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PART 3/3

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT REPORT

Accompanying the document

Proposal for a Council Directive

restructuring the Union framework for the taxation of energy products and electricity (recast)

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ANNEX 6: COST ASSESSMENT OF AIR POLLUTION

1. Objective

The objective of this methodology is to assess the cost of non-GHG air pollutants emitted by the consumption of energy products (e.g. fuel combustion) and to take it into account in the EU-wide minimum rates defined in the Energy Taxation Directive (ETD).

The amount of air pollution emitted by individual sources depends a lot on the combustion characteristics and filtering systems. In addition, the impact of the pollutants emitted depends on the location of air pollutant emissions (notably on the proximity to densely populated areas). The ETD however relies on EU-wide minimum rates for types of energy products (e.g. gasoil, petrol, coal, natural gas) and for two usages (motor fuel and heating fuel). For these reasons, the methodology adopts a conservative approach and targets an approximate low-end value for the air pollution cost assessment so that it can be applied to the ETD's types of fuels and usages for all motors and heating systems independently of combustion and filtering devices or of location.

2. Scope

The methodology focusses on the types of energy products and usages that are in the scope of the proposed revision of the ETD.

Consequently, only the end use or final consumption of energy products are in the methodology's scope and, in particular, energy products used for the production of electricity are out of scope.

3. Overview

An ETD air pollution component, expressed in €/quantity of fuel[1] used, can be computed for (non-GHG) air pollution as the sum of a PM2.5 tailpipe emission component and a NOx emission component, where each of these components is computed by multiplying an emission factor, by a mortality ratio (in terms of premature deaths or years of life lost), by a compatible valuation of mortality (also related to premature deaths or years of life lost):

$$A_p * \frac{B_p\ (or B_p{}^*)}{C_p} * D\ (or D^*) = \frac{€_p}{quantity\ of\ fuel}$$

Where

- A_p = pollutant emission factor for the fuel and user category considered (in g per quantity of fuel), as used to compute the pollutant p Emission Inventories under the National Emission reduction Commitments (NEC) directive;
- B_p or B_p* = premature deaths or Years of Life Lost (in number per year) attributable to the pollutant p, as computed and reported by the European Environment Agency;
- C_p = are the emissions of pollutant p (in kt per year), as reported by the MS in their inventories under the NEC directive;
- D or D* = Value of Statistical Life or Value of Life Years for the EU (in € per premature death or Year of Life Lost), as computed by the OECD and used in

[1] In this explanation we use "fuel" to mean any type of energy source used by activities under the scope of the ETD, be it in liquid, gas or solid form, of renewable or fossil source, and including electricity.

different impact assessments. Each of these components has to be used in an internally consistent way, specifically use Value of Statistical Life (D) to value premature deaths due to the emissions (B), and Value of Life Years (D*) to value Years of Life Lost (B*).

In other words, the ETD air pollution component is computed as

$$\frac{€_{PM2.5}}{quantity\ of\ fuel} + \frac{€_{NOx}}{quantity\ of\ fuel}$$

This can be expressed in € per mass (kg), or € per volume (litre), or € per energy content, through simple multiplication with the appropriate conversion factors for each fuel considered.

4. Detailed description and Assumptions

It should be noted that this approach limits the computation to covering only the main health impacts of air pollution (i.e., ignores non-health impacts such as impacts on resource availability, ecosystem impacts -including on agricultural output-, impacts to buildings and aesthetic/ethical impacts), and even then only a sub-set of the health impacts are covered (e.g., it ignores impacts on morbidity). It is generally considered in the literature that in the EU, health impacts account for about 90% of the value of air pollution impacts[2].

Moreover, we also only cover the impacts arising from PM2.5 and from NOx emissions, thus ignoring other air pollutants relevant under the NEC. This choice to cover only PM2.5 and NOx is based on the fact that these are generally considered to be the two main health concerns in terms of air pollution in the EU[3]. A third air pollutant of concern is ozone. However, whereas ozone results from primary pollutants emissions related to fuel combustion, ozone is not directly emitted and its formation is strongly driven by weather patterns, making it extra difficult to establish stable links to fuel consumption. As such, although fuel combustion does play an important role in ozone formation, we choose to ignore it in the computations and restrict the calculation to primary pollutants (directly emitted by the vehicles) to avoid the introduction of assumptions that would increase complexity and uncertainty.

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[2] See for instance the Second Clean Air Outlook report (COM(2021)3) and its supporting reports:
https://ec.europa.eu/environment/air/pdf/CAO2-MAIN-final-21Dec20.pdf
https://ec.europa.eu/environment/air/pdf/CAO2-ANNEX-final-21Dec20.pdf
But also : https://epha.org/wp-content/uploads/2018/11/embargoed-until-27-november-00-01-am-cet-time-ce-delft-4r30-health-impacts-costs-diesel-emissions-eu-def.pdf; See in particular table 2 (page 8) and the 1st para in the executive summary *"(…)the total of the health and non-health related costs of road traffic related air pollution in the EU28 in 2030 is estimated at €19.5 billion; of which € 18.3 billion are health-related (…). When using the adjusted emission factors (TRUE), the sum of the 2030 health and non-health related costs amount €25.6 billion (of which € 23.3 billion are health-related) (…)"*. The first sentence in page 24 "*Most of the damage costs for traffic air pollution are related to health costs (90-100%)*" and Table 9 (page 27) also states the same thing.

[3] The WHO (https://www.who.int/airpollution/ambient/pollutants/en/) and EEA state that the pollutants with the strongest evidence of health effects are particulate matter (PM), ozone (O3), nitrogen dioxide (NO2) and sulphur dioxide (SO2).
While remains pertinent in other regions of the world, SO_2 is by now a much smaller issue in the EU where its emissions went from 7604 Gg in 2005 to 2031 Gg in 2018 (https://www.eea.europa.eu/data-and-maps/dashboards/necd-directive-data-viewer-3).

The overall goal is to capture the value of the externality generated by the combustion of the fuels covered, following the segmentation of fuel types, user categories and usages allowed/used in the ETD. The separation of distribution channels for each fuel type should also be taken into consideration, as it is relevant for the practical feasibility of the segmentation. For instance Diesel used for road transport might be differentiated for Diesel used for Agriculture or for diesel used for Rail transport (to the extent that these have different distribution channels), but it is only feasible to segregate Diesel used by road passenger cars from diesel used by trucks if these would be effectively segregated in the distribution channel (eg by always using separate pumping/measuring facilities). Since this is currently not the case, all uses for road fuels are aggregated together by fuel type.

It should also be noted that usage of electricity (for instance, in battery-electric vehicles) and of hydrogen in fuel cells generates no combustion air pollution emissions and as such the corresponding ETD air pollution component for these energy sources is always zero.

Beyond this general setup there are a series of specific choices to be made about each of the components of the computation regarding:

1) Valuation of Mortality (D)
   This expresses the social cost of the health impacts, in terms of €/premature death, or €/Year of Life lost attributable to emissions of the pollutant. This is the same for all air pollutants.
   One option is to do the computations based on the number of premature deaths (i.e., using Value of Statistical Life and mortality factors in terms of Premature Deaths). Another option is to do the computations based on the number of Years of Life Lost, combined with the Value of Life Years (VOLY).
   Under both options we use the **same VSL/VOLY value for the whole EU population**, rather than MS-specific values.
   We use the VSL/VOLY values recommended by DG ENV's consultants when valuing air pollution (which are based on the latest OECD meta-study of VSL and VOLY). These are 3,060,000€ for VSL and 79,500€ for VOLY, both expressed in 2005€s, which are then converted to 2019€ to account for EU 27 inflation since then (about 26%). We do this by considering the values of the Annual Consumer Price Index for the EU, as published by Eurostat.
   We eventually used the **Years of Life Lost and VOLY** for the assessment of the cost of air pollution due to fuel combustion. Indeed, Premature Deaths and VSL are more appropriate for assessing the impact of sudden deaths such as in car accidents.

2) Mortality ratios (B/C)
   This expresses the number of Premature Deaths/kg of emissions, or the number of Years of Life Lost /kg of emissions. This varies with each air pollutant.
   Consistent with using the same VOLY for the whole EU, we use **EU27 average mortality ratios**, rather than MS-specific values (i.e. we consider B/C, where B is EU number of Years of Life Lost attributable to emissions of the pollutant and C is EU total emissions of the pollutant).
   It is important to recognise that the measures of mortality B are computed based on actual measurements of pollutant concentrations at different locations in the EU 27 and considering the populations exposed to them. As such, these concentrations (and the resulting mortalities) capture the effects of all sources of emissions, including primary and secondary pollutants, as well as both natural and anthropogenic sources. It is thus important to ensure that the same scope of emissions driving the mortality (the numerator B) is captured in the denominator (C) of the mortality ratio. If some of

the emission sources explaining the mortality values are not counted in C, then we would be charging fuel-consuming entities for the damage attributable to non-anthropogenic and secondary pollutants. As such, in order that the emission amounts considered for the denominator C have the same scope as the mortality numbers used in the numerator B of the mortality ratio, we compute C using the emission data from the CLRTAP emission inventories with the following rules:

a. We include all sources of primary pollutants, except for international maritime and cruising aviation emissions
b. We compute secondary PM2.5 pollution based on non-PM2.5 primary pollutants, using the MS specific mortality equivalent conversion factors used for the NEC Directive impact assessment (TSAP report 15, Annex 2), ie

$$PM2.5sec_i = K_{SO2i}*SO_{xi} + K_{NOxi}*NO_{xi} + K_{NH3i}*NH_{3i} + K_{VOCi}*NMVOC_i$$

One may note that B/C*D gives a measure of the damage value of the air pollutant, i.e. €/kg of emissions. This will vary with each air pollutant.

3) Emission Factors (A).

These express the amount of emissions which results from the combustion of one unit of the fuel.
We take the emission factor values from the EMEP/EEA guidebook[4] , which Member States must use[5] when submitting their national emission inventory data.
Regardless of the unit used to measure fuel used (be it energy, mass, or volume), the emission factors will vary depending not only on the fuel considered, but also on the broad user category (e.g., road transport vs residential heating), specific type of usage (e.g., large cars/small cars/vans/trucks), and technology used in the combustion and emission after-treatment (each with different emission factors). In this regard, it should be noted that the emission factor for a given technology and user category will vary from one type of usage to another, based on the different usage patterns of each usage type. Moreover, for each fuel/user category/usage combination, the emission factors used by MS for the determination of their national emissions inventories are in many cases presented in a range (capturing the different technologies available), with the MSs then using the values from those ranges that best capture their specific realities of usage in each MS (the validity of this process is assessed by the Commission at the moment of submitting the emission inventories).

In our computations, we chose to always **use the minimum value of emission factors** available in the EMEP/EEA guidebook for a given fuel/user category combination, to provide a conservative measure of the externality, consistent with it being used for establishing minimum rates.

[4] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019
[5] unless they can provide better data more suited to national circumstances

Specific attention is also devoted to several user categories, where there is more detailed information about the distribution of usages and technologies for each fuel in the EU is available.

a. Road Transport

i. Aggregating emission factors for multiple usages of a given fuel up to a value per fuel.

Road transport emission factors vary with the category of vehicle used (passenger car vs light commercial vehicle, vs buses vs heavy-duty trucks vs L-category vehicles), segment within each category (small vs large-SUV-Executive passenger cars, rigid heavy duty trucks <7.5T vs articulated heavy duty trucks 50-60T), the technology used (older vehicles tend to equip less efficient emission reduction technologies), but also the patterns of usage inherent in each vehicle category (cold-engine combustion typically represent a much smaller proportion of fuel consumption in buses or heavy duty trucks than in small passenger cars.

We compute the powertrain type & vehicle type-weighted average emission factor for each fuel under the conservative **assumption that all the users of a given fuel would only have vehicles with the cleanest technology as of 2020**. This is implemented by only considering the emission factors of the new vehicles as of 2020, based on the SIBYL 2015 dataset projections for 2020.

In other words, we treat all the dirtier, older vehicles on the road as if they were brand-new vehicles with the cleanest technologies on the market by 2020. It is clear that this conservative hypothesis captures only a fraction of all the road emissions that will actually take place in 2020. Indeed the overwhelming majority of road transport fuel consumption in 2020 will be made by vehicles with more than 1 year, which generally have dirtier technologies (sometimes by several multiples for vehicles only a few years apart) and in reality will generate more pollutants per amount of fuel consumed than what assign them with our estimates.

For each of the vehicle categories and segments within a given fuel, we compute the disaggregated "new 2020 vehicle" emission factors as the EU27 average emission factor for new vehicles as of 2020 (total EU27 emissions by each vehicle category and segment divided by total EU27 TJ of fuel consumed by the vehicle category and segment). These disaggregated "new 2020 vehicle" emission factors are then aggregated up to a value per fuel as the weighted average of the disaggregated "new 2020 vehicle" emission factors of each vehicle category and segment, weighted by the share of total 2020 fuel consumption by new vehicles that comes from the new vehicles of each vehicle category and segment.

For a given fuel F (e.g. diesel), the calculation described above is summarised by the following formula:

$$weighed\ EF\ (F) = \sum_{C,S} \left(\frac{emission\ (C,F,S,A=0)}{consumpion\ (C,F,S,A=0)} \right) \times weight\ (C,F,S,A=0)$$

where

- "weighed EF" is the weighed emission factor of a given pollutant (e.g. PM2.5) for fuel F, in mass of pollutant per quantity of fuel (e.g. t per TJ); it is calculated by summing elements (see below) for all categories and segments for vehicles of age zero (i.e. new) in 2020;
- "emission" is the 2020 forecast pollutant emissions for a given vehicle category C, fuel F, segment S and Age zero, in mass of pollutant (e.g. ton);
- "consumption" is the 2020 forecast fuel F consumption for a given category C, segment S and Age zero, in quantity of fuel (e.g. TJ);
- "weight" is the ratio of the 2020 forecast fuel F consumption of vehicles of a given category C, segment S and Age zero over the total consumption of all vehicles that consume fuel F.

Note: for PM2.5, the term of the sum in the formula above is multiplied by the exhaust emission factor (see item "ii" below).

This allows us to capture the relative weight of different types of vehicles and usages in the relative consumption of each fuel as of 2020 (e.g. medium passenger cars of all ages are expected to consume about 35% of all diesel in 2020, but only about 31% of the diesel consumed by new vehicles in 2020).

Considering in the formula that all vehicles use the 2020 technology takes into account the revised ETD's date of application (2023 at the earliest) and the rapidly evolving composition of the road vehicles fleet towards newer and cleaner technology.

ii. Exhaust vs other road transport emission sources

In the ETD we aim to **cover only the air pollution emissions arising from the combustion of fuel**.
However, the EMEP road transport emission factors cover not only emissions arising from fuel combustion, but also evaporative emissions, emissions arising from brake and tyre wear, and emissions arising from the combustion of lubricants. This issue is particularly pertinent for PM2.5 emissions, where the non-combustion/exhaust share of emissions can be particularly large.
The share of exhaust emissions in total emissions depends on the filtering and catalysing technologies used (which are themselves fuel-specific), as well as on the usage patterns, and on the types of vehicles they are applied to. Generally, the heavier the vehicles the greater the

amount of emissions, and the more recent the technology the lower the exhaust emissions, per amount of fuel used. Whereas hydrogen fuel cell and purely electric driven vehicles have no exhaust emissions, for other fuels (e.g. diesel, petrol) we need to determine the % of the EMEP emission factors which corresponds to combustion/exhaust emissions.
This is computed for each type of road fuel, but considering the COPERT data on total and on non-exhaust PM2.5 emissions.
This data allows to compute the non-exhaust % of total PM2.5 emissions for each fuel/ technology type and usage, given the actual patterns of technology use in the EU (i.e. EURO6 may be used in smaller or in larger petrol vehicles, and EURO VI may be used in buses or in different types of heavy-duty trucks, all of them with different usage patterns). We then compute the average exhaust % of total PM2.5 emissions for each fuel, as the weighted average of the exhaust % of total PM2.5 emissions for each fuel/technology type and usage, considering only the cleanest technologies available in 2020 for each fuel and usage type. The weights used are the share that each of these cleanest 2020 technology usages has in all the 2020 PM2.5 emissions done with the cleanest technologies. The resulting number captures the EU average % of total PM2.5 which would be combustion driven for a given fuel, if all the usages of that fuel only had the cleanest technology as of 2020.

For a given type of fuel F (e.g. diesel), the calculation described above is summarised by the following formula:

$$\%\, exhaust\ (F) = \sum_{C,S,Tech2020} \left(1 - \frac{non\ exhaust\ (C,F,S,T)}{total\ (C,F,S,T)}\right) \times \frac{total\ (C,F,S,T)}{total\ Tech\ 2020\ (F)}$$

where

- "% exhaust" is the percentage of the 2020 forecast exhaust PM2.5 emissions on the total emissions, for a given fuel F; it is calculated by summing elements (see below) for all categories, segments and latest 2020 technologies;
- "non exhaust" and "total" are the 2020 forecast PM2.5 emissions (non-exhaust only and total respectively) for a given category C, fuel F, segment S and technology T;
- "total Tech 2020" is the sum of the 2020 forecast total PM2.5 emissions for a given fuel F and for all categories and all segments of vehicles of the latest technology available in 2020

The resulting values (ranging from 0% for purely electric, to 7.9% for Diesel, to 14.8% for CNG) are then applied to the aggregation of the EMEP road transport emission factors described in the previous step.

b. Aviation

Only the Landing-and-Take-off (LTO) portion of the emissions from aviation are considered for the purposes of the NEC directive (cruising air pollutant emissions are considered not to have impacts on human health). As such, only a fraction of all the air pollutant emissions from the fuel combusted in aviation activities is to be covered in the ETD. The actual share of LTO in total air pollutant emissions depends on the departure and arrival airports taxing time and flight distance.
Based on CLRTAP cruise and LTO emission factors for international and domestic aviation, we compute the share of LTO emissions in aviation emissions and therefore apply a correction coefficient to the EMEP emissions, leading to the following values:

- PM2.5 26.0%
- NOx 12.9%

EMEP/EEA Tier 1 data provides data for aviation gasoline and we tentatively assume the emission factors for jet gasoline (kerosene) are the same as for aviation gasoline.

5. Experts review

The methodology was reviewed by members of the following organisations:

- European Environment Agency (EEA)
- Joint Research Centre (JRC) units C4 (Sustainable Transport) and C5 (Air and Climate)
- IIASA – Markus Amann (external reviewer)
- Economics Research Consulting – Mike Holland (external reviewer)

Reviewers all support the idea of pricing instruments via ETD to reduce air pollution. Overall the reviewers believe our approach underestimates the cost of air pollution and does not take into account the local aspect of it. The former is due to the conservative approach chosen and the latter is inherent to having an EU-wide tax component for minimum rates. Several comments were requests for clarification which were implemented in the methodology description above.

The main more detailed comments were as follows:

1) General:

   a. JRC performed an **alternative calculation** for a part of our methodology (number of years of life lost per kg of pollutant), came up with similar results and concluded "The obtained values in proposed ETD methodology therefore appear to be justifiable";
   Mr Holland (ERC) made an alternative calculation from EEA and ETC-ATNI[6] work which led to a similar environmental cost (€ per kg of pollutant emission) for PM2.5 and an about twice higher cost for NOx. This is explained, inter alia, by not taking into account secondary formation of fine particulate matter arising from NOx emissions.

[6] European Topic Centre on Air Pollution, Transport, Noise and Industrial Pollution

b. The **scope** of the methodology should be extended to other pollutants and/or to other impacts than mortality impact as the current approach underestimates the cost of air pollution; however this proved to be difficult due to the lack of data and the time constraints on the exercise.

c. **National environmental performance and/or the location** (e.g. urban area or countryside) of air pollutant emissions should be taken into account. This is impossible in the ETD where the minimum tax rates apply EU-wide; however Member States have the flexibility to take these factors into account by taxing above the minimum rates.

d. Solid **biomass** should be in the ETD's scope, especially but not only in an option with a tax component on air pollution

2) Road transport:

a. Considering that **all vehicles use 2020 technology** is very "generous". This is due to the conservative approach, which intends at not penalising new technology; moreover, the ETD will be applicable as of 2023 at the very earliest, at which time the 2020 technology will be more spread out in the road vehicle fleet.

b. Counting only the **exhaust emissions** (directly due to fuel combustion) and not the non-exhaust ones such as tyre/brake wear was perceived as generous too but is consistent with the scope of the ETD.

6. Results

Environmental Cost of air pollutants

The environmental cost of an air pollutant computed by the methodology presented above is summarised below (in euro per kg of air pollutant emission):

Air Pollutant	**Environmental cost (€ / kg)**
PM2.5	103.1
NOx	8.1

Cost of Air Pollution per ETD type of fuel and usage

The cost of air pollution computed via the methodology described before, per ETD type of fuel and usage is provided in option 3c. This cost is also the value of the air pollution component in the EU minimum energy tax rate.

ANNEX 7: AVIATION TAXATION

1. Introduction

In support of the impact assessment on the revision of the Energy Taxation Directive, DG TAXUD commissioned an external study specifically on the taxation of the air transport sector for various reasons. There is increasing international pressure for appropriate pricing measures properly reflecting the environmental and climate impacts of aviation activities. Several Member States have introduced or are considering introducing aviation ticket taxes, partly because there is no fuel tax applied to aviation fuel. Therefore, the Study compares the possible impacts of a harmonised fuel tax to the possible impacts of ticket taxes on aviation. Furthermore, the taxation of air transport is a legally complex issue and specific impacts like connectivity, fuel tankering, economic competitiveness and competition within the sector need to be taken into account.

A consortium led by Ricardo together with the partners GWS, Ipsos NV, TAKS/Vital Link and Alice Pirlot have carried out this Study.

The study provides an analysis of the impact of various sub options of a fuel tax on the traditional aviation fuel (kerosene) and used the same baseline (EU Reference Scenario) as in the impact assessment of the ETD. One of the analysed sub options of a fuel tax of 0.33 €/1.000 litre or 9.35 €/GJ, is comparable with the proposed rate for kerosene for aviation in the Impact Assessment of the ETD and has been analysed on basis of the GINFORS model (section 6.8 of the |IA ETD). The GINFORS model includes the aggregates of the whole aviation sector. The JRC modelled the impact of the intra EU fuel tax by multiplying the rate of intra EU fuel tax with a factor that represents the share of intra-EU fuel use. Thus, instead of applying a high rate to a small sector, JRC applied a lower rate to a broader sector.

In the support study, as described in this annex, a more sector specific model is used, the AERO-MS model. This model differentiates for example between the types of flights (between intra and extra EU, low cost carriers and traditional carriers, passenger and cargo) and uses different elasticities per type of flight. Despite the different models used, we can conclude that the outcomes of impact of the proposed intra EU fuel tax on the aviation sector do not deviate substantially and seem to be coherent.

Additionally, the study provides an analysis of the possible use of ticket taxes in air transport (this is beyond the scope of the ETD) and given the possible limitation on the use of fuel taxation beyond intra-EEA aviation the study also looks into a possible combined application of a ticket tax and a fuel tax.

The study covers the whole of the European Economic Area (EEA), namely the EU27 plus Norway and Iceland. It assumes that potential policy options would be implemented in 2023, with the impacts being assessed for the period up to 2050.

This annex describes the approach and methodology of the study and summarizes the outcome of the assessment and presents the comparison of the different options.

2. Approach and methodology

The analysis assesses the impacts of the proposed policy options against two baseline scenarios. The use of two baselines was motivated by the severe impacts on the aviation sector, and society more widely, from the global COVID-19 pandemic. The health and economic crises generated by the pandemic have affected and will continue to impact demand for travel, potentially inducing long-term changes to businesses and people's habits, making any forecast of aviation demand very uncertain. Therefore, a main baseline scenario reflecting developments under current trends and adopted policies is used. It builds on the baseline scenario underpinning the impact assessment accompanying the 2030 Climate Target Plan and the staff working document accompanying the Sustainable and Smart Mobility Strategy, but it additionally considers the impacts of the COVID-19 pandemic and the National Energy and Climate Plans. In this scenario, air passenger traffic recovers by 2025, with a return to growth rates akin to historic rates in subsequent years. A sensitivity baseline with lower future growth is also used, based on EUROCONTROL's scenarios for the post-COVID recovery for the aviation sector.

The following tools are used to assess the impacts:

- A model, AERO-MS, focussed on the aviation sector, with detailed data at an airport pair level. This model is used to quantify impacts on the aviation sector of the various policy options.
- Results from the AERO-MS are transferred to a macro-economic model, GINFORS-E. This model, which includes bilateral world trade data, is used to quantify wider economic impacts on other transport modes and other economic sectors for the different policy options.
- The use of both models provides a comprehensive overview of impacts in comparison with each of the baselines included in the study, with results produced for short-term (2025), mid-term (2030) and long-term (2050) impacts.
- The study also includes a thorough legal analysis of the EU and international legal framework currently in place, in order not only to ensure the effectiveness of the different policy options under current legislation, but also to assess the potential legal consequences of the interventions.
- A focused field research programme is also part of the study, with conversations held with experts in the competent ministries of Austria, Germany, Sweden and the Netherlands. All of these are Member States with experience in levying national air ticket taxes.
- A case study on peripheral and island regions is also conducted, to investigate and quantify possible negative socio-economic impacts that could take place on those regions, given their reliance on aviation for their economic activities, if taxation on the aviation sector is implemented in the EU. The regions and Member States under analysis were the Canary Islands (Spain), Crete (Greece), Ireland and Malta.

3. Assessment of policy options

3.1. Fuel tax

3.1.1. Overview of policy options

The policy options implementing a fuel tax for intra-EEA aviation activity would amend the current exemption from excise duty of aircraft fuel in Article 14(1) of the ETD. This responds to the need for a harmonised approach, since the capacity to waive current exemptions for domestic flights or intra-community flights via bilateral agreements between Member States under Article 14(2) has not been used so far. The current minimum excise duty rate for kerosene, according to the Energy Taxation Directive, is € 330/1,000 L (or 33 cents/L). The sub-options consider variations around (above and below) the minimum kerosene tax rate that would be applicable to commercial aviation, as well as a number of exemptions. This is summarised in the table below.

Summary of policy options for the implementation of a fuel tax

Policy package	Tax rate	Other considerations
Harmonised fuel tax for intra-EEA aviation under the revised ETD	€0.17, €0.33 and €0.50/litre[7] (equivalent to approximately €4.82, €9.35 and €14.17 per GJ, respectively) Tax applies to passenger flights but not to cargo-only flights[8] Tax is either implemented at once or over a ten-year period (increments of 10% of the full value in each year) Sustainable aviation fuels are exempt from fuel tax	Exemptions for flights operated under public service obligations Exemptions for flights to and from EU outermost regions No earmarking of revenues

The tax rates shown in the table above can also be related to the CO_2 emissions produced from the combustion of the fuel. The three rates shown are equivalent to approximately €67, €131 and €198 per tonne CO_2, respectively.

A tax on the fuel loaded for (or used on) a flight can help towards internalising the external costs of greenhouse gases and air pollutants emissions, related to the quantity of fuel consumed. The airline is expected to pass through the cost to consumers by raising ticket prices, leading to a reduction in passenger demand and hence fuel consumption. To a more limited extent, airlines are also incentivised to choose more efficient aircraft for their operations to reduce the fuel consumed. The effectiveness of the fuel tax in achieving those goals could be reduced if the airlines use the practice of 'tankering' to reduce their tax burden (i.e. filling up the aircraft in destinations where there is no fuel tax and then using the same aircraft to fly intra-EEA flights where fuel would be taxed) or if they shift some of their intra-EEA flights to destinations in third countries.

From an efficiency perspective, the collection of a fuel tax is not expected to be problematic. Member States already have experience in collecting fuel taxes in other modes, namely on road transport. It is expected that an aviation fuel tax would be collected in a similar manner, with the fuel suppliers collecting the tax when they supply kerosene at airports, then transferring those funds to the relevant tax authorities.

