

COMMISSION DELEGATED REGULATION (EU) .../...

of

supplementing Directive (EU) of the European Parliament and of the Council by specifying a methodology for assessing greenhouse gas emissions savings from low carbon fuels

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive (EU) of the European Parliament and of the Council of xx on common rules for the internal markets for renewable gas, natural gas and hydrogen¹, and in particular Article 9(5) thereof,

Whereas:

- (1) Clear rules need to be set, based on objective and non-discriminatory criteria, for calculating greenhouse gas emissions savings for low carbon fuels and their fossil fuel comparators.
- (2) The greenhouse gas emissions accounting methodology for low carbon fuels should take into account the full life-cycle emissions and consider indirect emissions resulting from the diversion of rigid inputs from producing low carbon fuels as well as methane upstream emissions and actual carbon capture rates. In order to ensure consistency with the methodology for assessing greenhouse gas emissions savings from renewable fuels of non-biological origin and from recycled carbon fuels the methodology should apply similar approaches as the methodology set out in Delegated Regulation (EU) 2023/1185² for assessing greenhouse gas emissions savings from renewable fuels of non-biological origin and from recycled carbon-fuels.
- (3) The certification framework of low-carbon fuels is fully aligned with the certification framework set out in Directive (EU) 2018/2001 for renewable fuels. Accordingly, raw materials used for the production of low carbon fuels as well as the low carbon fuels themselves will be traced via the Union database in the same way as raw materials used for the production of renewable fuels and renewable fuels. It is therefore appropriate to distinguish the value for the upstream methane emissions between individual batches of fuels and raw material based on the methane performance profile of the supplier supplying the fuel used to produce the low-carbon fuel.
- (4) The global warming potential of hydrogen has not yet been unequivocally determined with the level of precision required to be included in the greenhouse gas emission

¹ OJ L 328, 21.12.2018, p. 82.

² Reference to be added

calculation methodology. Relevant values for the global warming potential of hydrogen should be added as soon as scientific evidence has sufficiently matured and applied for measuring the impact of hydrogen leakage over the whole supply chain in the greenhouse gas emissions accounting methodologies for both low carbon fuels and renewable fuels on non-biological origin.

- (5) The methodology set out in Delegated Regulation (EU) 2023/1185 applies to determine the greenhouse gas emissions savings of renewable fuels on non-biological origin as well as for recycled carbon fuels, which are a sub-category of low carbon fuels. It is therefore appropriate to refer to the Regulation (EU) 2023/1185 for the purpose of determining the greenhouse gas emissions savings of recycled carbon fuels,

HAS ADOPTED THIS REGULATION:

Article 1

This Regulation specifies the methodology to calculate the greenhouse gas emissions savings from low carbon fuels.

Article 2

The greenhouse gas emissions savings from the use of recycled carbon fuels shall be determined as set out on in Commission Delegated Regulation (EU) 2023/1185.

Article 3

The greenhouse gas emissions savings from low carbon fuels, other than recycled carbon fuels, shall be determined in accordance with the methodology set out in Annex.

Article 4

This Regulation shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels,

For the Commission
The President
Ursula VON DER LEYEN

ANNEX

**Methodology for determining greenhouse gas emissions savings from low carbon fuels
other than recycled carbon fuels**

A. METHODOLOGY

1. Greenhouse gas emissions from the production and use of low carbon fuels other than recycled carbon fuels shall be calculated as follows:

$$E = e_i + e_p + e_{td} + e_u - e_{ccs} - e_{ccu}$$

where:

E = total emissions from the use of the fuel (gCO₂eq / MJ fuel)

$e_i = e_{i \text{ elastic}} + e_{i \text{ rigid}} - e_{\text{ex-use}}$: emissions from supply of inputs (gCO₂eq / MJ fuel)

$e_{i \text{ elastic}}$ = emissions from elastic inputs (gCO₂eq / MJ fuel)

$e_{i \text{ rigid}}$ = emissions from rigid inputs (gCO₂eq / MJ fuel)

$e_{\text{ex-use}}$ = emissions from inputs' existing use or fate (gCO₂eq / MJ fuel)

e_p = emissions from processing (gCO₂eq / MJ fuel)

e_{td} = emissions from transport and distribution (gCO₂eq / MJ fuel)

e_u = emissions from combusting the fuel in its end-use (gCO₂eq / MJ fuel)

e_{ccs} = net emission savings from carbon capture and geological storage (gCO₂eq / MJ fuel)

e_{ccu} = net emission savings from carbon captured and permanently chemically bound in long-lasting products (gCO₂eq / MJ)

Emissions from the manufacture of machinery and equipment shall not be taken into account.

