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COMMISSION

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ANNEXES 1 to 9

ANNEXES

to the

COMMISSION IMPLEMENTING REGULATION (EU)

on rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria

ANNEX I

DATA TO BE TRANSMITTED THROUGH THE WHOLE SUPPLY CHAIN AND TRANSACTION DATA

1. Data to be transmitted through the whole supply chain

(a) name of the voluntary or national scheme;

(b) proof of sustainability number;

(c) sustainability and GHG emission savings characteristics, including:

(i) statement on whether the raw material or fuel complies with the criteria set out in Article 29(2) to (7) of Directive (EU) 2018/2001;

(ii) GHG emission data calculated according to the methodology set out in Annexes V and VI to Directive (EU) 2018/2011 or Delegated Regulation (EU) 2019/807;

(iii) description of when the installation started operation (for fuels only);

(d) name of raw material or name of raw material that the fuel is produced from;

(e) waste or animal by-product permit number (if applicable);

(f) fuel type (for fuels only);

(g) country of origin of raw material;

(h) country of fuel production;

(i) statement on whether the raw material or fuel complies with the criteria set out for low indirect land-use change-risk biofuels;

(j) information on whether support has been provided for the production of that consignment, and if so, the type of support scheme.

2. Transaction data

(a) supplier company name and address;

(b) buyer company name and address;

(c) date of (physical) loading;

(d) place of (physical) loading or logistical facility or distribution infrastructure entry point;

(e) place of (physical) delivery or logistical facility or distribution infrastructure exit point;

(f) volume: For fuels, the energy quantity of the fuel must also be included. For the calculation of the energy quantity, conversion factors in Annex III to Directive (EU) 2018/2001 must be used.

ANNEX II

MINIMUM CONTENT OF AUDIT REPORTS, SUMMARY AUDIT REPORTS OR CERTIFICATES

A. Minimum content of the audit report

1. With regard to the economic operator:
   (a) contact details of main certified entity (company name and address, details of the designated point of contact);
   (b) scope of certification;
   (c) longitude and latitude coordinates (for farms and plantations certified as single entities);
   (d) area of certification (for first gathering points, or individually certified farms and plantations);
   (e) estimated amount of sustainable material that could be harvested annually (for agricultural and forestry supply chains);
   (f) estimated amount of sustainable material that could be collected annually (for waste and residue collection points);
   (g) list of sites under the scope of certification (name and address);
   (h) input/output materials (physically) handled by the certified sites – classifications must be in conformity with the requirements set out in Annex IX to Directive (EU) 2018/2001;
   (i) estimated amount of sustainable input material used annually (producers of the final product only);
   (j) estimated amount of sustainable final product that could be produced annually (producers of the final product only).

2. With regard to the certification body:
   (a) contact details (name and address) and logo;
   (b) composition of the audit team ;
   (c) accrediting body and scope and date of accreditation.

3. With regard to the audit process:
   (a) date of audit;
   (b) audit itinerary and duration (split by duration spent on-site and remotely – where relevant) ;
   (c) scheme standards audited/certified (including version number);
   (d) sites audited;
   (e) audit method (risk assessment and sampling basis, stakeholder consultation);
   (f) certification of other voluntary schemes or standards;
   (g) GHG data type (default, NUTS2 or actual values – including information on the application of GHG emission savings factors).

4. With regard to the audit results:
   (a) place and date of issuance;
   (b) list of non-conformities identified.

B. Minimum content of the summary audit report or certificate

1. With regard to the economic operator:

(a) contact details of main certified entity (company name and address, details of the designated point of contact);
(b) scope of certification;
(c) longitude and latitude coordinates (for farms and plantations certified as single entities);
(d) optional for first gathering points, points of origin, traders with storage: list of sites under the scope of certification (name and address);
(e) input/output materials (physically) handled by the certified sites – classifications must be in conformity with the requirements set out in Annex IX to Directive (EU) 2018/2001 (for traders with/without storage, the type of material traded).

2. With regard to the certification body: contact details (name and address) and logo

3. With regard to the audit process:

(a) date of audit;
(b) scheme standards audited/certified (including version number);
(c) sites audited;
(d) GHG data type (default, NUTS2 or actual values – including information on the application of GHG emission savings factors).

4. With regard to the audit results:
(a) the (unique) certificate number or code;
(b) place and date of issuance;
(c) list of non-conformities identified;
(d) certificate valid from/to dates (and date certified if applicable);
(e) stamp and/or signature of issuing party.