From a legal perspective, no issues are identified for the implementation of a tax on fuel loaded for intra-EU flights by EEA carriers. Furthermore, most air services agreements (horizontal agreements, HAs, and comprehensive air transport agreements, CATAs) between

[7] Prices are modelled, and presented in the report, in constant 2019 Euros
[8] Due to modelling limitations, the impact results presented include the application of the fuel tax to cargo-only flights. The contribution of such flights to the overall emissions is small, so the effects of including the tax on them is also considered to be small.

the EU and third countries also allow the taxation of fuel used by their carriers on intra-EU flights. Updates to these agreements might be needed to allow the taxation of fuel used by their carriers on flights between the EU and the other EEA countries.

3.1.2. Assessment of impacts

Overall, the options implementing a tax on fuel loaded for intra-EEA flights all have noticeable impacts on CO_2 emissions in the long-term, with reductions of between 6% and 15% for intra-EEA flights, relative to the baseline, for tax rates from €0.17 to €0.50 per litre (the short-term impacts depend on whether a transition period is included). This result corresponds closely to the level of the reduction in passenger demand – while the fuel tax leads to a small improvement in aircraft fuel efficiency, the large majority of the reduction in emissions is due to a reduction in demand due to increased ticket prices. These results are only marginally affected when considering them against a lower baseline demand (representing a slower recovery following the COVID-19 pandemic).

The impacts of the fuel tax and the consequent changes in demand reduce total GDP in the EU27 by approximately €9 billion (about 0.05%) by 2050, under the assumption that revenues collected are used for deficit reduction purposes. Should the revenues be recycled, for example to fund reduction in other taxes, the negative impact on GDP would be smaller. In terms of tax revenue, the existing national ticket taxes contribute €2.6 billion of revenue from intra-EEA flights in 2025; under the €0.33 per litre option, the tax on fuel contributes about €6.7 billion per annum in 2050. The wider impacts on the economy from the reduction in aviation demand then reduce the rise in total tax revenue over the baseline to €5.4 billion per annum.

Regarding the impact on connectivity, the lower demand resulting from the introduction of a ticket tax would be expected to reduce flight frequencies across all routes. In principle, this could potentially lead to the loss of air transport on some routes, should these cease to be financially viable for air carriers to operate. However, this negative effect may be limited. This is because the expected number of intra EEA flights in the baseline for 2025 is 21% higher compared to base year 2016. By 2025, the introduction of a fuel tax of €0.33/litre (with no transition period) would lead to a reduction of 10% in the number of flights when compared to the baseline. Given this, it is expected that, overall, the flight frequency on most routes would be still higher than it was in 2016, although some variations are expected and specific regions could indeed see their connectivity reduced.

In terms of competitiveness of EEA carriers in relation to third country carriers (and between different EEA carriers) there could negative impacts on the former. This is because non-EEA carriers might be subject to a more lenient tax regime in their 'home' market, allowing them to be more profitable overall and be in a better position to compete with the EEA carriers on the routes on which the two sets of carriers compete.

The implementation of a fuel tax on intra-EEA flights could give rise to concerns regarding 'hub switching', as carriers change the connection airport on an indirect flight (between an EEA departure and a non-EEA destination) from an EEA airport to a non-EEA airport, to take advantage of the lack of fuel tax on the initial leg. This is more likely to impact traditional network carriers than low-cost carriers, as the latter tend to fly mainly direct flights. However, the extent to which hub switching may occur depends on a number of factors, including slot availability at airports and passenger preferences, so it is not possible to quantify the likely impact at this stage.

3.2. Ticket tax

3.2.1. Overview of policy options

The policy options implementing a fuel tax define a minimum, EU-wide ticket tax applicable to passenger services and, potentially, to air freight services. A number of EU Member States and their neighbours (Austria, France, Germany, Italy, Netherlands, Portugal and Sweden, together with Norway and the UK) already implement a ticket tax – in some jurisdictions better defined as a levy or charge – on all departing air passengers. While the applicable rates of existing national ticket taxes vary significantly, most of them share some common features: exemptions for transit and transfer passengers; differentiation between short haul and long haul flights, based on different criteria; and no earmarking of revenues to a dedicated fund. Air freight services are typically not affected by national taxes on the ground of international competitiveness. Many of these features also characterise the ticket tax policy option, as summarised in the table below.

Summary of policy options for the implementation of a ticket tax

Policy package	Tax rate	Other considerations

Harmonised ticket tax across the EU	Different types of passenger taxes considered:
	• Flat tax
	    ○ €10.43 for all passengers
	• Tax increasing with the distance flown
	    ○ €10.12 for intra-EEA flights
	    ○ €25.30 for extra-EEA flights of up to 6,000km
	    ○ €45.54 for extra-EEA flights over 6,000km
	• Tax decreasing with the distance flown
	    ○ €25.30 for flights of up to 350km
	    ○ €10.12 for flights over 350km
	Tax could be the same for all passengers in a flight, or be differentiated depending on the class of travel (non-premium/premium tickets).
		Exemptions for flights operated under public service obligations
		Exemptions for flights to and from EU outermost regions
		No earmarking of revenues

In terms of efficiency, conversations with Member States government officials indicate that the administrative burden of implementing and managing a ticket tax is relatively low both for public administrations and airlines. Overall administrative costs are expected to be lower than equivalent costs for implementing a fuel tax. Analysis indicates administrative costs of €465 thousand to €1 million per Member State per year (€12.6 million to €27.6 million across the EU).

From an effectiveness perspective, unlike a fuel tax, ticket taxes can at most have an indirect relationship with fuel consumption (e.g. if they increase with distance). They do not provide direct incentives for increased fuel efficiency (passengers on two different aircraft with different fuel efficiencies would pay the same ticket tax) but are essentially a demand management measure, as they essentially increase the price of air tickets. This gives a small disadvantage of ticket taxes compared to fuel taxes. An advantage of a ticket tax is that it can be more easily applied (from a legal perspective) to an increased scope (intra-EEA, extra-EEA flights or both), which increases the potential demand effects of such a measure and reduces the need for renegotiating some international air transport agreements.

3.2.2. Assessment of impacts

The impacts of the different types of ticket tax considered were as follows:

- For the flat ticket tax, where a single tax rate applies to all flights, the reduction in demand is 9% on intra-EEA flights and 1.5% on extra-EEA flights. The total tax revenue is about €6.7 billion in 2025, rising to €9.9 billion in 2050, representing increases of €4.1 billion to €6.2 billion above the baseline values.
- The stepped rate option, with a higher tax rate applying to longer flights (over 6,000 km), has a slightly lower impact on intra-EEA demand, but a significantly greater impact on extra-EEA demand (about 4.5% reduction in demand), compared to the flat rate option. The tax revenue from this option in 2050 is €6 billion over the baseline.
- The inverse stepped rate, with a higher rate applying to short flights (below 350 km), has a slightly higher impact on intra-EEA demand, and a very similar impact on extra-EEA demand, compared to the flat rate option. The tax revenue from this option in 2050 is €7 billion over the baseline.

In terms of CO_2 emissions, the different ticket tax options lead to reductions of between 8% and 10% on intra-EEA flights and between 3% and 5.5% on extra-EEA flights.

Regarding other potential sub-options, the application of tax multipliers of 3.0 and 7.5 for premium seats has only a small effect on the demand impacts of the tax options as they target passengers with more inelastic demand. Multipliers have a more significant effect on the tax revenue, increasing revenue to about €13 billion in 2050 under the flat rate tax with a 7.5 premium multiplier. The relative impacts of the ticket tax (as percentage changes) do not change when considering them against a lower baseline demand (representing a slower recovery following the COVID-19 pandemic).

With respect to the impact on connectivity, and not unlike the options introducing a fuel tax, the lower demand resulting from the fuel tax would be expected to reduce flight frequencies across all routes. However, under the different policy options that introduce a ticket tax, by 2025 demand is expected to be above 2016 levels – e.g., under a stepped ticket tax with no reduction in national ticket taxes, by 2025 number of flights by legacy carriers is expected to be 12% higher than in 2016, and for low-cost carriers 9% higher. That is, the introduction of a ticket tax, while reducing the expected growth in demand, is not expected to reduce demand when compared to 2016 levels and thus the impacts on connectivity are expected to be limited.

The implementation of a ticket tax, covering both intra-EEA and extra-EEA flights, might also raise concerns on the potential for hub switching. The ticket tax options considered in this study all exempt passengers travelling from a non-EEA origin to a non-EEA destination, connecting via an EEA airport; this exemption is expected to reduce the risk of airlines deciding to move their hubs away from EEA airports. The risk of passengers electing to travel from the EEA to a non-EEA destination, with a connection at a non-EEA airport (rather than connecting at an EEA airport) will depend on the exact design of the tax (e.g. whether the tax is calculated on the 'ticket' for the full journey or individual legs). Overall, the impact of hub switching on the competitiveness of EEA carriers and airports is expected to be limited.

3.3. Combined tax options

3.3.1. Overview of policy options

Different combinations of the two types of taxes were developed to identify whether there are advantages in having such combinations. Sub-options include the case where the ticket tax is applied to all flights (intra-EEA and extra-EEA), to intra-EEA flights only and to extra-EEA flights only. Otherwise, the combined tax options have the same considerations in terms of efficiency, effectiveness and legal issues as the fuel and ticket taxes considered individually.

3.3.2. Assessment of impacts

All the combined tax options considered in this study include a tax on the fuel supplied for intra-EEA flights and a ticket tax on extra-EEA flights. The cases considered have combined a €0.33 per litre fuel tax on intra-EEA flights and a ticket tax (flat, stepped or inverse stepped) on extra-EEA flights.

All tax options analysed have significant impacts on CO_2 emissions in the long-term, with reductions of about 10% on intra-EEA flights and up to almost 5% on extra-EEA flights. The option with the stepped ticket tax on extra-EEA flights has a greater impact than the other two combined tax options considered. The impacts on demand are very similar to those on emissions, with slightly lower magnitudes of change (up to 9.7% on intra-EEA flights and 4.0% on extra-EEA flights).

The additional tax revenue from aviation under the combined tax options ranges from €14 billion to €16 billion per annum by 2050. The impacts on the economy from the reduction in aviation demand reduce the rise in total tax revenue from the transport sector to about €12 billion per annum. A similar reduction in GDP is also expected by 2050 in the EU27 Member States.

4. Comparison of options

The table below presents a quantitative comparison of the impacts of the main indicators for the 'main' sub-option of each policy option – the heading of the table provides the details of the sub-option under consideration. All impacts are presented for the year 2030. To simplify the table, all increases in parameters (demand, tax revenue, etc.) are marked as '+', while all reductions are marked as '-'.

Comparison of main policy options

	Policy option 1: €330 per 1,000 litres fuel tax on fuel loaded for intra-EEA flights	Policy option 2: Stepped rate ticket tax (€10.12 per ticket on intra-EEA flights, €25.30 per ticket on extra-EEA flights up to 6,000km, €45.54 per ticket on extra-EEA flights over 6,000km)	Policy option 3: €330 per 1,000 litres fuel tax on fuel loaded for intra-EEA flights, €25.30 per ticket on extra-EEA flights up to 6,000km, €45.54 per ticket on extra-EEA flights over 6,000km
Economic impacts			
Total flights	-9.1% intra-EEA; 0.0% extra-EEA	-8.1% intra-EEA; -8.9% extra-EEA	-9.1% intra-EEA; -5.9% extra-EEA[9]
Total aviation passenger demand (p-km)	-9.2% intra-EEA; 0.0% extra-EEA	-8.3% intra-EEA; -4.6% extra-EEA	-9.2% intra-EEA; -2.7% extra-EEA
Total rail + aviation passenger demand (p-km)	-5.6% (1,078.8 billion p-km)	-5.0% (1,097.0 billion p-km)	-5.6% (1,090.3 billion p-km)
Revenues in aviation sector[10]	-0.5% intra-EEA; 0.0% extra-EEA; -3.2% total net revenue	-0.7% intra-EEA; +0.8% extra-EEA; -8.5% total net revenue	-0.5% intra-EEA; +0.5% extra-EEA; -6.5% net revenue

[9] Although the ticket tax rates on extra-EEA flights are the same under policy options 1 and 2, the impacts of policy option 3 are lower in 2030 as the tax (including both fuel tax and ticket tax elements) is implemented with a 10-year transition period starting in 2024, whereas under policy option 2 the tax is implemented in full from 2024.

[10] The aviation sector revenues are the incomes to the airlines from passenger tickets and freight charges. The gross impacts (presented for intra-EEA and extra-EEA flights) include additional incomes from passing through the ticket taxes to passengers (and cargo taxes to freight companies), while the impact on net revenues includes the payment of the ticket and cargo taxes collected, and fuel taxes, to the tax authorities.

	Policy option 1: €330 per 1,000 litres fuel tax on fuel loaded for intra-EEA flights	Policy option 2: Stepped rate ticket tax (€10.12 per ticket on intra-EEA flights, €25.30 per ticket on extra-EEA flights up to 6,000km, €45.54 per ticket on extra-EEA flights over 6,000km)	Policy option 3: €330 per 1,000 litres fuel tax on fuel loaded for intra-EEA flights, €25.30 per ticket on extra-EEA flights up to 6,000km, €45.54 per ticket on extra-EEA flights over 6,000km
Revenues from taxation (aviation), including existing ticket taxes	€7.44 billion intra-EEA; €10.36 billion total	€7.44 billion intra-EEA; €19.14 billion total	€7.43 billion intra-EEA; €15.87 billion total
GDP	-0.04%	-0.06%	-0.04%
Environmental impacts			
CO_2 emissions (aviation sector)	-9.9% intra-EEA; 0.0% extra-EEA; -3.7% total	-7.8% intra-EEA; -5.2% extra-EEA; -6.2% total	-9.9% intra-EEA; -3.6% extra-EEA; -6.0% total
Social impacts – number of persons employed			
Air transport services	-1.0%	-1.8%	-1.3%
Total transport services	+0.02%	+0.04%	+0.02%

All three policy options are found to have similar impacts on intra-EEA flights: introducing a tax (either fuel tax or ticket tax) on commercial aviation increases ticket prices and reduces demand. Options 2 and 3 add in the extra impacts of including extra-EEA flights in their scope and, therefore, give greater total reductions in emissions and total tax revenues. Although options 2 and 3 include the same ticket tax rates on extra-EEA flights, the impacts are slightly greater in the table for option 2 as the taxes are assumed to be implemented immediately (in 2024) under that option, while option 3 assumes a 10-year transition period (in line with that used for the fuel tax on intra-EEA flights).

.ANNEX 8: ENERGY SYSTEM IMPACT OF THE CENTRAL OPTION OF THE ETD REVISION (CONTRIBUTION BY DG ENER)

By increasing the minima applied to energy taxes, the proposed energy content option of the ETD in the context of the "Fit for 55" package will contribute, to a limited extent, to the required evolution of the EU's energy mix away from fossil fuels.[11] Changes occur in Member States that apply taxes below the proposed minima and in those that are affected by the changes of the tax base.

End-user prices for fuels, sectors and Member States are differently affected, depending on the current tax levels. On the one hand, the impacts on end-user fuels with relatively high levels of existing taxation across the EU, like diesel and gasoline end-user prices for private road transport or electricity for households, are limited. On the other hand, the ETD energy content option would lead to an increase of end-user prices for fuels with low levels of existing of taxation. This is the case of the fossil fuels end-user prices for households, up to 5.8% for coal prices on average at EU level in 2030, and higher for gas and LPG in the road transport sector.

As a consequence, the ETD energy content option would contribute to reduced final energy consumption of fossil fuels through energy efficiency and fuel switch. In particular, coal consumption sees a significant impact (-3.5%) in final energy consumption in 2030. While the renewable energy shares in transport (RES-T) and in electricity (RES-E) would not be affected by the ETD energy content option, the contribution of renewables in heating and cooling (RES-H&C) in final energy consumption would increase, by one percentage point, notably through electrification and ambient heat in buildings.

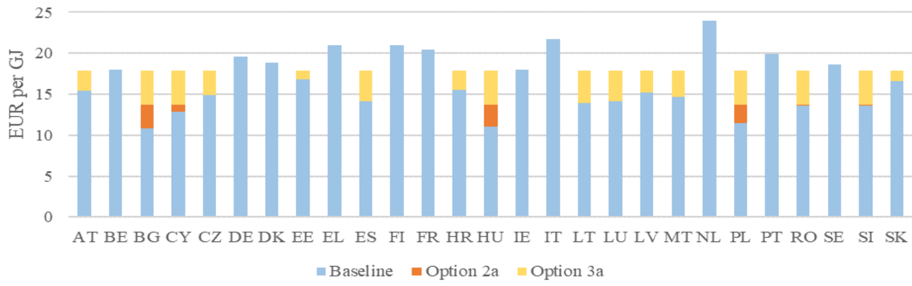
Overall, the changes lead to an increase in system costs by 2030 due to the increase in energy related expenses. In absolute terms, the transport sector sees the highest increase compared to a world in which the ETD was not revised but where other initiatives of the 'Fit for 55' package are implemented.

[11] The analysis is based on stylised modelling with the PRIMES model using the MIX scenario used by several initiatives of the "FitFor55" package which includes the revision of the ETD under the energy content option with a counterfactual setting removing the changes proposed by the ETD revision but keeping all other policy elements and drivers of the modelling constant.

ANNEX 9: STATISTICAL ANNEX

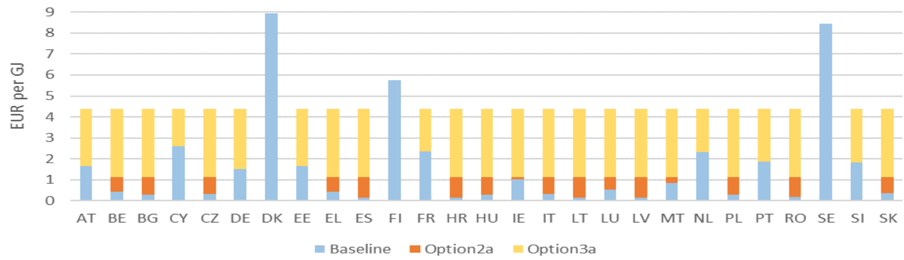
Additional statistics on the convergence of tax rates against the minima (impact on the internal market)

Figure 1: Tax rates by 2035 – Households, Motor, Petrol



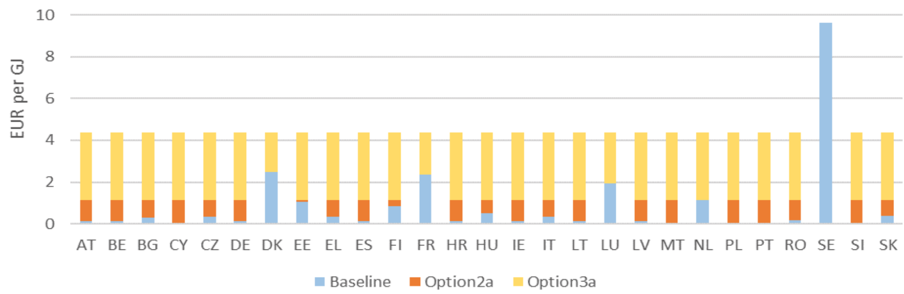
Source: JRC

Figure 2: Tax rates by 2035 – Services, Natural gas



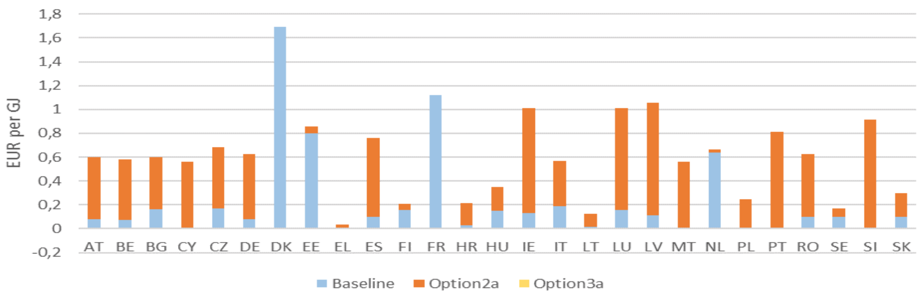
Source: JRC

Figure 3: Tax rates by 2035 – Other industries not covered by ETS, Natural gas



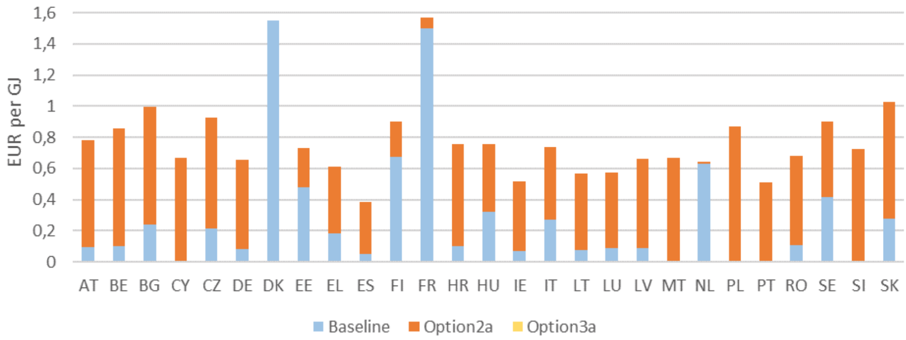
Source: JRC

Figure 4: Tax rates by 2035 – Chemicals, Natural gas[12]



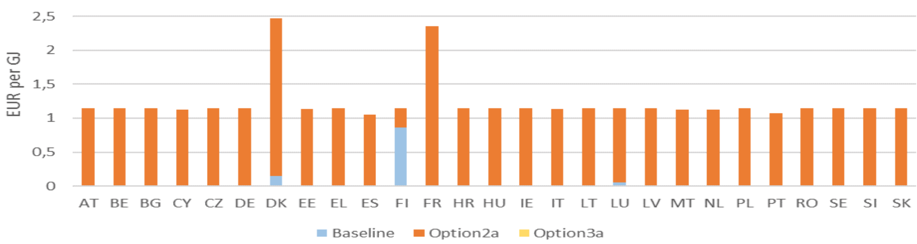
Source: JRC

Figure 5: Tax rates by 2035 – Paper and pulp, Natural gas



Source: JRC

Figure 6: Tax rates by 2035 – Non-metallic minerals, Natural gas

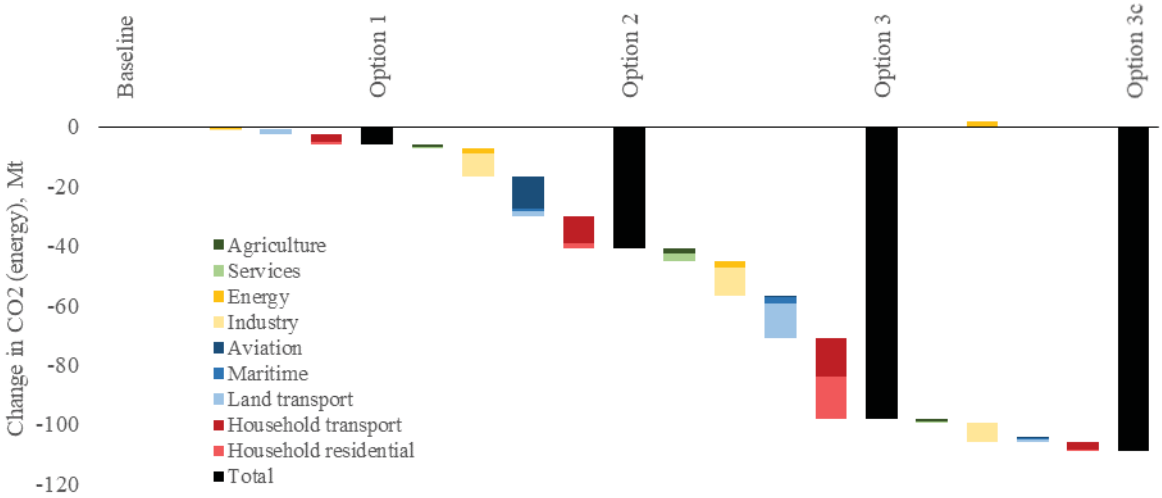


Source: JRC

Additional statistics on GHG

[12] For energy intensive industries, the effective tax rates are calculated net of energy volumes defined as out-of-scope of the Directive (therefore not taxed). Some out of scope processes (such as dual use) remain outside the revised ETD. Hence the extent to which each Member States relies on those processes remaining out-of-scope defines how much the rates will change. This explains the remaining national differences in effective rates for EIIs in Options 3a, 3b and 3c, despite the equalisation of most rates in EUR/GJ by 2035.