The greenhouse gas emissions intensity of low-carbon fuels shall be determined by dividing the total emissions of the process covering each element of the formula by the total amount of fuel stemming from the process and shall be expressed in terms of grams of CO₂ equivalent per MJ of fuel (g CO₂eq/MJ fuel). If a fuel is a mix of low carbon fuels and other fuels, all (fuel) types shall be considered to have the same emission intensity.

The exception to this rule is the case of co-processing where low carbon fuels, excluding recycled carbon fuels, are only partially replacing a conventional fossil fuel input in a process.

In such a situation it shall be distinguished in the calculation of the greenhouse gas emissions intensity on a proportional basis of the energetic value of inputs between:

- the part of the process that is based on the conventional fossil fuel input and
- the part of the process that is based on low carbon fuels, other than recycled carbon fuels, assuming that the process parts are otherwise identical.

An analogous distinction between processes shall be applied where low carbon fuels, excluding recycled carbon, are processed together with biomass, recycled carbon fuels or renewable fuels of non-biological origin.

The greenhouse gas emissions intensity of low-carbon fuels may be calculated as an average for the entire production of fuels occurring during a period of at most one calendar month but may also be calculated for shorter time intervals. Where electricity qualifying as fully renewable according to the methodology set out in Directive

2018/2001 is used as input that enhances the heating value of the fuel or intermediate products, the time interval shall be in line with the requirements applying for temporal correlation. Where relevant, greenhouse gas emissions intensity values calculated for individual time intervals may then be used to calculate an average greenhouse gas emissions intensity for a period of up to one month, provided that the individual values calculated for each time period meet the minimum savings threshold of 70%.

2. Greenhouse gas emission savings from low carbon fuels shall be calculated as follows:

$$\text{Savings} = (E_F - E) / E_F$$

where:

E = total emissions from the use of the fuel.

E_F = total emissions from the fossil fuel comparator.

For all low carbon fuels, the total emissions from the fossil fuel comparator shall be equal to the fossil fuel comparator for renewable fuels of non-biological origin set out in Commission Delegated Regulation (EU) 2023/1185.

3. If the output of a process does not fully qualify as low carbon fuels excluding recycled carbon fuels, the fraction of low carbon fuels excluding recycled carbon fuels shall be determined by dividing the relevant renewable energy input into the process by the total relevant energy inputs into the process.

The relevant energy for material inputs is the lower heating value of the material input that enters into the molecular structure of the fuel³.

For electricity inputs that are used to enhance the heating value of the fuel or intermediate products the relevant energy is the energy of the electricity.

For industrial off-gases, it is the energy in the off-gas based on their lower heating value. In case of heat that is used to enhance the heating value of the fuel or intermediate product, the relevant energy is the useful energy in the heat that is used to synthesise the fuel. Useful heat is the total heat energy multiplied by the Carnot efficiency, as defined in Annex V, part C, point (1)(b) of Directive (EU) 2018/2001. Other inputs are only taken into account when determining the emission intensity of the fuel.

4. When determining emissions from supply of inputs e_i , it shall be distinguished between elastic inputs and rigid inputs. Rigid inputs are those whose supply cannot be expanded to meet extra demand. Thus, all inputs qualifying as a carbon source for the production of recycled carbon fuels are rigid, as well as outputs produced in fixed ratio by an incorporated process⁴ and which represent less than 10% of the economic value of the output. If it represents 10% or more of the economic value, it shall be treated as elastic. In principle, elastic inputs are those whose supply can be increased to meet extra demand. Petroleum products from refineries fall into this category because

³ For material inputs containing water, the lower heating value is taken to be the lower heating value of the dry part of the material input (i.e. not taking into account the energy needed to evaporate the water). Renewable liquid and gaseous transport fuels of non-biological origin used as intermediate products for the production of conventional fuels are not considered.

⁴ Incorporated processes include processes that take place in the same industrial complex, or that supply the input via a dedicated supply infrastructure, or that supply more than half of the energy of all inputs to the production of the renewable liquid and gaseous transport fuel of non-biological origin or recycled carbon fuel.

refineries can change the ratio of their products. Emissions from energy and materials inputs to the CCS operations (e.g. from fuel combustion, of heat and electricity used, as well as from materials and chemicals) shall be calculated following by analogy the approach described in points from 7 to 11 on process inputs.

5. Electricity qualifying as fully renewable according to Article 27(6) of Directive 2018/2001, shall be attributed zero greenhouse gas emissions.
6. One of the three following alternative methods shall be applied during each calendar year to attribute greenhouse gas emissions values to the electricity taken from the grid that does not qualify as fully renewable according to Article 27(6) of Directive (EU) 2018/2001 and is used to produce low carbon fuels:
 - (a) greenhouse gas emissions values shall be attributed according to part C of this Annex. This is without prejudice to the assessment under State aid rules;
 - (a) greenhouse gas emissions values shall be attributed depending on the number of full load hours the installation producing low carbon fuels is operating. Where the number of full load hours is equal or lower than the number of hours in which the marginal price of electricity was set by installations producing renewable electricity or nuclear power plants in the preceding calendar year for which reliable data are available, grid electricity used in the production process of low carbon fuels shall be attributed a greenhouse gas emissions value of zero g CO₂eq/MJ. Where this number of full load hours is exceeded, grid electricity used in the production process of low carbon fuels shall be attributed a greenhouse gas emissions value of 183 g CO₂eq/MJ; or
 - (b) the greenhouse gas emissions value of the marginal unit generating electricity at the time of the production of the low carbon fuels in the bidding zone may be used if this information is publicly available from the national transmission system operator.

