20.3 tons) in 2019, more than half of energy and transport taxation was paid by non-residents, which is far above the European average (3.5%). Moreover, only a small proportion of emissions in Luxembourg is covered by the ETS system (16.4%), while this share makes up almost 40% in the neighboring countries. In contrast, 64.6% of all ETS allowances in Luxembourg are free allocations, but only 55.9% Europe-wide. The data also suggests that Luxembourg will most likely not reach the EU's 2020 reduction goals.

Our EE-IO model allows us to calculate the sectoral effects of fictive carbon taxation schemes. Changes of consumption behavior, caused by changes in relative prices through new taxes, could not be considered. However, our results can provide first insights into short-term effects, as individual decision makers usually need time to adapt to new circumstances.

An analysis of current carbon-related taxation shows that 44% of the revenues generated by these were paid by non-resident corporations in 2019. The data also reveals a certain imbalance between households and companies. In 2019, resident households paid 17.1% more per emitted ton of GHG or 2% more per ton of CO_2 than the average resident corporation.

In the first fictive scenario we analyzed the effects of the planned carbon tax in Luxembourg in 2023, which amount to 30 Euros per ton of non-ETS CO_2 emissions. We find that this tax would generate 290 million Euros in revenue in the short run in addition to current taxation. In a revenue-neutral scenario in which every ton of GHG emission is taxed with the same amount, the agricultural sector would see the largest increase in tax burden compared to the current taxation as a result of its high methane production. Substituting all carbon-related taxation by a tax that equals Luxembourg's neighbors (plus the Netherlands) would on average increase revenues by 1.13 (CO_2 scenario) or 0.74 (GHG scenario) billion Euros in the short run. Introducing a carbon tax that aims at reflecting the

social cost of carbon (203.14 Euros per ton) would generate additional revenues of 1.96 (CO_2 scenario) or 2.16 (GHG scenario) billion Euros.

We find that the selected carbon-related subsidies analyzed in this study amount to 418 million Euros. Entities outside Luxembourgian territory (foreign households and corporations) profit the most from these subsidies, while households located in Luxembourg profit the least. Looking at the subsidies in detail reveals that the manufacturing sector (C) received the largest share of direct subsidies (68.5 million Euros) among the individual sectors. Along the value chains in Luxembourg the sector C receives another 13.6 million Euros of subsidies indirectly. All resident corporations collectively received 182.8 million Euros subsidies directly (43.8% of all direct subsidies). Resident households received 68.2 million Euros of direct subsidies (16.4% of all direct subsidies) and 97 million Euros subsidies in total, including indirect subsidies (considering the entire value chain in Luxembourg). Notably, non-resident entities received an overall share of direct subsidies of 165.9 million Euros, 39.8% of all direct subsidies) and in total (direct plus indirect) subsidies of 285.3 million Euros.

Finally, a sensitivity analysis with higher ETS prices was conducted. In the scenarios mentioned above, payments of Luxembourgian firms for ETS allowances are included in the Eurostat tax data of 2019. The average spot market price in 2019 was 24.65 Euros per ton of CO_2e emissions. The prices saw a strong increase after 2019 with an average price of 52.63 Euros in 2021. This sensitivity analysis was conducted ceteris paribus using the average ETS price for 2021 instead of the average price for 2019. As a second version, an ETS price of 100 Euros per ton of CO_2e emissions was used as a sensitivity check.

The total direct costs of a higher ETS price would be 19.4 million Euros (52.63 Euros per certificate) and 52.2 million Euros (100 Euros per certificate), respectively. These costs would be mainly paid by the resident corporations, more specifically by the manufacturing (C) and energy sectors (D) in Luxembourg. Considering the indirect effects and therefore the Luxembourgian value chain, the additional costs for the resident households would increase to 4 million Euros (10.7 million Euros). If we include indirect effects along the European value chains these costs increase to 15.3 million Euro (41.3 million. Euros). Furthermore, resident households would have to pay an additional VAT of 1.4 million Euros (3.8 million Euros). Overall, the amount of total carbon-related taxes paid by the resident households would increase by 5.6% with an ETS price of 52.63 Euros per certificate and by 15.2% with a price of 100 Euros compared to the base scenario (status quo in the year 2019).

We conclude that Luxembourg's economy is highly interconnected with its neighbors and the entire European Union. A large share of emissions in Luxembourg is produced by non-residents. Consequently, these non-domestic corporations and households already pay a

large share of carbon-related taxation and would continue to pay a large part of any planned tax. At the same time, non-domestic entities profit the most from carbon subsidies in Luxembourg. We suggest that policy makers in Luxembourg should develop a taxation scheme that is stronger linked to actual GHG and CO_2 emissions produced by the taxed unit, as this is currently not the case. In line with the OECD (2020a; 2010), we highly recommend that most carbon subsidies should be abolished, as they have the potential to undermine any future decarbonization attempt. We also recommend that Luxembourg should implement more ambitious measures for reaching the EU's 2030 GHG-reduction goals, as not reaching these goals would come with enormous damages that future generations worldwide (and thus also in Luxembourg) would have to carry.

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12 Appendix

Table 26: All energy and transport taxes (in million Euros) received by EU- and selected partner countries in 2019, as reported to Eurostat (2021b).

Country/Geographic unit	Energy taxes	Transport taxes
European Union - 27 countries (from 2020)	256 031.58	63 029.77
Belgium	8 945	3 066.3
Bulgaria	1 691.61	180.5
Czechia	4 301.44	269.38
Denmark	5 285.1	4 441.09
Germany	50 573.45	10 539.27
Estonia	817.05	13.37
Ireland	3 015.24	1 986.75
Greece	5 575	1 501
Spain	18 077	2 962.96
France	46 297	6 747
Croatia	1 474.98	429.47
Italy	47 127	10 687
Cyprus	458.9	114.22
Latvia	794.23	116.41
Lithuania	836.77	38.27
Luxembourg	1 012.59	68.27
Hungary	2 507.15	464.91
Malta	176.48	136.54
Netherlands	15 793	8 236
Austria	5 556.19	3 403.79
Poland	12 312.45	1 185.32
Portugal	3 919.59	1 458.62
Romania	4 408.93	313.93
Slovenia	1 344.12	204.42
Slovakia	1 984.19	233.09
Finland	4 584.3	2 113.15
Sweden	7 162.84	2 118.75
Iceland	245.7	114.3
Liechtenstein	22.01	25.83
Norway	4 705.97	2 637.07
Switzerland	6 387.72	2 541.22
United Kingdom	43 345.07	14 109.62
Serbia	1 630.69	133.97
Turkey	10 074.94	4 651.11

Table 27: Economic units (NACE-2) as used in Eurostat (2021a) Air Emissions Accounts.