ANNEX III

LIST OF INFORMATION TO BE REPORTED BY VOLUNTARY SCHEMES IN THEIR ANNUAL ACTIVITY REPORTS TO THE COMMISSION

Voluntary schemes must report the following information in their annual activity reports to the Commission:

(a) rules on the independence, method and frequency of audits as approved by the Commission upon accreditation of the voluntary scheme and any changes to them over time to reflect Commission guidance, the modified regulatory framework, findings from internal monitoring on the auditing process of certification bodies and evolving industry best practice.

(b) rules and procedures for identifying and dealing with non-compliance by economic operators and members of the scheme.

(c) evidence of fulfilling the legal requirements on transparency and publication of information in line with Article 6.

(d) stakeholder involvement, in particular on the consultation of indigenous and local communities prior to decision-making during the drafting and review of the scheme as well as during audits and the response to their contributions.

(e) overview of the activities carried out by the voluntary scheme in cooperation with the certification bodies in order to improve the overall certification process and the qualification and independence of auditors and relevant scheme bodies.

(f) market updates of the scheme, the amount of feedstock, biofuels, bioliquids, biomass fuels, recycled carbon fuels and renewable fuels of non-biological origin all certified, by country of origin and type, and the number of participants.

(g) overview of the effectiveness of the implementing system put in place by the governance body of the voluntary scheme in order to track proof of conformity with the sustainability criteria that the scheme gives to its member(s). This shall cover, in particular, how the system effectively prevents fraudulent activities by ensuring timely detection, treatment and follow-up of suspected fraud and other irregularities and where appropriate, the number of cases of fraud or irregularities detected.

(h) criteria for the recognition of certification bodies.

(i) rules on how the internal monitoring system is conducted and the results of its periodic review, specifically on oversight of the work of certification bodies and their auditors as well as on the system of handling complaints against economic operators and certification bodies;

(j) possibilities to facilitate or improve the promotion of best practices.

(k) voluntary schemes certifying forest biomass must include information on the way the risk assessment required in article 29 (6) and (7) of the Directive (EU) 2018/2011 is made.

ANNEX IV

NON-EXHAUSTIVE LIST OF WASTE AND RESIDUES CURRENTLY COVERED BY ANNEX IX TO DIRECTIVE (EU) 2018/2001

The substances listed in this annex shall be considered as falling under a category of raw material set out in Annex IX to Directive (EU) 2018/2001 without being explicitly mentioned. The list is not comprehensive and complements the existing list of materials in Annex IX to Directive (EU) 2018/2001.

Category in Annex IX of Directive (EU) 2018/2001	**Feedstock sub-category/examples**
Annex IX Part A d	Drink waste
Annex IX Part A d	Fruit / vegetable residues and waste (Only tails, leaves, stalks and husks)
Annex IX Part A d)	Bean shells, silverskin, and dust: cocoa, coffee
Annex IX Part A p)	Shells/husks and derivatives:, soy hulls
Annex IX Part A d)	Residues and waste from production of hot beverages: spent coffee grounds, spent tea leaves
Annex IX Part A d)	Dairy waste scum
Annex IX Part A d)	Food waste oil: oil extracted from waste food from industry
Annex IX Part A d)	Non-edible cereal residues and waste from grain milling and processing: wheat, corn, barley, rice
Annex IX Part A d)	Olive oil extraction residues and waste: olive stones
Annex IX Part A p)	Agricultural harvesting residues
Annex IX Part A q)	Palm fronds, palm trunk
Annex IX Part A q)	Damaged trees
Annex IX Part A p)	Unused feed/fodder from ley
Annex IX Part B b)	Waste fish oil classified as categories 1 and 2 in accordance with Regulation (EC) No 1069/2009.
Annex IX Part A d)	Other slaughterhouse waste (Animal residues (non-fat) Cat 1)
Annex IX Part A d)	Industrial wastewater and derivatives
Annex IX Part A g)	Palm sludge oil (PSO)
Annex IX Part A d)	Industrial storage settlings
Annex IX Part A d)	Biogenic fraction of end-of-life tyres
Annex IX Part A (q)	Recycled/waste wood
Annex IX Part A d)	Humins
Annex IX Part A d)	Spent bleaching earth

ANNEX V

METHODOLOGY FOR DETERMINING THE EMISSION SAVINGS FROM SOIL CARBON ACCUMULATION VIA IMPROVED AGRICULTURAL MANAGEMENT

Economic operators seeking to claim emission savings from soil carbon accumulation via improved agricultural management (**e_{sca}**) in terms of g CO_2eq/MJ should use the following formula to calculate their actual values:

$$e_{sca} = (CS_A - CS_R) \times 3.664 \times 10^6 \times \frac{1}{n} \times \frac{1}{P} + e_f$$

Where:

CS_R is the mass of soil carbon stock per unit area associated with the reference crop management practice in Mg of C per ha.