If the method set in point (b) is used, it shall also be applied to electricity that is used to produce low carbon fuels and qualifies as fully renewable according to Article 27(6) to Directive (EU) 2018/2001.

7. GHG emissions of elastic inputs that are obtained from an incorporated process shall be determined based on data from their actual production process. This shall include all emissions arising due to their production over the whole supply chain (including emissions arising from the extraction of the primary energy required to make the input, processing of the input and transportation of the input). Combustion emissions related to the carbon content of fuel inputs shall not be included⁵.

GHG emissions from the elastic inputs that are not obtained from an incorporated process shall be determined based on the values included in Part B of this Annex. If the input is not included in the list, information of the emission intensity may be drawn from the latest version of the JEC-WTW report, the ECOINVENT database, official sources such as the IPCC, IEA or government, other reviewed sources such as the E3 and GEMIS database and peer reviewed publications.

However, the methane intensity of the production of fossil-based elastic inputs that enhance the heating value of low carbon fuels produced in the Union shall be calculated in

⁵ If carbon intensities are taken from the table in part B, combustion emissions shall not be considered. This is because combustion emissions are counted in processing or in the combustion emissions of the final fuel.

accordance with the methodology set by the Commission according to Article 29(4) of Regulation (EU) 2024/... [methane regulation].

Until such date when that methodology is established, the methane intensity shall be calculated based on the methane emissions reported by Union producers in accordance with Article 12 of Regulation (EU) 2024/... [methane regulation].

Where no methane intensity value is available, the methane intensity shall be calculated by applying a 40% increase on the relevant value for the upstream methane emissions per unit of fuel included in Part B of this Annex.

Until such date when Union producers are required to submit methane emissions reports in accordance with Article 12 of Regulation (EU) 2024/... [methane regulation], the methane intensity shall be determined based on the values included in Part B of this Annex.

The methane intensity of the production of fossil-based elastic inputs that enhance the heating value of low carbon fuels produced outside the Union shall be calculated in accordance with the methodology set by the Commission according to Article 29(4) of Regulation (EU) 2024/... [methane regulation].

Until such date when that methodology is established, the methane intensity shall be calculated based on methane emissions information reported by importers in accordance with Article 27(1) and Article 28(1), (2) and (5) of Regulation (EU) 2024/... [methane regulation]. Where no methane intensity value is available, the methane intensity shall be calculated by applying a 40% increase on the relevant value for the upstream methane emissions per unit of fuel included in Part B of this Annex.

Until such date when importers are required to submit methane emissions reports in accordance with Article 27(1) and Article 28(1), (2) and (5) of Regulation (EU) 2024/... [methane regulation], the methane intensity shall be determined based on the values included in Part B of this Annex.

8. The supplier of each elastic input, excluding those where the values are taken from part B of this Annex, shall calculate the emissions intensity⁶ of the input following the procedures in this document, and report the value to the next production step or final fuel producer. The same rule applies to the suppliers of inputs further back in the supply chain.
9. Emissions from rigid inputs $e_{i \text{ rigid}}$ shall include the emissions resulting from the diversion of those inputs from a previous or alternative use. These emissions shall take into account the loss of production of electricity, heat or products that were previously generated using the input as well as any emissions due to additional treatment of the input and transport. The following rules shall apply:
 - (a) emissions attributed to the supply of rigid inputs shall be determined by multiplying the lost production of electricity, heat or other products with the relevant emission factor. In case of lost electricity production, the emission factors to consider are for grid electricity generation in the country where the displacement occurred determined according to the appropriate methodology set out under points 5 or 6. In case of diverted material, the emissions to be attributed to the replacement material are calculated as for material inputs in this

⁶ Consistent with section 6 the emissions intensity shall not include the emissions embedded in the carbon content of the supplied input.

methodology. For the first 20 years after the start of production of low carbon fuels, the loss of production of electricity, heat and material shall be determined based on the average amount of electricity and heat that was produced from the rigid input over the last three years before the start of production of low carbon fuels. After 20 years of production, the loss of production of electricity, heat or other products shall be determined based on the minimum energy performance standards assumed in pertinent best available technology (BAT) conclusions. Where the process is not covered by a BAT, the estimation of lost production shall be based on a comparable process applying state of the art technology.