Code	Description
A	Agriculture. forestry and fishing
A01	Crop and animal production, hunting and related service activities
A02	Forestry and logging
A03	Fishing and aquaculture
B	Mining and quarrying
C	Manufacturing
C10-C12	Manufacture of food products; beverages and tobacco products
C13-C15	Manufacture of textiles, wearing apparel, leather and related products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31_C32	Manufacture of furniture; other manufacturing
C33	Repair and installation of machinery and equipment
D	Electricity. gas. steam and air conditioning supply
E	Water supply; sewerage, waste management and remediation activities
E36	Water collection, treatment and supply
E37-E39	Sewerage, waste management, remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
G46	Wholesale trade, except of motor vehicles and motorcycles
G47	Retail trade, except of motor vehicles and motorcycles
H	Transportation and storage
H49	Land transport and transport via pipelines
H50	Water transport

H51	Air transport
H52	Warehousing and support activities for transportation
H53	Postal and courier activities
I	Accommodation and food service activities
J	Information and communication
J58	Publishing activities
J59_J60	Motion picture, video, television program production; programming and broadcasting activities
J61	Telecommunications
J62_J63	Computer programming, consultancy, and information service activities
K	Financial and insurance activities
K64	Financial service activities, except insurance and pension funding
K65	Insurance. reinsurance and pension funding, except compulsory social security
K66	Activities auxiliary to financial services and insurance activities
L	Real estate activities
L68A	Imputed rents of owner-occupied dwellings
M	Professional. scientific and technical activities
M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities
M71	Architectural and engineering activities; technical testing and analysis
M72	Scientific research and development
M73	Advertising and market research
M74_M75	Other professional, scientific and technical activities; veterinary activities
N	Administrative and support service activities
N77	Rental and leasing activities
N78	Employment activities
N79	Travel agency. tour operator and other reservation service and related activities
N80-N82	Security and investigation. service and landscape. office administrative and support activities
O	Public administration and defense; compulsory social security
P	Education
Q	Human health and social work activities
Q86	Human health activities
Q87_Q88	Residential care activities and social work activities without accommodation
R	Arts. entertainment and recreation
R90-R92	Creative. arts and entertainment activities; libraries. archives. museums and other cultural activities; gambling and betting activities
R93	Sports activities and amusement and recreation activities
S	Other service activities
S94	Activities of membership organizations
S95	Repair of computers and personal and household goods
S96	Other personal service activities

T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
U	Activities of extraterritorial organizations and bodies
TOTAL_HH	All NACE activities plus households
HH	Total activities by households
HH_HEAT	Heating/cooling activities by households
HH_TRA	Transport activities by households
HH_OTH	Other activities by households

Table 28: Full list of energy and transport taxes (in million Euros) in Luxembourg in 2019, as reported to Eurostat (2021b).

Code	Energy taxes	Transport taxes
A	0.07	0.00
A01	0.02	0.00
A02	0.05	0.00
A03	0.00	0.00
B	1.84	0.16
C	23.83	1.30
C10-C12	2.02	0.16
C13-C15	2.29	0.19
C16	0.53	0.04
C17	(c)	(c)
C18	(c)	(c)
C19	0.00	0.00
C20	(c)	(c)
C21	(c)	(c)
C22	(c)	(c)
C23	(c)	(c)
C24	(c)	(c)
C25	(c)	(c)
C26	(c)	(c)
C27	(c)	(c)
C28	(c)	(c)
C29	(c)	(c)
C30	(c)	(c)
C31_C32	(c)	(c)
C33	(c)	(c)
E36	0.13	0.01

E37-E39	3.24	0.27
F	43.61	3.69
G	32.92	2.66
G45	6.90	0.58
G46	20.48	1.63
G47	5.54	0.45
H	158.60	14.15
H49	146.77	12.72
H50	(c)	(c)
H51	(c)	(c)
H52	(c)	(c)
H53	(c)	(c)
I	1.88	0.15
J58	0.33	0.03
J59_J60	1.00	0.08
J61	(c)	(c)
J62_J63	(c)	(c)
K64	3.67	0.23
K65	0.00	0.00
K66	2.31	0.19
M69_M70	6.25	0.53
M71	2.98	0.25
M72	(c)	(c)
M73	0.96	0.08
M74_M75	(c)	(c)
N77	(c)	(c)
N78	(c)	(c)
N79	(c)	(c)
N80-N82	4.64	0.39
Q86	3.83	0.32
Q87_Q88	2.31	0.19
R90-R92	0.25	0.02
R93	0.52	0.04
S94	0.41	0.03
S95	0.32	0.03
S96	0.69	0.06
EP_HH	77.32	40.16
NAL	0.00	0.00
TOTAL_HH_NRES	1 012.59	68.27
D	5.00	0.09
E	3.37	0.28

EP_NRES	595.85	0
I-U	70.18	5.78
L	(c)	(c)
O	2.47	0.19
P	0.67	0.05
T	0.00	0.00
TOTAL	339.42	28.11
U	0.00	0.00

Note: (c) stands for values where Eurostat confidentiality rules apply and data cannot be reported.

Table 29: Standard VAT rates for selected European countries in 2021.

Country	Rate (%)	Country	Rate (%)
Belgium	21	Malta	18
Bulgaria	20	Netherlands	21
Czech Republic	21	Austria	20
Denmark	25	Poland	23
Germany	19	Portugal	23
Estonia	20	Romania	19
Ireland	23	Slovenia	22
Greece	24	Slovakia	20
Spain	21	Finland	24
France	20	Sweden	25
Croatia	25	Iceland	24
Italy	22	Liechtenstein	7.7
Cyprus	19	Norway	25
Latvia	21	Switzerland	7.7
Lithuania	21	United Kingdom	20
Luxembourg	17	Serbia	20
Hungary	27	Turkey	18

Sources: European Commission (2021b); GOV.UK (2022); Skatturinn (2022); OECD (2020b); PwC (2022); ch.ch (2022); Skatteetaten (Skatteetaten, 2022).

Table 30: Data basis for calculation of average carbon-related taxation in Luxembourg's neighboring countries, 2019 (2023).

	GHG	CO_2
Current energy and transport taxes (2019, Euros)	150 197 020 000.00	150 197 020 000.00
German Carbon Tax Revenues (2023, Euros)	15 619 786 536.90	12 183 948 385.00
ETS Revenues (2019, Euros)	4 687 454 400.00	4 687 454 400.00
Relevant taxation (Euros)	161 129 352 136.90	157 693 513 985.00
Emissions on national territory (2019, tons)	1 542 984 947.54	1 290 960 021.00
Verified ETS emissions (t CO_2e., 2019)	603 425 801.00	603 425 801.00
Relevant emissions	939 559 146.54	687 534 220.00
Tax per unit of emissions excl. ETS (Euros per ton)	171.49	229.36
Tax per unit of all emissions (Euros per ton)	107.46	125.78