CS_A is the mass of soil estimated carbon stock per unit area associated with the actual crop management practices after at least 10 years of application in Mg of C per ha.

3.664 is the quotient obtained by dividing the molecular weight of CO_2 (44.010g/mol) by the molecular weight of carbon (12.011g/mol) in g CO_{2eq}/g C.

n is the period (in years) of the cultivation of the crop considered.

P is the productivity of the crop (measured as MJ biofuel or bioliquid energy per ha per year).

ef emissions from the increased fertilisers or herbicide use

Improved agriculture management practices, accepted for the purpose of achieving emission savings from soil carbon accumulation, include shifting to reduced or zero-tillage, improved crop/rotation, the use of cover crops, including crop residue management, and the use of organic soil improver (e.g. compost, manure fermentation, digestate, biochar etc.,).

The calculation of the actual values of CS_R and CS_A shall be based on measurements of soil carbon stocks. The measurement of CS_R shall be carried out at farm level before the management practice changes in order to establish a baseline, and then the CS_A shall be measured at regular intervals no later than 5 years apart.

The entire area for which the soil carbon stocks are calculated shall have a similar climate and soil type as well as similar management history in terms of tillage and carbon input to soil. If the improved management practices are only applied to part of the farm, the GHG emissions savings can only be claimed for the area covered by them. If different improved management practices are applied on a single farm, a claim of GHG emission savings shall be calculated and claimed individually for each Esca practice.

To ensure reduced year-to-year fluctuations in the measured soil carbon stocks and to reduce associated errors, fields that have the same soil and climate characteristics, similar management history in terms of tillage and carbon input to soil and that will be subject to the same improved management practice may be grouped, including those fields belonging to different farmers.

After the first measurement of the baseline, the increase in soil carbon can be estimated based on representative experiments or soil models, before a second measurement of the increase in carbon stock is made. From the second measurement onwards, the measurements shall constitute the ultimate basis for determining the actual values of the increase in soil carbon stock.

However, after the second measurement, modelling to enable economic operators to estimate the annual increase in soil carbon stocks may only be permitted until the next measurement if the models used have been calibrated, based on the real values measured. Economic operators shall be obliged to use only models that have been validated by voluntary schemes. Voluntary schemes shall be obliged to inform the economic operators and the certification bodies, performing audits on their behalf, about the models that they have validated for such use.

The models used shall take into account the different soil, climate and field management history to simulate carbon dynamics in soil. The voluntary scheme shall be obliged to prepare a detailed report, presenting the validated modelling method used and its underlying assumptions. The related final actual values that are established based on the soil measurement results, shall be used to adjust the annual claims of emissions savings from soil carbon accumulation via agricultural management (e_{sca}), made on the basis of modelling.

To claim emissions savings from soil carbon accumulation via agricultural management (e_{sca}), measurements of soil carbon stocks shall be performed by certified laboratories and samples shall be retained for a period of at least 5 years for auditing purposes.

A long-term commitment by the farmer or economic operator to continue applying the improved management practice for a minimum of 10 years shall be required by voluntary schemes in order for GHG emission savings to be taken into account. Such commitment may be implemented as a 5-years renewable commitment.

Failure to meet this criterion will lead to all Esca values of the current year for the farmer or economic operator being added as emissions to the overall GHG emissions of the energy crop delivered, instead of being deducted as a GHG emission savings and a prohibition to include an Esca value in the GHG calculations for 5 years, whatever the certification scheme used. If a commitment has been signed in the name of an economic operator on behalf of several farmers and one of these farmers withdraws early, the above-mentioned penalties shall apply only to the farmer concerned and not to all the commitments of the economic operator. The voluntary scheme that has issued the certificate shall be obliged to enforce the penalties and dully inform all other voluntary schemes as well as to publish this information on its website and included it in the annual activity reports to be sent to the Commission.

In addition, a continuous minimum period of 3 years for the application of the improved management practice shall be required before a claim can be made.