- (b) in case of rigid inputs that are intermediate streams in industrial processes, such as coke oven gas, blast furnace gas in a steelworks, or refinery gas in an oil refinery, if the effect of diverting it for fuel production cannot be measured directly, the emissions due to the diversion of inputs shall be determined based on simulations of the plant operation before and after it is modified. If the modification of the plant caused a reduction of output of some products, the emissions attributed to the rigid input shall include the emissions associated with replacing the lost products.
- (c) where the process makes use of rigid inputs from new installations, the impact of diverting the input from the most economical alternative use shall be taken into account. Then the emission implications are calculated according to the minimum energy performance standards assumed in the pertinent BAT conclusions. For industrial processes which are not covered by such BAT conclusion, the saved emissions shall be calculated on the basis of the comparable process applying state of the art technology.

10. Emissions from existing use or fate *e_{ex-use}* include all emissions in the existing use or fate of the input that are avoided when the input is used for fuel production. These emissions shall include the CO₂ equivalent of the carbon incorporated in the chemical composition of the fuel that would have otherwise been emitted as CO₂ into the atmosphere. This includes CO₂ that was captured and incorporated into the fuel provided that at least one of the following conditions is fulfilled:

- (a) The CO₂ has been captured from an activity listed under Annex I of Directive 2003/87/EC and has been taken into account upstream in an effective carbon pricing system and is incorporated in the chemical composition of the fuel before 2036. This date shall be extended to 2041 in other cases than CO₂ stemming from the combustion of fuels for electricity generation; or
- (b) The CO₂ has been captured from the air; or
- (c) The captured CO₂ stems from the production or the combustion of biofuels, bioliquids or biomass fuels complying with the sustainability and greenhouse gas saving criteria; or
- (d) The captured CO₂ stems from the combustion of renewable fuels of non-biological origin or low carbon fuels complying with the greenhouse gas saving criteria, set out in Article 29a of Directive (EU) 2018/2001 and this Regulation; or
- (e) The captured CO₂ stems from a geological source of CO₂ and the CO₂ was previously released naturally.

Captured CO₂ stemming from a fuel that is deliberately combusted for the specific purpose of producing the CO₂ and CO₂, the capture of which has received an emissions credit under other provisions of the law shall not be included.

Emissions associated with the inputs like electricity and heat and consumable materials used in the capture process of CO₂ shall be included in the calculation of emissions attributed to inputs.

11. The dates established in point 10(a) will be subject to review considering the implementation in the sectors covered by Directive 2003/87/EC of the Union-wide climate target for 2040 established in accordance with Article 4(3) of Regulation (EU) 2021/1119.
12. Emissions from processing e_p shall include direct atmospheric emissions from the processing itself, from waste treatment and from leakages.
13. Emissions from combustion of the fuel e_u refer to the total combustion emissions of the fuel in use.
14. The greenhouse gases taken into account in emissions calculations, and their carbon dioxide equivalents, shall be the same as specified in paragraph 4 of Annex V, part C, of Directive (EU) 2018/2001.
15. Where a process yields multiple co-products such as fuels or chemicals, as well as energy co-products such as heat, electricity or mechanical energy exported from the plant, greenhouse gas emissions shall be allocated to these co-products applying the following approaches in the following manner:
 - (a) the allocation shall be conducted at the end of the process that produces the co-products. The emissions allocated shall include the emissions from the process itself, as well as the emissions attributed to inputs to the process.
 - (b) the emissions to be allocated shall be e_i plus any fractions of e_p , e_{td} and e_{ccs} that take place up to and including the process step at which the co-products are produced. If an input into the process is itself a co-product of another process, the allocation at the other process shall be done first to establish the emissions to be attributed to the input.
 - (c) if any installation inside the project boundary treats only one of the project's co-products, then the emissions from that installation shall be ascribed entirely to that co-product.
 - (d) where the process allows to change the ratio of the co-products produced, the allocation shall be done based on physical causality by determining the effect on the process' emissions of incrementing the output of just one co-product whilst keeping the other outputs constant.
 - (e) where the ratio of the products is fixed and the co-products are all fuels, electricity or heat, the allocation shall be done by energy content. If allocation concerns exported heat on the basis of the energy content, only the useful part of the heat may be considered, as defined in paragraph 16 of Directive 2018/2001 Annex V, part C.
 - (f) where the ratio of the products is fixed and some co-products are materials with no energy content, the allocation shall be done by the economic value of the co-products. The economic value considered shall be the average factory-gate value of the products over the last three years. If such data is not available, the value

shall be estimated from commodity prices minus the cost of transport and storage⁷.

