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ANNEX

ANNEXES

to the

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

on establishing a minimum threshold for greenhouse gas emissions savings of recycled carbon fuels and specifying a methodology for assessing greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels

ANNEX

Methodology for determining greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels

A. METHODOLOGY

1. Greenhouse gas emissions from the production and use of renewable liquid and gaseous transport fuels of non-biological origin or recycled carbon fuels shall be calculated as follows:

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

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

Emissions from the manufacture of machinery and equipment and emissions from compressing and distribution of hydrogen¹ for its direct use in vehicles shall not be taken into account.

The greenhouse gas emissions shall be determined by dividing the total emissions of the process concerning 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 renewable liquid and gaseous transport fuels of non-biological origin, recycled carbon fuels and other fuels, all (fuel) types shall be considered to have the same emission intensity.

2. Greenhouse gas emission savings from renewable liquid and gaseous transport fuels of non-biological origin or from recycled carbon fuels shall be calculated as follows:

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

where:

E = total emissions from the use of renewable liquid and gaseous transport fuel of non-biological origin or recycled carbon fuel

E_F = total emissions from the fossil fuel comparator.

¹ Emissions from compressing and transport of hydrogen are also excluded from the fossil fuel comparator applied for hydrogen.

For all renewable liquid and gaseous transport fuels of non-biological origin and recycled carbon fuels, the total emissions from the fossil fuel comparator referred to under point 2 shall be 94 gCO₂eq/MJ.

3. If the output of a process does not fully qualify as liquid and gaseous transport fuels of non-biological origin or recycled carbon fuel, their respective shares in the total output shall be determined as follows:
 - (a) the fraction of renewable liquid and gaseous transport fuels of non-biological origin shall be determined by dividing the relevant renewable energy input into the process by the total relevant energy inputs into the process.
 - (b) the fraction of recycled carbon fuel shall be determined by dividing the relevant energy input qualifying as a source for the production of recycled carbon fuels 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 fuel².

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 LHV. 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, 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 process³ and which represent less than 10% of the economic value of the output. If it represents more than 10% 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.
5. Electricity qualifying as fully renewable according to the methodology set out in Directive 2018/2001, shall be attributed zero greenhouse gas emissions.
6. Grid electricity used in the production process of renewable liquid and gaseous transport fuels of non-biological origin and recycled carbon fuels that does not qualify as fully renewable according to Article 27(3) of Directive 2018/2001, shall be attributed the greenhouse gas emissions values according to part C of this Annex. This is without prejudice to the assessment under State aid rules.

² 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).

³ 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.

Alternatively, electricity taken from the electricity grid that is used in the production process of renewable liquid and gaseous transport fuels of non-biological origin and recycled carbon fuels that does not qualify as fully renewable according to Article 27(3) of Directive 2018/2001, may be attributed greenhouse gas emissions values depending on the number of full load hours the installation producing renewable liquid and gaseous transport fuels of non-biological origin and recycled carbon fuels is operating. Where the number of full load hours the electrolyser is producing 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 renewable liquid and gaseous transport fuels of non-biological origin and recycled 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 renewable liquid and gaseous transport fuels of non-biological origin and recycled carbon fuels shall be attributed a greenhouse gas emissions value of 183 g CO₂eq/MJ.

7. Alternatively, the greenhouse gas emissions value of the marginal unit generating electricity at the time of the production of the renewable liquid and gaseous transport fuels of non-biological origin in the bidding zone may be used if this information is publicly available from a reliable source.
8. 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 included⁴.

However, 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.

9. The supplier of each input, excluding those where the values are taken from part B of this Annex, shall calculate the emissions intensity⁵ 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.
10. Emissions from rigid inputs 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:

⁴ 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.

⁵ Consistent with section 6 the emissions intensity shall not include the emissions embedded in the carbon content of the supplied input.

- (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. These are set out in part C of the Annex. In case of heat, the economic operator shall consider what it has been replaced by and associate the emissions accordingly. In case of diverted material, the emissions to be attributed to the replacement material are calculated as for material inputs in this methodology. For the first 20 years after the start of production of renewable liquid and gaseous transport fuels of non-biological origin or recycled 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 renewable liquid and gaseous transport fuels of non-biological origin or recycled 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, where 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 to produce recycled carbon fuels. 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 such as a new steelworks that uses its blast furnace gas for making recycled carbon fuels, the impact of diverting the input from the most economic 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 a BAT, the saved emissions shall be calculated on the basis of the comparable process applying state of the art technology.
11. Emissions from existing use or fate 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 was or 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 and is incorporated in the chemical composition of the fuel before 2036, 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 and the CO₂ capture did not receive credits for emission savings from CO₂ capture and replacement, set out in Annex V and VI of Directive (EU) 2018/2001, or;
- (d) The captured CO₂ stems from a geological source of CO₂ and the CO₂ was previously released naturally;

with the exception of 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.

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.

12. Emissions from processing shall include direct atmospheric emissions from the processing itself, from waste treatment and leakages.
13. Emissions from combustion of the fuel refers 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 not used for fuels, 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 storage⁶.
16. Emissions from transport and distribution 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 renewable liquid and gaseous transport fuels of non-biological origin or recycled 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} . Emissions arising due to the storage operation (including transport of the carbon dioxide) will also need to be taken into account under e_p .

⁶ Note that it is the relative values of the co-products that matters, so general inflation is not an issue.