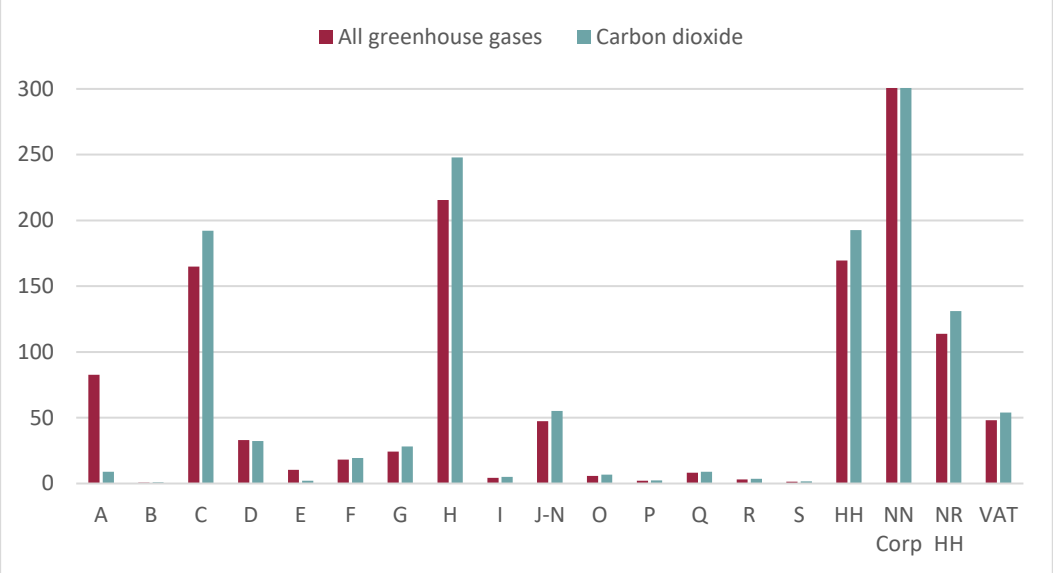
Sources: Eurostat (2021a; 2013); European Energy Exchange (2022); European Environmental Agency (2022); own calculations.

Table 31: Direct and indirect effects of taxation scenario 3, including ETS, in million Euros.

	All GHGs			CO_2		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	82.62	83.39	86.40	8.82	9.35	12.35
B	0.74	0.91	1.35	0.86	1.03	1.47
C	164.81	230.83	355.56	192.05	227.75	352.48
D	32.93	35.36	43.94	32.29	34.74	43.32
E	10.30	13.57	19.33	2.20	5.42	11.18
F	18.26	61.58	102.25	19.32	61.71	102.38
G	24.33	42.77	98.25	28.26	46.02	101.50
H	215.44	227.33	260.67	247.97	259.36	292.70
I	4.27	14.11	22.49	4.97	8.56	16.94
J-N	47.43	92.21	359.62	55.10	98.47	365.88
O	5.70	9.04	15.59	6.63	9.82	16.37
P	2.09	3.46	5.54	2.43	3.74	5.83
Q	8.15	12.16	20.05	8.83	12.16	20.05
R	3.11	4.46	7.12	3.62	4.88	7.54
S	1.34	2.43	4.01	1.56	2.59	4.17
Households	169.66	260.67	367.74	192.72	258.31	365.38
Sum of domestic entities	791.17	-	-	807.63	-	-
Govern.	-	25.04	55.34	-	25.54	55.12
NGOs	-	2.99	5.14	-	2.95	55.85
Invest.	-	47.47	111.22	-	47.75	111.50
Exports	539.38	994.09	1 410.61	621.94	1 094.69	1 511.20
Non-Resident Househ.	113.73	114.64	126.72	131.15	132.13	144.21
Non-Resident Corp.	425.64	429.01	474.24	490.79	494.46	539.68
Sum of domestic entities plus exports	1 330.54	-	-	1 429.57	-	-
VAT Residents	28.81	44.25	51.69	31.63	42.39	49.57
VAT Non-Residents	19.33	19.49	21.54	22.29	22.46	24.52

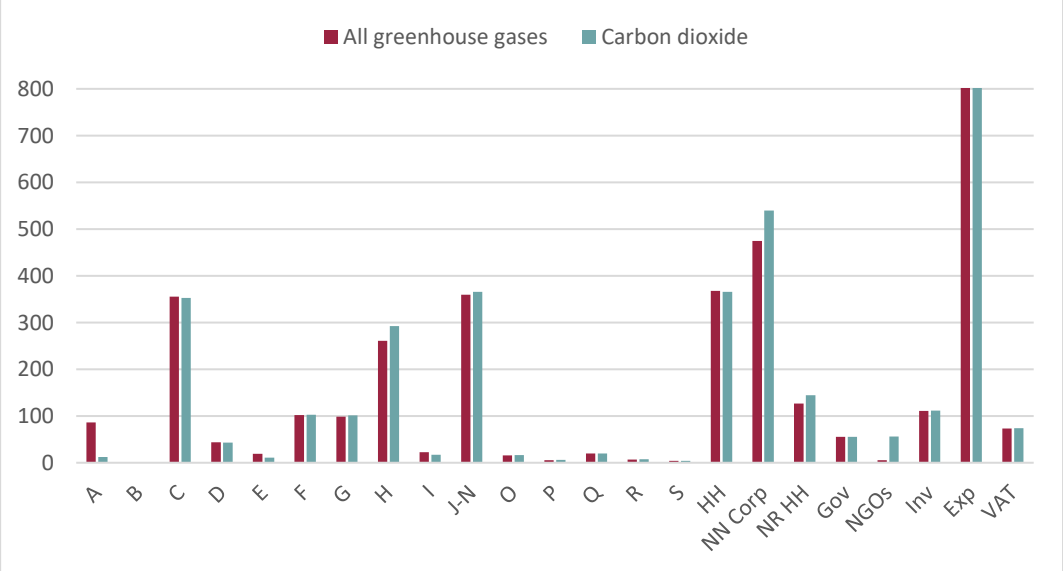
Source: Eurostat (2021a. 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 34: Direct effects of taxation scenario 3, including ETS, in million Euros.



Source: Eurostat (2021b; Eurostat, 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, VAT: Value-added tax.

Figure 35: Direct and indirect effects of taxation scenario 3, including ETS, in million Euros.



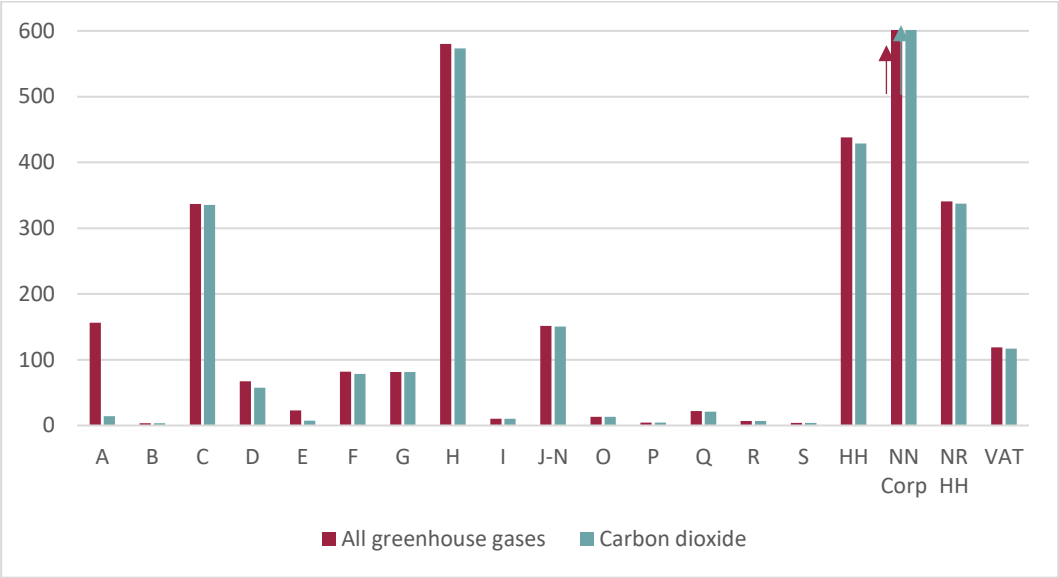
Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households.