16. Emissions from transport and distribution e_{td} shall include emissions from the storage and distribution of the finished fuels. Emissions attributed to inputs e_i shall include emissions from their associated transport and storage.
17. Where a process for making low carbon fuels produces carbon emissions that are permanently stored in accordance with Directive 2009/31/EC on the geological storage of carbon dioxide, this may be credited to the products of the process as a reduction in emissions under e_{ccs} (in gCO₂eq/MJ fuel). The term e_{ccs} shall consider the capture rate of CO₂ from LCF production (e.g. H₂ through steam methane reforming, auto-thermal reforming, gasification, methane pyrolysis and other processes), as well as all emissions from the operation activities for carbon capture, transport of CO₂ and emissions from injection into the permanent storage site shall be taken into account under e_p , as follows:

$$e_{ccs} = cCO_2 - e_{CO_2-c} - e_{CO_2-t} - e_{CO_2-i}$$

where:

cCO_2 : CO₂ captured at the carbon capture plant (gCO₂eq/MJ fuel)

e_{CO_2-c} : emissions associated with all operations for carbon capture, dehydration, compression and liquefaction of the CO₂ (gCO₂eq/MJ fuel)

e_{CO_2-t} : emissions from transport of CO₂ by pipeline, ships, barges, rail, or trucks from the capture site to the permanent storage site (gCO₂eq/MJ fuel)

e_{CO_2-i} : emissions from injection operations of CO₂ into permanent storage site (gCO₂eq/MJ fuel)

The term e_{ccs} shall include:

18. GHG emissions per MJ of fuel from CO₂ capture operations (e_{CO_2-c}), for the purposes of permanent geological storage in a storage site permitted under Directive 2009/31/EC. This includes emissions from fuel, heat and electricity use and material input use for capture, as well as all material replacements (due to losses or degradation). It shall be calculated according to Regulation (EU) 2018/2066, Annex IV, Section 21.
19. GHG emissions per MJ of fuel from transport of CO₂ (e_{CO_2-t}) by pipeline, ships, rail, or trucks or other maritime modals from the capture site to the permanent storage site shall include all emissions from fuel combustion at stationary equipment used in CO₂ transport, including emissions from electricity and emissions of fuels used in CO₂ transport. GHG emissions due to the transportation of CO₂ shall be calculated based on distance travelled, type of modal and load. If the injected CO₂ comes via two or more different transport modes, the emissions shall be calculated as a sum for each transport mode. Transport emissions for multiple sources shall be allocated using the mass-based allocation method. If a pipeline carries CO₂ to multiple geological sites or serves multiple uses, CO₂ transport emissions are allocated using the

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Note that it is the relative values of the co-products that matters, so general inflation is not an issue.

mass-based allocation method. Dispatching CO₂ by pipelines shall be calculated according to Regulation (EU) 2018/2066, Annex IV, Section 22.

20. GHG emissions per MJ of fuel from injection (e CO₂-i) into a geological storage permitted under Directive 2009/31/EC. This includes all emissions from fuel combustion at stationary equipment used in CO₂ transport, including emissions from electricity and emissions of fuels used in CO₂ transport by associated booster stations and other combustion activities including on-site power plants. It shall be calculated according to Regulation (EU) 2018/2066, Annex IV, Section 23.

Any potential leakages released from the permitted storage shall be treated according to Directive 2009/31/EC on the geological storage of carbon dioxide (CCS Directive). The CCS Directive places legal obligations (e.g. liability for emissions from a storage site, including leakage) only on the storage operator: the CCS Directive does not create any direct legal responsibility for the operator that captured the CO₂.

GHG emissions from fuel, heat and electricity use and material input use for capture, dehydration, compression and liquefaction operations are considered for all steps in the CO₂ value chain, from capture to storage.

Any CO₂ amount shipped or dispatched to third countries could be accounted for only if both the storage facilities where the CO₂ is permanently stored and the pipelines are certified according to EU legislation or subject to legislation that the EU recognises as equivalent to the CCS Directive.

Emissions from energy and materials inputs to the CCS operations (e.g. from fuel combustion, of heat and electricity used, as well as from materials and chemicals) shall be calculated following by analogy the above points 7 to 11 on process inputs.

All emissions from venting as well as fugitive emissions and other CO₂ leakages shall be considered from carbon capture, dehydration, and compression and liquefaction, transport of CO₂ and from injection operations.