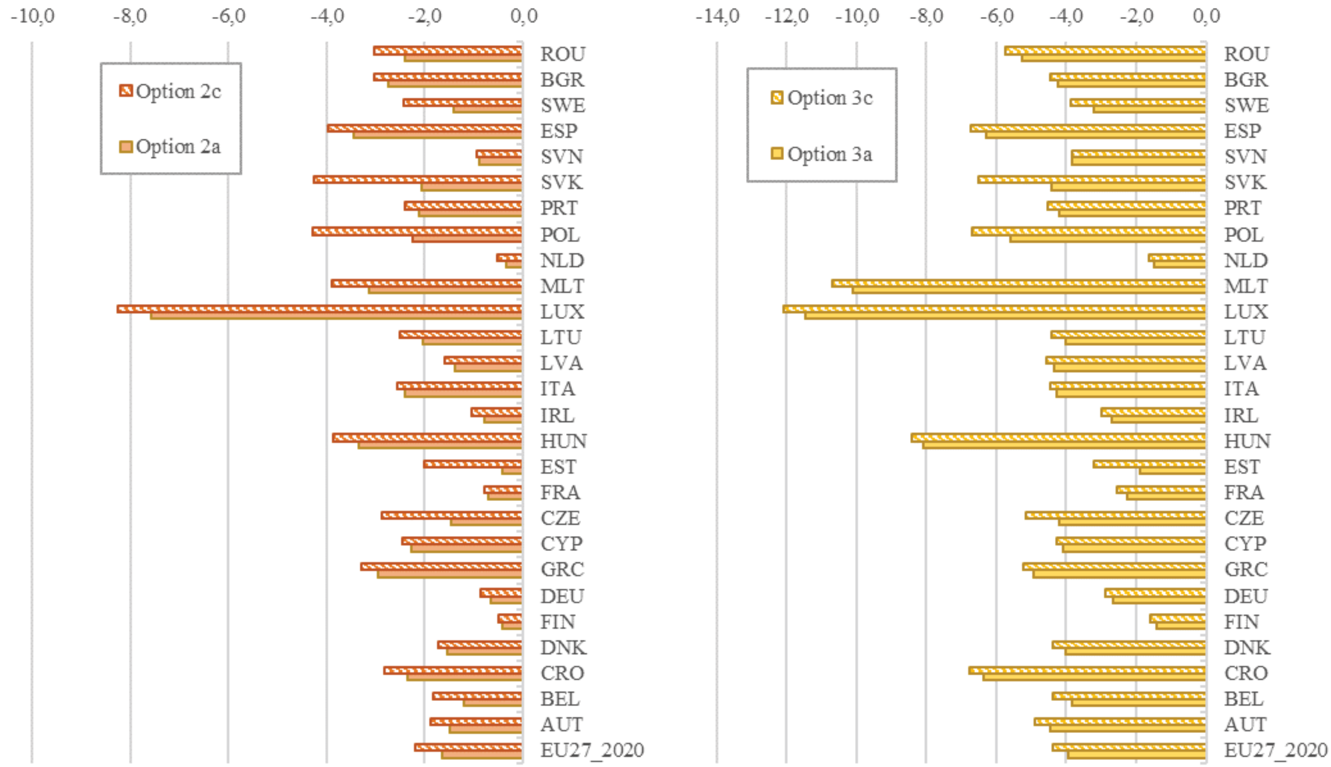
Figure 7: Change in CO2 emissions, Mt under different options



\Source: JRC-GEM-E3

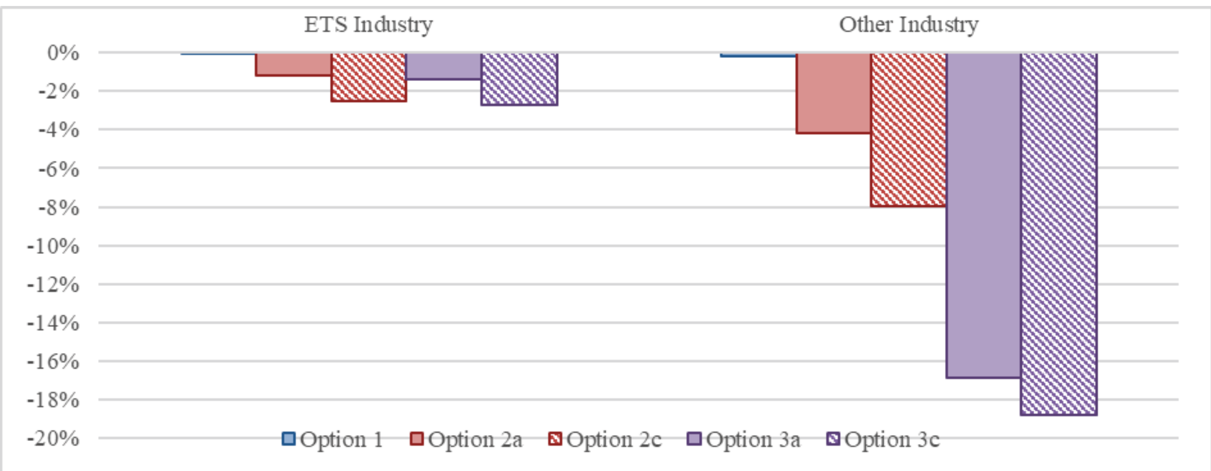
Figure 8: Member States percentage decrease in GHG emissions for options inclusive of pollution component compared to baseline in 2035

Option 2a and 2c **Option 3a and 3c**



Source: JRC-GEM-E3

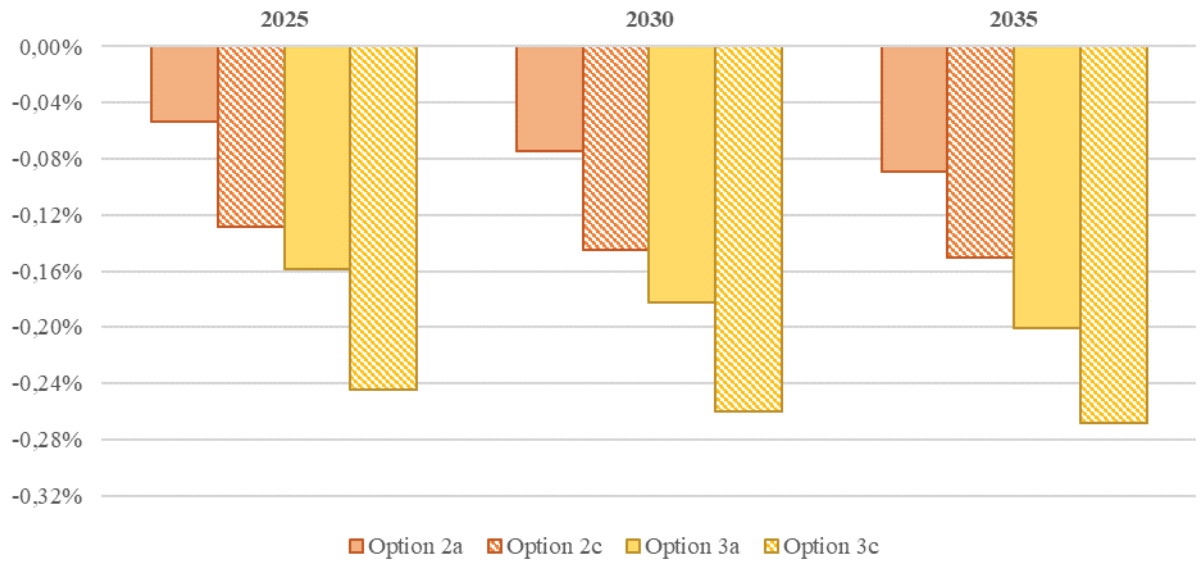
Figure 9: Decrease in industrial GHG emissions for all options compared to baseline in 2035



Source: JRC-GEM-E3

Statistics on macroeconomic and revenue impact

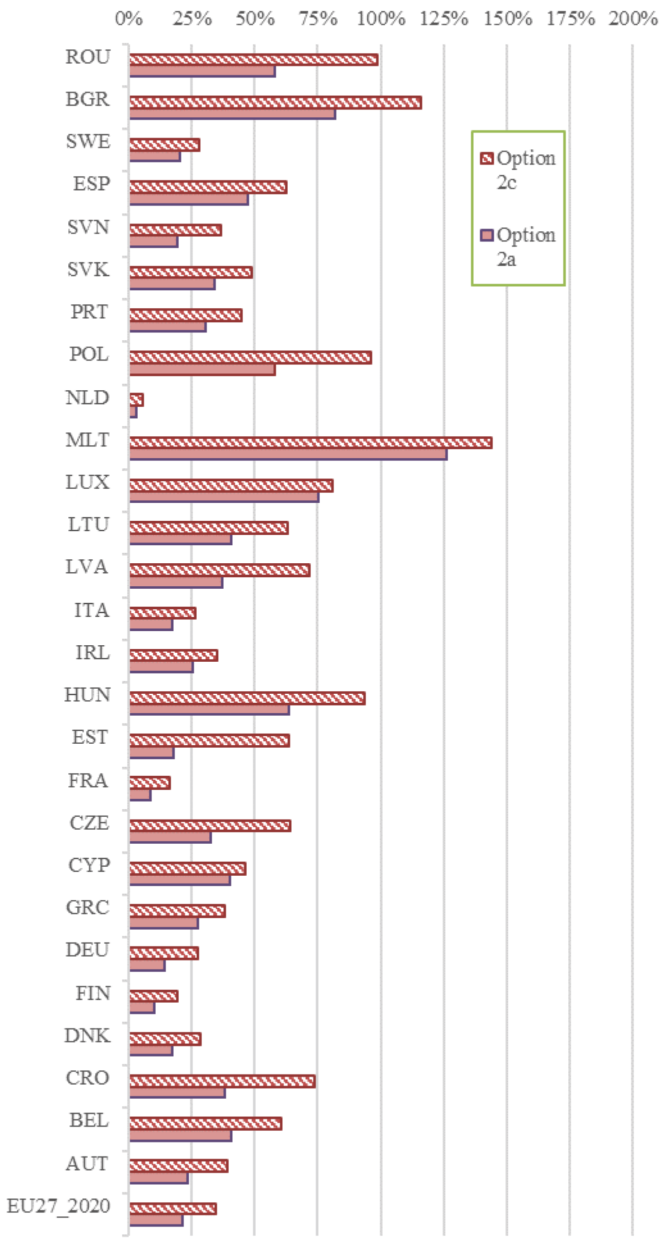
Figure 10: Change in EU 27 GDP compared to the baseline Options 2 and 3 with and without the pollution component



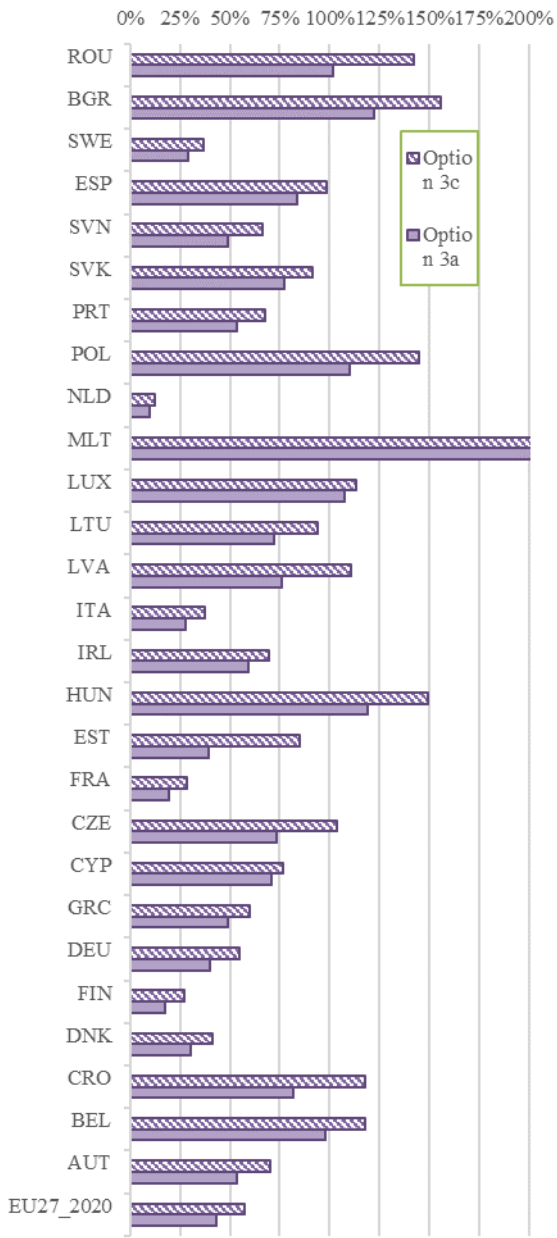
Source: JRC-GEM-E3

Figure 11: Change in tax revenues by Member State inclusive of the pollution component in 2035 (% change relative to the baseline)

Option 2a

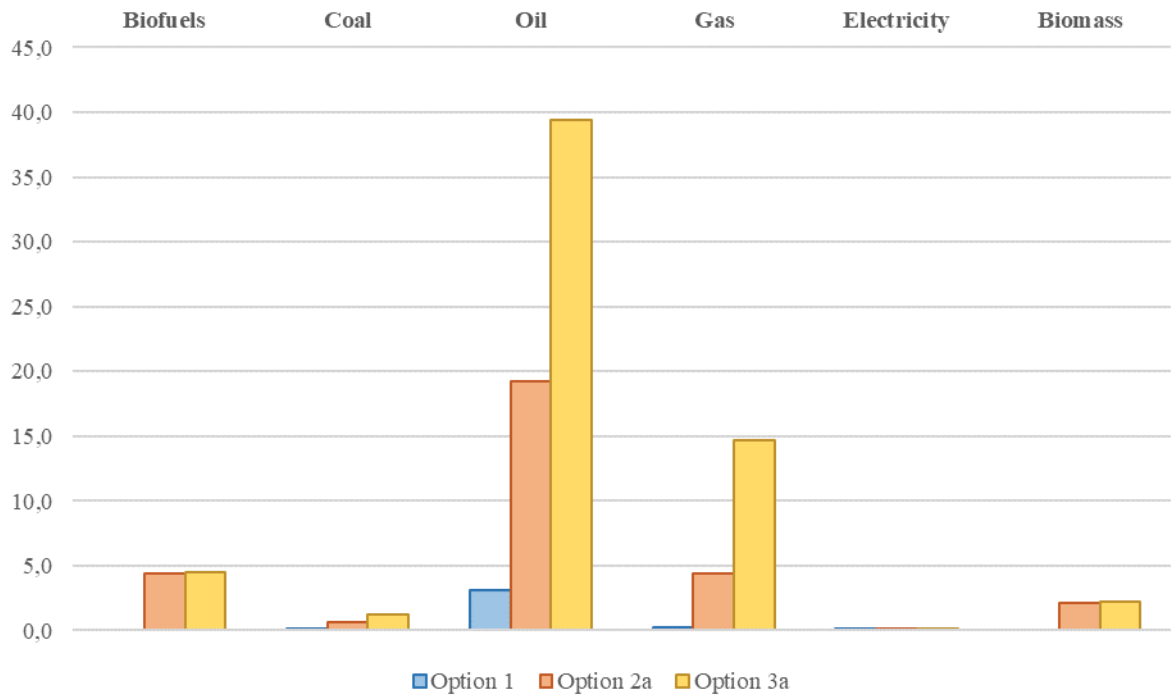


Option 3a



Source: JRC-GEM-E3

Figure 12: Change in revenue by product group compared to baseline EU27 – 2035 (% change for baseline)



Source: JRC-GEM-E3

Statistical details on distributional effects by Member State

a. Methodological issues

Input microdata

This analysis uses EUROMOD´s ITT extension and microdata from two household surveys:

- the European Union Statistics on Income and Living Conditions database, EU-SILC, which contains information on household income and other household- and individual-level characteristics.
- and the EU Household Budget Surveys, from where information on household consumption expenditures at the 4-digits COICOP categories of goods/services is extracted.

The EUROMOD´s ITT extension uses as input a database obtained from matching these two surveys, in order to compute indirect tax liabilities (VAT and specific excises) for each household. These are calculated on top of the direct taxes, social contributions and cash benefits simulated by the core EUROMOD model.

Link between GEM-E3 and EUROMOD

First, the macroeconomic impacts of the energy tax reform scenarios are simulated in the GEM-E3 macro model. Then, in order to study the distributional impacts of the ETD options on households at the micro level, key variables from the macro simulation are used to feed the micro model. By linking the two models in this way, the distributional analysis at the micro level is able to account for the economy-wide impact of the tax policy reform under consideration and captures the effects of the policy option not only through its direct impact on the tax burden, but also through its broader implications on consumer prices and household incomes.

It is important in this sense to mention the variables that are passed on from the macro model GEM-E3 to the micro model EUROMOD, as this can help interpret the microsimulation results. Firstly, on the expenditure side, EUROMOD is fed with the tax policy-induced consumer price changes, relative to the baseline, as simulated by GEM-E3. This concerns 14 aggregate consumption categories based on COICOP groups.[13] Since expenditures are imputed for each household at the commodity level, the mapping into these 14 categories only requires aggregation (without further assumptions nor correspondence matrices). These price changes include both direct effects of tax changes and indirect price changes through inputs along the supply chain. Secondly, on the household income side, the relative changes to the baseline for both labour and capital income also feed the microsimulation. In this way, the economic environment of EUROMOD is approximated to the one foreseen by the GEM-E3 model.

Besides, an additional scenario is analysed for each of the policy options, which assumes the recycling of the energy taxation revenues through a lump-sum transfer, equally distributed among individuals. This compensation mechanism ensures budget neutrality within the EUROMOD environment.

The impact of each policy option on household budgets, across the income distribution, is disentangled across three effects:

- The ´price effect´, which captures the distributional effect of the energy tax reform under analysis arising only from the predicted changes in consumer prices.
- The ´price and income effect´, which adds the predicted changes in market income to the changes in consumer prices for the distributional analysis.
- The ´price, income and compensation mechanism effect´, which draws on the results of the scenario with the lump-sum transfer to analyse the distributional impacts.

All options are compared against the baseline, given by the tax-benefit policy system in place in 2019 in the Member State under consideration.

b. Results

[13] The 14 categories are: food beverages and tobacco, clothing and footwear, housing and water charges, fuels and power, household equipment and operation excluding heating and cooking appliances, heating and cooking appliances, medical care and health, purchase of vehicles, operation of personal transport equipment, transport services, communication, recreational services, miscellaneous goods and services and education.

Option 1

Figure 13 presents the change in equivalized[14] household adjusted disposable income[15], relative to disposable income, resulting from ETD revision option 1, and including the compensation mechanism.

Each figure groups a number of countries, classifying them according to the magnitude of the impact of the reform over the first decile of the income distribution. Figure a shows the group of countries with strongest impact on the first decile, c the countries with the mildest impact and b those in between.

Results for the 18 Member States suggest:

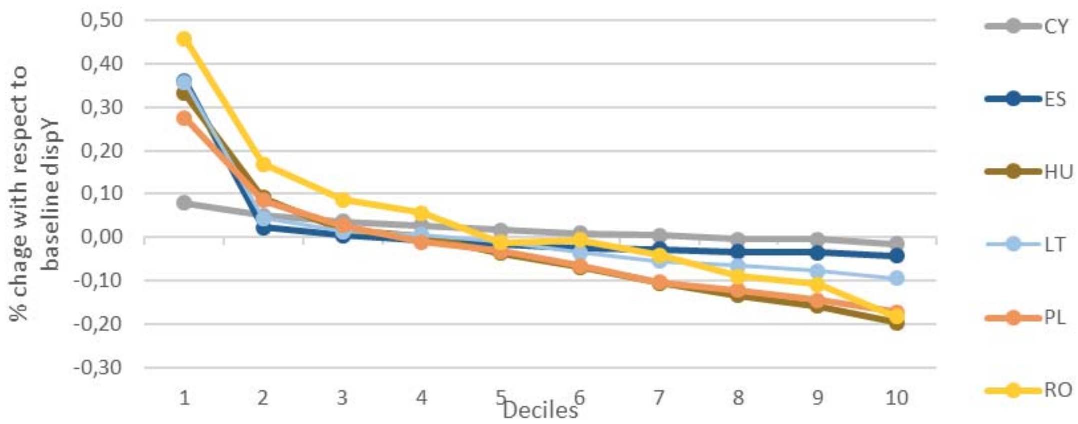
- For all countries, the policy impact of the energy tax reform together with the compensation mechanism over households' income is negligible. Whether positive or negative, the impact on adjusted disposable income is – in absolute terms - less than 0.5% (with respect to baseline disposable income) for countries in figure 1a, and less than 0.05% for all the remaining.
- Except for Portugal, the overall impact of the reform (including the compensatory measure) in the first decile is positive. This impact is however very small. On average, adjusted disposable income for the first decile is expected to increase by 0.1% with respect to disposable income in the baseline.
- Overall, the tax reform when combined with the compensation mechanism is progressive.

[14] Indicators reported here are based on *equivalised* household disposable income, considering economies of scale in consumption within the household: *equivalised* income refers to the fact that household members are made equivalent by weighting them according to their age, using the so-called modified OECD equivalence scale.

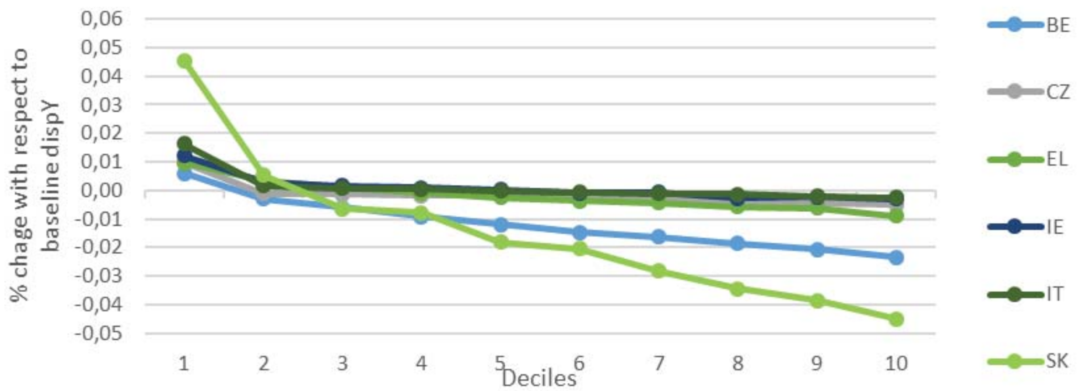
[15] Disposable income is household market income (gross wages and capital income, among others) net of direct taxes and social contributions, including cash benefits (unemployment benefits, social assistance, among others). To take into account the effect of indirect taxes, here we report the *adjusted* disposable income, which is defined as disposable income minus indirect tax payments (VAT and excises).

Figure 13. % change in adjusted disposable income resulting from ETD option 1, including the lump-sum compensation mechanism: country grouping

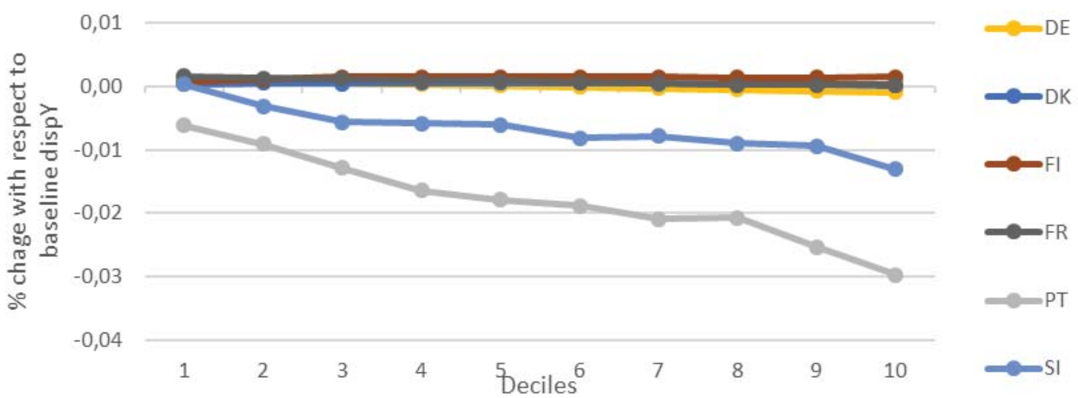
a. Strongest positive effect on the first decile



b. Moderate (intermediate) effect on the first decile



c. Mildest negative effect on the first decile



Note: Plots show the **total effect of the energy tax reform and the budget-neutral compensatory measures** expressed as the % change in equivalent adjusted disposable income in relation to equivalent household disposable income in the baseline. Households are classified in deciles based on equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excises). The scaling of y-axis differs across the three groupings. Equivalence scales used are the standard "OECD-modified" ones.

Source: European Commission's Joint Research Centre, based on the EUROMOD model.

Figure 14 shows the disaggregated 'price', 'price and income' and 'price, income and compensation' effects country by country for this reform scenario. There we can note that the policy is progressive when combined with compensation mechanisms. Without compensation, it is generally regressive in most countries with the exception of Belgium, Hungary, Portugal, Romania and Slovakia. In these countries, instead, changes in prices and income predicted by the macro model harm more households at the middle and top of the income distribution for the income effect more than offset the regressive impact of the price increase.

Figure 14 % change in adjusted disposable income resulting from ETD revision option 1: disaggregated effects country by country

Note: Plots show the total effect of the energy tax reform and the budget-neutral compensatory measures expressed as the % change in adjusted disposable income in relation to household disposable income in the baseline. Deciles of equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excises). Equivalence scales used are the standard "OECD-modified" ones. Source: European Commission's Joint Research Centre, based on the EUROMOD model.

Option 2a

Figure 15 presents the change in equivalized household adjusted disposable income, relative to disposable income, resulting from ETD revision option 2, and including the compensation mechanism.

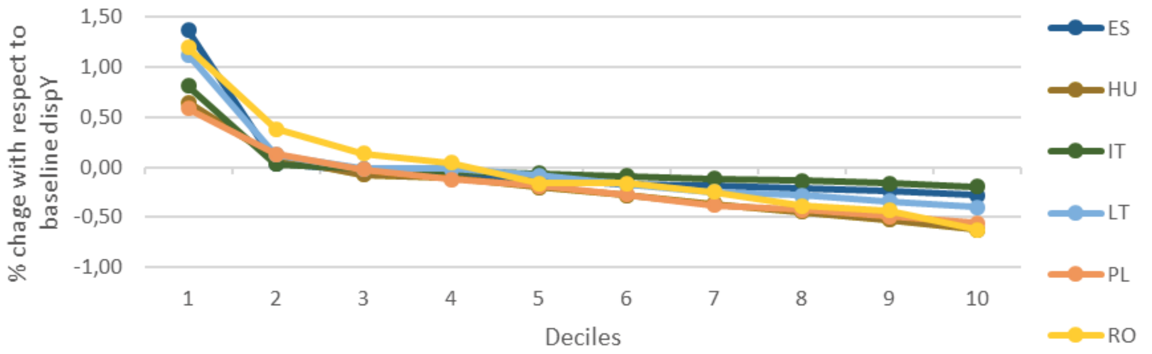
Each figure groups a number of countries, classifying them according to the magnitude of the impact of the reform over the first decile of the income distribution. Figure a shows the group of countries with strongest impact on the first decile, c the countries with the mildest impact and b those in between.

Results for the 18 Member States suggest:

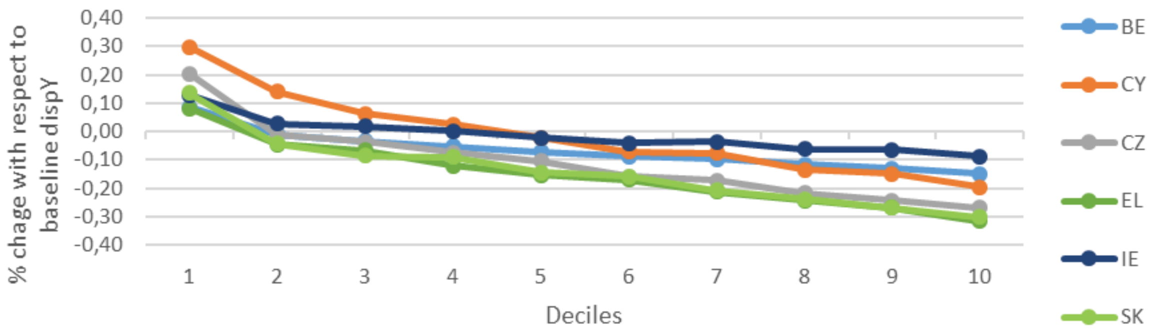
- The impact of this energy tax reform along with the compensation mechanism on household adjusted disposable income ranges from -0.62% of baseline disposable income (Hungary, tenth decile) to 1.37% (Spain, first decile).
- As in option 1 above, except for Portugal, the impact of the reform in combination with the lump-sum transfers over household adjusted disposable income is positive for all households in the first decile. The largest increase takes place in Lithuania, Romania and Spain, where adjusted disposable incomes increase by more than 1%. For the rest of the households (i.e. second decile of the distribution onwards), the impact is generally very small (being – in absolute terms – typically less than 0.5%,).
- Overall, this energy tax reform when combined with the compensation mechanism is progressive.

Figure 15 % change in adjusted disposable income resulting from ETD option 2a, including the lump-sum compensation mechanism: country grouping

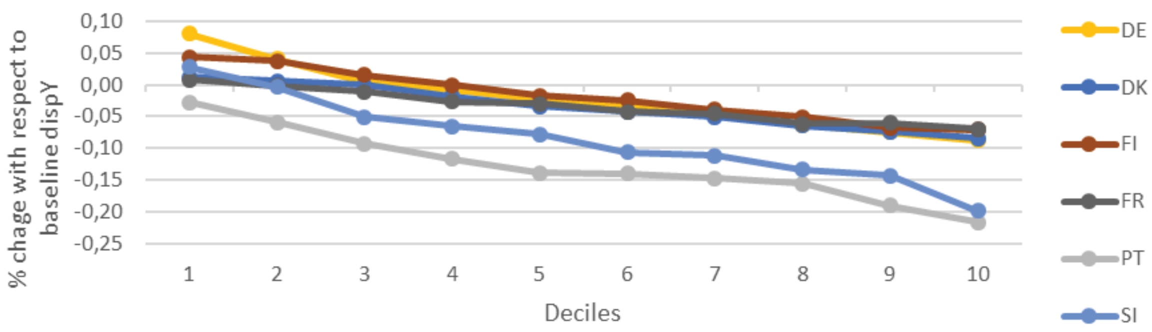
a. Strongest positive effect on the first decile



b. Moderate (intermediate) effect on the first decile



c. Mildest positive effect on the first decile



Note: Plots show the total effect of the energy tax reform and the budget-neutral compensatory measures expressed as the % change in equivalent adjusted disposable income in relation to equivalent household disposable income in the baseline. Households are classified in deciles based on equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excises). The scaling of y-axis differs across the three groupings. Equivalence scales used are the standard “OECD-modified” ones.

Source: European Commission’s Joint Research Centre, based on the EUROMOD model.