Table 32: Direct and indirect effects of taxation scenario 4, including ETS, in million Euros.

	All GHGs			CO_2		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	156.25	158.05	161.05	14.31	15.51	18.51
B	3.40	3.83	4.27	3.38	3.78	4.22
C	336.68	526.60	651.33	335.30	458.07	582.79
D	67.34	73.58	82.16	57.24	62.84	71.42
E	23.12	32.47	38.23	7.20	15.57	21.33
F	81.82	175.31	215.98	78.50	158.56	199.23
G	81.56	138.74	194.21	81.23	132.22	187.69
H	580.01	610.98	644.32	573.23	600.12	633.46
I	10.10	30.47	38.85	10.05	17.62	26.00
J-N	151.19	266.42	533.84	150.53	251.14	518.55
O	13.43	22.16	28.71	13.37	20.93	27.48
P	4.66	7.99	10.07	4.64	7.50	9.58
Q	22.06	31.63	39.52	20.91	28.29	36.17
R	6.71	9.97	12.62	6.68	9.42	12.07
S	4.08	6.85	8.43	4.06	6.44	8.02
Househ.	438.20	657.31	764.38	428.73	581.72	688.79
Sum of domestic entities	1 980.61	-	-	1 789.36	-	-
Govern.	-	82.17	112.48	-	76.09	106.40
NGOs	-	7.43	9.59	-	6.55	8.70
Investm.	-	133.36	197.10	-	120.74	184.48
Exports	1 615.48	2 715.20	3 131.72	1 600.32	2 603.96	3 020.48
Non-Resident Househ.	340.65	343.06	367.23	337.45	339.74	363.91
Non-Resident Corp.	1 274.82	1 283.86	1 374.30	1 262.87	1 271.43	1 361.88
Sum of domestic entities plus exports	3 596.09	-	-	3 389.68	-	-
VAT Residents	60.79	91.16	97.23	59.29	80.43	86.49
VAT Non-Residents	57.91	58.32	62.43	57.37	57.76	61.86

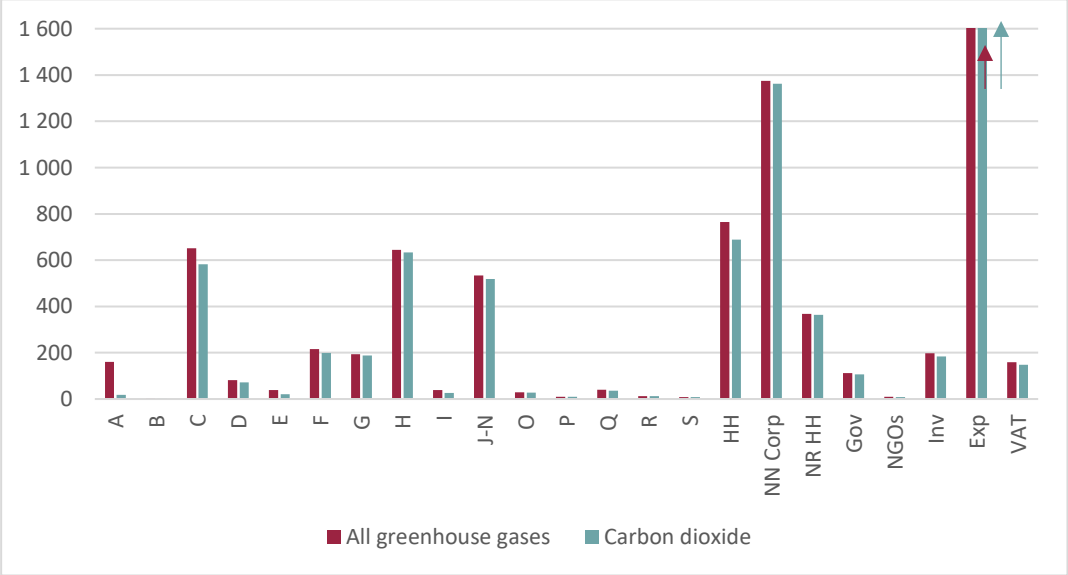
Source: Eurostat (2021a. 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Figure 36: Direct effects of taxation scenario 4, including ETS, in million Euros.



Source: Eurostat (2021b; Eurostat, 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, VAT: Value-added tax.

Figure 37: Direct and indirect effects of taxation scenario 4, including ETS, in million Euros.



Source: Eurostat (2021b; 2021a); own calculations. HH: Households, NR HH: Non-resident households, NR Corp: Non-resident corporations, Gov: Government consumption, NGOs: Non-governmental organizations, Inv: Investments, Exp: Exports. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households.

Table 33: Direct and indirect effects of taxation scenario 4 with no discount factor, excluding ETS, in million Euros.

	All GHGs			CO_2		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	545.93	550.66	553.66	49.84	52.54	55.54
B	6.89	7.81	8.25	6.83	7.62	8.06
C	249.73	721.84	846.56	248.66	489.48	614.21
D	24.64	38.12	46.70	21.46	32.78	41.36
E	71.69	90.30	96.06	16.07	31.44	37.21
F	167.94	381.68	422.34	156.35	324.47	365.14
G	196.29	316.51	371.99	195.11	294.63	350.11
H	1 407.86	1 473.74	1 507.07	1 385.82	1 438.25	1 471.59
I	30.23	93.19	101.57	30.07	48.59	56.97
J-N	374.88	639.63	907.04	372.57	588.76	856.18
O	40.31	59.56	66.11	40.08	55.60	62.15
P	14.50	21.39	23.47	14.42	19.97	22.05
Q	60.50	83.08	90.97	56.49	71.96	79.85
R	21.39	28.47	31.13	21.28	26.82	29.48
S	10.40	16.81	18.40	10.34	15.49	17.07
Househ.	1 238.39	1 811.76	1 918.83	1 205.30	1 553.75	1 660.82
Sum of domestic entities	4 461.58	-	-	3 830.69	-	-
Govern.	-	185.01	215.32	-	164.88	195.19
NGOs	-	19.89	22.05	-	16.93	19.08
Investm.	-	202.03	265.78	-	162.63	226.38
Exports	4 159.42	6 401.65	6 818.17	4 106.44	6 038.26	6 454.78
Non-Resident Househ.	877.08	883.23	937.55	865.91	871.65	925.97
Non-Resident Corp.	3 282.34	3 305.36	3 508.65	3 240.53	3 262.04	3 465.33
Sum of domestic entities + exports	8 621.00	-	-	7 937.13	-	-
VAT Residents	164.47	240.54	246.36	159.24	205.23	211.02
VAT Non-Residents	149.10	150.15	159.38	147.20	148.18	157.42

Source: Eurostat (2021a. 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Table 34: Direct and indirect effects of taxation scenario 4 with no discount factor, including ETS, in million Euros.