The maximum possible total value of the annual claim of emission savings from soil carbon accumulation due to improved agricultural management (Esca) shall be capped to 45 g CO2eq/MJ biofuel or bioliquid for the entire period of application of the Esca practices, if biochar is used as organic soil improver alone or in combination with other eligible Esca practices. In all other cases, the cap referred to above shall be 25 g CO2eq/MJ biofuel or bioliquid for the entire period of application of the Esca practices.

Primary producers or economic operators, who are already engaged in eligible Esca practices and have made respective Esca claims before the entry into force of this Implementing regulation, may apply a cap of 45 g CO2eq/MJ biofuel or bioliquid in a transition period until the first measurement of the carbon stock increase is made at the 5th year. In such a case, the measured carbon stock increase at the 5th year will become a cap for the annual claims to be made in the following period of 5 years. If the first measurement of the carbon stock increase at the 5th year shows higher total annual carbon stock increase, compared to the annual claims made, the annual difference can be claimed by primary producers or economic operators in subsequent years to compensate for lower carbon stock increases. Respectively, if the first measurement of the carbon stock increase at the 5th year shows lower total annual soil carbon stock increase, compared to the annual claims made, the annual difference has to be deducted accordingly by farmers or economic operators from their claims in the subsequent five years.

If the application of eligible improved agricultural management practices (Esca) started in the past but no previous Esca claims were made, annual retroactive Esca claims can be made but for no longer than 3 years prior to the moment of Esca certification. The economic operator shall be obliged to provide adequate evidence about the start of the application of the improved farming practices. In such a case, the estimate of the CS_R value can be based on a comparative measurement of a neighbouring or other field with similar climatic and soil conditions as well as similar field management history. If there is no available data from such a field, the CS_Restimated value can be based on modelling. In that case, a first measurement shall be done immediately, at the moment of commitment. The next measurement of carbon stock increase will have to be made 5 years later.

The increased emissions resulting from the increased fertilisers or herbicide use due to the application of improved agricultural practices, shall be considered. For this purpose, adequate evidence shall be provided on the historic use of fertilisers or herbicide that shall be counted as the average for the three years before the application of the new agricultural practices. The contribution of nitrogen fixation crops used to reduce the need for additional fertilisers can be considered in the calculations.

The following rules shall be applied to sampling:

1. Representative sampling method:
   - (a) sampling shall be made for each plot or field;
   - (b) at least one grab sample of 15 well distributed sub-samples per every 5 hectares or per field, whichever is smaller (taking into account the heterogeneity of the plot's carbon content), shall be taken;
   - (c) smaller fields with same climatic conditions, soil type, reference farming practice, and Esca practice can be grouped;

(d) sampling shall be done either in spring before soil cultivation and fertilisation or in autumn, a minimum of 2 months after harvest;
(e) direct measurements of soil carbon stock changes shall be taken for the first 30 cm of soil;
(f) the points of the initial sampling to measure the baseline of soil carbon stocks shall be used under identical field conditions (especially soil moisture);
(g) The sampling protocol shall be well documented.

2. Measurement of the soil carbon content:
(a) soil samples shall be dried, sieved, and if necessary grounded;
(b) if the combustion method is used, inorganic carbon shall be excluded.

3. Determination of dry bulk density:
(a) changes in bulk density over time shall be taken into account;
(b) bulk density should be measured using the tapping method, that is to say by mechanically tapping a cylinder into the soil, which greatly reduces any errors associated with bulk density measurement;
(c) if the tapping method is not possible, especially with sandy soils, a reliable method shall be used instead;
(d) samples should be oven-dried prior to weighing.

The application of the above methodology on Esca and the calculation of the actual GHG emissions values shall be duly verified by certification bodies and documented in audit reports. Voluntary schemes are obliged to issue detailed guidance on the application of this methodology, including on their validated soil models to economic operators and certification bodies as well as to support their auditors in their verification tasks. Voluntary schemes shall be also obliged to include detailed statistical information and qualitative feedback on the implementation of the Esca methodology in their annual activity reports to be submitted to the Commission.

The Commission shall duly monitor the implementation of the Esca methodology as part of its monitoring of the activities of the voluntary schemes covering inter alia:

- Project implementation which should allow for, amongst others, evaluating the relation of modelling results against field measurements;
- Comparing claims and results against estimates of SOC-saturation to derive criteria and recommendations and possibly requirements for long term maintenance of a given equilibrium to secure results in the long term;
- Derive recommendations and requirements for an appropriate model selection and calibration as well as reliable indicators to model results.