Figure 16 % change in adjusted disposable income resulting from ETD revision option 2a: disaggregated effects country by country

Figure 16 shows the disaggregated 'price', 'price and income' and 'price, income and compensation' effects country by country for this reform scenario. There we can note that the reform is progressive when combined with compensation mechanisms. Without compensation, the most affected households tend to be at the bottom and top of the income distribution. The reform is in many countries regressive or shows no clear impact on inequality, with the main exception of Czech Republic, Romania, Slovenia and Slovakia. In these countries, the income effects more than offset the price effects, which makes the overall reform (price + income) progressive.

Option 3a

Figure 17 presents the change in equivalized household adjusted disposable income relative to disposable income, resulting from ETD revision option 3a, and including the compensation mechanism.

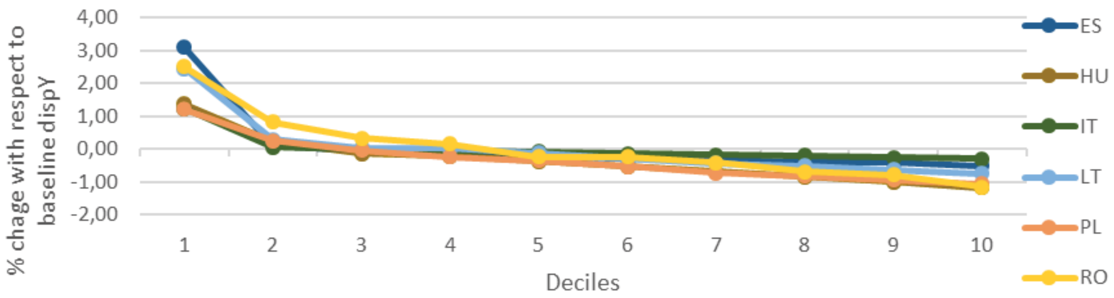
Each figure groups a number of countries, classifying them according to the magnitude of the impact of the reform over the first decile of the income distribution. The figure show the group of countries with strongest impact on the first decile, c the countries with the mildest impact and b those in between.

Results for the 18 Member States suggest:

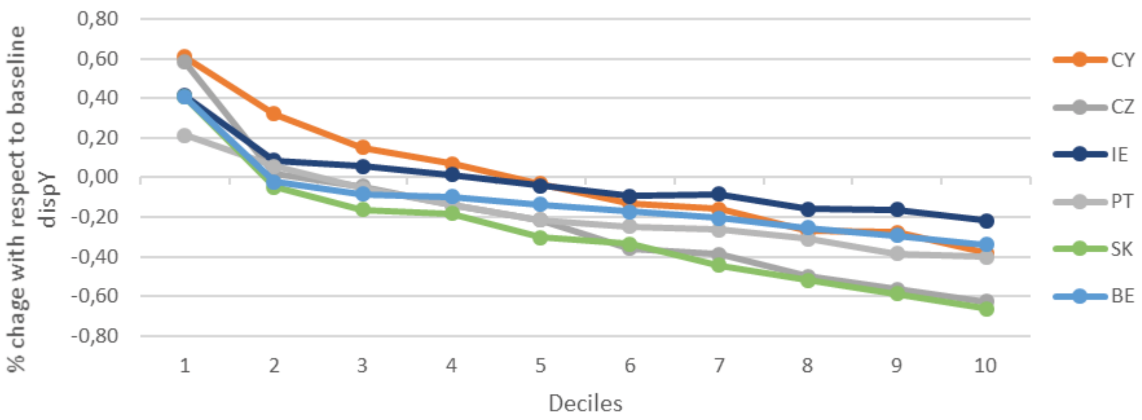
- The impact of this energy tax reform combined with the compensation mechanism on household adjusted disposable income ranges from -1.2% with respect to baseline disposable income (Hungary, tenth decile) to 3.1% (Spain, first decile).
- The impact of the energy tax reform in combination with the lump-sum transfers over household income is positive for all households in the first decile. The larger increase takes place in Lithuania, Romania and Spain, where income increases by more than 2%. For the rest of the households (i.e. second decile of the distribution onwards), the impact is generally small. The largest impact is experienced by Romanian and Polish 10th decile, seeing an income reduction of about 1%.
- Overall, this energy tax reform when combined with the compensation mechanism is progressive.

Figure 17 % change in adjusted disposable income resulting from ETD option 3a, including the lump-sum compensation mechanism

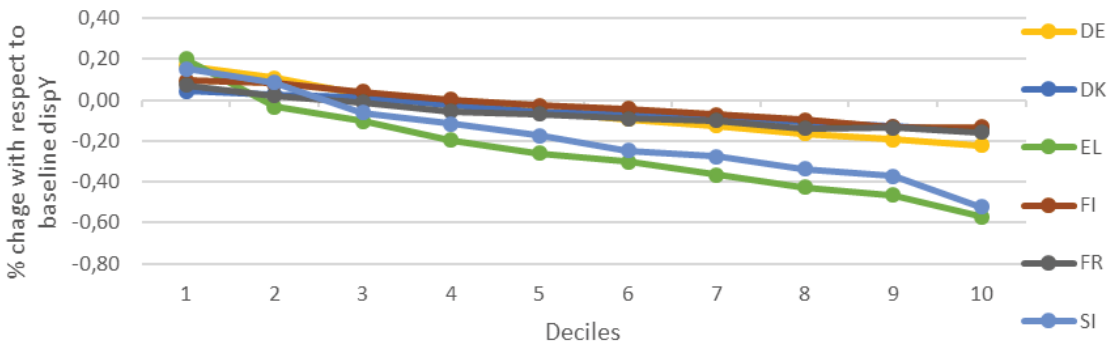
a. Strongest positive effect on the first decile



b. Moderate (intermediate) effect on the first decile



c. Mildest positive effect on the first decile



Note: Plots show the total effect of the energy tax reform and the budget-neutral compensatory measures expressed as the % change in equivalent adjusted disposable income in relation to equivalent household disposable income in the baseline. Households are classified in deciles based on equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excises). The scaling of y-axis differs across the three groupings. Equivalence scales used are the standard "OECD-modified" ones.

Source: European Commission's Joint Research Centre, based on the EUROMOD model.

Figure 18 shows the disaggregated 'price', 'price and income' and 'price, income and compensation' effects country by country for this reform scenario. There we can note that the reform is progressive when combined with compensation mechanisms. Without compensation, it is either neutral or regressive. Although, again, Romania and Czech Republic represent two important exceptions. Once more, in these countries the income effects more than offset the price effects causing the impact of the reform without compensation mechanisms to be progressive.

Figure 18 % change in adjusted disposable income resulting from ETD revision option 3a: disaggregated effects country by country

Note: Plots show the total effect of the energy tax reform and the budget-neutral compensatory measures expressed as the % change in adjusted disposable income in relation to household disposable income in the baseline. Deciles of equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excises Equivalence scales used are the standard "OECD-modified" ones. Source: European Commission's Joint Research Centre, based on the EUROMOD model.

Option 3c

Figure 19 presents the change in equivalized household adjusted disposable income relative to disposable income, resulting from ETD option 3c with air pollution component ("wap"), and including the compensation mechanism.

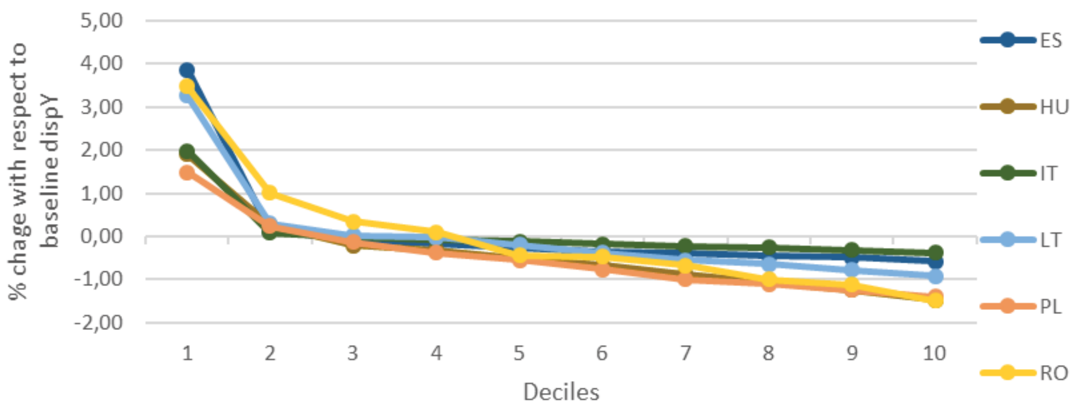
Each figure groups a number of countries, classifying them according to the magnitude of the impact of the reform over the first decile of the income distribution. Figure 68a shows the group of countries with strongest impact on the first decile, 68c the countries with the mildest impact and 68b those in between.

Results for the 18 Member States suggest:

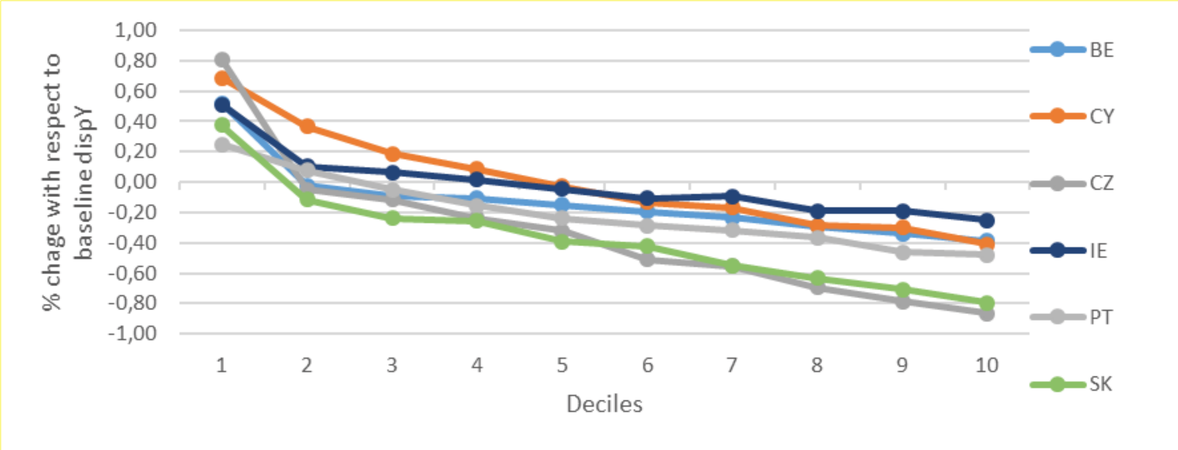
- The impact of this energy tax reform option, combined with the compensation mechanism, over household adjusted disposable income is positive for all households in the first decile. The larger increase is taking place in Lithuania, Romania and Spain, where income increases by more than 3%.
- For the rest of the households (second decile of the distribution onwards) the impact is generally small. The largest impact is experienced by Romanian and Polish 10th decile, seeing an income reduction of about 1.5%.
- Overall, this energy tax reform, when combined with the compensation mechanism, is progressive.

Figure 19. % change in adjusted disposable income resulting from ETD option 3c, including the lump-sum compensation mechanism: country grouping

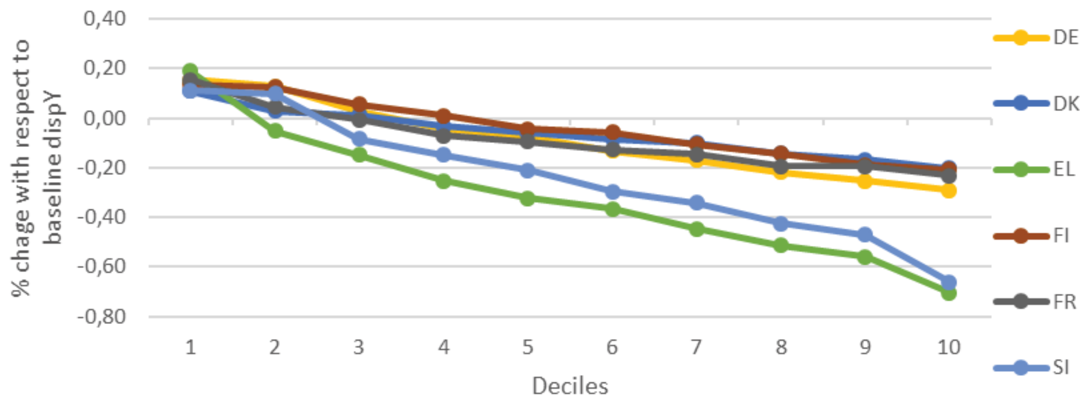
a. Strongest effect on the first decile



b. Moderate (intermediate) effect on the first decile



c. Mildest negative effect on the first decile

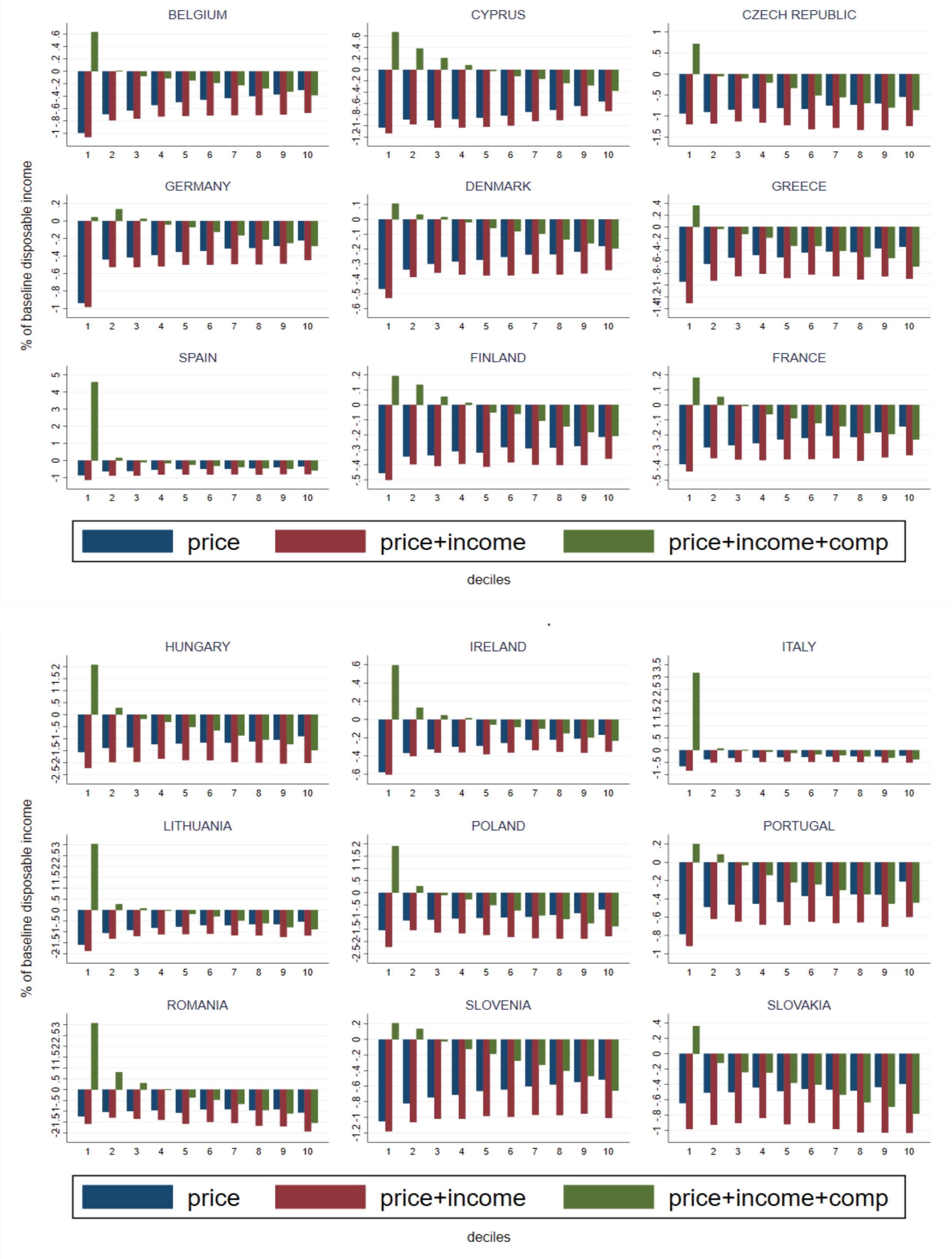


Note: Plots show the total effect of the energy tax reform and the budget-neutral compensatory measures expressed as the % change in equivalent adjusted disposable income in relation to equivalent household disposable income in the baseline. Households are classified in deciles based on equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excises). The scaling of y-axis differs across the three groupings. Equivalence scales used are the standard "OECD-modified" ones.

Source: European Commission's Joint Research Centre, based on the EUROMOD model.

Figure 20 shows the disaggregated 'price', 'price and income' and 'price, income and compensation' effects country by country for this reform scenario. There we can note that the overall reform is progressive when combined with compensation mechanisms. Without compensation, it is either neutral or regressive. Although, again, this is not true for some countries, such as Romania and Czech Republic where the income effect more than offset the price effect therefore implying that the reform without compensation mechanisms is already progressive.

Figure 20. % change in adjusted disposable income resulting from ETD option 3c.: disaggregated effects country by country



Note: Plots show the total effect of the energy tax reform and the budget-neutral compensatory measures expressed as the % change in adjusted disposable income in relation to household disposable income in the baseline. Deciles of equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excises Equivalence scales used are the standard “OECD-modified” ones. Source: European Commission’s Joint Research Centre, based on the EUROMOD model.

Table 1 Energy poverty in low income and (lower) middle-income households, by Member State (population shares in % of total population in the Member State)

		under 60% of median income			between 60% and the median inc		
	COUNTRY	N EP	EP	Total	N EP	EP	Total
2019	AT	11,8%	1,4%	13,2%	34,9%	2,2%	37,1%
2019	BE	11,3%	3,3%	14,6%	32,8%	2,9%	35,7%
2019	BG	7,2%	15,3%	22,5%	13,8%	14,0%	27,8%
2019	CH	13,9%	2,0%	15,9%	32,5%	2,0%	34,4%
2019	CY	7,0%	7,6%	14,6%	24,1%	11,6%	35,7%
2019	CZ	8,7%	1,4%	10,0%	38,5%	1,8%	40,3%
2019	DE	13,0%	1,9%	14,9%	33,8%	1,6%	35,4%
2019	DK	10,4%	2,0%	12,3%	35,7%	2,3%	38,0%
2019	EE	17,6%	3,9%	21,5%	26,2%	2,6%	28,8%
2019	EL	6,0%	11,7%	17,7%	17,6%	15,0%	32,6%
2019	ES	14,2%	6,3%	20,5%	25,9%	3,9%	29,8%
2019	FI	9,2%	2,3%	11,5%	34,1%	4,7%	38,8%
2019	FR	9,2%	4,3%	13,5%	32,1%	4,7%	36,8%
2019	HR	11,3%	6,8%	18,1%	25,3%	6,9%	32,2%
2019	HU	8,7%	3,5%	12,2%	31,8%	6,4%	38,2%
2019	LT	11,1%	9,3%	20,4%	19,5%	10,3%	29,9%
2019	LU	15,5%	1,9%	17,4%	31,5%	1,5%	33,0%
2019	LV	17,2%	5,5%	22,7%	22,1%	5,5%	27,6%
2019	MT	13,1%	3,8%	16,9%	27,5%	5,9%	33,4%
2019	NL	11,2%	1,9%	13,1%	35,5%	1,8%	37,3%
2019	NO	11,5%	1,0%	12,5%	35,6%	2,2%	37,8%
2019	PL	12,3%	2,9%	15,3%	31,4%	3,6%	35,1%
2019	PT	9,7%	7,4%	17,1%	24,6%	8,6%	33,2%
2019	RO	16,4%	7,2%	23,6%	21,7%	5,0%	26,6%
2019	RS	11,3%	11,7%	23,0%	18,6%	8,6%	27,2%
2019	SE	15,0%	1,9%	16,9%	32,1%	1,3%	33,4%
2019	SI	8,9%	2,8%	11,8%	31,8%	6,8%	38,6%
2019	SK	6,9%	4,9%	11,7%	33,4%	5,1%	38,5%
2018	AT	11,9%	1,5%	13,4%	34,6%	1,6%	36,2%
2018	BE	11,4%	4,0%	15,4%	31,1%	3,0%	34,1%
2018	BG	5,5%	15,4%	20,8%	13,4%	15,3%	28,8%
2018	CH	11,8%	1,9%	13,7%	33,8%	2,2%	36,0%
2018	CY	6,6%	7,9%	14,5%	21,8%	13,3%	35,2%
2018	CZ	7,7%	1,2%	9,0%	38,9%	1,9%	40,8%
2018	DE	12,9%	2,1%	15,0%	32,5%	2,1%	34,6%
2018	DK	9,5%	2,4%	11,9%	34,5%	3,3%	37,8%
2018	EE	18,2%	2,6%	20,7%	25,9%	2,8%	28,8%
2018	EL	5,5%	12,0%	17,5%	15,5%	16,6%	32,1%
2018	ES	13,7%	6,7%	20,4%	24,5%	4,6%	29,1%
2018	FI	9,4%	1,9%	11,3%	34,0%	4,4%	38,4%
2018	FR	8,6%	4,0%	12,6%	33,0%	4,2%	37,1%
2018	HR	10,7%	7,5%	18,2%	23,5%	7,8%	31,3%
2018	HU	7,6%	4,4%	12,0%	30,4%	7,3%	37,7%
2018	IE	10,3%	3,8%	14,0%	30,8%	4,7%	35,6%
2018	IS	7,4%	0,9%	8,2%	39,0%	2,5%	41,5%
2018	IT	12,6%	6,6%	19,2%	25,0%	5,4%	30,3%
2018	LT	12,6%	9,2%	21,8%	17,9%	9,9%	27,8%
2018	LU	13,7%	2,0%	15,8%	32,2%	1,7%	34,0%
2018	LV	15,8%	6,4%	22,2%	22,1%	5,2%	27,4%
2018	MT	11,9%	4,0%	15,9%	28,6%	5,2%	33,8%
2018	NL	11,3%	1,2%	12,5%	35,5%	1,8%	37,2%
2018	NO	10,9%	1,2%	12,1%	35,9%	1,6%	37,6%
2018	PL	11,1%	2,9%	13,9%	31,5%	4,2%	35,7%
2018	PT	9,4%	6,9%	16,3%	24,2%	9,2%	33,4%
2018	RO	15,5%	6,9%	22,3%	21,3%	5,9%	27,2%
2018	RS	11,0%	12,1%	23,0%	16,3%	10,1%	26,4%
2018	SE	13,9%	1,5%	15,4%	32,2%	1,8%	34,1%
2018	SI	8,6%	3,8%	12,4%	30,5%	6,6%	37,2%
2018	SK	8,2%	3,2%	11,4%	34,1%	4,0%	38,1%
2018	UK	14,1%	3,5%	17,5%	28,3%	3,9%	32,1%

Source: ESTAT EU-SILC UDB 2019; own calculations.

Note: The table shows the respective population shares (not) in energy poverty by income groups (income below 60% of national median income; and income between 60% and 100% of national median income). Energy poor (EP) households are defined as households that have arrears with utility bills or are unable to keep their home adequately warm.

ANNEX 10: QUANTIFICATION OF THE INDUSTRIAL ENERGY CONSUMPTION WITHIN THE SCOPE OF ARTICLE 2 OF THE ENERGY TAXATION DIRECTIVE

Contents

1. Introduction

Upon request of the Directorate General for Taxation and Customs (TAXUD), the JRC has estimated, using the most recent and detailed data available, the amount of energy consumed by the industry that is exempt from taxation according to article 2 of the Energy Taxation Directive 2003/96/EC (ETD). In order to estimate these amounts, two questions have to be addressed:

- **How much energy is actually consumed by each industrial sector?**
- **What share of the energy consumed by each industry is exempt from taxation and why?**

As regards the first question, three aspects have to be considered:

- The energy consumed by each industry is reported in the “final non-energy consumption” and “final energy consumption” blocks of EUROSTAT’s energy balances (EUROSTAT, 2020) but the sum of both terms is not the total industrial energy use. The industry also consumes energy for the autoproduction of electricity and heat and those energy inputs are registered partially in the “transformation input” and “energy sector” blocks of the energy balances. These energy inputs are not disaggregated by industry in the energy balances and need to be estimated in order to calculate the total energy used by each sector.
- Some outputs of the energy transformation processes (coke ovens, blast furnaces, and autoproducers’ power plants) are fed back into autoproduction and final energy and non-energy consumption, but those energy flows should be deducted in order to prevent double counting of the taxed energy.
- The consumption of energy for non-energy uses accounts for a significant share of the total energy use in the industry (26% for the EU in 2018, 87 061 ktoe of 329 288 ktoe, varying between 4% and 55% depending on the MS) but it is not disaggregated by industry in the energy balances.
- A small, but non-negligible part of the industrial energy consumption is reported as “not elsewhere specified” (3.8% for the EU in 2018, 12 580 ktoe out of 329 288 ktoe).

With respect to the second question, article 2 of the ETD establishes a series of energy carriers and energy uses that are out of the scope of the directive:

- Fuel wood, wood charcoal, and peat.
- Energy products used for “purposes other than as motor fuels or as heating fuels”.
- “Dual use of energy products”, including chemical reduction, electrolytic, and metallurgical processes.
- Electricity used for chemical reduction, electrolytic, and metallurgical processes.
- Electricity when it accounts for more than 50% of the cost of a product.
- Energy used in mineralogical processes for the manufacture of non-metallic mineral products.

However the ETD does not define further those exceptions nor provide any list of chemical reduction, electrolytic, metallurgical and mineralogical processes. Therefore, additional information and assumptions (subject to interpretation) are needed to determine the amounts of energy within the scope of the ETD.

The remainder of the report is structured as follows:

- Section 1 describes the four steps followed to estimate the results, detailing the assumptions made and the limitations of this approach.
- Section 2 contains summary tables with the results for each industry in each EU MS.
- Section 3 closes with some conclusions and recommendations for further work.

2. Methodology

The estimations are calculated in four main steps, described in the following sub-sections:

- Section 1: Disaggregation of the inputs for autoproduction in the energy balances of 2018 for the 12 industrial sectors considered in EUROSTAT's energy balances (listed in Table 1).
- Section 2.2: Disaggregation of the inputs for non-energy uses consumed by each industry in 2018.
- Section 2.3: Estimation of the total energy used (net inputs) by each industry in 2018.
- Section 2.4: Breakdown of the total energy use of each industry into in and out of scope categories.

The analysis described in this annex provides a plausible quantification of the amounts of energy consumed by the industry (detailed by groups of energy products) that can be considered within the scope of article 2 of the ETD. These results cover all the industrial sectors considered in EUROSTAT's energy balances, including non-energy uses of energy product, and are consistent with the latest data available.

Note that the methodology described in this annex is limited by the level of detail of EUROSTAT's energy balances, and the ambiguities of the definitions of the ETD categories (e.g. definition of motor and heating fuels, definition of metallurgical processes, etc.) and the processes listed in JRC-IDEES (e.g. electric mechanical processes in the wood and wood products industry), which are open to interpretation.