	All GHGs			CO_2		
Economic Unit	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A	545.93	551.38	554.38	49.84	53.19	56.19
B	6.89	8.14	8.58	6.83	7.95	8.39
C	1 113.99	1 615.32	1 740.05	1 109.18	1 375.80	1 500.52
D	222.66	240.34	248.93	187.34	202.81	211.40
E	71.69	96.45	102.22	16.07	37.40	43.16
F	167.94	465.76	506.43	156.35	407.24	447.91
G	196.29	340.47	395.95	195.11	317.67	373.15
H	1 596.11	1 683.16	1 716.50	1 572.42	1 645.20	1 678.54
I	30.23	97.02	105.40	30.07	52.11	60.49
J-N	374.88	701.32	968.74	372.57	647.91	915.33
O	40.31	64.82	71.36	40.08	60.51	67.06
P	14.50	24.29	26.37	14.42	22.59	24.67
Q	60.50	88.97	96.86	56.49	77.29	85.18
R	21.39	31.00	33.66	21.28	29.08	31.74
S	10.40	18.31	19.89	10.34	16.88	18.46
Househ.	1 238.39	1 886.77	1 993.84	1 205.30	1 622.58	1 729.65
Sum of domestic entities	5 712.12	-	-	5 043.70	-	-
Govern.	-	200.27	230.58	-	179.01	209.32
NGOs	-	21.54	23.69	-	18.45	20.60
Investm.	-	357.27	420.94	-	313.16	376.91
Exports	4 159.42	7 403.78	7 818.63	4 106.44	7 015.01	7 431.52
Non-Resident Househ.	877.08	883.74	938.06	865.91	872.14	926.46
Non-Resident Corp.	3 282.34	3 307.28	3 510.57	3 240.53	3 263.85	3 467.15
Sum of domestic entities + exports	9 871.54	-	-	9 150.14	-	-
VAT Residents	164.47	250.50	256.31	159.24	214.32	220.10
VAT Non-Residents	149.10	150.24	159.47	147.20	148.26	157.50

Source: Eurostat (2021a. 2021b); own calculations. Values that include indirect effects must not be added up, as this can lead to double counting of emissions. Exports also include non-resident corporations and non-resident households. Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Table 35: Disaggregated results, part 1.

	Tons of GHG in CO_2e			Tons of CO_2			Energy Taxes in mio. Euros			Transport Taxes in mio. Euros		
Sector	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A01	768 233	775 329	872 088	69 500	73 645	116 399	0.02	0.32	2.98	0.00	0.02	0.32
A02	610	2 629	4 201	600	895	1 683	0.05	0.06	0.11	0.00	0.00	0.01
B	6 886	8 500	18 454	6 800	8 225	17 040	1.84	1.94	2.32	0.16	0.17	0.22
C10-12	38 478	294 556	522 453	38 300	72 515	178 084	2.02	2.83	9.19	0.16	0.22	0.95
C13-15	66 648	74 700	138 162	66 500	73 275	128 943	2.29	2.77	5.51	0.19	0.23	0.57
C16	24 326	30 492	65 815	24 000	27 586	57 329	0.53	0.79	2.47	0.04	0.06	0.22
D	306 452	329 037	605 761	256 700	276 174	533 098	5.00	6.53	14.58	0.09	0.21	0.75
E36	907	3 158	16 658	900	2 771	14 882	0.13	0.23	0.65	0.01	0.02	0.06
E37-39	94 931	123 255	244 774	16 600	40 402	130 992	3.24	6.04	10.60	0.27	0.54	1.30
F	169 929	573 078	1 661 517	153 600	490 648	1 422 549	43.61	54.47	90.55	3.69	4.42	9.01
G45	36 543	46 181	88 673	36 200	44 067	78 461	6.90	7.66	9.37	0.58	0.64	0.92
G46	110 137	226 106	930 499	109 200	205 067	801 347	20.48	36.32	69.96	1.63	3.00	8.77
G47	79 688	131 891	381 564	79 300	122 440	333 881	5.54	10.29	22.99	0.45	0.82	3.05
H49	159 224	203 601	426 777	142 165	181 197	384 139	146.77	149.33	157.52	12.72	12.93	14.06
I	39 721	131 304	340 167	39 500	68 055	191 385	1.88	3.53	10.94	0.15	0.27	1.24
J58	5 238	10 914	39 648	5 200	10 063	35 145	0.33	1.25	2.80	0.03	0.11	0.38
J59_60	1 611	14 386	62 106	1 600	12 228	53 174	1.00	2.25	4.86	0.08	0.20	0.78
K64	230 347	420 723	2 455 363	229 300	392 237	2 191 533	3.67	21.08	156.59	0.23	1.62	47.16
K66	13 622	64 151	855 042	13 500	55 801	748 332	2.31	7.55	64.84	0.19	0.59	21.39

M69_70	20 566	108 737	523 872	20 300	97 120	465 280	6.25	11.83	29.90	0.53	0.97	5.12
M71	15 676	32 608	82 700	15 500	30 771	75 087	2.98	3.93	6.00	0.25	0.33	0.69
M73	2 431	6 211	24 576	2 400	5 643	21 666	0.96	1.32	2.29	0.08	0.11	0.27
N80	17 499	70 813	234 922	17 300	54 311	187 979	4.64	8.64	16.29	0.39	0.76	2.26
O84	53 034	84 156	233 670	52 700	78 087	206 550	2.47	4.71	10.37	0.19	0.36	1.24
P85	19 406	32 169	80 122	19 300	29 766	72 583	0.67	1.35	3.18	0.05	0.10	0.35
Q86	36 211	51 819	136 094	30 800	43 128	117 256	3.83	4.65	8.29	0.32	0.38	0.97
Q87_88	39 638	62 210	151 856	39 400	54 311	121 518	2.31	3.42	6.69	0.19	0.27	0.72
R90-92	10 760	17 713	53 451	10 700	16 252	47 942	0.25	0.60	1.86	0.02	0.05	0.20
R93	18 204	24 035	54 420	18 100	22 774	49 641	0.52	0.84	1.95	0.04	0.06	0.21
S94	5 633	11 703	29 807	5 600	10 408	24 872	0.41	0.83	1.53	0.03	0.06	0.17
S95	810	1 431	4 114	800	1 352	3 725	0.32	0.36	0.47	0.03	0.03	0.05
S96	6 042	9 491	25 334	6 000	8 850	22 833	0.69	0.89	1.47	0.06	0.07	0.15
Conf.	3 384 176	3 818 424	7 176 688	3 360 392	3 651 951	6 596 997	67.53	134.69	281.62	5.26	10.91	36.43

Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Table 36: Disaggregated results, part 2.