21. Where a process for making low-carbon fuels generates CO₂ emissions that are permanently chemically bound in long-lasting products, in accordance with Article 12(3b) of Directive 2003/87/EC, this shall be credited to the LCF products of the process as a reduction in emissions under e_{ccu} (in gCO₂eq/MJ fuel). The term e_{ccu} shall consider the capture rate of CO₂ from LCF production (e.g. H₂ through Steam Methane Reforming, Auto-Thermal Reforming, gasification, methane pyrolysis and other processes), as well as all emissions from the operation activities for carbon capture, transport of CO₂ and emissions from the transformation and utilisation process to make them permanently chemically bound in a product, as follows:

$$e_{ccu} = c_{CO_2} - e_{CO_2-c} - e_{CO_2-t} - e_{CO_2-u}$$

where:

c_{CO_2} : CO₂ captured at the carbon capture plant (gCO₂eq/MJ fuel)

e_{CO_2-c} : emissions associated with all operations for carbon capture, dehydration, compression and liquefaction of the CO₂ (gCO₂eq/MJ fuel)

e_{CO_2-t} : emissions from transport of CO₂ by pipeline, ships, barges, rail, or trucks from the capture site to the utilisation site (gCO₂eq/MJ fuel)

e_{CO_2-u} : emissions from utilisation of CO_2 to chemically bind it permanently in products
(gCO_2eq/MJ fuel)

The requirements for considering that CO_2 have permanently become chemically bound shall follow the provisions of Article 12(3b) of Directive 2003/87/EC.

Table Briefings

B. 'STANDARD VALUES' FOR GHG EMISSION INTENSITIES OF ELASTIC INPUTS

The GHG emission intensities of elastic inputs other than electricity are shown in the tables below:

Fuel	Total GHG emissions gCO ₂ eq/MJ	Upstream GHG emissions gCO ₂ eq/MJ				Midstream GHG emissions gCO ₂ eq/MJ	Combustion GHG emissions gCO ₂ eq/MJ
		CO ₂	CH ₄ (*)	N ₂ O	All GHG upstream		
Natural gas		5,4	5	0,05		Not applicable	56,2
Crude oil		5	5,7				
Diesel		1,09*5	1,09*5,7			10,2	73,2
Gasoline		1,08*5	1,08*5,7			8,4	73,4
Heavy fuel oil		1,01*5	1,01*5,7			-5,1 (**)	80,6
Hard coal		6,5	9,75	0,07		Not applicable	96,1
Lignite		1,68	0,04	0,02		Not applicable	115,0

(*) An allocation factor shall be considered to calculate the upstream emissions of oil products (from the actual methane upstream emission factor of the crude oil considered): 1,09, 1,08, 1,01 (MJ crude oil/MJ product), respectively for diesel, gasoline and HFO.

(**) A negative refining emissions value for HFO is due to the marginal approach chosen for its estimation: if a refinery increases the HFO production, the refinery emissions decrease.

Material input	Total emissions gCO ₂ eq/kg
Ammonia	2 351,3
Calcium chloride (CaCl ₂)	38,8
Cyclohexane	723,0
Hydrochloric acid (HCl)	1 061,1
Lubricants	947,0
Magnesium sulphate (MgSO ₄)	191,8
Nitrogen	56,4
Phosphoric acid (H ₃ PO ₄)	3 124,7
Potassium hydroxide (KOH)	419,1
Pure CaO for processes	1 193,2
Sodium carbonate (Na ₂ CO ₃)	1 245,1

Sodium chloride (NaCl)	13,3
Sodium hydroxide (NaOH)	529,7
Sodium methoxide (Na(CH ₃ O))	2 425,5
SO ₂	53,3
Sulphuric acid (H ₂ SO ₄)	217,5
Urea	1 846,6

Source: WtW and RED calculations

C. GHG EMISSION INTENSITY OF ELECTRICITY

The GHG emission intensity of electricity shall be determined at the level of countries or at the level of bidding zones. The GHG emission intensity of electricity may be determined at the level of bidding zones only, if the required data are publicly available. The carbon intensity of electricity, expressed as gCO₂eq/MJ electricity, shall be calculated by considering all potential primary energy sources for electricity generation, actual type of plant, conversion efficiencies and own electricity consumption in each power plant.

The calculation shall consider all CO₂ equivalent emissions, associated with the combustion and supply of the fuels used for electricity production. This relies on the amount of different fuels used in the electricity production facilities and the emission factors from fuel combustion and the upstream fuel emission factors.

Greenhouse Gases other than CO₂ shall be converted to CO₂eq by multiplying their Global Warming Potential (GWP) relative to CO₂ over the 100-year time horizon as set out in Annex V, part C, point 4 to Directive (EU) 2018/2001. When combusting biogenic fuels, CO₂ emissions are not accounted for because of their biogenic origin, but emissions of CH₄ and N₂O shall be accounted for.

For the calculation of the GHG emissions from fuels combustion, the IPCC default emission factors for stationary combustion in the energy industries shall be used (IPCC 2006). The upstream emissions shall include emissions from all the processes and phases required to make the fuel ready to supply the power production; they result from the extraction, refining and transport of the fuel used for electricity production.

In addition, all the upstream emissions from the cultivation, harvesting, collection, processing and transport of biomass shall be considered. Peat and the components of waste materials that are from fossil origins shall be treated as a fossil fuel.