B. "STANDARD VALUES" FOR GREENHOUSE GAS EMISSION INTENSITIES OF ELASTIC INPUTS

The GHG intensities of inputs other than electricity are shown in the table below:

	Total emissions gCO₂eq/ MJ	Upstream emissions gCO₂eq/ MJ	Combustion emissions gCO₂eq/ MJ
Natural gas	66.0	9.7	56.2
Diesel	95.1	21.9	73.2
Gasoline	93.3	19.9	73.4
Heavy fuel oil	94.2	13.6	80.6
Methanol	97.1	28.2	68.9
Hard coal	112.3	16.2	96.1
Lignite	1.7	115.0	116.7

	gCO₂eq/kg
Ammonia	2351.3
Calcium chloride (CaCl ₂)	38.8
Cyclohexane	723.0
Hydrochloric acid (HCl)	1061.1
Lubricants	947.0
Magnesium sulphate (MgSO ₄)	191.8
Nitrogen	56.4
Phosphoric acid (H ₃ PO ₄)	3124.7
Potassium hydroxide (KOH)	419.1
Pure CaO for processes	1193.2

Sodium carbonate (Na_2CO_3)	1245.1
Sodium chloride (NaCl)	13.3
Sodium hydroxide (NaOH)	529.7
Sodium methoxide ($\text{Na}(\text{CH}_3\text{O})$)	2425.5
SO_2	53.3
Sulphuric acid (H_2SO_4)	217.5
Urea	1846.6

C. GHG EMISSION INTENSITY OF ELECTRICITY

The calculation the carbon intensity of electricity, expressed as $\text{g CO}_2 \text{ eq} / \text{kWh electricity}$, shall consider all potential primary energy sources for electricity generation, type of plant, conversion efficiencies and own electricity consumption in the power plant.

The calculation shall consider all carbon 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 CO_2 should be converted to $\text{CO}_{2\text{eq}}$ by multiplying their Global Warming Potential (GWP) relative to CO_2 over the 100-year time horizon as recommended in the IPCC Fourth Assessment Report 2007, summarized in Table 4. Because of their biogenic origin, CO_2 emissions from the combustion of biomass fuels are not accounted for, but emissions of CH_4 and N_2O 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), 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 are considered to be equal to zero.

The CO₂ equivalent emissions from gross electricity production should 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 Greenhouse Gas Inventories (IPCC 2006) listed in Tables 1 and 2. The upstream emissions for supplying the fuel used are 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:

$$e_{gross_prod} = \sum_{i=1}^k (c_{i-ups} + c_{i-comb}) * B_i \quad (3)$$

where: e_{gross_prod} – CO₂ equivalent emissions [gCO_{2eq}]

c_{i-ups} – upstream CO₂ equivalent emission factors [$\frac{gCO_{2eq}}{MJ}$]

c_{i-comb} – CO₂ equivalent emission factors from fuels combustion [$\frac{gCO_{2eq}}{MJ}$]

B_i – fuel consumption 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.

$$E_{net} = E_{gross} - E_{own} - E_{pump} \quad (5)$$

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 for pumping [MJ]

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

$$CI = \frac{e_{gross_prod}}{E_{net}} \quad (1)$$

Where: CI – CO₂ equivalent emissions from electricity production [$\frac{gCO_{2eq}}{MJ}$]

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 (sourced from: <https://www.iea.org/data-and-statistics/data-tables?country=>).

For EU member states, Eurostat data are more detailed and can be used instead.

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 biofuels, renewable municipal waste, hydro, ocean, geothermal, wind, solar and heat pumps.

Input data from literature sources

Table 1 Default emissions factors for stationary combustion [g/MJ fuel on a net calorific value]. Note: values have to be multiplied with GWP factor of Table 4.

Fuel	CO ₂	CH ₄	N ₂ O
Solid fossil fuels			
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
Manufactured gases			
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
Oil and petroleum products			
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

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	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 3. Fuel upstream emission factors [g CO_{2eq}/MJ fuel on a net calorific value]

Fuel	Emission factor
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Hard coal	16
Brown coal	1.7
Peat	0
Coal gases	0
Petroleum Products	10.7
Natural gas	12.8
Solid biofuels	0.7
Liquid biofuels	46.8
Industrial Waste	0
Municipal waste	0
Biogases	14.9
Nuclear	1.4

Source: JEC WTW v5

Table 4 Global Warming Potential of different gases

Gas	100-year GWP
CO ₂	1
CH ₄	25
N ₂ O	298

Source: IPCC, Fourth Assessment Report (AR4)

Values for the GHG emission intensity of electricity in the European Union can be found in Table A .

Table A: Emission intensity of electricity in the European Union 2018

Country code	Country	Emission intensity of generated electricity (g CO ₂ eq/MJ)
AT	Austria	46
BE	Belgium	68
BG	Bulgaria	141
HR	Croatia	47
CY	Cyprus	218
CZ	Czech Republic	148

DK	Denmark	54
EE	Estonia	223
FI	Finland	37
FR	France	20
DE	Germany	124
EL	Greece	171
HU	Hungary	85
IE	Ireland	108
IT	Italy	103
LV	Latvia	52
LT	Lithuania	22
LU	Luxembourg	22
MT	Malta	126
NL	Netherlands	132
PL	Poland	221
PT	Portugal	91
RO	Romania	105
SK	Slovakia	54
SI	Slovenia	77
ES	Spain	85
SE	Sweden	6

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