	Scenario 1, mio. €			Scenario 2 (GHG), mio. €			Scenario 2 (CO_2), mio. €		
Sector	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A01	2.11	2.52	5.48	75.70	76.30	79.26	7.55	7.91	10.86
A02	0.07	0.09	0.15	0.06	0.26	0.31	0.07	0.09	0.15
B	2.20	2.34	2.78	0.68	0.79	1.23	0.74	0.84	1.28
C10-12	3.33	5.13	12.22	3.79	28.68	35.77	4.16	7.53	14.62
C13-15	4.48	5.14	8.22	6.57	7.15	10.23	7.23	7.74	10.83
C16	1.29	1.64	3.49	2.40	2.89	4.74	2.61	2.89	4.74
D	5.78	7.84	16.42	2.71	4.36	12.94	2.51	3.99	12.57
E36	0.17	0.32	0.77	0.09	0.24	0.69	0.10	0.23	0.69
E37-39	4.01	7.56	12.88	9.35	11.36	16.69	1.80	3.55	8.87
F	51.91	70.12	110.78	16.74	44.80	85.47	16.69	40.65	81.32
G45	8.57	9.57	11.56	3.60	4.36	6.35	3.93	4.60	6.58
G46	25.39	44.86	84.27	10.85	20.19	59.60	11.87	20.05	59.45
G47	8.37	14.47	29.40	7.85	11.89	26.82	8.62	12.15	27.09
H49	163.75	167.42	176.74	15.69	19.11	28.43	15.45	18.69	28.02
I	3.22	5.69	14.07	3.91	12.41	20.79	4.29	6.86	15.24
J58	0.52	1.63	3.44	0.52	0.97	2.78	0.57	0.98	2.79
J59_60	1.13	2.73	5.92	0.16	1.14	4.33	0.17	1.03	4.22
K64	10.78	33.45	214.50	22.70	37.93	218.98	24.92	38.93	219.98
K66	2.91	9.56	87.66	1.34	5.47	83.57	1.47	5.15	83.25
M69_70	7.39	15.31	37.54	2.03	9.37	31.60	2.21	9.12	31.34

M71	3.70	5.11	7.54	1.54	2.95	5.39	1.68	3.07	5.50
M73	1.11	1.58	2.71	0.24	0.55	1.68	0.26	0.55	1.68
N80	5.55	10.71	19.86	1.72	5.92	15.07	1.88	4.77	13.92
O84	4.24	7.20	13.75	5.23	7.56	14.11	5.73	7.73	14.28
P85	1.30	2.23	4.32	1.91	2.77	4.85	2.10	2.83	4.92
Q86	5.07	6.20	10.43	3.57	4.68	8.91	3.35	4.27	8.49
Q87_88	3.68	5.21	8.93	3.91	5.73	9.45	4.28	5.50	9.22
R90-92	0.59	1.08	2.49	1.06	1.55	2.96	1.16	1.57	2.98
R93	1.10	1.54	2.80	1.79	2.21	3.47	1.97	2.32	3.58
S94	0.61	1.18	1.98	0.56	1.04	1.84	0.61	1.02	1.82
S95	0.37	0.43	0.56	0.08	0.12	0.25	0.09	0.13	0.26
S96	0.93	1.21	1.86	0.60	0.85	1.51	0.65	0.88	1.54
Conf.	129.36	209.51	381.96	187.39	225.02	397.47	204.90	231.51	403.96

Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Table 37: Disaggregated results, part 3.

	Scenario 3 (GHG. exc. ETS), mio. €			Scenario 3 (CO_2. exc. ETS), mio. €			Scenario 3 (GHG. incl. ETS), mio. €			Scenario 3 (CO_2. incl. ETS), mio. €		
Sector	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A01	131.74	132.79	135.75	15.94	16.69	19.64	82.55	83.32	86.27	8.74	9.26	12.22
A02	0.10	0.45	0.50	0.14	0.20	0.25	0.07	0.28	0.34	0.08	0.11	0.17
B	1.18	1.38	1.82	1.56	1.78	2.22	0.74	0.91	1.35	0.86	1.03	1.47
C10-12	6.60	49.92	57.01	8.78	15.89	22.98	4.13	31.65	38.74	4.82	9.12	16.21
C13-15	11.43	12.44	15.52	15.25	16.34	19.42	7.16	8.03	11.11	8.36	9.22	12.30
C16	4.17	5.03	6.88	5.50	6.09	7.94	2.61	3.28	5.13	3.02	3.47	5.32
D	4.72	7.58	16.16	5.29	8.41	17.00	32.93	35.36	43.94	32.29	34.74	43.32
E36	0.16	0.41	0.87	0.21	0.48	0.94	0.10	0.34	0.80	0.11	0.35	0.81
E37-39	16.28	19.77	25.10	3.81	7.49	12.81	10.20	13.24	18.57	2.09	5.08	10.40
F	29.14	77.97	118.63	35.23	85.80	126.46	18.26	61.58	102.25	19.32	61.71	102.38
G45	6.27	7.60	9.58	8.30	9.70	11.69	3.93	4.96	6.95	4.55	5.54	7.53
G46	18.89	35.14	74.55	25.05	42.31	81.72	11.84	24.30	63.70	13.74	25.79	65.20
G47	13.67	20.70	35.63	18.19	25.65	40.58	8.56	14.17	29.10	9.97	15.40	30.33
H49	27.31	33.25	42.58	32.61	39.46	48.78	17.11	21.88	31.20	17.88	22.79	32.11
I	6.81	21.59	29.97	9.06	14.47	22.85	4.27	14.11	22.49	4.97	8.56	16.94
J58	0.90	1.68	3.49	1.19	2.06	3.88	0.56	1.17	2.99	0.65	1.27	3.08
J59_60	0.28	1.98	5.17	0.37	2.18	5.37	0.17	1.55	4.74	0.20	1.54	4.73
K64	39.50	66.01	247.06	52.59	82.16	263.21	24.75	45.21	226.26	28.84	49.34	230.39
K66	2.34	9.52	87.61	3.10	10.88	88.98	1.46	6.89	84.99	1.70	7.02	85.12
M69_70	3.53	16.31	38.53	4.66	19.25	41.48	2.21	11.68	33.91	2.55	12.22	34.44

M71	2.69	5.14	7.57	3.56	6.47	8.90	1.68	3.50	5.94	1.95	3.87	6.30
M73	0.42	0.96	2.09	0.55	1.16	2.29	0.26	0.67	1.80	0.30	0.71	1.84
N80	3.00	10.31	19.46	3.97	10.07	19.22	1.88	7.61	16.76	2.18	6.83	15.98
O84	9.09	13.16	19.71	12.09	16.33	22.87	5.70	9.04	15.59	6.63	9.82	16.37
P85	3.33	4.81	6.90	4.43	5.98	8.07	2.09	3.46	5.54	2.43	3.74	5.83
Q86	6.21	8.15	12.37	7.06	9.00	13.23	3.89	5.57	9.80	3.87	5.42	9.65
Q87_88	6.80	9.97	13.70	9.04	11.61	15.33	4.26	6.69	10.41	4.96	6.83	10.55
R90-92	1.85	2.69	4.10	2.45	3.32	4.73	1.16	1.90	3.31	1.35	2.04	3.45
R93	3.12	3.85	5.11	4.15	4.90	6.16	1.96	2.58	3.84	2.28	2.86	4.13
S94	0.97	1.81	2.62	1.28	2.14	2.95	0.61	1.26	2.06	0.70	1.31	2.11
S95	0.14	0.22	0.34	0.18	0.27	0.40	0.09	0.15	0.28	0.10	0.17	0.30
S96	1.04	1.49	2.14	1.38	1.86	2.51	0.65	1.02	1.67	0.75	1.11	1.77
Conf.	326.12	391.61	564.05	432.46	488.63	661.08	363.66	410.33	582.78	422.67	459.34	631.79

Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Table 38: Disaggregated results, part 4.