Table 1: Industrial sectors considered in the analysis

Industry	Description
Iron and steel	NACE Rev. 2 Groups 24.1, 24.2 and 24.3; and NACE Rev. 2 Classes 24.51 and 24.52[16] C241: Manufacture of basic iron and steel and of ferroalloys C242: Manufacture of tubes, pipes, hollow profiles and related fittings, of steel C2451: Casting of iron C2452: Casting of steel
Chemical and petrochemical	NACE Rev. 2 Divisions 20 and 21 C201: Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms C202: Manufacture of pesticides and other agrochemical products C203: Manufacture of paints, varnishes and similar coatings, printing ink and mastics C204: Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations C205: Manufacture of other chemical products C206: Manufacture of man-made fibres C21: Manufacture of basic pharmaceutical products and pharmaceutical preparations
Non-ferrous metals	NACE Rev. 2 Group 24.4; and NACE Rev. 2 Classes 24.53 and 24.54 C244: Manufacture of basic precious and other non-ferrous metals C2453: Casting of light metals C2454: Casting of other non-ferrous metals
Non-metallic minerals	NACE Rev. 2 Division 23 C231: Manufacture of glass and glass products C232: Manufacture of refractory products C233: Manufacture of clay building materials C234: Manufacture of other porcelain and ceramic products C235: Manufacture of cement, lime and plaster C236: Manufacture of articles of concrete, cement and plaster C237: Cutting, shaping and finishing of stone C239: Manufacture of abrasive products and non-metallic mineral products n.e.c.
Transport equipment	NACE Rev. 2 Divisions 29 and 30 C29: Manufacture of motor vehicles, trailers and semi-trailers C30: Manufacture of other transport equipment
Machinery	NACE Rev. 2 Divisions 25, 26, 27 and 28 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.
Mining and quarrying	NACE Rev. 2 Divisions 07 (excluding 07.21: mining of uranium and thorium ores) and 08 (excluding 08.92: extraction of peat), NACE Rev. 2 Group 09.9 B07: Mining of metal ores B08: Other mining and quarrying B099: Support activities for other mining and quarrying
Food, beverages and tobacco	NACE Rev. 2 Divisions 10, 11 and 12 C10: Manufacture of food products C11: Manufacture of beverages C12: Manufacture of tobacco products
Paper, pulp and printing	NACE Rev. 2 Divisions 17 and 18 C171: Manufacture of pulp, paper and paperboard C172: Manufacture of articles of paper and paperboard C18: Printing and reproduction of recorded media
Textile and leather	NACE Rev. 2 Divisions 13, 14 and 15 C13: Manufacture of textiles C14: Manufacture of wearing apparel C15: Manufacture of leather and related products

[16] In the calculations the energy used in coke ovens and blast furnaces is attributed to the iron and steel industry, although they are considered part of the energy sector in EUROSTAT energy balances. The latter is done to better represent energy flows in the energy statistics, but the raison d'être of coke ovens and blast furnaces is to produce coke and pig iron, not to produce manufactured gases.

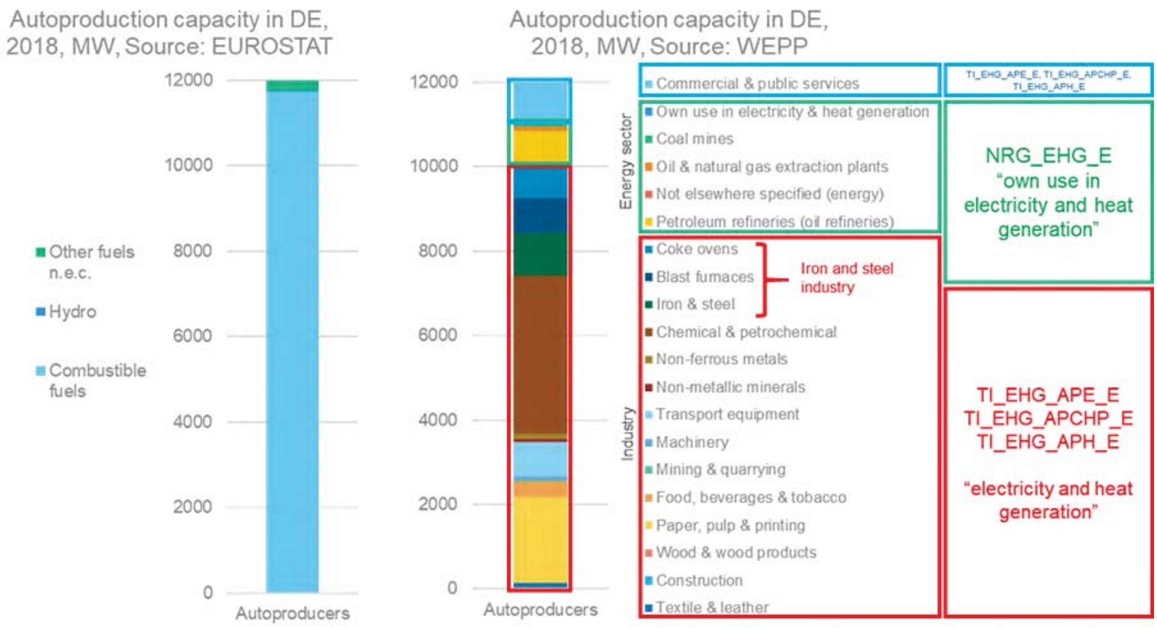
Industry	Description
Construction	NACE Rev. 2 Division 41, 42 and 43 F41: Construction of buildings F42: Civil engineering F43: Specialised construction activities
Wood and wood products	NACE Rev. 2 Division 16 C161: Sawmilling and planing of wood C162: Manufacture of products of wood, cork, straw and plaiting materials

Source: JRC, 2020

2.1 Disaggregation of the autoproduction blocks in the energy balances

The transformation inputs reported in EUROSTAT's energy balances for the autoproduction of "electricity and heat generation" (items TI_EHG_APE_E, TI_EHG_APCHP_E, and TI_EHG_APH_E in the energy balances) and the "own use in electricity and heat generation" (item NRG_EHG_E) are broken down by industry according to the installed capacities reported by S&P Global Platts "World Electric Power Plant Database" (WEPP) (S&P Global Platts, 2019)[17]. Autoproducers related to coke ovens and blast furnaces are considered part of the iron and steel industry.

Figure 1. Disaggregation of the autoproduction capacity



Source: JRC, 2020

To this purpose, the business types used in WEPP are matched with the sectors included in the energy balances of EUROSTAT, considering only the capacities of industrial autoproducers (see Table 2) to estimate the additional energy inputs not included as final energy consumption or non-energy use. The correspondences between WEPP and EUROSTAT are further refined depending on whether WEPP reports the power plants as CHP or not, as autoproducers or utilities, the fuel types used, or the owning company.

[17] Similarly to coke ovens and blast furnaces, EUROSTAT considers the energy inputs necessary for the autoproduction of electricity and heat in the transformation and own use blocks of the energy balances, in order to better represent the energy flows in the statistics. However, the energy bills (and the corresponding taxes) of industrial autoproducers are paid by the industry they belong to, and therefore the energy consumed by industrial autoproducers is allocated to the corresponding sector.

Table 2. Correspondences between WEPP business types and EUROSTAT sectors

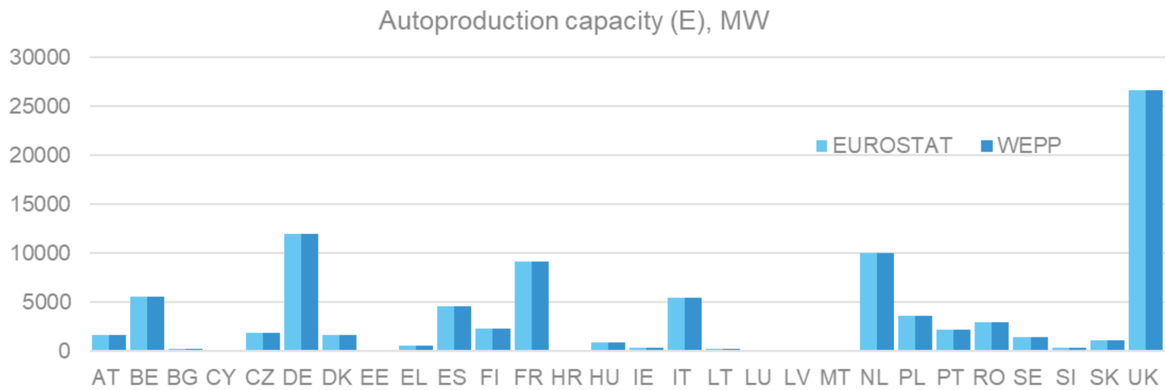
WEPP's business type	EUROSTAT sector
Commercial: Agriculture	Commercial & public services
Commercial: Leisure/recreation centres & swimming pools	Commercial & public services
Commercial: Greenhouse	Commercial & public services
Commercial: Hospitals & nursing homes	Commercial & public services
Commercial: Hotels & resorts	Commercial & public services
Commercial: Laundry & dry cleaning	Commercial & public services
Commercial: Media/publishing/book vendor	Commercial & public services
Commercial: Misc	Commercial & public services
Commercial: Misc commercial/industrial autoproducers	Commercial & public services
Commercial: Misc services	Commercial & public services
Commercial: Retailing	Commercial & public services
Commercial: Sugar Mill or Plant	Commercial & public services
Commercial: Trade/holding/diversified/conglomerate	Commercial & public services
Energy: DSM & energy services (ESCO)	Own use in electricity & heat generation
Energy exchanges	Own use in electricity & heat generation
Energy: Operating services company (non-utility)	Own use in electricity & heat generation
Energy: PUC/regulatory body	Own use in electricity & heat generation
Energy: Trading/brokers/marketeers (electric power and/or gas)	Own use in electricity & heat generation
Fuels: Coal	**Coke ovens** Coal mines Patent fuel plants BKB & PB plants Coal liquefaction plants
Fuels: Gas	Oil & natural gas extraction plants Gas works
Fuels: Gas and oil	Oil & natural gas extraction plants
Fuels: Gas and/or oil	Oil & natural gas extraction plants
Fuels: Other	Nuclear industry Liquefaction & regasification plants (LNG) Gasification plants for biogas Gas-to-liquids (GTL) plants Charcoal production plants
Fuels: Petroleum refinery	Petroleum refineries (oil refineries)
Fuels: ZZ (unspecified)	Not elsewhere specified (energy)
Fuels: Uranium mining & milling	**Mining & quarrying**
Govt: National	Commercial & public services
Govt: Regional (local/municipal/state)	Commercial & public services
Govt: Regional (County/District)	Commercial & public services
Govt: Regional (Local/Municipal)	Commercial & public services
Govt: Regional (State)	Commercial & public services
Mfg: Cement	**Non-metallic minerals**
Mfg: Chemicals & fertilzers	**Chemical & petrochemical**
Mfg: Equipment/Misc	**Machinery** **Transport equipment**
Mfg: Food products	**Food, beverages & tobacco**
Mfg: Metals & mining & smelters	**Iron & steel** **Blast furnaces** **Non-ferrous metals** **Mining & quarrying**
Mfg: Pulp & paper & forest products	**Paper, pulp & printing** **Wood & wood products**

WEPP's business type	**EUROSTAT sector**
Mfg: Textiles & clothing	**Textile & leather**
Mfg: ZZ/Unspecified	**Construction** **Not elsewhere specified (industry)**
Services: University/academic/library/laboratory	Commercial & public services
Services: Architect/Engineer/Constructor	Commercial & public services
Services: Association	Commercial & public services
Services: Association (Electric)	Commercial & public services
Trade groups and other types of membership organizations	Commercial & public services
Trade groups and other types of membership organizations	Commercial & public services
Trade groups and other types of membership organizations	Commercial & public services
Services: Association (Trade)	Commercial & public services
Services: Consulting	Commercial & public services
Services: Environmental	Commercial & public services
Services: Banking/finance/accounting/insurance	Commercial & public services
Services: Banking & finance (Banking)	Commercial & public services
Services: Banking & finance (Insurance)	Commercial & public services
Merchant transmission companies	Commercial & public services
Services: Waste to energy companies/plants	Commercial & public services
Trade groups and other types of membership organizations	Commercial & public services
Services: Private power project development	Commercial & public services
Services: Power plant services	Commercial & public services
Services: Real Estate	Commercial & public services
Services: Railroad/shipping/ports/airports	Commercial & public services
Services: Telecommunications and information technology	Commercial & public services
Util Other: Gas	Own use in electricity & heat generation
Util Other: Heating (Steam)	Own use in electricity & heat generation
Util Other: Telecommunications	Commercial & public services
Util Other: Water and wastewater	Commercial & public services
Elec Util & Comb: Cooperative ownership (US=Rural Elec Coops)	Own use in electricity & heat generation
District heating and/or cooling utility	Commercial & public services
Elec Util & Comb: Government ownership	Commercial & public services
Elec Util & Comb: Government ownership (County)	Commercial & public services
Elec Util & Comb: Government ownership (Irrigation District)	Commercial & public services
Elec Util & Comb: Government ownership (Local/Municipal)	Commercial & public services
Elec Util & Comb: Government ownership (Federal/Provincial)	Commercial & public services
Elec Util & Comb: Government ownership (Public Power/Public Utility District)	Commercial & public services
Elec Util & Comb: Government ownership (Regional)	Commercial & public services
Elec Util & Comb: Government ownership (State)	Commercial & public services
Elec Util & Comb: Holding	Commercial & public services
Elec Util & Comb: Investor/private ownership (IOU)	Commercial & public services
Elec Util & Comb: Operating service company (regulated utility)	Commercial & public services

Source: JRC, 2020
In bold: industrial sectors

The result of this process allows matching fairly well the amount of autoproduction capacity reported by EUROSTAT for each EU MS (Figure 2).

Figure 2. Comparison of the autoproduction capacity in EUROSTAT and WEPP

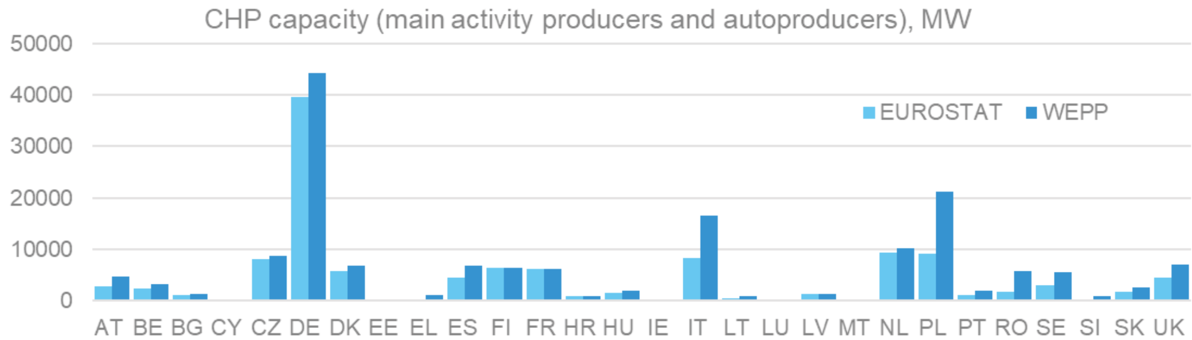


Source: JRC, 2020

However, the following caveats need to be taken into account:

- The disaggregation of the energy balances by industry should be based on activity-based indicators, but there are no data on the utilisation rates of these autproduction facilities. The resulting capacity-based disaggregation of the energy balances is therefore only a plausible approximation built upon the available information.
- There are mismatches between the operational status of autoproducers in WEPP and EUROSTAT. While EUROSTAT reports 69 GW of autoproduction capacity, only 61 GW were operational according to WEPP. If that were taken into account, the disaggregation of the autoproduction would yield different results, especially in some industries where the amount of energy used for autoproduction represents a noticeable share of the total energy use (e.g. pulp, paper and printing, 12% on average for the EU).
- CHP data do not match in some countries (WEPP reports higher capacities in some countries, notably PL, IT, DE, RO, SE) (Figure 3). The calculations are based on WEPP's data.
- There are no data on the capacities of autoproducers of heat only, thus it is assumed that the capacity of autoproduction of heat follows the same distribution as the CHP capacity.

Figure 3. Comparison of the CHP capacity in EUROSTAT and WEPP.



Source: JRC, 2020

2.2 Disaggregation of non-energy use by industry

Energy products are used as feedstocks for different purposes (Table 3). The consumption of energy for non-energy uses accounts for a significant share of the total energy use in the industry (between 4% and 55% depending on the MS, 28% on average for the EU) but it is not disaggregated by industry in EUROSTAT's energy balances. The disaggregation by industrial sector has been done according to the "memo items" available from the IEA's Extended World Energy Balances (International Energy Agency, 2020).

Table 3. Possible non-energy uses of energy carriers (non-exhaustive)

Energy carrier	Purpose
Gas/diesel oil	Ammonia, petrochemicals
LPG	Petrochemicals
Naphtha	Ethylene, petrochemicals
Lubricants, solvents, paraffin waxes, greases	All industrial sectors
Oil products	Ammonia
Coke, coal	Titanium dioxide, carbide, aluminium, ferroalloys
Coke	Lead, zinc, food and beverages
Natural gas	Ammonia, methanol, carbon black, nitric acid, petrochemicals, hydrogen
Bitumen	Construction
Refinery gas	Petrochemicals
Petroleum coke	Carbide production

Source: JRC, 2020, adapted from Annex 8A.2, Table 2.12, in (Eggleston et al., 2006).

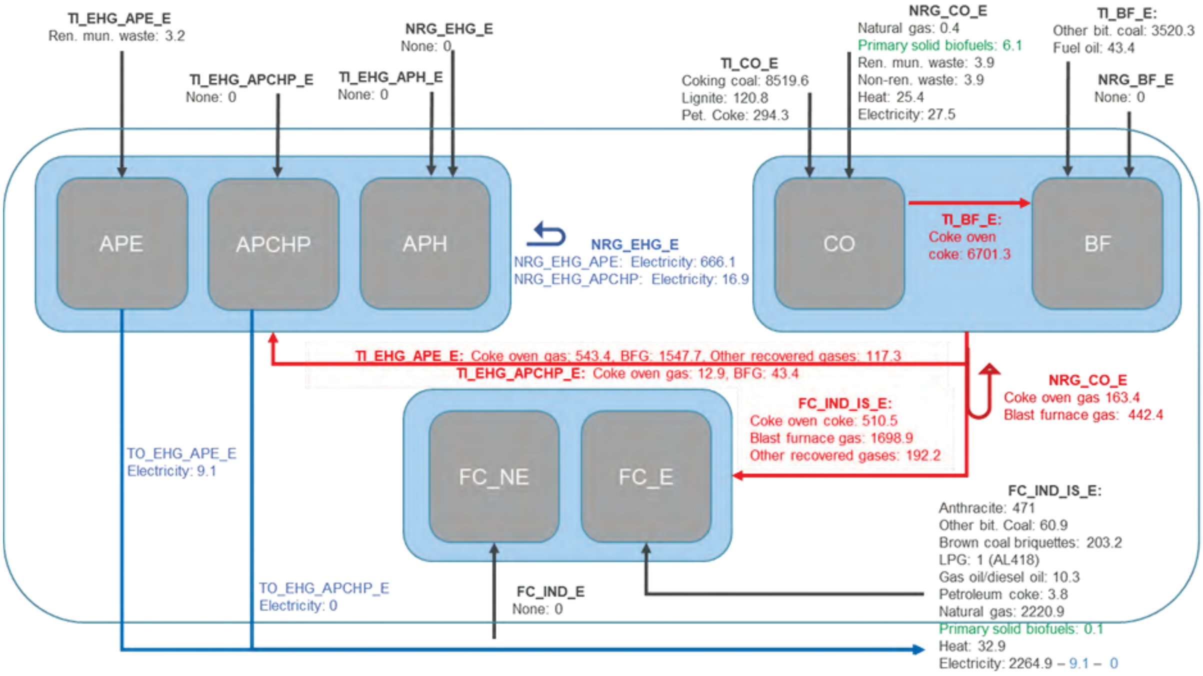
3.3 Estimation of the total energy use by industry

Once all the blocks of the energy balances are fully disaggregated it is possible to estimate the total amount of energy used by each industrial sector. This is done by subtracting the feedbacks from coke ovens[18], blast furnaces[19], and power plants[20] from the total amount of energy inputs[21]. Only the inputs from external sources are considered to be taxable. The feedbacks of energy carriers that are produced internally are considered exempt from additional taxation.

Figure 4 and Figure 5 illustrate this approach with the examples of the energy balances of the German iron and steel and chemical and petrochemical industries in 2018.

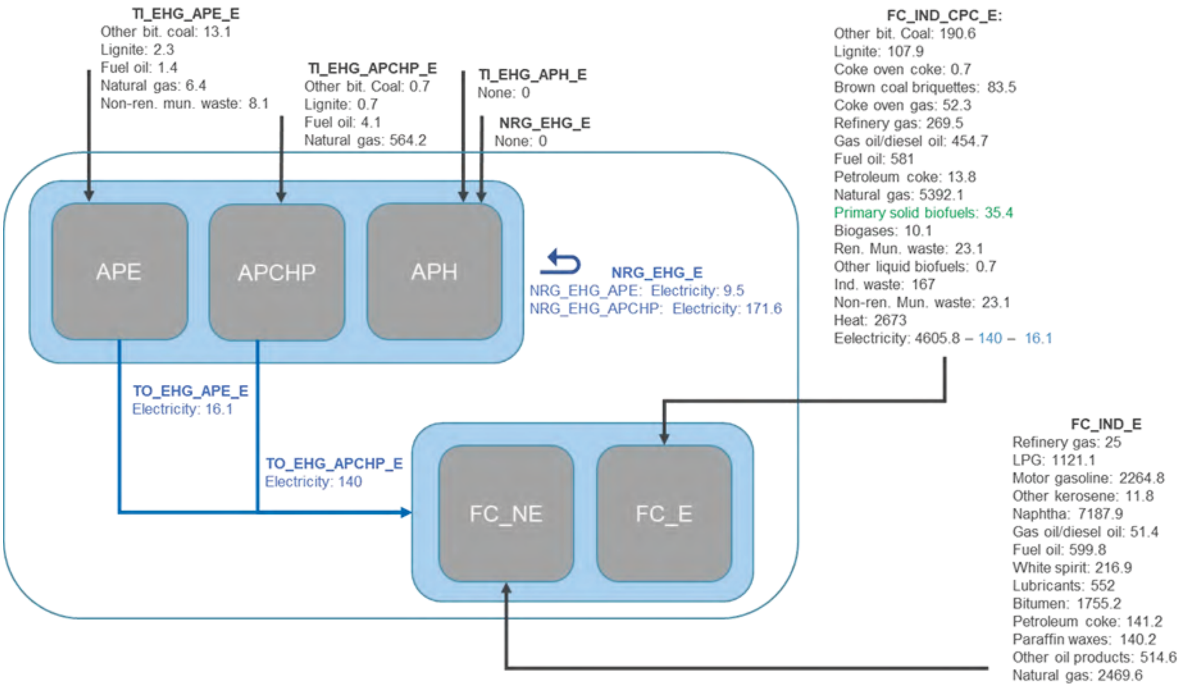
[18] Columns "coke oven coke", "coal tar" and "coke oven gas" in the final energy consumption block.
[19] Columns "blast furnace gas" and "other recovered gases" in the final energy consumption block.
[20] Column "electricity" from autoproducers of electricity and heat.
[21] Rows TI_EHG_APE_E, TI_EHG_APCHP_E, TI_EHG_APH_E (transformation inputs for the autoproduction of electricity, CHP, and heat); TI_CO_E (transformation inputs into coke ovens), TI_BF_E (transformation inputs into blast furnaces), NRG_EHG_E (own consumption of autoproducers), FC_IND_NE (non-energy use in industry), and FC_IND_E (final energy consumption in industry) in the energy balances.

Figure 4. Energy balance of the German iron and steel industry in 2018



Source: JRC, 2020 with data from EUROSTAT

Figure 5. Energy balance of the German chemical and petrochemical industry in 2018



Source: JRC, 2020 with data from EUROSTAT

All figures in ktoe.Colour legend:
Inputs from external sources: taxes may be applied on these items only
Feedbacks of coke oven coke, coal tar, and coke oven gas from coke ovens: produced internally, not taxed
Feedbacks of blast furnace gas and other recovered gases from blast furnaces produced internally, not taxed
Feedbacks of electricity from autoproducers of electricity and CHP: produced internally, not taxed
Wood and wood products, peat not taxed according to article 2 ETD

2.4 *Breakdown of the total energy use by industry*

The total energy used by each industry is split into in/out of scope categories according to the shares resulting from assigning the processes included in the detailed energy balances of JRC-IDEES 2015 to the categories considered in the ETD. The shares calculated in this process are assumed to be valid for 2018.

The assignations and the shares are corrected with more detailed information at facility level whenever available (only in the cases of the chemical and petrochemical (Boulamanti and Moya, 2017); pulp, paper and printing (Moya and Pavel, 2018); and iron and steel industries (Pardo et al., 2012)). The assignations also take into account relevant rulings of the Court of Justice of the European Union (CJEUC) interpreting article 2 of the ETD (see Table 4).

According to the ETD some energy carriers and processes can be considered out of scope:

- **Chemical reduction**: in the calculations part of the energy used for the production of hydrogen, ammonia and methanol in the chemical and petrochemical industry, and the inputs to blast furnaces would fall under this category.
- **Electrolysis**: the use of electricity for the production of chlorine in the chemical and petrochemical industry and for the smelting of aluminium in the non-ferrous metals industry.
- **Metallurgical processes** in the iron and steel and the non-ferrous metal industries. This includes shaping processes (such as casting, forging, rolling, extrusion, machining, cutting, or bending), heat treatments (annealing, tempering, or quenching), and surface treatments (plating, shot peening or thermal spraying). Therefore, the "products finishing", "thermal foundries" and "thermal and electric connections" processes listed in JRC-IDEES are considered as metallurgical processes.
- **Mineralogical processes**. This category includes all processes in the non-metallic minerals industries (as specified in article 2 of the ETD), as well as the production of lime within the pulp, paper and printing industry.
- **Other dual uses** would include the consumption of energy products used as process feedstocks.
- **Wood and wood products**: this is the consumption of products CN-4401 and CN-4402[22], as stipulated in article 2.4.a of the ETD, which is estimated as the consumption of "primary solid biofuels" and charcoal, which are used as proxy due to the lack of better data. The actual amount of wood and wood products would be a fraction of this value.
- **Peat**: according to article 2.3 of the ETD, the amounts of "peat" and "peat products" recorded in the energy balances.
- **Electricity**: when it accounts for 50% of the cost of a product, but this is not estimated due to lack of data.
- **Uses other than motor or heating fuels**: these would include diverse processes (such as lighting or cooling). Electricity is considered as a motor fuel when it can be replaced by another energy product.

Any other uses not explicitly included in the above list have been considered by default within the scope of the ETD.

[22] Combined nomenclature codes, Commission Regulation (EC) No 2031/2001 of 6 August 2001, amending Annex I to Council Regulation (EEC) No 2658/87 on the tariff and statistical nomenclature and on the Common Customs Tariff

The following tables (Table 6 to Table 17) summarise how the processes used in JRC-IDEES are considered to be in/out of scope of the ETD.

Table 4. CJEUC rulings interpreting article 2 of the ETD.