The fuels used for gross electricity production in electricity only plants are determined based on the electricity production and the efficiency of conversion to electricity. In the case of Combined Heat and Power (CHP) plants, the fuels used for heat produced in CHP shall be counted by considering alternative heat production with average overall efficiencies of 85 %, while the rest shall be attributed to electricity generation.

For nuclear power plants, the conversion efficiency from nuclear heat shall be assumed to be 33 % or data provided by Eurostat or a similar, accredited source.

No fuels are associated with electricity production from renewables that include hydro, solar, wind and geothermal. The emissions from the construction and decommissioning and waste management of electricity-producing facilities are not considered. Thus, the carbon equivalent emissions associated with the renewable electricity (wind, solar, hydro and geothermal) production and with electricity production from nuclear power plants are considered to be equal to zero.

The CO₂ equivalent emissions from gross electricity production shall include upstream emissions from JEC WTW v5 (Prussi et al, 2020) listed in Table 3 and the default emission factors for stationary combustion from IPCC Guidelines for National GHG Inventories (IPCC 2006) listed in Tables 1 and 2.

The upstream emissions for supplying the fuel used shall be calculated applying the JEC WTW v5 upstream emission factors (Prussi et al, 2020).

The calculation of the carbon intensity of electricity shall be done following the formula:

$$e_{\text{gross_prod}} = \sum_{i=1}^k (c_{i-\text{ups}} + c_{i-\text{comb}}) \times B_i$$

where:

$e_{\text{gross_prod}}$ = CO₂ equivalent emissions [gCO₂eq]

d

$c_{i-\text{ups}}$ = upstream CO₂ equivalent emission factors [gCO₂eq/MJ]

$c_{i-\text{comb}}$ = CO₂ equivalent emission factors from fuels combustion [gCO₂eq/MJ] . For the cases where the CO₂ is permanently stored by CCS facilities, the CO₂ equivalent emission factor from fuels combustion shall not be the default values for CO₂ given in Table 1 and it shall be calculated by including the CCS impacts.

B_i = consumption of fuel i for electricity generation [MJ]

$i=1 \dots k$ = fuels used for electricity production

The amount of net electricity production is determined by the gross electricity production, own electricity consumption in the power plant and the electricity losses in pump storage.

$$E_{\text{net}} = E_{\text{gross}} - E_{\text{own}} - E_{\text{pump}}$$

where:

1.

E_{net} = net electricity production [MJ]

E_{gross} = gross electricity production [MJ]

E_{own} = own internal electricity consumption in power plant [MJ]

E_{pump} = electricity losses in pump storage [MJ]

The carbon intensity of net produced electricity shall be the total gross GHG emissions for producing the net electricity:

$$CI = e_{\text{gross_prod}} / E_{\text{net}}$$

where: CI = CO₂ equivalent emissions from electricity production expressed in [gCO₂eq/MJ].

• Electricity production and fuel consumption data

Data on electricity production and fuel consumption shall be sourced from IEA Data and statistics that provides data on energy balances and electricity produced using various fuels, e.g. from IEA website, Data and Statistic section ('Energy Statistics Data Browser') ⁽⁶⁾.

For EU Member States, Eurostat data are more detailed and can be used instead. Where the GHG emission intensity is established at the level of bidding zones, data from official national statistics, from transmission system operators, or from ENTSO-E of the same level of detail as the IEA data shall be used. Fuel consumption data shall include available data at the highest level of detail available from national statistics: solid fossil fuels, manufactured gases, peat and peat products, oil shale and oil sands, oil and petroleum products, natural gas, renewables and biofuels, non-renewable waste and nuclear. Renewables and biofuels include all biogenic fuels, biogenic waste, hydro, ocean, tidal, wave, geothermal, wind, solar and ambient energy from heat pumps.

Input data from literature sources

Table 1

Default emissions factors for stationary combustion [g/MJ fuel on a net calorific value]

Fuel	CO ₂	CH ₄	N ₂ O
<i>Solid fossil fuels</i>			
Anthracite	98,3	0,001	0,0015
Coking coal	94,6	0,001	0,0015
Other bituminous coal	94,6	0,001	0,0015
Sub-bituminous coal	96,1	0,001	0,0015
Lignite	101	0,001	0,0015
Patent fuel	97,5	0,001	0,0015
Coke oven coke	107	0,001	0,0015
Gas coke	107	0,001	0,0001
Coal tar	80,7	0,001	0,0015
Brown coal briquettes	97,5	0,001	0,0015
<i>Manufactured gases</i>			
Gas works gas	44,4	0,001	0,0001
Coke oven gas	44,4	0,001	0,0001
Blast furnace gas	260	0,001	0,0001
Other recovered gases	182	0,001	0,0001
<i>Peat and peat products</i>	106	0,001	0,0015
<i>Oil shale and oil sands</i>	73,3	0,003	0,0006
<i>Oil and petroleum products</i>			
Crude oil	73,3	0,003	0,0006
Natural gas liquids	64,2	0,003	0,0006
Refinery feedstocks	73,3	0,003	0,0006
Additives and oxygenates	73,3	0,003	0,0006
Other hydrocarbons	73,3	0,003	0,0006
Refinery gas	57,6	0,001	0,0001
Ethane	61,6	0,001	0,0001

