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ANNEX

ANNEX

to the

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

**supplementing Directive (EU) 2024/1788 of the European Parliament and of the Council
by specifying a methodology for assessing greenhouse gas emissions savings from low-
carbon fuels**

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, only partially replace 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.

If more than one relevant energy input is used in the process, the delineation between the two parts of the process is determined based on the share of the input qualifying

as low-carbon fuel, other than recycled carbon fuel, that replaces the highest share of the conventional fossil fuel input ⁽¹⁾.

An analogous distinction between processes shall be applied where low-carbon fuels, excluding recycled carbon, are processed together with biomass.

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 one calendar month. However, where electricity that is fully counted as renewable according to the methodology set out in Article 27(6) of 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 other than recycled 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 Delegated Regulation (EU) 2023/1185.

3. If the output of a process does not fully qualify as low-carbon fuels other than recycled carbon fuels, the fraction of low-carbon fuels other than recycled carbon fuels shall be determined by dividing the relevant energy input into the process by the total relevant energy inputs into the process ⁽²⁾.

The relevant energy for material inputs is the lower heating value of the material input that enters into the molecular structure of the fuel ⁽³⁾.

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, the relevant energy is the energy in the off-gas based on their lower heating value. In the 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 Carnot efficiency, as defined in Part C, point (1)(b) of Annex V to Directive (EU)

⁽¹⁾ This share is determined by comparing the same type of input, for example the share of low-carbon hydrogen, in all hydrogen used in the process.

⁽²⁾ If a fuel is produced in several subsequent processes, the fraction shall be determined for each process unless it is common industrial practice to integrate the processes technically and geographically.

⁽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 (that is to say 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.

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 , a distinction shall be made 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 a fixed ratio by an incorporated process ⁽⁴⁾ 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 refineries can change the ratio of their products. Emissions from energy and material inputs to carbon capture and storage (CCS) operations (for example, from fuel combustion, heat and electricity used, as well as from materials and chemicals) shall be calculated based on the approach set out in points 5 to 11 on process inputs.
5. Electricity which may be fully counted as renewable in accordance with Article 27(6), second subparagraph, of Directive (EU) 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 that cannot qualify as fully renewable in accordance with to Article 27(6), second subparagraph, of Directive (EU) 2018/2001 and is used to produce low-carbon fuels:
 - (a) greenhouse gas emissions values shall be attributed based on Part C of this Annex. This is without prejudice to the assessment under State aid rules;
 - (b) greenhouse gas emissions values shall be attributed depending on the number of full load hours that 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 0 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;
 - (c) 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 has been made publicly available by the national transmission system operator.

If the method set in point (b) is used, it shall be applied to all the electricity that is used to produce low-carbon fuels, including electricity that may be fully counted as renewable in accordance with Article 27(6), second subparagraph of Directive (EU) 2018/2001.

⁽⁴⁾ Incorporated processes include processes that take place in the same industrial complex, supply the input via a dedicated supply infrastructure, or 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.

7. Greenhouse gas (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, process and transport it). Combustion emissions related to the carbon content of fuel inputs shall not be included ⁽⁵⁾.

GHG emissions from 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 on the emission intensity may be obtained 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 database, the Global Emission Model for Integrated Systems (GEMIS) database and peer reviewed publications.

The methane intensity of the production of fossil-based elastic inputs that increase the heating value of low-carbon fuels produced in the Union shall be calculated in accordance with the methodology set by the Commission in accordance with Article 29(4) of Regulation (EU) 2024/1787⁶.

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) 2024/1787.

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.

Until such date when Union producers are required to submit methane emissions reports in accordance with Article 12 of Regulation (EU) 2024/1787, 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 increase the heating value of low-carbon fuels produced outside the Union shall be calculated in accordance with the methodology set by the Commission pursuant to Article 29(4) of Regulation (EU) 2024/1787.

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) 2024/1787.

Where no methane intensity value is available, the methane intensity shall be calculated by applying a 40% increase to 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) 2024/1787, the

⁽⁵⁾ If carbon intensities are taken from Part B of this Annex, combustion emissions shall not be considered. This is because combustion emissions are counted in processing or in the combustion emissions of the final fuel.