Ruling	Summary
CJEUC-606/13, OKG AB, ECLI:EU:C:2015	The case concerns the taxation of thermal power of nuclear reactors. The scope of the ETD, defined by Art.2, does not include the thermal power of a nuclear reactor, hence it cannot be considered an "energy product". The definition of "electricity" in Art.2.2, defined by CN code 22716, means that the thermal power of a nuclear reactor does not come within the definition of "electricity".
CJEUC-517/07, Afton Chemical Limited, ECLI:EU:C:2008	The case concerns whether fuel additives which are themselves not designed to power vehicles (they are cleaning agents, solvents, demulsifiers, etc.) should be taxed under the ETD. The court case itself states that the wording is unclear and imprecise. The ruling shows that any additive to a fuel should be taxed to the same extent as the motor fuel (Art.2.3).
CJEUC-43/13 and C-44/13, Kronos Titan GmbH, ECLI:EU:C:2014	The case concerns how the equivalent taxes for energy products that are not directly specified in the ETD should be determined (should they be taxed as heating fuels or motor fuels based on its use or its closest energy product listed in the ETD). In this case, a producer of titanium dioxide powder needs a temperature of 1 650 degrees to produce the chemical reaction desired. To do so, they burn toluene spraying into an oxygen stream. Another manufacturer of surface coatings burns white spirit for a thermal treatment process. The court rules that the equivalent rate of taxation, is first determined based on its use as either as a heating fuel or motor fuel (in both cases above they are heating fuels), before identifying for which of the motor or heating fuels in Annex I is closest to it
CJEUC-426/12, X, ECLI:EU:C:2014	The case concerns a sugar producer who argues that the use of coal as a fuel in the lime kiln, and the use of the resulting CO_2 to produce lime-kiln gas (indispensable for the purification of raw juice) and the subsequent absorption of CO_2 into earth form (sold as fertiliser to the agricultural sector), corresponds to dual-use under Art.2.4.b, and should be exempt under the ETD. A product has "dual use" under Art.2.4.b when it is used both as heating fuel and for purposes other than as motor fuel and heating fuel. In the case of sugar production, the gas which is needed for purification can only be obtained by using coal (due to impurities), so coal can be considered both as a heating fuel and as a raw material (to produce CO_2). The court ruled that in this case, using coal as the heating fuel and then using the generated CO_2 from the combustion within the same production process does constitute "dual use". However, the use of gas as a residue that is then recycled to produce chemical fertiliser (which is then used as a primary material in a separate manufacturing process) does not constitute "dual use". From the ruling: "… there may be dual use of an energy product burned in a manufacturing process where … that process cannot be completed without a substance that can be generated only by the combustion of that energy product".
CJEUC-529/14, YARA Brunsbüttel GmbH, ECLI:EU:C:2015	This case concerns an ammonia producer, who uses natural gas in a superheater mixed with the "poor" waste gases of the ammonia production. The heat used fulfilled multiple functions: heating and drying of vapour; chemical decomposition of waste gas; evacuation of waste gases. The producer argues that the natural gas should be considered "dual use" (and thus exempt under the ETD), as it is partly used as a heating fuel (steam for the ammonia production) but also in the waste-gas treatment (decomposition of waste-gas). An expert stated that the ammonia production could take place without the natural gas (sufficient heat from the waste gases) and that its purpose was to evacuate waste-gases (to be in agreement with environmental regulations). The court ruled that it does not constitute dual use, for two reasons: i. First, the production process could be completed without the natural gas. ii. Even if it could not be, vapour is not a substance that can be generated only using natural gas (does this mean that any steam production is automatically in scope?). It is implicit in both the sugar and ammonia case "that the energy product could only benefit from the 'dual use' exception to the extent that it had been physically transformed and contributed in that altered state to the production process".
CJEUC-465/15, Hüttenwerke Krupp Mannesmann	The case concerns a steel producer, who argues that the electricity used to power turbo blowers which compress air that is then injected into the blast furnace to trigger the reduction of iron ore should be exempt under Art.2.4.b ("electricity used principally for

Ruling	Summary
GmbH, ECLI:EU:C:2017	the purposes of chemical reduction”). The court rules that this is not the case. It argues that if the turbo blowers were operated with diesel instead of electricity, the diesel would not be exempt from the ETD (it would not fall under the “dual use” concept), since it would solely be a motor fuel. As the ETD aims to tax energy products and electricity to the same extent when they are interchangeable, it means that in this case the electricity is also not exempt. “If, however, the turbo blower had operated not with electricity, but rather by using an energy product such as diesel, the latter would not fall within the concept of ‘dual use’ of Art.2.4.b, since the use of the energy product concerned would only serve to produce a driving force, which would therefore correspond to use as a fuel”.

Source: JRC, 2020

Specific assumptions for the chemical and petrochemical industry

In the case of the chemical and petrochemical industry, additional data at facility level (Boulamanti and Moya, 2017) have been used to determine how much of the energy consumed in each of the main production processes is in scope of the ETD, or used for chemical reduction or electrolysis.

Table 5 shows the 45 main processes used in the chemical industry across the EU (Boulamanti and Moya, 2017). The processes are split into three types: “electrolysis”, “redox”, and “other”. In a “redox” reaction the oxidation states of the atoms change (oxidation: increment of the oxidation state, reduction: decrease of the oxidation state), while they do not in “other” reactions. The shares of thermal and electric energy necessary for each process are assigned to “electrolysis”, “reduction” (when at least one of the elements of the main product is reduced and the others do not change their oxidation state), or “in scope” (when the elements of the main product are only oxidized, reduced and oxidized, or do not change at all).

The breakdown of the energy uses in the chemical and petrochemical industry at national level is shown in Table 6. These values result from the data for each process (Table 5) with the available information at facility level (Boulamanti and Moya, 2017). They are used when there is not a straightforward allocation of processes from JRC-IDEES to the ETD categories (processes “steam processing”, “generic electric processes”, and “high enthalpy processing”, which appear under different ETD categories in Table 7).

The dataset provides a snapshot of the chemical and petrochemical industry in 2013 that accounts for a share of its final energy consumption in that year. For that reason it has been assumed that the uncovered share of final energy consumption is considered in scope by default since the same structure cannot be extrapolated to the whole industry. The resulting distribution of the energy uses is then applied to the 2018 energy balances of the chemical and petrochemical industry. It is also assumed that the database includes all the production capacity of chlorine, the only product that requires electrolysis, in 2018.

Table 5. Types of production processes in the chemical and petrochemical industry

Process	Product	Reaction(s)	Type	Electricity share			Thermal energy share		
				Elec.	C. red.	I. S.	Elec.	C. red.	I. S.
Ammoxidation (Sohio process)	Propylene	C_6H_{14} (-2.33,+1) → 2 $\mathbf{C_3H_6}$ (-2,+1) + H_2 (0)	Redox	0	0	100	0	0	100
	Acrylonitrile	C_3H_6 (-2,+1) + NH_3 (-3,+1) + 1.5 O_2 (0) → $\mathbf{C_3H_3N}$ (-2,+1,+3) + 3 H_2O (+1,-2)							
Chloralkali diaphragm cell	Chlorine		Electrolysis	100	0	0	0	0	100
Chloralkali membrane cell	Chlorine		Electrolysis	100	0	0	0	0	100
Chloralkali mercury cell	Chlorine		Electrolysis	100	0	0	0	0	100
Cyclohexane KA oxidation	Adipic acid	$C_6H_{10}O$ (-1.33,+1,-2) + $C_6H_{12}O$ (-1.67,+1,-2) + x HNO_3 (+1,+5,-2) → 2 $\mathbf{C_6H_{10}O_4}$ (-0.33,+1,-2) + y N_2O (+1,-2) + z H_2O (+1,-2)	Redox	0	0	100	0	0	100
Direct chlorination	Ethylene dichloride	C_2H_4 (-2,+1) +Cl_2 (0) → $\mathbf{C_2H_4Cl_2}$ (-1,+1,-1)	Redox	0	0	100	0	0	100
Direct oxidation	Ethylene oxide	C_2H_4 (-2,+1) + 0.5 O_2 (0) → $\mathbf{C_2H_4O}$ (-1,+1,-2)	Redox	0	0	100	0	0	100
EDC cracking	Vinyl chloride monomer	C_2H_4Cl (-1,+1,-1) → $\mathbf{C_2H_3Cl}$ (-1,+1,-1) + HCl (+1,-1)	Other	0	0	100	0	0	100
Emulsion polymerisation	PVC-e	n C_2H_3Cl (-1,+1,-1) → $\mathbf{(C_2H_3Cl)_n}$ (-1,+1,-1)	Other	0	0	100	0	0	100
ETB dehydrogenation	Styrene	C_8H_{10} (-1.25,+1) → $\mathbf{C_8H_8}$ (-1,+1) + H_2 (0)	Redox	0	0	100	0	0	100
Fluid catalytic cracking	Propylene	C_6H_{14} (-2.33,+1) → 2 $\mathbf{C_3H_6}$ (-2,+1) + H_2 (0)	Redox	0	0	100	0	0	100
Friedel crafts	Ethylbenzene	C_6H_6 (-1,+1) + C_2H_4 (-2,+1) → $\mathbf{C_6H_5CH_2CH_3}$ (-0.83,+1,-2,+1,-3,+1)	Redox	0	0	100	0	0	100
Furnace black	Carbon black	C_xH_y (-y/x,+1) + z O_2 (0) → x $\mathbf{C}$ (0) + H_2O (+1,-2)	Redox	0	0	100	0	0	100
Heavy oil partial oxidation	Methanol	C_xH_y (-y/x,+1) + z O_2 (0) → x $\mathbf{CH_4O}$ (-2,+1,-2) + z H_2O (+1,-2)	Redox	0	0	100	0	0	100
Heavy residue based ammonia	Hydrogen	C_xH_y (-y/x,+1) + 0.5x O_2 (0) → 0.5y $\mathbf{H_2}$ (0) + x CO (+2,-2)	Redox	0	26.8	73.2	0	93	7
		C (0) + H_2O (+1,-2) → $\mathbf{H_2}$ (0) + CO (+2,-2)							
		C (0) + 0.5 O_2 (0) → $\mathbf{CO}$ (+2,-2)							
	Ammonia	N_3 (0) + 3 H_2 (0) → 2 $\mathbf{NH_3}$ (-3,+1)							
Hydration	Monoethylene glycol	C_2H_40 (-1,+1,-2) + H_2O (+1,-2) → $\mathbf{C_2H_6O_2}$ (-1,+1,-2)	Other	0	0	100	0	0	100
Naphtha based - benzene	Benzene	C_6H_{14} (-2.33,+1) → $\mathbf{C_6H_6}$ (-1,+1) + 4 H_2 (0)	Redox	0	0	100	0	0	100
Naphtha based - only benzene	Benzene	C_6H_{14} (-2.33,+1) → $\mathbf{C_6H_6}$ (-1,+1) + 4 H_2 (0)	Redox	0	0	100	0	0	100
Naphtha based - toluene	Toluene	7 C_6H_{14} (-2.33,+1) → 6 $\mathbf{C_7H_8}$ (1.14,+1) + 25 H_2 (0)	Redox	0	0	100	0	0	100
Naphtha based - xylenes	Xylenes	6 C_6H_{14} (-2.33,+1) → 3 $\mathbf{C_8H_{10}}$ (-1.25,+1) + 13 H_2 (0)	Redox	0	0	100	0	0	100
Naphtha reforming	Hydrogen	Steam cracking	Redox	0	0	100	0	0	100
Natural gas based ammonia	Nitrogen, hydrogen	CH_4 (-4,+1) + H_2O (+1,-2) → 3 $\mathbf{H_2}$ (0) + CO (+2,-2)	Redox	0	37.7	62.3	0	67.7	32.3
		CO (+2,-2) + H_2O (+1,-2) → $\mathbf{H_2}$ (0) + CO_2 (+4,-2)							
		CH_4 (-4,+1) + air (0) →2 $\mathbf{N_2}$ (0) + CO (+2,-2) + 2 H_2 (0)							
	Ammonia	N_3 (0) + 3 H_2 (0) → 2 $\mathbf{NH_3}$ (-3,+1)							
Ostwald: dual pressure	Nitric acid	NH_3 (-3,+1) + 5 O_2 (0) → 4 $\mathbf{NO}$ (+2,-2) + 6 H_2O (+1,-2)	Redox	0	0	100	0	0	100
		2 NO (+2,-2) + O_2 (0) → 2 $\mathbf{NO_2}$ (+4,-2)							
		3 NO_2 (+4,-2) + H_2O (+1,-2) → 2 $\mathbf{HNO_3}$ (+1,+5,-2) + NO (+2,-2)							
Ostwald: single pressure	Nitric acid	NH_3 (-3,+1) + 5 O_2 (0) → 4 $\mathbf{NO}$ (+2,-2) + 6 H_2O (+1,-2)	Redox	0	0	100	0	0	100
		2 NO (+2,-2) + O_2 (0) → 2 $\mathbf{NO_2}$ (+4,-2)							
		3 NO_2 (+4,-2) + H_2O (+1,-2) → 2 $\mathbf{HNO_3}$ (+1,+5,-2) + NO (+2,-2)							

Process	Product	Reaction(s)	Type	Electricity share			Thermal energy share		
				Elec.	C. red.	I. S.	Elec.	C. red.	I. S.
Oxychlorination	Ethylene dichloride	2 C_2H_4 (-2,+1) + 4 HCl (+1,-1) + O_2 (0) $\rightarrow$ **$C_2H_4Cl_2$** (-1,+1,-1) + H_2O (+1,-2)	Redox	0	100	0	0	100	0
Partial oxidation	Hydrogen	Heavy oil partial oxidation	Redox	0	0	100	0	0	100
Phenol KA oxidation	Adipic acid	2 C_6H_6O (-0.67,+1,-2) + 4 H_2O (+1,-2) + O_2 (0) $\rightarrow$ 2 **$C_6H_{10}O_4$** (-0.33,+1,-2)	Redox	0	0	100	0	0	100
PVC - mechanical recycling	PVC recycled		Other	0	0	100	0	0	100
Pygas based - benzene	Benzene	C_6H_{14} (-2.33,+1) $\rightarrow$ **C_6H_6** (-1,+1) + 4 H_2 (0)	Redox	0	0	100	0	0	100
Pygas based - only benzene	Benzene	C_6H_{14} (-2.33,+1) $\rightarrow$ **C_6H_6** (-1,+1) + 4 H_2 (0)	Redox	0	0	100	0	0	100
Pygas based - toluene	Toluene	7 C_6H_{14} (-2.33,+1) $\rightarrow$ 6 **C_7H_8** (1.14,+1) + 25 H_2 (0)	Redox	0	0	100	0	0	100
Pygas based - xylenes	Xylenes	6 C_6H_{14} (-2.33,+1) $\rightarrow$ 3 **C_8H_{10}** (-1.25,+1) + 13 H_2 (0)	Redox	0	0	100	0	0	100
Solvay	Soda ash	2 $Na_3H(CO_3)_2$ (+1,+1,+4,-2) $\rightarrow$ 3 **Na_2CO_3** (+1,+4,-2) +H_2O (+1,-2) + CO_2 (+4,-2)	Other	0	0	100	0	0	100
	Soda ash	NaCl (+1,-1) + $CaCO_3$ (+2,+4,-2) $\rightarrow$ **Na_2CO_3** (+1,+4,-2) + $CaCl_2$ (+2,-1)	Other	0	0	100	0	0	100
Steam cracking ethane-based	Ethylene	C_2H_6 (-3,+1) $\rightarrow$ **C_2H_4** (-2,+1) + H_2 (0)	Redox	0	0	100	0	0	100
Steam cracking gas oil-based	Ethylene	2 $C_nH_{(2n+2)}$ (-(2n+2)/n,+1) $\rightarrow$ n **C_2H_4** (-2,+1) + 2 H_2 (0)	Redox	0	0	100	0	0	100
Steam cracking naphtha-based	Butadiene	2 C_6H_{14} (-2.33,+1) $\rightarrow$ 3 **C_4H_6** (-1.5,+1) + 5 H_2 (0)	Redox	0	0	100	0	0	100
Steam cracking naphtha-based	Butenes	2 C_6H_{14} (-2.33,+1) $\rightarrow$ 3 **C_4H_8** (-2,+1)) + 2 H_2 (0)	Redox	0	0	100	0	0	100
Steam cracking naphtha-based	Ethylene	C_6H_{14} (-2.33,+1) $\rightarrow$ 3 **C_2H_4** (-2,+1) + H_2 (0)	Redox	0	0	100	0	0	100
Steam cracking naphtha-based	Propylene	C_6H_{14} (-2.33,+1) $\rightarrow$ 2 **C_3H_6** (-2,+1) + H_2 (0)	Redox	0	0	100	0	0	100
Steam reforming	Hydrogen	CH_4 (-4,+1) + H_2O (+1,-2) $\rightarrow$ 3 **H_2** (0) + CO (+2,-2)	Redox	00	100	0	0	100	0
		CO (+2,-2) + H_2O (+1,-2) $\rightarrow$ **H_2** (0) + CO_2 (+4,-2)							
		CH_4 (-4,+1) + air (0) $\rightarrow$ 2 **H_2** (0) + CO (+2,-2) + 2 N_2 (0)							
Steam reforming - methanol	Hydrogen	CH_4 (-4,+1) + H_2O (+1,-2) $\rightarrow$ 3 **H_2** (0) + CO (+2,-2)	Redox	0	22.6	77.4	0	12.5	87.5
		CO (+2,-2) + H_2O (+1,-2) $\rightarrow$ **H_2** (0) + CO_2 (+4,-2)							
		CH_4 (-4,+1) + air (0) $\rightarrow$ 2 **H_2** (0) + CO (+2,-2) + 2 N_2 (0)							
	Methanol	CO (+2,-2) + 2 H_2 (0) $\rightarrow$ **CH_4O** (-2,+1,-2)							
		CO_2 (+4,-2) + 3 H_2 (0) $\rightarrow$ **CH_4O** (-2,+1,-2) + H_2O (+1,-2)							
		CH_4 (-4,+1) + 0.5 O_2 (0) $\rightarrow$ **CH_4O** (-2,+1,-2) + 2 H_2 (0) + CO (+2,-2)							
Suspension polymerisation	PVC-S	n C_2H_3Cl (-1,+1,-1) $\rightarrow$ **$(C_2H_3Cl)_n$** (-1,+1,-1)	Other	0	0	100	0	0	100
Urea synthesis	Ammonia	See ammonia processes	Other	0	0	100	0	0	100
	Urea	NH_3 (-3,+1) + CO_2 (+4,-2) $\rightarrow$ **CH_4N_2O** (+4,+1,-3,-2) + H_2O (+1,-2)							

Source: JRC, 2020

1: Main product in bold
2: Colour code: red = oxidation, green = reduction, blue = oxidation and reduction
3: Numbers within brackets show the oxidation states
4: Elec.: electrolysis
5: C. red.: chemical reduction
6: I. S.: in scope

Table 6. Breakdown of the energy uses in the chemical and petrochemical industry from (Boulamanti and Moya, 2017)

Country	FEC[1] (2013, ktoe)		FEC coverage[3]	"In scope" by default	Electricity shares[4]			Thermal energy shares[4]		
	EUROSTAT	Database[2]			Electrolysis	Chemical reduction	In scope	Electrolysis	Chemical reduction.	In scope
AT	995	111.1	11.2%	88.8%	3%	3%	93%	0%	8%	92%
BE	4201	1792.7	42.7%	57.3%	11%	3%	86%	0%	7%	93%
BG	781	408.0	52.3%	47.7%	0%	1%	99%	0%	8%	92%
CY	3	0.0	1.2%	98.8%	0%	0%	100%	0%	0%	0%
CZ	1039	349.6	33.7%	66.3%	12%	0%	88%	0%	0%	100%
DE	14232	6200.4	43.6%	56.4%	18%	3%	79%	0%	6%	94%
DK	268	0.6	0.2%	99.8%	0%	0%	100%	0%	0%	100%
EE	75	26.6	35.7%	64.3%	0%	2%	98%	0%	32%	68%
EL	111	30.4	27.3%	72.7%	8%	1%	90%	0%	25%	75%
ES	4075	1080.0	26.5%	73.5%	21%	5%	74%	0%	2%	98%
FI	1055	78.8	7.5%	92.5%	6%	1%	93%	0%	0%	100%
FR	4753	2271.1	47.8%	52.2%	15%	2%	82%	0%	7%	93%
HR	137	119.7	87.2%	12.8%	0%	4%	96%	0%	40%	60%
HU	1048	435.9	41.6%	58.4%	21%	1%	79%	0%	6%	94%
IE	228	3.9	1.7%	98.3%	1%	0%	99%	0%	0%	100%
IT	4137	1155.0	27.9%	72.1%	2%	2%	95%	0%	5%	95%
LT	362	71.5	19.7%	80.3%	0%	0%	100%	0%	15%	85%
LU	70	0.1	0.2%	99.8%	0%	0%	100%	0%	0%	100%
LV	25	0.0	0.1%	99.9%	0%	0%	100%	0%	0%	100%
MT	3	0.0	0.4%	99.6%	0%	0%	100%	0%	0%	0%
NL	7232	2584.7	35.7%	64.3%	14%	4%	81%	0%	7%	93%
PL	2790	1137.9	40.8%	59.2%	4%	0%	96%	0%	15%	85%
PT	495	62.4	12.6%	87.4%	11%	1%	88%	0%	1%	99%
RO	1645	716.8	43.6%	56.4%	32%	2%	66%	0%	17%	83%
SE	536	524.9	97.9%	2.1%	8%	3%	89%	0%	4%	96%
SI	150	4.1	2.7%	97.3%	5%	0%	95%	0%	0%	100%
SK	295	113.1	38.3%	61.7%	17%	0%	83%	0%	22%	78%
EU	50742	14003	38.0%	62.0%	13%	3%	84%	0%	7%	93%

Source: JRC. 2020

1: FEC: final energy consumption
2: Source: (Boulamanti and Moya, 2017)
3: Ratio Database / EUROSTAT. Low values in the "FEC coverage" column correspond to countries where the chemical and petrochemical industry is fairly small.
4: These shares are used to allocate the JRC-IDEES processes "steam processing", "generic electric processes", and "high enthalpy processing" to ETD categories in Table 7.

Table 7. Chemical and petrochemical processes

In scope	Out of scope						
	Uses other than motor or heating fuel	**Chemical reduction**	**Metallurgical processes**	**Electrolysis**	**Mineralogical processes**	**Other dual uses**	**Excluded energy carriers**
Autoproduction of electricity and heat	Lighting	Production of hydrogen, ammonia, and methanol		Production of chlorine		Feedstocks	Wood and wood products
Low enthalpy heat	Process cooling (based on natural gas, steam or electricity)	Steam processing[1]					Peat
Air compressors		Generic electric processes[1]					
Motor drives							
Fans and pumps							
Steam processing[1]							
Thermal and electric furnaces							
Generic electric processes[1]							
High enthalpy heat processing							

Source: JRC. 2020

1: This corresponds to the share not covered in (Boulamanti and Moya, 2017) that cannot be identified explicitly as out of scope, according to Table 5.

Table 8. Pulp, paper and printing.

In scope	Out of scope						
	Uses other than motor or heating fuel	**Chemical reduction**	**Metallurgical processes**	**Electrolysis**	**Mineralogical processes**	**Other dual uses**	**Excluded energy carriers**
Autoproduction of electricity and heat	Lighting				Lime production[1]	Feedstocks	Wood and wood products
Low enthalpy heat	Wood preparation and grinding						Peat
Air compressors	Stock preparation (electricity)						
Motor drives	Paper machine (electricity)						
Fans and pumps	Electric pulping						
Thermal pulping	Cleaning						
Stock preparation (thermal energy)	Product finishing						
Paper machine (thermal energy)							

Source: JRC, 2020

1: From (Moya and Pavel, 2018)

Table 9. Iron and steel

In scope	Out of scope						
	Uses other than motor or heating fuel	**Chemical reduction**	**Metallurgical processes**	**Electrolysis**	**Mineralogical processes**	**Other dual uses**	**Excluded energy carriers**
Autoproduction of electricity and heat	Lighting	Blast furnaces and basic oxygen furnaces	Sinter and pellet making			Feedstocks	Wood and wood products
Low enthalpy heat			Furnaces, refining and rolling				Peat
Air compressors			Products finishing				
Motor drives			Electric arc				
Fans and pumps							

Source: JRC. 2020

Table 10. Non-metallic minerals

In scope	Out of scope						
	Uses other than motor or heating fuel	**Chemical reduction**	**Metallurgical processes**	**Electrolysis**	**Mineralogical processes**	**Other dual uses**	**Excluded energy carriers**
Autoproduction of electricity and heat					All processes (article 2 of the ETD)	Feedstocks	Wood and wood products
							Peat

Source: JRC, 2020

Table 11. Non-ferrous metals

In scope	Out of scope						
	Uses other than motor or heating fuel	**Chemical reduction**	**Metallurgical processes**	**Electrolysis**	**Mineralogical processes**	**Other dual uses**	**Excluded energy carriers**
Autoproduction of electricity and heat	Lighting		Alumina refining	Aluminium smelting		Feedstocks	Wood and wood products
Low enthalpy heat			Aluminium processing and finishing				Peat
Air compressors			Metal production, processing and finishing				
Motor drives							
Fans and pumps							
High enthalpy heat							

Source: JRC. 2020

Table 12. Food, beverages and tobacco

In scope	Out of scope						
	Uses other than motor or heating fuel	Chemical reduction	Metallurgical processes	Electrolysis	Mineralogical processes	Other dual uses	Excluded energy carriers
Autoproduction of electricity and heat	Lighting					Feedstocks	Wood and wood products
Low enthalpy heat	Cooling						Peat
Air compressors	Electric machinery						
Motor drives							
Fans and pumps							
Direct heat							
Process heat							
Steam processing							
Drying processes							

Source: JRC, 2020

Table13. Machinery equipment

In scope	Out of scope						
	Uses other than motor or heating fuel	Chemical reduction	Metallurgical processes	Electrolysis	Mineralogical processes	Other dual uses	Excluded energy carriers
Autoproduction of electricity and heat	Lighting		Products finishing			Feedstocks	Wood and wood products
Low enthalpy heat	General machinery		Thermal foundries				Peat
Air compressors			Thermal and electric connection				
Motor drives							
Fans and pumps							
Heat treatment							
Steam processing							

Source: JRC, 2020

Table 14. Textiles and leather

In scope	Out of scope						
	Uses other than motor or heating fuel	**Chemical reduction**	**Metallurgical processes**	**Electrolysis**	**Mineralogical processes**	**Other dual uses**	**Excluded energy carriers**
Autoproduction of electricity and heat	Lighting					Feedstocks	Wood and wood products
Low enthalpy heat	Product finishing						Peat
Air compressors	Electric machinery						
Motor drives							
Fans and pumps							
Pre-treatment with steam							
Wet processing with steam							
Drying processes							

Source: JRC, 2020

Table 15. Transport equipment

In scope	Out of scope						
	Uses other than motor or heating fuel	**Chemical reduction**	**Metallurgical processes**	**Electrolysis**	**Mineralogical processes**	**Other dual uses**	**Excluded energy carriers**
Autoproduction of electricity and heat	Lighting		Thermal foundries			Feedstocks	Wood and wood products
Low enthalpy heat	Product finishing		Thermal and electric connection				Peat
Air compressors	General machinery						
Motor drives							
Fans and pumps							
Heat treatment							
Steam processing							

Source: JRC, 2020

Table 16. Wood and wood products

In scope	Out of scope						
	Uses other than motor or heating fuel	**Chemical reduction**	**Metallurgical processes**	**Electrolysis**	**Mineralogical processes**	**Other dual uses**	**Excluded energy carriers**
Autoproduction of electricity and heat	Lighting					Feedstocks	Wood and wood products
Low enthalpy heat	Products finishing						Peat
Air compressors	Electric mechanical processes						
Motor drives							
Fans and pumps							
Specific processes with steam							
Drying processes							

Source: JRC, 2020

3. **Results**

The analysis of the results shows that the chemical and petrochemical industry accounts for one third of the total energy used by the EU industry (Table 17) 123517 ktoe out of 361020 ktoe). The chemical and petrochemical sector is followed by the iron and steel industry (which uses 18.93% of the energy, 66122 ktoe), the pulp, paper and printing industry (9.8 %, 35247 ktoe)), the non-metallic minerals account (10.29.5 %, 34187 ktoe), the food, beverages and tobacco industry (7.8 %, 28239 ktoe), construction (5.7 %, 20634), and the machinery industry (5.0%, 17957 ktoe). These seven industries account for 90.3 % of total industrial energy use. The remaining industries use less than 3% each.

Most of the energy products, 60.7% (219004 ktoe), are used for energy purposes within the industries. Again the chemical and petrochemical sector explains the largest share (22%, 48193 ktoe). The non-metallic minerals, the pulp, paper and printing, and the food, beverages, and tobacco account for similar shares (15.3% - 33563 ktoe, 13.9% - 30483 ktoe, and 12.4% - 27069 ktoe respectively), followed by the iron and steel industry (9.1%, 19911 ktoe), and the machinery industry (7.9%, 17320 ktoe).