The Commission may revise the methodological approach described in this annex as well as the caps applied to annual claims of carbon stock accumulation, based on the outcomes of this monitoring or with the aim to align it with evolving knowledge or with new legislation in this area in the future (i.e. EU carbon farming initiative).

ANNEX VI

NON-EXAUSTIVE LISTS OF EXAMPLES OF ESSENTIAL MANAGEMENT AND MONITORING PRACTICES TO PROMOTE AND MONITOR SOIL CARBON SEQUESTRATION AND SOIL QUALITY

Table 1. Examples of essential soil management practices to promote soil carbon sequestration (given the absence of residues) and promote soil quality

Requirement	Soil quality parameter
At least a 3-crop rotation, including legumes or green manure in the cropping system, taking into account the agronomic crop succession requirements specific to each crops grown and climatic conditions. A multi-species cover crop between cash crops counts as one.	Promoting soil fertility, soil carbon, limiting soil erosion, soil biodiversity and promoting pathogen control
Sowing of cover/catch/intermediary crops using a locally appropriate species mixture with at least one legume. Crop management practices should ensure minimum soil cover to avoid bare soil in periods that are most sensitive.	Promoting soil fertility, soil carbon retention, avoiding soil erosion, soil biodiversity
Prevent soil compaction (frequency and timing of field operations should be planned to avoid traffic on wet soil; tillage operation should be avoided or greatly reduced on wet soils; controlled traffic planning can be used).	Retention of soil structure, avoiding soil erosion, retaining soil biodiversity
No burning of arable stubble except where the authority has granted an exemption for plant health reasons.	Soil carbon retention, resource efficiency
On acidic soils where liming is applied, where soils are degraded and where acidification impacts crop productivity.	Improved soil structure, soil biodiversity, soil carbon
Reduce tillage/ no tillage - Erosion control – addition of organic amendments (biochar, compost, manure, crop residues) – use of cover crops, rewetting Revegetation: planting (species change, protection with straw mulch) - landscape features - agroforestry	Increase soil organic carbon

Table 1. Examples of monitoring practices for soil quality and carbon mitigation impacts

Monitoring approach	Method of verification/ demonstration
Risk assessment	Identifying areas with high risk of soil quality decline helps prevent these risks and focus on areas with the greatest impact.
Soil organic matter analysis	Consistent sampling of soil organic matter improves monitoring so that this matter can be maintained or improved.
Soil organic carbon analysis	Soil organic carbon is seen as a good marker for wider soil quality.
Soil conditioning index sampling	A positive value indicates the system is expected to have increasing soil organic matter.
Soil erosion assessment	Ensures that erosion is below a tolerable level, i.e. USDA Agricultural Research Service ‘t’ levels.
Nutrient management plan	A plan outlining nutrient strategy (focusing mostly on N, P, K) and fertiliser regimes can prevent nutrient imbalances.
Regular soil pH analysis	Monitoring pH helps identify imbalances in pH.

ANNEX VII

METHODOLOGY FOR DETERMINING THE EMISSIONS FROM THE EXTRACTION OR CULTIVATION OF RAW MATERIALS

To calculate the emissions from the extraction or cultivation of raw materials Part C, point 5 of Annex V and Part B, point 5 of Annex VI to Directive 2018/2001 (EU) state that the calculation shall include the sum of all emissions from the extraction or cultivation process itself; from the collection, drying and storage of raw materials; from waste and leakages; and from the production of chemicals or products used in extraction or cultivation.

The capture of CO_2 in the cultivation of raw materials shall be excluded. Estimates of emissions from agriculture biomass cultivation may be derived from the use of regional averages for cultivation emissions included in the reports referred to in Article 31(4) of Directive 2018/2001 (EU) or the information on the disaggregated default values for cultivation emissions included in this Annex, as an alternative to using actual values. In the absence of relevant information in those reports, averages can be calculated based on local farming practices, for instance on data of a group of farms, as an alternative to using actual values.

EMISSIONS FROM THE EXTRACTION OR CULTIVATION PROCESS ITSELF

The emissions from the extraction or cultivation process itself shall include all emissions from (i) the provision of the fuels for farm machinery used; (ii) the production of seeding material for crop cultivation; (iii) the production of fertilisers and pesticides; (iv) fertiliser acidification and liming application; and (v) soil emissions from crop cultivation.