⁽⁶⁾ Regulation (EU) 2024/1787 of the European Parliament and of the Council of 13 June 2024 on the reduction of methane emissions in the energy sector and amending Regulation (EU) 2019/942 (OJ L, 2024/1787, 15.7.2024, p. 32, ELI: <http://data.europa.eu/eli/reg/2024/1787/oj>).

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 inputs where the values are taken from Part B of this Annex, shall calculate the emissions intensity ⁽⁷⁾ of the input following the procedures in this Annex, 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. Those 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 shall be calculated as for material inputs. For the first 20 years after the start of production of low-carbon fuels, the loss of production of electricity, heat and materials shall be determined based on the average amount of electricity and heat that was produced from the rigid input over the last 3 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 conclusion, 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 towards 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 in the 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. The emission implications shall be then calculated according to the minimum energy performance standards assumed in the relevant BAT conclusions. For industrial processes that are not covered by BAT conclusions, the emissions saved shall be calculated on the basis of the comparable process applying state-of-the-art technology.

⁽⁷⁾ Consistent with point 6, the emissions intensity shall not include the emissions embedded in the carbon content of the supplied input.

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. Those 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 all forms of carbon provided that at least one of the following conditions is fulfilled:
- (a) CO₂ has been captured from an activity listed under Annex I to Directive 2003/87/EC of the European Parliament and of the Council⁸, has been taken into account upstream in an effective carbon pricing system and is incorporated in the chemical composition of the fuel before 1 January 2036. That date shall be extended to 1 January 2041 in other cases than CO₂ stemming from the combustion of fuels for electricity generation;
 - (b) the CO₂ has been captured from the air;
 - (c) the captured CO₂ stems from biofuels, bioliquids or biomass fuels complying with the sustainability and greenhouse gas saving criteria set out in Article 29 of Directive (EU) 2018/2001;
 - (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 in this Regulation;
 - (e) the captured CO₂ stems from a geological source of CO₂ and the CO₂ was previously released naturally;
 - (f) the carbon stems from inputs qualifying as a carbon source for the production of recycled carbon fuels.

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

Emissions associated with 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 referred to in point 10(a) shall be subject to review, taking into consideration 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 of the European Parliament and of the Council⁹.
12. Emissions from processing (*e_p*) shall include direct atmospheric emissions from the processing itself, from waste treatment and from leakages, as well as any CO₂ stream that leaves the processing plant and is captured at the carbon capture plant and considered under *e_{ccs}* or *e_{ccu}*.

⁸ Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (OJ L 275, 25.10.2003, p. 32, ELI: <http://data.europa.eu/eli/dir/2003/87/oj>).

⁹ Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law') (OJ L 243, 9.7.2021, p. 1, ELI: <http://data.europa.eu/eli/reg/2021/1119/oj>).

13. Emissions from combustion of the fuel (e_u) shall refer to the total combustion emissions of the fuel in use, including emissions from the combustion of carbon of biological origin.
14. The greenhouse gases taken into account in emissions calculations and their carbon dioxide equivalents shall be the same as specified in Part C, point 4 of Annex V to 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 those 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 the ratio of the co-products produced to be changed, 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 while 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 Part C, point 16 of Annex V to Directive (EU) 2018/2001, .
 - (f) Where the ratio of the products is fixed and some co-products are materials with no energy content, the allocation shall be done based on the economic value of the co-products. The economic value considered shall be the average factory gate value of the products over the last 3 years. If such data is not available, the value shall be estimated from commodity prices minus the cost of transport and storage ⁽¹⁰⁾.
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 in solid state or carbon emissions that are permanently stored in a geological storage site, that carbon may be credited to the products of the process as a reduction in emissions under e_{ccs}

⁽¹⁰⁾ Note that it is the relative values of the co-products that matter, so general inflation is not an issue.