Liquefied petroleum gases	63,1	0,001	0,0001
Motor gasoline	69,3	0,003	0,0006
Aviation gasoline	70	0,003	0,0006
Gasoline-type jet fuel	70	0,003	0,0006
Kerosene-type jet fuel	71,5	0,003	0,0006
Other kerosene	71,5	0,003	0,0006
Naphtha	73,3	0,003	0,0006
Gas oil and diesel oil	74,1	0,003	0,0006
Fuel oil	77,4	0,003	0,0006
White spirit and SBP	73,3	0,003	0,0006
Lubricants	73,3	0,003	0,0006
Bitumen	80,7	0,003	0,0006
Petroleum coke	97,5	0,003	0,0006
Paraffin waxes	73,3	0,003	0,0006
Other oil products	73,3	0,003	0,0006
Natural gas	56,1	0,001	0,0001
Waste			
Industrial waste (non-renewable)	143	0,03	0,004
Non-renewable municipal waste	91,7	0,03	0,004
Note: values have to be multiplied with GWP factors set out in Annex V, part C, point 4 to Directive (EU) 2018/2001.			
Source: IPCC, 2006.			

Table 2

Default emissions factors for stationary combustion of fuels of biomass origin
[g/MJ fuel on a net calorific value]

Fuel	CO₂	CH₄	N₂O
Primary solid biofuels	0	0,03	0,004
Charcoal	0	0,2	0,004
Biogases	0	0,001	0,0001
Renewable municipal waste	0	0,03	0,004
Pure biogasoline	0	0,003	0,0006
Blended biogasoline	0	0,003	0,0006
Pure biodiesels	0	0,003	0,0006
Blended biodiesels	0	0,003	0,0006

Pure bio jet kerosene	0	0,003	0,0006
Blended bio jet kerosene	0	0,003	0,0006
Other liquid biofuels	0	0,003	0,0006
<i>Source:</i> IPCC, 2006.			

Table 3

Fuel upstream emission factors per MJ of fuel on a net calorific value

	Emission factor gCO ₂ eq/MJ fuel
	All GHGs
Hard coal	refer to the table in Part B of this Annex
Lignite	refer to the table in Part B of this Annex
Peat	0
Coal gases	0
Petroleum Products	refer to the table in Part B of this Annex
Natural gas	refer to the table in Part B of this Annex
Solid biofuels	0,7
Liquid biofuels	46,8
Industrial Waste	0
Municipal waste	0
Biogases	13,7
Nuclear	1,2
<i>Source:</i> JEC WTW v5.	

Table A includes the values for the GHG emission intensity of electricity at **country level** in the European Union. If the GHG emission intensity of electricity is determined at country level, these values shall be used for electricity sourced in the European Union only until updated data becomes available to determine the emission intensity of electricity ⁽⁷⁾.

Table A

Emission intensity of generated electricity in EU Member States in 2022

Country	Emission intensity of generated electricity (gCO ₂ eq/MJ)
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		2022
Austria		41,6
Belgium		50,6
Bulgaria		150,3
Cyprus		197
Czechia		139,1
Germany		114.5
Denmark		28,9
Estonia		177,3
Greece		109,1
Spain		59
Finland		22
France		23,8
Croatia		60.8
Hungary		62,3
Ireland		96,7
Italy		107
Latvia		25,6

Lithuania		34,3
Luxembourg		43,3
Malta		122,5
Netherlands		91
Poland		195,1
Portugal		54,9
Romania		88,7
Slovakia		42,8
Slovenia		65,4
Sweden		4,3
Source: JRC, 2024.		

⁽¹⁾ For material inputs containing water, the lower heating value is taken to be the lower heating value of the dry part of the material input (i.e. not taking into account the energy needed to evaporate the water).

⁽²⁾ Incorporated processes include processes that take place in the same industrial complex, or that supply the input via a dedicated supply infrastructure, or that supply more than half of the energy of all inputs to the production of the low-carbon fuel.

⁽³⁾ If carbon intensities are taken from the table in part B, combustion emissions shall not be considered. This is because combustion emissions are counted in processing or in the combustion emissions of the final fuel.

⁽⁴⁾ Consistent with section 6 the emissions intensity shall not include the emissions embedded in the carbon content of the supplied input.

⁽⁵⁾ Note that it is the relative values of the co-products that matters, so general inflation is not an issue.

⁽⁶⁾ Example: <https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=GERMANY&fuel=Energy%20supply&indicator=TESbySource>.

⁽⁷⁾ Updated data will be made available by the European Commission on a regular basis.