	Scenario 4 (GHG. exc. ETS), mio. €			Scenario 4 (CO_2. exc. ETS), mio. €			Scenario 4 (GHG. incl. ETS), mio. €			Scenario 4 (CO_2. incl. ETS), mio. €		
Sector	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A01	156.08	157.64	160.60	14.14	15.12	18.07	156.08	157.84	160.79	14.14	15.30	18.25
A02	0.17	0.59	0.65	0.17	0.24	0.30	0.17	0.60	0.65	0.17	0.25	0.30
B	3.40	3.74	4.18	3.38	3.69	4.12	3.40	3.83	4.27	3.38	3.78	4.22
C10-12	10.00	62.19	69.28	9.96	17.12	24.22	10.00	62.89	69.98	9.96	17.78	24.87
C13-15	16.02	17.73	20.82	15.99	17.47	20.56	16.02	18.18	21.26	15.99	17.89	20.97
C16	5.51	6.81	8.66	5.45	6.24	8.09	5.51	7.04	8.89	5.45	6.45	8.30
D	10.68	15.72	24.30	9.77	14.19	22.77	67.34	73.58	82.16	57.24	62.84	71.42
E36	0.32	0.74	1.20	0.32	0.68	1.14	0.32	0.89	1.35	0.32	0.82	1.27
E37-39	22.79	30.00	35.32	6.88	13.21	18.53	22.79	31.61	36.94	6.88	14.78	20.11
F	81.82	151.25	191.92	78.50	134.88	175.55	81.82	175.31	215.98	78.50	158.56	199.23
G45	14.90	17.30	19.29	14.83	16.89	18.88	14.90	17.68	19.67	14.83	17.25	19.24
G46	44.48	80.95	120.36	44.29	76.80	116.21	44.48	85.26	124.66	44.29	80.98	120.39
G47	22.18	35.63	50.56	22.10	33.83	48.76	22.18	37.91	52.84	22.10	35.99	50.92
H49	191.83	201.65	210.97	188.37	197.20	206.52	191.83	203.61	212.94	188.37	199.06	208.38
I	10.10	29.37	37.75	10.05	16.61	24.99	10.10	30.47	38.85	10.05	17.62	26.00
J58	1.42	3.35	5.16	1.42	3.19	5.00	1.42	3.58	5.39	1.42	3.40	5.22
J59_60	1.41	4.80	7.99	1.41	4.37	7.56	1.41	5.37	8.56	1.41	4.93	8.12
K64	50.69	100.89	281.94	50.48	95.47	276.52	50.69	108.17	289.22	50.48	102.38	283.43
K66	5.27	19.41	97.51	5.24	17.78	95.87	5.27	21.17	99.27	5.24	19.48	97.57
M69_70	10.96	32.12	54.34	10.90	29.85	52.07	10.96	34.89	57.11	10.90	32.53	54.75

M71	6.41	10.35	12.78	6.38	9.99	12.43	6.41	10.89	13.32	6.38	10.51	12.95
M73	1.53	2.57	3.70	1.53	2.46	3.59	1.53	2.69	3.82	1.53	2.58	3.71
N80	8.58	21.61	30.75	8.54	18.31	27.46	8.58	23.78	32.93	8.54	20.43	29.57
O84	13.43	20.66	27.21	13.37	19.53	26.08	13.43	22.16	28.71	13.37	20.93	27.48
P85	4.66	7.16	9.24	4.64	6.75	8.83	4.66	7.99	10.07	4.64	7.50	9.58
Q86	11.51	14.68	18.90	10.41	13.00	17.23	11.51	15.55	19.78	10.41	13.79	18.02
Q87_88	10.55	15.51	19.23	10.50	13.97	17.70	10.55	16.33	20.05	10.50	14.73	18.45
R90-92	2.46	3.84	5.25	2.44	3.59	4.99	2.46	4.24	5.65	2.44	3.95	5.36
R93	4.26	5.46	6.72	4.24	5.24	6.50	4.26	5.78	7.04	4.24	5.52	6.79
S94	1.58	3.05	3.85	1.58	2.80	3.60	1.58	3.28	4.08	1.58	3.01	3.81
S95	0.51	0.65	0.78	0.51	0.64	0.76	0.51	0.68	0.81	0.51	0.67	0.79
S96	1.98	2.72	3.38	1.97	2.61	3.26	1.98	2.89	3.54	1.97	2.76	3.41
Conf.	459.10	609.48	781.93	455.81	578.37	750.82	760.25	921.28	1 093.72	755.42	887.46	1 059.91

Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Table 39: Disaggregated results, part 5.

	Subsidies, mio. €		Base sc. varying ETS (52.63 Euros), mio. €			Base sc. varying ETS (100 Euros, mio. €)		
Sector	**Direct**	**Direct and indirect (LU)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A01	9.94	10.13	0.02	0.38	3.52	0.02	0.44	3.90
A02	0.11	0.14	0.05	0.07	0.12	0.05	0.07	0.13
B	0.48	0.54	2.00	2.12	2.61	2.00	2.14	2.71
C10-12	3.47	7.09	2.18	3.17	10.71	2.18	3.36	11.68
C13-15	0.69	0.96	2.66	3.25	6.65	2.95	3.66	7.61
C16	0.57	0.78	0.68	1.00	3.01	0.87	1.26	3.54
D	7.48	8.41	12.74	14.50	26.30	25.41	27.38	44.61
E36	0.12	0.19	0.14	0.29	0.87	0.14	0.34	1.15
E37-39	1.48	2.58	3.51	6.74	12.45	3.51	7.02	13.37
F	7.57	22.96	47.30	61.61	106.62	47.30	66.20	118.58
G45	2.22	2.54	7.48	8.36	10.55	7.48	8.45	10.99
G46	5.14	8.93	22.11	39.78	81.78	22.11	40.55	86.95
G47	10.17	12.02	5.99	11.43	27.64	5.99	11.97	30.33
H49	7.96	9.33	159.49	162.55	173.10	159.49	163.04	175.68
I	2.63	4.69	2.03	3.99	12.98	2.03	4.33	14.35
J58	0.56	0.77	0.36	1.39	3.33	0.36	1.44	3.60
J59_60	0.04	0.61	1.08	2.51	5.90	1.08	2.61	6.34
K64	17.74	25.11	3.90	23.67	213.64	3.90	25.32	230.38
K66	1.47	3.47	2.50	8.34	89.40	2.50	8.68	94.75
M69_70	0.77	3.16	6.78	13.11	37.11	6.78	13.63	40.66

M71	1.12	1.58	3.23	4.33	6.98	3.23	4.44	7.45
M73	0.10	0.23	1.04	1.45	2.65	1.04	1.47	2.81
N80	0.58	2.51	5.03	9.63	19.37	5.03	10.04	20.78
O84	6.38	7.52	2.66	5.31	12.87	2.66	5.73	14.98
P85	1.79	2.22	0.72	1.62	4.10	0.72	1.91	5.05
Q86	3.06	3.59	4.15	5.21	10.02	4.15	5.52	11.31
Q87_88	3.44	4.20	2.50	3.85	8.05	2.50	4.11	9.13
R90-92	1.08	1.30	0.27	0.73	2.47	0.27	0.88	3.18
R93	1.30	1.49	0.56	0.97	2.49	0.56	1.08	3.04
S94	0.62	0.83	0.44	0.93	1.82	0.44	0.99	2.03
S95	0.02	0.04	0.35	0.40	0.54	0.35	0.41	0.57
S96	0.30	0.41	0.75	1.00	1.76	0.75	1.05	2.00
Conf.	82.36	94.90	84.23	159.05	344.08	103.59	181.82	388.16

Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Table 40: Disaggregated results, part 6.