(in gCO₂eq/MJ fuel). The term e_{ccs} shall consider the capture rate ⁽¹¹⁾ of CO₂ from low carbon fuel production, 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 CO₂ (gCO₂eq/MJ fuel);

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

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

The term e_{ccs} shall include:

- (a) GHG emissions per MJ of fuel from CO₂ capture operations (e_{CO_2-c}) for the purpose of permanent geological storage in a storage site permitted under Directive 2009/31/EC of the European Parliament and of the Council¹² or under applicable national law in third countries, and which is not used for enhanced oil and gas recovery. Those emissions shall include emissions from fuel, heat and electricity use and material input use for capture, as well as all material replacements (due to losses or degradation). Those emissions shall be calculated in accordance with Section 21 of Annex IV to Commission Implementing Regulation (EU) 2018/2066¹³.
- (b) GHG emissions per MJ of fuel from the transport of CO₂ (e_{CO_2-t}) by pipeline, ship, rail, truck or other maritime modal from the capture site to the permanent geological storage site permitted under Directive 2009/31/EC or under applicable national law in third countries 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 the distance travelled, modal type 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

⁽¹¹⁾ Referring to the capture rate means that net emission savings must be proportionally allocated to the entire fuel output.

¹² Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 (OJ L 140, 5.6.2009, p. 114, ELI: <http://data.europa.eu/eli/dir/2009/31/oj>).

¹³ Commission Implementing Regulation (EU) 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 601/2012 (OJ L 334, 31.12.2018, p. 1, ELI: http://data.europa.eu/eli/reg_impl/2018/2066/oj).

multiple geological sites or serves multiple uses, CO₂ transport emissions shall be allocated using the mass-based allocation method. Dispatching CO₂ by pipeline shall be calculated in accordance with Section 22 of Annex IV to Regulation (EU) 2018/2066.

- (c) GHG emissions per MJ of fuel from injection (e_{CO_2-i}) into a permanent geological storage site permitted under Directive 2009/31/EC or under applicable national law in third countries. Those emissions 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 by associated booster stations and other combustion activities including on-site power plants. Those emissions shall be calculated in accordance with Section 23 of Annex IV to Regulation (EU) 2018/2066.

The applicable national law that regulates geological storage sites shall provide for appropriate monitoring, reporting and verification requirements to detect leaks, as well as place legal obligations on the storage operator to ensure remediation in line with the legal provisions applicable in the Union. In case of leak the equivalent amount of carbon emissions shall not be credited as a reduction in emissions under e_{ccs} . Geological storage sites that repeatedly leak shall not be accepted for injection (e_{CO_2-i}).

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

Emissions from energy and material inputs to the CCS operations (for example, from fuel combustion, heat and electricity used, as well as from materials and chemicals) shall be calculated by applying by analogy points 5 to 11 on process inputs.

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

18. Where a process for producing low-carbon fuels generates CO₂ emissions that are permanently chemically bound in one of the products listed in the delegated act adopted in accordance with Article 12(3b), second subparagraph, of Directive 2003/87/EC, this shall be credited to the low carbon fuel 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⁽¹⁴⁾ of CO₂ from low carbon fuel production, 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);

⁽¹⁴⁾ Referring to the capture rate means that net emission savings must be proportionally allocated to the entire fuel output.

e_{CO_2-c} : emissions associated with all operations for carbon capture, dehydration, compression and liquefaction of CO_2 (gCO_2eq/MJ fuel);

e_{CO_2-t} : emissions from the transport of CO_2 by pipeline, ship, barge, rail or truck from the capture site to the utilisation site (gCO_2eq/MJ fuel);

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

Emissions shall only be considered to be permanently chemically bound in a product where the product is listed in the delegated act adopted pursuant to Article 12(3b), second subparagraph, of Directive 2003/87/EC.

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

The Tables 1 and 2 establish the GHG emission intensities of elastic inputs other than electricity:

Table 1: Default GHG emissions of different stages of supply and combustion of fossil fuels

Fuel	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		
Natural gas	5,4	5	0,05	Not applicable	56,2
Crude oil	5	5,7 (CH ₄ _crude)			
Diesel	5.45	1,09*CH ₄ _crude		10,2	73,2
Gasoline	5.4	1,08*CH ₄ _crude		8,4	73,4
Heavy fuel oil	5,05	1,01*CH ₄ _crude		-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 for calculating 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) for diesel, gasoline and heavy fuel oil (HFO) respectively.