Non-energy use of energy products accounts for 23.4% of the total energy use in the EU, 84534 ktoe. Most of the non-energy use takes place also in the chemical and petrochemical sector (84.9%, 71754 ktoe) and the construction industry (13.6%, 11502 ktoe).

Finally, about 3.2% (11620 ktoe) of the total energy use is needed for the autoproduction of electricity and heat. Approximately 40.7 % (4727 ktoe) of this energy is used by autoproducers within the pulp, paper and printing industry, followed by the chemical and petrochemical sector (30.7%, 3570 ktoe), and the food, beverage and tobacco (9.8 %, 1134 ktoe).

In terms of out of scope categories, one third of the total energy use (33.2%, 120010 ktoe) is considered to have a dual use, especially in the chemical and petrochemical industry (59.8% of the energy excluded, 71754 ktoe), and the iron and steel industry (29.6%, 35523 ktoe).

Mineralogical processes require about 9.3 % of the total energy use, 33719 ktoe. Almost all the energy used in mineralogical processes is consumed in the non-metallic minerals sector (96.6 %, 32579 ktoe), and the rest in the pulp, paper and printing (3.4 %, 1140 ktoe).

Energy used for metallurgical processes account for 8.7% of the total energy use, 31341 ktoe. Most of the energy for metallurgical processes is used by the iron and steel (59.1%, 18513 ktoe), the non-ferrous metals (23.5%, 7375 ktoe), the machinery (14.4%, 4508 ktoe), and the transport industries (3%, 945 ktoe).

About 7.2 % (25908 ktoe) of the total energy use is for uses other than motor or heating fuel, especially in the food, beverages and tobacco (22.3 %, 5776 ktoe), pulp, paper and printing (18.0 %, 4652 ktoe), machinery (15.9 %, 4117 ktoe), and chemical and petrochemical industry (15.4 %, 3990 ktoe).

Wood and wood products represent 6.3 % of the total energy use, 22568 ktoe. They are mostly used in the pulp, paper and printing industry (66.8 %, 15083 ktoe) and the wood and wood products industry (22.0 %, 4976 ktoe).

The energy used for chemical reduction accounts only for 3.3 % of the total energy use, 11971 ktoe. 86.7 % of the energy use in reduction processes is used by the iron and steel industry (10380 ktoe), while the rest (13.3 %, 1591 ktoe) is used in the chemical and petrochemical sector.

Electrolysis requires 0.4% of total energy use (1437 ktoe of electricity) and it is used only in the non-ferrous metals industry (92.7 %, 1333 ktoe), and the chemical industry (7.3 %, 104 ktoe).

Finally, peat represents only 0.05% of the total energy use, 174 ktoe, mostly in the pulp, paper and printing industry (94.2%, 164 ktoe) and in a very few MS.

The results are also provided per group of energy product (described in Table 18), defined in agreement with TAXUD). The categories most used by all the EU industries are “natural gas” (Table 19), 27.9 % of the total energy use), 100680 ktoe), “not taxed” products (21.5 %, 77516 ktoe), electricity (20 %, 72094 ktoe), coal (15.6 %, 56202 ktoe). The “out of scope” group accounts for 6.3% to total energy use, 22749 ktoe. The other groups are used in much smaller amounts. Most of the “not taxed” products (52437 ktoe), gasoline (2684 ktoe), kerosene (233 ktoe), and LPG (11377 ktoe) have a non-energy use.

The aggregate results per industry for each MS are shown in Table 20 to Table 31.

Table 17. Overview of the EU results per industry

		Chemical & petrochemical	Iron & Steel	Paper, pulp & printing	Non-metallic minerals	Food, beverages & tobacco	Machinery	Non-ferrous metals	Construction	Wood & wood products	Transport equipment	Mining & quarrying	Textile & leather	EU
Net inputs	**Energy use**	**51763**	**66076**	**35210**	**33853**	**28203**	**17677**	**10029**	**9131**	**8524**	**7744**	**4277**	**3999**	**276486**
	Autoproducers E	187	40	376	14	33	91	45	19	0	15	88	1	909
	Autoproducers CHP	3353	230	4258	276	1065	251	68	97	1	149	393	354	10495
	Autoproducers H	29	33	93	1	37	15	1	1	1	2	3	1	217
	Coke ovens	0	35482	0	0	0	0	0	0	0	0	0	0	35482
	Blast furnaces	0	10380	0	0	0	0	0	0	0	0	0	0	10380
	Final energy consumption	48193	19911	30483	33563	27069	17320	9915	9014	8522	7578	3794	3643	219004
	Non-energy use	**71754**	**47**	**36**	**334**	**36**	**280**	**444**	**11502**	**20**	**23**	**35**	**23**	**84534**
	Total energy use	**123517**	**66122**	**35247**	**34187**	**28239**	**17957**	**10473**	**20634**	**8544**	**7767**	**4311**	**4022**	**361020**
Out of scope	**Out of scope**	**77732**	**64510**	**21075**	**33897**	**6751**	**9048**	**9194**	**14179**	**5258**	**3195**	**1370**	**918**	**247128**
	Chemical reduction	1591	10380	0	0	0	0	0	0	0	0	0	0	11971
	Electrolysis	104	0	0	0	0	0	1333	0	0	0	0	0	1437
	Metallurgical processes	0	18513	0	0	0	4508	7375	0	0	945	0	0	31341
	Minerological processes	0	0	1140	32579	0	0	0	0	0	0	0	0	33719
	Dual use	71754	35523	36	334	36	280	444	11502	20	23	35	23	120010
	Wood and wood products	290	14	15083	983	938	143	2	59	4976	13	47	20	22568
	Peat	3	0	164	1	1	0	0	0	6	0	0	0	174
	Uses other than motor or heating fuel	3990	80	4652	0	5776	4117	40	2618	256	2215	1288	875	25908
In scope	**Uses as motor or heating fuel**	**45785**	**1613**	**14172**	**291**	**21488**	**8909**	**1279**	**6454**	**3286**	**4572**	**2941**	**3104**	**113892**
	Final energy consumption	42271	1310	11876	0	20419	8594	1164	6353	3286	4406	2458	2748	104885
	Autoproducers E	186	40	118	14	23	89	45	6	0	15	88	1	625
	Autoproducers CHP	3300	230	2147	276	1023	219	68	95	0	149	393	354	8253
	Autoproducers H	29	33	30	1	22	8	1	0	0	2	3	1	130
	Ratio (in scope / total energy use)	**37.1%**	**2.4%**	**40.2%**	**0.9%**	**76.1%**	**49.6%**	**12.2%**	**31.3%**	**38.5%**	**58.9%**	**68.2%**	**77.2%**	**31.5%**

Source: JRC, 2020

Table 18. Groups of energy products

Energy products used in EUROSTAT's energy balances	Group of energy products	Products listed in article 2 of the ETD	
		CN code	Description
Anthracite Coking coal Other bituminous coal Sub-bituminous coal	Coal	2701	Coal; briquettes, ovoids and similar solid fuels manufactured from coal
Lignite	Coal	2702	Lignite, whether or not agglomerated, excluding jet
Patent fuel Coke oven coke Gas coke	Coal	2704	Coke and semi-coke of coal, of lignite or of peat, whether or not agglomerated; retort carbon
Coal tar	Coal	2706	Tar distilled from coal, from lignite or from peat, and other mineral tars, whether or not dehydrated or partially distilled, including reconstituted tars
Brown coal briquettes	Coal	2701	Coal; briquettes, ovoids and similar solid fuels manufactured from coal
Gas works gas Coke oven gas Blast furnace gas Other recovered gases	Natural gas [1]	2705	Coal gas, water gas, producer gas and similar gases, other than petroleum gases and other gaseous hydrocarbons
Peat Peat products	Out of scope [2]	2703	Peat (including peat litter), whether or not agglomerated
Oil shale and oil sands	Coal	2714	Bitumen and asphalt, natural; bituminous or oil-shale and tar sands; asphaltites and asphaltic rocks
Crude oil Natural gas liquids Refinery feedstocks	Not taxed	2709	Petroleum oils and oils obtained from bituminous minerals, crude
Additives and oxygenates (excluding biofuel portion)	Additives	3811 3817 3824	Anti-knock preparations, oxidation inhibitors, gum inhibitors, viscosity improvers, anticorrosive preparations and other prepared additives, for mineral oils (including gasoline) or for other liquids used for the same purposes as mineral oils Mixed alkylbenzenes and mixed alkylnaphthalenes, other than those of heading 2707 or 2902 Prepared binders for foundry moulds or cores; chemical products and preparations of the chemical or allied industries (including those consisting of mixtures of natural products), not elsewhere specified or included
Other hydrocarbons	Not taxed	2901 2902 2905 11 00 2707 [5]	Acyclic hydrocarbons Cyclic hydrocarbons Methanol (Methyl Alcohol) Oils and other products of the distillation of high temperature coal tar; similar products in which the weight of the aromatic constituents exceeds that of the nonaromatic constituents
Refinery gas Ethane	Natural gas[1]	2711	Petroleum gases and other gaseous hydrocarbons

Energy products used in EUROSTAT's energy balances	Group of energy products	Products listed in article 2 of the ETD	
		CN code	Description
Liquefied petroleum gases			
Motor gasoline (excluding biofuel portion)	Gasoline	2710	Petroleum oils and oils obtained from bituminous minerals, other than crude; preparations not elsewhere specified or included, containing by weight 70 % or more of petroleum oils or of oils obtained from bituminous minerals, these oils being the basic constituents of the preparations; waste oils
Aviation gasoline			
Gasoline-type jet fuel			
Kerosene-type jet fuel (excluding biofuel portion)	Kerosene		
Other kerosene			
Naphtha [3]	Not taxed		
Gas oil and diesel oil (excluding biofuel portion)	Diesel		
Fuel oil	Heavy fuel		
White spirit and special boiling point industrial spirits	Not taxed		
Lubricants		3403	Lubricating preparations (including cutting-oil preparations, bolt or nut release preparations, anti-rust or anti-corrosion preparations and mould- release preparations, based on lubricants) and preparations of a kind used for the oil or grease treatment of textile materials, leather, furskins or other materials, but excluding preparations containing, as basic constituents, 70 % or more by weight of petroleum oils or of oils obtained from bituminous minerals
Bitumen		2715	Bituminous mixtures based on natural asphalt, on natural bitumen, on petroleum bitumen, on mineral tar or on mineral tar pitch (for example, bituminous mastics, cutbacks)
Petroleum coke		2713 2708	Petroleum coke, petroleum bitumen and other residues of petroleum oils or of oils obtained from bituminous minerals Pitch and pitch coke, obtained from coal tar or from other mineral tars
Paraffin waxes		2712	Petroleum jelly; paraffin wax, microcrystalline petroleum wax, slack wax, ozokerite, lignite wax, peat wax, other mineral waxes, and similar products obtained by synthesis or by other processes, whether or not coloured
Other oil products		3824 90 99	Other
Natural gas	Natural gas	2711	Petroleum gases and other gaseous hydrocarbons
Hydro	Not taxed [4]	2716	Electricity
Tide, wave, ocean			

Energy products used in EUROSTAT's energy balances	Group of energy products	Products listed in article 2 of the ETD	
		CN code	Description
Wind			
Solar photovoltaic			
Solar thermal			
Geothermal			
Primary solid biofuels	Out of scope [2]	4401	Fuel wood, in logs, in billets, in twigs, in faggots or in similar forms; wood in chips or particles; sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms
Charcoal		4402	Wood charcoal (including shell or nut charcoal), whether or not agglomerated
Biogases	Natural gas [1]		
Renewable municipal waste	Not taxed		
Pure biogasoline	Gasoline	1507	Soya-bean oil and its fractions, whether or not refined, but not chemically modified
Blended biogasoline		1508	Ground-nut oil and its fractions, whether or not refined, but not chemically modified
Pure biodiesels	Diesel	1509	Olive oil and its fractions, whether or not refined, but not chemically modified
Blended biodiesels		1510	Other oils and their fractions, obtained solely from olives, whether or not refined, but not chemically modified, including blends of these oils or fractions with oils or fractions of heading 1509
Pure bio jet kerosene	Kerosene	1511	Palm oil and its fractions, whether or not refined, but not chemically modified
Blended bio jet kerosene		1512	Sunflower-seed, safflower or cotton-seed oil and fractions thereof, whether or not refined, but not chemically modified
Other liquid biofuels	Diesel	1513	Coconut (copra), palm kernel or babassu oil and fractions thereof, whether or not refined, but not chemically modified
		1514	Rape, colza or mustard oil and fractions thereof, whether or not refined, but not chemically modified
		1515	Other fixed vegetable fats and oils (including jojoba oil) and their fractions, whether or not refined, but not chemically modified
		1516	Animal or vegetable fats and oils and their fractions, partly or wholly hydrogenated, inter-esterified, re-esterified or elaidinised, whether or not refined, but not further prepared
		1517	Margarine; edible mixtures or preparations of animal or vegetable fats or oils or of fractions of different fats or oils of this Chapter, other than edible fats or oils or their fractions of heading
		1518	Animal or vegetable fats and oils and their fractions, boiled, oxidised, dehydrated, sulphurised, blown, polymerised by heat in vacuum or in inert gas or otherwise chemically modified, excluding those of heading 1516; inedible mixtures or preparations of animal or vegetable fats or oils or of fractions of different fats or oils of this chapter, not elsewhere specified or included
Ambient heat (heat pumps)	Not taxed		
Industrial waste (non-renewable)	Not taxed		

Energy products used in EUROSTAT's energy balances	Group of energy products	Products listed in article 2 of the ETD	
		CN code	**Description**
Non-renewable municipal waste	Not taxed		
Nuclear heat	Not taxed[4]		
Heat	Not taxed		
Electricity	Electricity	2716	Electricity

Source: JRC, 2020

1: products that can replace natural gas.
2: out of scope according to article 2 of the ETD.
3: normally used as a feedstock.
4: electricity or heat that only appears in the supply blocks of the energy balances.
5: this group includes hydrogen.

Table 19: Overview of the EU results for all industries per group of energy products

		Total	Coal	Gasoline	Kerosene	Diesel	Heavy fuel	Additives	LPG	Natural gas	Electricity	Out of scope	Not taxed
Net inputs	**Energy use**	**276486**	**56202**	**252**	**94**	**8899**	**3572**	**0**	**2510**	**85035**	**72094**	**22749**	**25079**
	Autoproducers E	909	67	0	0	4	29	0	0	244	0	284	280
	Autoproducers CHP	10495	225	0	0	22	591	0	3	6889	0	2247	517
	Autoproducers H	217	48	0	0	0	1	0	4	66	0	88	9
	Coke ovens	35482	34807	0	0	0	0	0	0	128	130	6	410
	Blast furnaces	10380	10086	0	0	1	43	0	0	99	122	0	29
	Final energy consumption	219004	10968	252	94	8871	2907	0	2502	77609	71842	20123	23835
	Non-energy use	**84534**	**0**	**2684**	**233**	**1183**	**975**	**0**	**11377**	**15645**	**0**	**0**	**52437**
	Total energy use	**361020**	**56202**	**2936**	**327**	**10083**	**4546**	**0**	**13887**	**100680**	**72094**	**22749**	**77516**
Out of scope	**Out of scope**	**247128**	**51520**	**2737**	**265**	**4063**	**2177**	**0**	**12446**	**51928**	**34147**	**22742**	**65103**
	Chemical reduction	11971	10225	3	0	20	78	0	19	799	526	0	302
	Electrolysis	1437	0	0	0	0	0	0	0	0	1437	0	0
	Metallurgical processes	31341	1637	6	2	327	280	0	473	12341	15435	0	840
	Minerological processes	33719	3977	1	9	513	453	0	221	13408	6092	0	9044
	Dual use	120010	34807	2684	233	1184	975	0	11377	15773	130	0	52847
	Wood and wood products	22568	0	0	0	0	0	0	0	0	0	22568	0
	Peat	174	0	0	0	0	0	0	0	0	0	174	0
	Uses other than motor or heating fuel	25908	874	43	21	2019	391	0	356	9607	10527	0	2070
In scope	**Uses as motor or heating fuel**	**113892**	**4682**	**200**	**62**	**6020**	**2369**	**0**	**1441**	**48752**	**37947**	**6**	**12413**
	Final energy consumption	104885	4342	199	62	5993	1748	0	1434	41552	37947	0	11607
	Autoproducers E	625	67	0	0	4	29	0	0	244	0	0	280
	Autoproducers CHP	8253	225	0	0	22	591	0	3	6889	0	6	517
	Autoproducers H	130	48	0	0	0	1	0	4	66	0	0	9
	Ratio (in scope / total energy use)	**32%**	**8%**	**7%**	**19%**	**60%**	**52%**	**0%**	**10%**	**48%**	**53%**	**0%**	**16%**

Source: JRC, 2020

Table 20. Results for the chemical and petrochemical industry

	Chemical & petrochemical	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	**Energy use**	**1172**	**4181**	**871**	**7**	**1100**	**15129**	**340**	**33**	**292**	**3762**	**1096**	**3971**	**155**	**1144**	**267**	**3851**	**417**	**46**	**30**	**4**	**7157**	**3425**	**636**	**1522**	**508**	**152**	**494**	**51763**
	Autoproducers E	28	0	0	0	0	31	0	0	0	116	0	9	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	187
	Autoproducers CHP	116	34	40	0	82	570	39	0	171	416	0	121	0	3	0	604	8	0	4	0	196	562	264	94	9	0	22	3353
	Autoproducers H	1	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	1	0	0	0	7	12	0	0	0	0	0	29
	Final energy consumption	1028	4147	831	7	1018	14528	301	33	122	3230	1096	3833	155	1141	267	3245	408	46	27	4	6953	2851	372	1428	499	152	472	48193
	Non-energy use	**1288**	**7194**	**226**	**0**	**1800**	**17474**	**1**	**0**	**730**	**3612**	**1163**	**9670**	**363**	**1996**	**0**	**5444**	**934**	**0**	**1**	**0**	**12538**	**3785**	**483**	**392**	**1700**	**11**	**950**	**71754**
petrochemical	**Total energy use**	**2460**	**11375**	**1097**	**7**	**2900**	**32603**	**341**	**33**	**1023**	**7374**	**2258**	**13641**	**518**	**3140**	**267**	**9296**	**1350**	**46**	**31**	**4**	**19694**	**7210**	**1119**	**1914**	**2207**	**164**	**1444**	**123517**
Out of scope	**Out of scope**	**1485**	**7686**	**313**	**1**	**1894**	**19077**	**47**	**8**	**752**	**3934**	**1267**	**10208**	**392**	**2141**	**31**	**5807**	**1009**	**5**	**7**	**0**	**13379**	**4266**	**523**	**646**	**1769**	**43**	**1042**	**77732**
	Chemical reduction	37	129	41	0	2	337	0	4	14	32	1	106	10	39	0	58	36	0	0	0	304	245	2	136	6	0	51	1591
	Electrolysis	1	4	0	0	2	50	0	0	0	3	2	22	0	4	0	3	0	0	0	0	4	1	1	2	3	0	1	104
	Metallurgical processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minerological processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dual use	1288	7194	226	0	1800	17474	1	0	730	3612	1163	9670	363	1996	0	5444	934	0	1	0	12538	3785	483	392	1700	11	950	71754
	Wood and wood products	76	14	7	0	0	35	13	0	0	5	6	67	0	1	0	3	11	0	4	0	0	3	4	4	19	18	0	290
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
	Uses other than motor or heating fuel	84	345	39	1	90	1180	33	4	7	281	96	343	19	100	31	299	29	5	2	0	532	232	33	113	38	13	40	3990
In scope	**Uses as motor or heating fuel**	**975**	**3690**	**784**	**6**	**1005**	**13527**	**294**	**25**	**270**	**3440**	**991**	**3433**	**126**	**1000**	**235**	**3489**	**342**	**40**	**25**	**4**	**6316**	**2944**	**596**	**1268**	**439**	**121**	**402**	**45785**
	Final energy consumption	867	3666	745	6	924	12925	255	25	100	2908	991	3295	126	997	235	2884	333	40	21	4	6112	2369	332	1174	436	121	380	42271
	Autoproducers E	28	0	0	0	0	31	0	0	0	116	0	9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	186
	Autoproducers CHP	80	23	40	0	82	570	39	0	171	416	0	121	0	3	0	604	8	0	4	0	196	562	264	94	3	0	22	3300
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	1	0	0	0	7	12	0	0	0	0	0	29
petrochemical	**Ratio (in scope / total energy use)**	**40%**	**32%**	**71%**	**81%**	**35%**	**41%**	**86%**	**75%**	**26%**	**47%**	**44%**	**25%**	**24%**	**32%**	**88%**	**38%**	**25%**	**88%**	**79%**	**89%**	**32%**	**41%**	**53%**	**66%**	**20%**	**74%**	**28%**	**37%**

Source: JRC, 2020

Table 21. Results for the construction industry

	Construction	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	**Energy use**	**318**	**205**	**66**	**10**	**275**	**1652**	**176**	**53**	**153**	**1226**	**409**	**1909**	**103**	**311**	**6**	**359**	**44**	**30**	**32**	**3**	**698**	**195**	**152**	**334**	**338**	**39**	**39**	**9131**
	Autoproducers E	0	0	0	0	1	0	0	0	0	10	0	2	0	2	0	1	0	0	0	0	2	0	0	0	0	0	0	19
	Autoproducers CHP	1	0	0	0	82	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	3	0	0	0	0	0	6	97
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Final energy consumption	316	204	66	10	192	1651	176	53	153	1216	409	1901	103	309	6	358	44	30	32	3	693	195	152	333	338	39	33	9014
	Non-energy use	**494**	**303**	**155**	**35**	**496**	**1846**	**189**	**54**	**105**	**894**	**149**	**2521**	**79**	**126**	**196**	**1084**	**162**	**17**	**63**	**5**	**102**	**1294**	**180**	**329**	**451**	**52**	**122**	**11502**
n	**Total energy use**	**812**	**507**	**221**	**45**	**771**	**3497**	**364**	**107**	**258**	**2120**	**558**	**4430**	**182**	**437**	**202**	**1443**	**206**	**47**	**95**	**8**	**800**	**1489**	**331**	**662**	**789**	**91**	**161**	**20634**
Out of scope	**Out of scope**	**592**	**372**	**186**	**38**	**549**	**2260**	**238**	**67**	**168**	**1236**	**247**	**3026**	**98**	**233**	**199**	**1330**	**185**	**34**	**71**	**6**	**240**	**1382**	**229**	**402**	**585**	**69**	**137**	**14179**
	Chemical reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electrolysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metallurgical processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minerological processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dual use	494	303	155	35	496	1846	189	54	105	894	149	2521	79	126	196	1084	162	17	63	5	102	1294	180	329	451	52	122	11502
	Wood and wood products	6	0	0	0	3	0	0	0	0	24	0	6	0	4	0	2	2	0	2	0	4	1	0	2	0	2	0	59
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Uses other than motor or heating fuel	92	69	31	3	50	414	50	12	62	318	97	499	19	103	3	243	21	17	6	1	134	88	49	72	134	15	15	2618
In scope	**Uses as motor or heating fuel**	**220**	**136**	**35**	**8**	**221**	**1237**	**126**	**40**	**90**	**884**	**312**	**1404**	**84**	**204**	**3**	**114**	**21**	**13**	**24**	**2**	**560**	**107**	**102**	**260**	**204**	**22**	**24**	**6454**
	Final energy consumption	219	135	35	8	139	1236	126	40	90	883	312	1401	84	202	3	114	21	13	24	2	555	107	102	260	204	22	18	6353
	Autoproducers E	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	6
	Autoproducers CHP	1	0	0	0	82	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	3	0	0	0	0	0	6	95
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
n	**Ratio (in scope / total energy use)**	**27%**	**27%**	**16%**	**17%**	**29%**	**35%**	**35%**	**38%**	**35%**	**42%**	**56%**	**32%**	**46%**	**47%**	**1%**	**8%**	**10%**	**27%**	**25%**	**25%**	**70%**	**7%**	**31%**	**39%**	**26%**	**24%**	**15%**	**31%**

Source: JRC, 2020

Table 22. Results for the food, beverages and tobacco industry

	Food, beverages & tobacco	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	**Energy use**	**528**	**1618**	**251**	**40**	**574**	**5253**	**600**	**56**	**462**	**2589**	**426**	**5157**	**199**	**663**	**521**	**2847**	**193**	**22**	**83**	**6**	**2247**	**2259**	**493**	**539**	**347**	**79**	**150**	**28203**
	Autoproducers E	6	7	0	0	0	0	0	0	0	9	0	1	0	0	0	1	0	0	0	0	6	2	1	0	0	0	0	33
	Autoproducers CHP	0	40	0	0	1	93	1	0	3	503	0	88	1	1	43	69	0	0	0	0	145	6	65	1	0	0	3	1065
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	12	0	0	1	0	0	0	37
	Final energy consumption	522	1571	251	40	573	5160	599	56	459	2077	425	5046	198	661	478	2777	193	22	83	6	2084	2251	427	537	347	79	147	27069
	Non-energy use	**2**	**1**	**0**	**0**	**0**	**5**	**1**	**0**	**0**	**25**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**36**
ages & tobacco	**Total energy use**	**530**	**1619**	**251**	**40**	**574**	**5258**	**601**	**56**	**462**	**2614**	**426**	**5157**	**199**	**663**	**521**	**2847**	**193**	**22**	**83**	**6**	**2247**	**2260**	**493**	**540**	**347**	**79**	**150**	**28239**
Out of scope	**Out of scope**	**133**	**363**	**95**	**9**	**106**	**1140**	**155**	**17**	**182**	**732**	**93**	**1218**	**53**	**207**	**140**	**649**	**54**	**10**	**29**	**4**	**342**	**541**	**129**	**144**	**146**	**21**	**39**	**6751**
	Chemical reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electrolysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metallurgical processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minerological processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dual use	2	1	0	0	0	5	1	0	0	25	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	36
	Wood and wood products	8	59	25	2	3	40	0	0	105	222	8	200	6	61	24	37	12	0	11	0	0	30	33	26	23	2	2	938
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Uses other than motor or heating fuel	122	303	71	7	103	1095	154	17	77	484	86	1017	47	147	116	611	42	10	19	4	342	511	96	117	123	19	37	5776
In scope	**Uses as motor or heating fuel**	**398**	**1256**	**156**	**32**	**467**	**4118**	**446**	**39**	**280**	**1882**	**333**	**3940**	**146**	**455**	**381**	**2198**	**138**	**12**	**54**	**2**	**1905**	**1719**	**364**	**396**	**201**	**59**	**111**	**21488**
	Final energy consumption	391	1210	155	32	466	4025	446	39	277	1389	332	3874	145	454	337	2129	138	12	54	2	1742	1710	298	394	201	59	108	20419
	Autoproducers E	6	7	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6	2	1	0	0	0	0	23
	Autoproducers CHP	0	40	0	0	1	93	1	0	3	493	0	57	1	1	43	69	0	0	0	0	145	6	65	1	0	0	3	1023
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	12	0	0	1	0	0	0	22
ages & tobacco	**Ratio (in scope / total energy use)**	**75%**	**78%**	**62%**	**79%**	**81%**	**78%**	**74%**	**70%**	**61%**	**72%**	**78%**	**76%**	**73%**	**69%**	**73%**	**77%**	**72%**	**54%**	**65%**	**34%**	**85%**	**76%**	**74%**	**73%**	**58%**	**74%**	**74%**	**76%**