	Scenario 1 (52.63 Euros), mio. €			Scenario 1 (100 Euros), mio. €		
Sector	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A01	2.11	2.56	5.70	2.11	2.63	6.09
A02	0.07	0.09	0.15	0.07	0.09	0.16
B	2.20	2.35	2.84	2.20	2.37	2.94
C10-12	3.33	5.25	12.79	3.33	5.44	13.75
C13-15	4.65	5.39	8.79	4.95	5.80	9.74
C16	1.40	1.80	3.81	1.59	2.06	4.34
D	13.43	15.60	27.40	26.10	28.48	45.71
E36	0.17	0.35	0.94	0.17	0.41	1.21
E37-39	4.01	7.72	13.43	4.01	8.00	14.35
F	51.91	72.83	117.85	51.91	77.42	129.80
G45	8.57	9.63	11.82	8.57	9.72	12.26
G46	25.39	45.31	87.32	25.39	46.08	92.48
G47	8.37	14.79	30.99	8.37	15.33	33.69
H49	163.75	167.71	178.26	163.75	168.20	180.84
I	3.22	5.89	14.88	3.22	6.22	16.24
J58	0.52	1.66	3.60	0.52	1.71	3.87
J59_60	1.13	2.79	6.18	1.13	2.89	6.62
K64	10.78	34.42	224.39	10.78	36.07	241.13
K66	2.91	9.76	90.82	2.91	10.10	96.17
M69_70	7.39	15.62	39.63	7.39	16.15	43.18

M71	3.70	5.17	7.82	3.70	5.28	8.29
M73	1.11	1.60	2.81	1.11	1.62	2.96
N80	5.55	10.95	20.69	5.55	11.36	22.10
O84	4.24	7.45	15.00	4.24	7.86	17.12
P85	1.30	2.40	4.88	1.30	2.69	5.83
Q86	5.07	6.39	11.20	5.07	6.70	12.49
Q87_88	3.68	5.36	9.57	3.68	5.62	10.65
R90-92	0.59	1.17	2.91	0.59	1.32	3.61
R93	1.10	1.61	3.13	1.10	1.72	3.68
S94	0.61	1.21	2.10	0.61	1.27	2.31
S95	0.37	0.43	0.57	0.37	0.44	0.61
S96	0.93	1.24	2.00	0.93	1.30	2.24
Conf.	140.79	222.96	408.00	160.15	245.74	452.07

Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.

Table 41: Disaggregated results, part 7.

	Scenario 4 GHG-based (52.63 Euros)			Scenario 4 GHG-based (100 Euros)			Scenario 4 CO_2-based (52.63 Euros)			Scenario 4 CO_2-based (100 Euros)		
Sector	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**	**Direct**	**Direct and indirect (LU)**	**Direct and indirect (Europe)**
A01	156.08	157.68	160.82	156.08	157.74	161.21	14.14	15.16	18.30	14.14	15.22	18.68
A02	0.17	0.59	0.65	0.17	0.59	0.66	0.17	0.24	0.30	0.17	0.24	0.31
B	3.40	3.75	4.24	3.40	3.77	4.34	3.38	3.70	4.19	3.38	3.72	4.29
C10-12	10.00	62.30	69.84	10.00	62.49	70.81	9.96	17.24	24.78	9.96	17.43	25.75
C13-15	16.20	17.98	21.38	16.49	18.40	22.34	16.17	17.72	21.12	16.46	18.14	22.08
C16	5.62	6.96	8.97	5.81	7.23	9.51	5.56	6.40	8.41	5.75	6.66	8.94
D	18.33	23.48	35.28	31.00	36.36	53.59	17.42	21.95	33.75	30.10	34.83	52.06
E36	0.32	0.77	1.36	0.32	0.83	1.64	0.32	0.71	1.30	0.32	0.77	1.58
E37-39	22.79	30.16	35.87	22.79	30.44	36.79	6.88	13.38	19.08	6.88	13.65	20.00
F	81.82	153.96	198.98	81.82	158.55	210.94	78.50	137.60	182.61	78.50	142.19	194.57
G45	14.90	17.36	19.55	14.90	17.45	19.99	14.83	16.95	19.14	14.83	17.05	19.58
G46	44.48	81.41	123.41	44.48	82.18	128.57	44.29	77.26	119.26	44.29	78.02	124.42
G47	22.18	35.95	52.15	22.18	36.49	54.85	22.10	34.15	50.36	22.10	34.69	53.05
H49	191.83	201.94	212.49	191.83	202.43	215.07	188.37	197.49	208.05	188.37	197.99	210.63
I	10.10	29.57	38.56	10.10	29.90	39.93	10.05	16.81	25.80	10.05	17.14	27.17
J58	1.42	3.38	5.32	1.42	3.43	5.59	1.42	3.22	5.16	1.42	3.26	5.43
J59_60	1.41	4.86	8.25	1.41	4.96	8.69	1.41	4.43	7.82	1.41	4.54	8.27
K64	50.69	101.87	291.83	50.69	103.51	308.57	50.48	96.44	286.41	50.48	98.09	303.15
K66	5.27	19.61	100.67	5.27	19.95	106.02	5.24	17.98	99.03	5.24	18.32	104.38
M69_70	10.96	32.43	56.43	10.96	32.95	59.98	10.90	30.16	54.16	10.90	30.68	57.71

M71	6.41	10.41	13.06	6.41	10.52	13.53	6.38	10.06	12.71	6.38	10.17	13.18
M73	1.53	2.58	3.79	1.53	2.61	3.95	1.53	2.47	3.68	1.53	2.50	3.84
N80	8.58	21.85	31.59	8.58	22.25	32.99	8.54	18.55	28.29	8.54	18.96	29.70
O84	13.43	20.90	28.46	13.43	21.32	30.57	13.37	19.77	27.32	13.37	20.18	29.44
P85	4.66	7.33	9.80	4.66	7.61	10.76	4.64	6.92	9.40	4.64	7.21	10.35
Q86	11.51	14.86	19.67	11.51	15.17	20.96	10.41	13.18	17.99	10.41	13.50	19.29
Q87_88	10.55	15.66	19.87	10.55	15.92	20.95	10.50	14.13	18.33	10.50	14.39	19.41
R90-92	2.46	3.93	5.66	2.46	4.07	6.37	2.44	3.67	5.41	2.44	3.82	6.12
R93	4.26	5.53	7.05	4.26	5.64	7.60	4.24	5.30	6.82	4.24	5.42	7.37
S94	1.58	3.08	3.97	1.58	3.14	4.18	1.58	2.83	3.72	1.58	2.89	3.93
S95	0.51	0.66	0.80	0.51	0.66	0.83	0.51	0.64	0.78	0.51	0.65	0.82
S96	1.98	2.76	3.52	1.98	2.81	3.76	1.97	2.64	3.41	1.97	2.70	3.65
Conf.	470.54	622.93	807.96	489.90	645.70	852.04	467.25	591.82	776.85	486.61	614.59	820.93

Europe includes EU27, the United Kingdom, Switzerland and Norway. Results are presented before handing over to the next element of the production process.