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

Table 2: Default GHG emissions of material inputs

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
Sulphur dioxide (SO ₂)	53,3
Sulphuric acid (H ₂ SO ₄)	217,5
Urea	1 846,6

Source: JEC-WTW report and Renewable Energy Directive calculations

C. GHG EMISSION INTENSITY OF ELECTRICITY

1. Methodology to calculate GHG emission intensities 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. That calculation shall rely on the amount of different fuels used in the electricity production facilities, together with the emission factors from fuel combustion and upstream fuel emission factors.

Greenhouse gases other than CO₂ shall be converted into CO₂eq by multiplying their global warming potential relative to CO₂ over a 100-year period as set out in Part C, point 4 of Annex V to Directive (EU) 2018/2001. When combusting biogenic fuels, CO₂ emissions shall not be accounted for because of their biogenic origin, but emissions of CH₄ and N₂O shall be accounted for.

For the calculation of GHG emissions from fuel combustion, the IPCC default emission factors for stationary combustion in energy industries shall be used IPCC Guidelines for National GHG Inventories (IPCC 2006). The upstream emissions shall include emissions from all the processes and phases required to make the fuel ready to supply power production. They shall 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 origin shall be treated as a fossil fuel.

The fuels used for gross electricity production in electricity-only plants shall be 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 shall be associated with electricity production from renewables that include hydro, solar, wind and geothermal. The emissions from the construction, decommissioning and waste management of electricity-producing facilities shall not be considered. The carbon equivalent emissions associated with renewable electricity production (wind, solar, hydro and geothermal) shall therefore be considered to be equal to zero.

The CO₂ equivalent emissions from gross electricity production shall include upstream emissions from the JEC Well-to-Wheels (WTW) report v5 (Prussi et al, 2020) listed in Table 5 and the default emission factors for stationary combustion listed in Tables 3 and 4. The upstream emissions for supplying the fuel used shall be calculated applying the JEC WTW v5 upstream emission factors (Prussi et al, 2020), (see Table 5).

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

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

where:

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

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

$c_{i\text{-comb}}$ = CO₂ equivalent emission factors from fuel combustion [gCO₂eq/MJ]. For the cases where the CO₂ is permanently stored by CCS facilities, the CO₂ equivalent emission factor from fuel combustion shall not be the default values for CO₂ given in Table 3 and shall be calculated by including the CCS impact

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:

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:

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

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

2. Electricity production and fuel consumption data

Data on electricity production and fuel consumption shall be sourced for IEA member and associate countries from IEA data and statistics that provide data on energy balances and electricity produced using various fuels, for example, from the IEA website, Data and Statistics section ('Energy Statistics Data Browser')¹⁵.

For Member States, Eurostat data are more detailed and may be used instead. Where the GHG emission intensity is established at the level of bidding zones, data from official national statistics, transmission system operators or the European Network of Transmission System Operators for Electricity (ENTSO-E) with 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 3

Default emission 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

⁽¹⁵⁾ Example: <https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=GERMANY&fuel=Energy%20supply&indicator=TESbySource>.

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
Peat and peat products	106	0,001	0,0015
Oil shale and oil sands	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 by global warming potential factors set out in Part C, point 4 of Annex V to Directive (EU) 2018/2001.			
Source: IPCC, 2006.			

Table 4

Default emission factors for stationary combustion of fuels of biomass origin

[g/MJ fuel on a net calorific value]

Fuel	CO ₂	CH ₄	N ₂ O
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
Source: IPCC, 2006.			

Table 5

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

	Emission factor gCO₂eq/MJ fuel
	All GHGs
Hard coal	see Table 1 in Part B of this Annex
Lignite	see Table 1 in Part B of this Annex
Peat	0
Coal gases	0
Petroleum products	see Table 1 in Part B of this Annex
Natural gas	see Table 1 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 6 includes the values for the GHG emission intensity of electricity calculated following the aforementioned formulas in this Part C at country level in the Union. Those values may be used for electricity sourced in the respective countries until updated data becomes available to determine the emission intensity of electricity¹⁶.

Table 6

Emission intensity of generated electricity in Member States in 2022

Country	Emission intensity of generated electricity (gCO₂eq/MJ)	
		2022
Austria		41,6

¹⁶ Updated data will be made available by the European Commission on a regular basis.

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
<i>Source:</i> JRC, 2024 from Eurostat data		