Source: JRC, 2020

Table 23. Results for the iron and steel industry

	Iron & Steel	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	**Energy use**	**2498**	**3116**	**126**	**0**	**3089**	**17829**	**90**	**194**	**130**	**3942**	**1726**	**6791**	**24**	**1179**	**163**	**5043**	**0**	**284**	**1**	**0**	**3436**	**10677**	**193**	**816**	**2000**	**145**	**2583**	**66076**
	Autoproducers E	2	0	0	0	0	3	0	0	0	2	0	1	0	0	0	0	0	0	0	0	30	0	0	1	0	0	0	40
	Autoproducers CHP	0	28	0	0	5	0	0	0	0	0	0	0	0	0	163	1	0	0	0	0	4	10	0	0	0	0	19	230
	Autoproducers H	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	33
	Coke ovens	1224	1106	0	0	2378	9002	0	194	0	1407	840	3141	0	984	0	1709	0	0	0	0	1870	9088	0	0	1037	0	1502	35482
	Blast furnaces	618	1093	0	0	199	3564	0	0	0	567	262	1777	0	42	0	256	0	0	0	0	1055	215	0	0	252	0	479	10380
	Final energy consumption	654	889	126	0	507	5260	90	0	130	1966	623	1871	24	152	0	3077	0	284	1	0	477	1333	193	815	711	145	582	19911
	Non-energy use	**3**	**3**	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**14**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**14**	**0**	**0**	**0**	**2**	**1**	**1**	**0**	**1**	**0**	**47**
	Total energy use	**2501**	**3118**	**127**	**0**	**3090**	**17829**	**91**	**194**	**130**	**3956**	**1726**	**6797**	**24**	**1179**	**163**	**5043**	**0**	**298**	**1**	**0**	**3436**	**10680**	**194**	**817**	**2000**	**146**	**2583**	**66122**
Out of scope	**Out of scope**	**2455**	**3033**	**121**	**0**	**3041**	**17471**	**87**	**194**	**122**	**3846**	**1693**	**6647**	**23**	**1166**	**0**	**4850**	**0**	**283**	**1**	**0**	**3361**	**10554**	**182**	**769**	**1960**	**141**	**2511**	**64510**
	Chemical reduction	618	1093	0	0	199	3564	0	0	0	567	262	1777	0	42	0	256	0	0	0	0	1055	215	0	0	252	0	479	10380
	Electrolysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metallurgical processes	607	828	120	0	461	4883	86	0	122	1852	588	1713	23	138	0	2874	0	268	1	0	433	1244	180	766	669	140	519	18513
	Minerological processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dual use	1227	1109	1	0	2379	8996	1	194	0	1421	840	3147	0	984	0	1709	0	14	0	0	1870	9090	1	1	1037	1	1502	35523
	Wood and wood products	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	14
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Uses other than motor or heating fuel	3	4	0	0	3	22	0	0	0	6	2	9	0	1	0	10	0	1	0	0	3	5	1	3	3	0	4	80
In scope	**Uses as motor or heating fuel**	**47**	**86**	**6**	**0**	**49**	**357**	**4**	**0**	**8**	**110**	**34**	**150**	**1**	**13**	**163**	**193**	**0**	**15**	**0**	**0**	**76**	**126**	**12**	**48**	**40**	**6**	**72**	**1613**
	Final energy consumption	45	58	6	0	43	354	4	0	8	108	34	149	1	13	0	193	0	15	0	0	42	83	12	46	40	5	53	1310
	Autoproducers E	2	0	0	0	0	3	0	0	0	2	0	1	0	0	0	0	0	0	0	0	30	0	0	1	0	0	0	40
	Autoproducers CHP	0	28	0	0	5	0	0	0	0	0	0	0	0	0	163	1	0	0	0	0	4	10	0	0	0	0	19	230
	Autoproducers H	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	33
	Ratio (in scope / total energy use)	**2%**	**3%**	**5%**	**0%**	**2%**	**2%**	**4%**	**0%**	**6%**	**3%**	**2%**	**2%**	**2%**	**1%**	**100%**	**4%**	**0%**	**5%**	**4%**	**0%**	**2%**	**1%**	**6%**	**6%**	**2%**	**4%**	**3%**	**2%**

Source: JRC, 2020

Table 24. Results for the machinery industry

	Machinery	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	**Energy use**	**586**	**336**	**136**	**3**	**694**	**5272**	**213**	**38**	**66**	**918**	**322**	**1877**	**70**	**465**	**330**	**3512**	**32**	**11**	**18**	**10**	**528**	**801**	**179**	**427**	**339**	**210**	**284**	**17677**
	Autoproducers E	0	42	0	0	1	7	0	0	0	1	0	7	0	18	1	0	0	0	0	0	13	0	0	1	0	0	0	91
	Autoproducers CHP	1	8	0	0	1	29	1	0	1	33	0	21	1	2	3	49	0	0	0	0	55	0	40	0	0	0	5	251
	Autoproducers H	0	0	0	0	7	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
	Final energy consumption	585	286	136	3	685	5236	212	38	64	883	322	1841	69	445	326	3462	32	11	18	10	460	801	139	426	339	210	279	17320
	Non-energy use	**9**	**1**	**5**	**0**	**2**	**1**	**4**	**0**	**0**	**24**	**0**	**0**	**6**	**1**	**13**	**202**	**0**	**0**	**0**	**0**	**0**	**7**	**2**	**2**	**0**	**0**	**0**	**280**
	Total energy use	**595**	**337**	**141**	**3**	**696**	**5272**	**217**	**38**	**66**	**942**	**322**	**1877**	**76**	**466**	**343**	**3714**	**32**	**11**	**18**	**10**	**528**	**809**	**181**	**430**	**339**	**210**	**284**	**17957**
Out of scope	**Out of scope**	**328**	**81**	**86**	**2**	**352**	**2504**	**113**	**16**	**15**	**427**	**128**	**1096**	**34**	**258**	**159**	**1953**	**21**	**5**	**9**	**7**	**223**	**432**	**72**	**246**	**185**	**121**	**177**	**9048**
	Chemical reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electrolysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metallurgical processes	136	33	33	1	153	1489	46	9	12	242	71	476	12	51	81	986	6	0	2	3	126	183	33	106	85	50	83	4508
	Minerological processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dual use	9	1	5	0	2	1	4	0	0	24	0	0	6	1	13	202	0	0	0	0	0	7	2	2	0	0	0	280
	Wood and wood products	8	7	0	0	3	53	15	1	0	1	1	27	0	3	0	3	1	0	3	0	0	1	0	6	0	3	5	143
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Uses other than motor or heating fuel	175	40	47	1	194	963	48	6	3	160	55	593	15	202	65	762	14	5	3	4	97	240	37	132	99	68	89	4117
In scope	**Uses as motor or heating fuel**	**267**	**256**	**55**	**1**	**344**	**2768**	**104**	**23**	**51**	**515**	**195**	**781**	**42**	**208**	**184**	**1761**	**11**	**6**	**9**	**4**	**305**	**377**	**109**	**183**	**154**	**89**	**108**	**8909**
	Final energy consumption	267	212	55	1	335	2742	103	23	50	481	195	768	42	188	180	1712	11	6	9	4	237	377	69	183	154	89	102	8594
	Autoproducers E	0	42	0	0	1	7	0	0	0	0	0	7	0	18	1	0	0	0	0	0	13	0	0	0	0	0	0	89
	Autoproducers CHP	0	3	0	0	1	19	1	0	1	33	0	5	1	2	3	49	0	0	0	0	55	0	40	0	0	0	5	219
	Autoproducers H	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
	Ratio (in scope / total energy use)	**45%**	**76%**	**39%**	**39%**	**49%**	**52%**	**48%**	**59%**	**77%**	**55%**	**60%**	**42%**	**56%**	**45%**	**54%**	**47%**	**35%**	**52%**	**49%**	**35%**	**58%**	**47%**	**60%**	**43%**	**45%**	**42%**	**38%**	**50%**

Source: JRC, 2020

Table 25 . Results for the mining and quarrying industry

	Mining & quarrying	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	**Energy use**	**359**	**52**	**126**	**6**	**337**	**535**	**85**	**10**	**115**	**453**	**164**	**403**	**15**	**35**	**113**	**120**	**6**	**1**	**8**	**1**	**127**	**460**	**71**	**39**	**544**	**23**	**68**	**4277**
	Autoproducers E	0	0	0	0	0	64	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88
	Autoproducers CHP	0	0	0	0	256	117	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	8	393
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	3
	Final energy consumption	359	52	126	6	81	354	85	10	115	452	164	379	15	35	113	120	6	1	8	1	127	448	71	39	544	23	59	3794
	Non-energy use	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**0**	**2**	**4**	**19**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**1**	**1**	**0**	**0**	**0**	**35**
uarrying	**Total energy use**	**359**	**52**	**127**	**6**	**337**	**535**	**87**	**10**	**117**	**457**	**183**	**403**	**15**	**35**	**113**	**120**	**6**	**1**	**8**	**1**	**127**	**466**	**72**	**39**	**544**	**23**	**68**	**4311**
Out of scope	**Out of scope**	**106**	**18**	**60**	**2**	**22**	**94**	**50**	**2**	**49**	**124**	**59**	**102**	**3**	**12**	**63**	**82**	**3**	**1**	**2**	**1**	**25**	**208**	**24**	**11**	**216**	**9**	**27**	**1370**
	Chemical reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electrolysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metallurgical processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minerological processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dual use	0	0	1	0	0	0	2	0	2	4	19	0	0	0	0	0	0	0	0	0	0	6	1	1	0	0	0	35
	Wood and wood products	0	0	0	0	0	7	33	0	0	0	1	3	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	47
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Uses other than motor or heating fuel	106	18	59	2	21	87	15	2	47	120	39	99	3	12	63	82	3	1	1	1	25	202	23	8	216	9	27	1288
In scope	**Uses as motor or heating fuel**	**253**	**35**	**67**	**5**	**315**	**441**	**37**	**8**	**68**	**333**	**124**	**301**	**13**	**23**	**50**	**38**	**3**	**1**	**6**	**1**	**102**	**258**	**48**	**29**	**328**	**14**	**41**	**2941**
	Final energy consumption	253	35	67	5	59	260	37	8	68	333	124	277	13	23	50	38	3	1	6	1	102	246	48	29	328	14	32	2458
	Autoproducers E	0	0	0	0	0	64	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88
	Autoproducers CHP	0	0	0	0	256	117	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	8	393
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	3
uarrying	**Ratio (in scope / total energy use)**	**70%**	**66%**	**53%**	**75%**	**94%**	**82%**	**43%**	**77%**	**58%**	**73%**	**68%**	**75%**	**81%**	**66%**	**45%**	**32%**	**46%**	**42%**	**75%**	**60%**	**81%**	**55%**	**67%**	**73%**	**60%**	**59%**	**60%**	**68%**

Source: JRC, 2020

Table 26. Results for the non-ferrous metals industry

	Non-ferrous metals	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	**Energy use**	**234**	**326**	**179**	**0**	**93**	**2341**	**0**	**1**	**714**	**1297**	**262**	**1161**	**20**	**127**	**502**	**709**	**0**	**0**	**0**	**0**	**293**	**520**	**31**	**470**	**331**	**165**	**253**	**10029**
	Autoproducers E	0	0	0	0	0	0	0	0	0	1	0	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45
	Autoproducers CHP	0	4	2	0	0	27	0	0	8	9	0	15	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	68
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Final energy consumption	234	322	177	0	93	2314	0	1	706	1288	262	1101	20	127	502	706	0	0	0	0	293	520	31	470	331	165	253	9915
	Non-energy use	**1**	**0**	**0**	**0**	**1**	**140**	**1**	**0**	**0**	**123**	**0**	**23**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**69**	**0**	**28**	**56**	**444**
metals	**Total energy use**	**235**	**326**	**180**	**0**	**94**	**2481**	**1**	**1**	**714**	**1420**	**262**	**1184**	**20**	**127**	**502**	**709**	**0**	**0**	**0**	**0**	**294**	**520**	**31**	**538**	**331**	**194**	**309**	**10473**
Out of scope	**Out of scope**	**231**	**312**	**175**	**0**	**93**	**2208**	**1**	**1**	**577**	**1181**	**255**	**960**	**19**	**105**	**349**	**690**	**0**	**0**	**0**	**0**	**288**	**510**	**31**	**470**	**324**	**190**	**227**	**9194**
	Chemical reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electrolysis	0	0	0	0	0	357	0	0	105	145	0	325	0	0	0	0	0	0	0	0	49	0	0	89	109	54	100	1333
	Metallurgical processes	228	311	174	0	91	1708	0	1	471	911	254	610	19	105	348	689	0	0	0	0	237	508	31	312	215	107	46	7375
	Minerological processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dual use	1	0	0	0	1	140	1	0	0	123	0	23	0	0	0	0	0	0	0	0	1	1	0	69	0	28	56	444
	Wood and wood products	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Uses other than motor or heating fuel	0	1	0	0	0	3	0	0	1	2	0	2	0	0	1	1	0	0	0	0	0	1	0	1	0	0	25	40
In scope	**Uses as motor or heating fuel**	**4**	**14**	**5**	**0**	**1**	**273**	**0**	**0**	**137**	**239**	**7**	**225**	**0**	**22**	**153**	**19**	**0**	**0**	**0**	**0**	**7**	**11**	**1**	**68**	**7**	**4**	**82**	**1279**
	Final energy consumption	4	11	3	0	1	246	0	0	129	230	7	164	0	22	153	16	0	0	0	0	7	11	1	68	7	4	82	1164
	Autoproducers E	0	0	0	0	0	0	0	0	0	1	0	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45
	Autoproducers CHP	0	4	2	0	0	27	0	0	8	9	0	15	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	68
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
metals	**Ratio (in scope / total energy use)**	**2%**	**4%**	**3%**	**100%**	**1%**	**11%**	**0%**	**2%**	**19%**	**17%**	**3%**	**19%**	**1%**	**17%**	**31%**	**3%**	**0%**	**0%**	**0%**	**0%**	**2%**	**2%**	**2%**	**13%**	**2%**	**2%**	**27%**	**12%**

Source: JRC, 2020

Table 27. Results for the non-metallic minerals industry

	Non-metallic minerals	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	**Energy use**	**929**	**1390**	**572**	**153**	**1171**	**6890**	**491**	**110**	**650**	**4166**	**314**	**3857**	**375**	**575**	**453**	**4319**	**155**	**144**	**170**	**0**	**625**	**3107**	**1106**	**1129**	**384**	**205**	**413**	**33853**
	Autoproducers E	0	13	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
	Autoproducers CHP	0	0	0	0	0	3	0	0	0	187	0	1	0	0	0	28	0	0	0	0	6	0	50	0	0	0	0	276
	Autoproducers H	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Final energy consumption	929	1376	572	153	1171	6886	491	109	650	3979	314	3855	375	575	453	4291	155	144	170	0	619	3107	1056	1129	384	205	413	33563
	Non-energy use	**2**	**1**	**23**	**0**	**1**	**6**	**2**	**0**	**1**	**5**	**0**	**33**	**11**	**52**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**24**	**1**	**141**	**0**	**6**	**18**	**334**
ic minerals	**Total energy use**	**931**	**1390**	**595**	**153**	**1172**	**6896**	**493**	**110**	**651**	**4171**	**314**	**3890**	**386**	**628**	**453**	**4319**	**161**	**144**	**170**	**0**	**625**	**3132**	**1107**	**1270**	**384**	**211**	**431**	**34187**
Out of scope	**Out of scope**	**931**	**1377**	**595**	**153**	**1172**	**6892**	**493**	**109**	**651**	**3984**	**314**	**3888**	**386**	**628**	**453**	**4291**	**161**	**144**	**170**	**0**	**619**	**3131**	**1057**	**1270**	**384**	**211**	**431**	**33897**
	Chemical reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electrolysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metallurgical processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minerological processes	874	1239	569	151	1170	6744	489	109	646	3750	309	3719	372	556	451	4159	143	139	165	0	619	3102	979	1127	384	205	413	32579
	Dual use	2	1	23	0	1	6	2	0	1	5	0	33	11	52	0	0	6	0	0	0	0	24	1	141	0	6	18	334
	Wood and wood products	55	138	3	2	2	142	2	0	4	229	5	136	4	20	2	133	11	5	5	0	0	5	77	2	0	0	0	983
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
	Uses other than motor or heating fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
In scope	**Uses as motor or heating fuel**	**0**	**13**	**0**	**0**	**0**	**3**	**0**	**1**	**0**	**187**	**0**	**1**	**0**	**0**	**0**	**28**	**0**	**0**	**0**	**0**	**6**	**0**	**50**	**0**	**0**	**0**	**0**	**291**
	Final energy consumption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Autoproducers E	0	13	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
	Autoproducers CHP	0	0	0	0	0	3	0	0	0	187	0	1	0	0	0	28	0	0	0	0	6	0	50	0	0	0	0	276
	Autoproducers H	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ic minerals	**Ratio (in scope / total energy use)**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**4%**	**0%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**5%**	**0%**	**0%**	**0%**	**0%**	**1%**

Source: JRC, 2020

Table 28. Results for the paper, pulp, and printing industry

	Paper, pulp & printing	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	**Energy use**	**2072**	**727**	**218**	**2**	**682**	**6068**	**68**	**77**	**54**	**2081**	**6850**	**2291**	**68**	**228**	**28**	**2307**	**52**	**6**	**6**	**2**	**616**	**1853**	**1845**	**197**	**6003**	**186**	**619**	**35210**
	Autoproducers E	82	5	0	0	0	72	0	0	0	24	120	53	0	0	0	0	0	0	0	0	3	0	16	0	0	0	0	376
	Autoproducers CHP	206	54	18	0	96	615	1	0	0	932	412	139	0	0	0	360	0	1	0	0	44	111	568	49	486	11	153	4258
	Autoproducers H	5	0	5	0	14	0	0	0	0	0	22	24	0	0	0	0	0	0	0	0	0	4	0	8	0	0	10	93
	Final energy consumption	1780	668	195	2	571	5382	68	77	54	1125	6296	2075	68	228	28	1947	52	5	5	2	568	1739	1261	140	5517	175	456	30483
	Non-energy use	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**16**	**0**	**5**	**0**	**0**	**0**	**0**	**36**
& printing	**Total energy use**	**2074**	**728**	**219**	**2**	**682**	**6068**	**69**	**77**	**54**	**2092**	**6850**	**2291**	**69**	**228**	**28**	**2307**	**52**	**6**	**6**	**2**	**632**	**1854**	**1850**	**197**	**6003**	**186**	**619**	**35247**
Out of scope	**Out of scope**	**1201**	**454**	**154**	**1**	**469**	**2356**	**34**	**45**	**27**	**889**	**5262**	**1065**	**25**	**92**	**15**	**591**	**35**	**1**	**3**	**1**	**218**	**1253**	**1295**	**111**	**4896**	**75**	**504**	**21075**
	Chemical reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electrolysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metallurgical processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minerological processes	41	20	8	0	50	36	0	14	0	23	344	50	0	0	0	0	0	0	0	0	0	148	55	0	333	0	18	1140
	Dual use	1	1	0	0	0	0	1	0	0	12	0	0	0	0	0	0	0	0	0	0	16	0	5	0	0	0	0	36
	Wood and wood products	916	340	136	0	364	811	10	5	3	709	4285	622	2	22	0	0	19	0	0	0	1	941	1180	55	4169	19	473	15083
	Peat	0	0	0	0	0	0	0	0	0	0	163	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	164
	Uses other than motor or heating fuel	242	93	10	1	55	1509	23	26	24	146	470	393	22	70	15	591	17	1	2	1	202	163	55	55	394	56	13	4652
In scope	**Uses as motor or heating fuel**	**873**	**274**	**64**	**1**	**213**	**3712**	**35**	**33**	**27**	**1203**	**1589**	**1226**	**44**	**136**	**13**	**1716**	**17**	**5**	**3**	**1**	**413**	**600**	**555**	**86**	**1107**	**110**	**115**	**14172**
	Final energy consumption	771	258	60	1	202	3309	35	32	27	394	1537	1065	44	136	13	1356	17	4	3	1	366	564	288	83	1107	107	96	11876
	Autoproducers E	35	5	0	0	0	3	0	0	0	10	10	51	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	118
	Autoproducers CHP	63	10	4	0	4	400	0	0	0	799	32	104	0	0	0	360	0	1	0	0	43	34	267	3	0	3	19	2147
	Autoproducers H	4	0	0	0	7	0	0	0	0	0	9	7	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	30
& printing	**Ratio (in scope / total energy use)**	**42%**	**38%**	**29%**	**41%**	**31%**	**61%**	**51%**	**42%**	**50%**	**57%**	**23%**	**54%**	**64%**	**60%**	**45%**	**74%**	**33%**	**80%**	**54%**	**44%**	**65%**	**32%**	**30%**	**44%**	**18%**	**59%**	**19%**	**40%**

Source: JRC, 2020

Table 29. Results for the textile and leather industry

	Textile & leather	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	**Energy use**	**63**	**189**	**66**	**0**	**126**	**487**	**17**	**9**	**101**	**365**	**23**	**320**	**24**	**43**	**15**	**1147**	**34**	**36**	**8**	**3**	**136**	**99**	**452**	**148**	**21**	**18**	**46**	**3999**
	Autoproducers E	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Autoproducers CHP	0	0	0	0	0	30	0	0	2	69	0	5	0	0	0	21	0	0	0	0	24	37	144	0	0	0	22	354
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Final energy consumption	63	189	66	0	126	457	17	9	99	296	23	315	24	43	15	1127	34	36	8	3	112	63	308	148	21	18	24	3643
	Non-energy use	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**19**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**23**
ather	**Total energy use**	**64**	**190**	**66**	**0**	**126**	**487**	**17**	**9**	**101**	**384**	**23**	**320**	**24**	**43**	**15**	**1147**	**34**	**36**	**8**	**3**	**136**	**99**	**453**	**150**	**21**	**18**	**46**	**4022**
Out of scope	**Out of scope**	**18**	**63**	**22**	**0**	**36**	**97**	**7**	**4**	**34**	**104**	**5**	**66**	**8**	**11**	**5**	**256**	**9**	**2**	**1**	**2**	**22**	**16**	**76**	**33**	**10**	**5**	**6**	**918**
	Chemical reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electrolysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metallurgical processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minerological processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dual use	1	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	23
	Wood and wood products	0	0	2	0	0	2	1	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	9	1	0	0	0	20
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Uses other than motor or heating fuel	17	62	20	0	36	96	6	4	34	81	5	66	7	11	5	256	9	2	1	2	22	16	66	29	10	4	5	875
In scope	**Uses as motor or heating fuel**	**46**	**127**	**44**	**0**	**90**	**389**	**10**	**5**	**67**	**281**	**18**	**254**	**17**	**31**	**10**	**891**	**25**	**33**	**7**	**1**	**114**	**84**	**377**	**117**	**11**	**14**	**41**	**3104**
	Final energy consumption	45	127	44	0	89	360	10	5	65	212	18	249	17	31	10	871	25	33	6	1	90	47	233	117	11	14	18	2748
	Autoproducers E	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Autoproducers CHP	0	0	0	0	0	30	0	0	2	69	0	5	0	0	0	21	0	0	0	0	24	37	144	0	0	0	22	354
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ather	**Ratio (in scope / total energy use)**	**72%**	**67%**	**67%**	**29%**	**71%**	**80%**	**60%**	**57%**	**67%**	**73%**	**79%**	**79%**	**68%**	**73%**	**66%**	**78%**	**72%**	**93%**	**82%**	**27%**	**84%**	**84%**	**83%**	**78%**	**52%**	**75%**	**88%**	**77%**

Source: JRC, 2020

Table 30. Results for the transport equipment industry

	Transport equipment	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	Energy use	148	125	19	0	484	2996	14	12	22	595	60	1113	13	241	27	426	5	2	8	2	122	469	79	298	214	34	217	7744
	Autoproducers E	0	3	0	0	0	1	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
	Autoproducers CHP	1	0	0	0	0	101	0	0	0	0	0	24	0	0	0	23	0	0	0	0	0	2	0	0	0	0	0	149
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Final energy consumption	148	122	19	0	484	2895	14	12	22	595	60	1077	13	241	27	403	5	2	8	2	122	467	79	298	214	34	217	7578
	Non-energy use	0	0	0	0	0	0	1	0	0	14	0	0	0	0	0	0	0	0	0	0	0	2	2	3	0	0	0	23
quipment	Total energy use	149	125	19	0	484	2996	15	12	22	610	60	1113	13	241	27	426	5	2	8	2	122	471	81	300	214	34	217	7767
Out of scope	Out of scope	67	69	7	0	208	1044	6	6	9	292	12	481	5	139	15	144	2	1	3	1	52	210	38	138	113	18	117	3195
	Chemical reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electrolysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metallurgical processes	21	15	3	0	38	336	2	1	2	96	7	162	2	33	1	37	1	0	1	0	19	63	12	28	24	5	34	945
	Minerological processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dual use	0	0	0	0	0	0	1	0	0	14	0	0	0	0	0	0	0	0	0	0	0	2	2	3	0	0	0	23
	Wood and wood products	1	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
	Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Uses other than motor or heating fuel	44	53	4	0	169	703	3	5	7	181	5	314	3	105	13	107	2	0	2	1	33	145	23	108	89	13	83	2215
In scope	Uses as motor or heating fuel	82	56	12	0	276	1952	9	6	13	318	48	633	8	102	12	282	3	1	5	1	70	261	43	162	101	16	100	4572
	Final energy consumption	82	53	12	0	276	1851	9	6	13	318	48	596	8	102	12	259	3	1	5	1	70	259	43	162	101	16	100	4406
	Autoproducers E	0	3	0	0	0	1	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
	Autoproducers CHP	1	0	0	0	0	101	0	0	0	0	0	24	0	0	0	23	0	0	0	0	0	2	0	0	0	0	0	149
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
quipment	Ratio (in scope / total energy use)	55%	45%	63%	48%	57%	65%	62%	48%	59%	52%	80%	57%	62%	42%	46%	66%	53%	64%	64%	42%	57%	55%	54%	54%	47%	48%	46%	59%

Source: JRC, 2020

Table 31. Results for the wood and wood products industry

	Wood & wood products	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU
Net inputs	Energy use	640	233	71	1	217	1802	114	67	38	497	573	671	76	124	174	488	90	13	486	0	42	1034	36	344	589	52	53	8524
	Autoproducers E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Autoproducers CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Final energy consumption	640	233	71	1	217	1802	114	67	38	497	573	671	76	122	174	488	90	13	486	0	42	1034	36	344	589	52	53	8522
	Non-energy use	1	0	1	0	0	0	0	0	0	9	0	0	0	0	0	0	1	0	6	0	0	1	2	0	0	0	0	20
od products	Total energy use	641	233	71	1	217	1802	114	67	38	505	573	671	76	124	174	488	91	13	492	0	42	1035	38	344	589	52	53	8544
Out of scope	Out of scope	349	182	46	0	142	1220	91	10	17	337	230	410	23	76	133	236	47	11	320	0	32	655	33	180	413	33	30	5258
	Chemical reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electrolysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metallurgical processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minerological processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dual use	1	0	1	0	0	0	0	0	0	9	0	0	0	0	0	0	1	0	6	0	0	1	2	0	0	0	0	20
	Wood and wood products	324	181	43	0	140	1199	89	6	15	321	214	378	13	70	129	167	40	11	311	0	31	639	31	167	397	32	29	4976
	Peat	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
	Uses other than motor or heating fuel	25	1	2	0	2	21	1	4	2	7	11	33	10	6	3	69	6	0	3	0	1	16	1	13	16	2	1	256
In scope	Uses as motor or heating fuel	292	51	25	0	75	581	23	56	21	169	343	260	53	48	42	252	44	3	172	0	10	380	5	164	176	18	23	3286
	Final energy consumption	292	51	25	0	75	581	23	56	21	169	343	260	53	48	42	252	44	3	172	0	10	380	5	164	176	18	23	3286
	Autoproducers E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Autoproducers CHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Autoproducers H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
od products	Ratio (in scope / total energy use)	45%	22%	35%	71%	35%	32%	20%	84%	55%	33%	60%	39%	69%	39%	24%	52%	49%	20%	35%	0%	23%	37%	12%	48%	30%	36%	43%	38%

Source: JRC, 2020

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