1.1. Fuel use (diesel oil, gasoline, heavy fuel oil, biofuels or other fuels) for farm machinery

The GHG emissions from crop cultivation (field preparation, seeding, fertiliser and pesticide application, harvesting, collection) shall include all emissions from the use of fuels (such as diesel oil, gasoline, heavy fuel oil, biofuels or other fuels) in farm machinery. The amount of fuel use in farm machinery shall be duly documented. Appropriate emission factors of the fuels must be used in accordance with Annex IX. Where biofuels are used, the default GHG emissions set out in Directive 2018/2001 must be used.

1.2. Chemical fertilisers and pesticides

The emissions from the use of chemical fertilisers and pesticides[1] for the cultivation of raw materials shall include all related emissions from the manufacture of chemical fertilisers and pesticides. The amount of the chemical fertilisers and pesticides, depending on the crop, local conditions and farming practices, shall be duly documented. Appropriate emission factors, including upstream emissions, must be used to account for the emissions from the production of chemical fertilisers and pesticides pursuant to Annex IX. If the economic operator knows the factory producing the fertiliser and it falls under the EU Emissions Trading System (ETS), then the economic operator can use the production emissions declared under ETS, adding the upstream emissions for natural gas etc. Transport of the fertilisers shall also be included, using the emissions from transport modes listed

[1] 'Pesticides' means all plant protection products, including herbicides, insecticides, fungicides, etc.

in Annex IX. If the economic operator does not know the factory supplying the fertiliser, it should use the standard values provided for in Annex IX.

1.3. Seeding material

The calculation of cultivation emissions from the production of seeding material for crop cultivation shall be based on actual data on the seeding material used. Emission factors for the production and supply of seeding material can be used to account for emissions associated with the production of seeds. The standard values for emission factors set out in Annex IX must be used. For other seeds, literature values from the following hierarchy must be used.

(a) version 5 of JEC-WTW report;
(b) ECOINVENT database;
(c) 'official' sources, such as Intergovernmental Panel on Climate Change (IPCC), International Energy Agency (IEA) or governments;
(d) other reviewed sources of data, such as E3 database, GEMIS database;
(e) peer-reviewed publications;
(f) duly documented own estimates.

1.4. Emissions from fertiliser acidification and liming application

The emissions from the neutralisation of fertiliser acidification and application of aglime shall account for the CO_2 emissions from neutralisation of acidity from nitrogen fertilisers or from aglime reactions in the soil.

1.4.1. Emissions from neutralisation of fertiliser acidification

The emissions resulting from acidification caused by nitrogen fertiliser use in the field shall be accounted for in the emission calculation, based on the amount of nitrogen fertilisers used. For nitrate fertilisers, the emissions from the neutralisation of nitrogen fertilisers in the soil shall be 0.783 kg CO_2/kg N; for urea fertilisers, the neutralisation emissions shall be 0.806 kg CO_2/kg N.

1.4.2. Soil emissions from liming (aglime)

The real amount of aglime used shall be duly documented. Emissions shall be calculated as follows:

1. On acid soils, where pH is less than 6.4, aglime is dissolved by soil acids to form predominantly CO2 rather than bicarbonate, releasing almost all of the CO2 into the aglime (0.44 kg CO2/kg CaCO3 equivalent aglime).

2. If soil pH is greater or equal to 6.4, an emission factor of 0.98/12.44 = 0.079 kg CO2/ (kg CaCO3-equivalent) aglime applied shall be taken into account in the calculation, in addition to the emissions due to the neutralisation of acidification caused by the fertiliser.

3. The liming emissions calculated from actual lime use, calculated in points 1 and 2 above, may be greater than the fertilizer neutralization emissions calculated in 1.4.1 if the fertilizer acidification was neutralized by the applied lime. In such a case, the fertilizer neutralization

emissions (in 1.4.1) may be subtracted from the calculated liming emissions to avoid that its emissions are counted twice.

The emissions from fertilizer acidification may exceed those attributed to liming. In such a case, the subtraction would result in apparently negative net liming emissions because not all of the fertilizer-acidity is neutralized by aglime but also partly by naturally-occurring carbonates. In this case, the net liming emissions shall be counted zero, but the fertilizer-acidification emissions that occur anyway shall be maintained in line with section 1.4.1.

If data on actual aglime use is not available, the aglime use recommended by the Agricultural Lime Association shall be assumed. This shall be a function of the type of crop, measured soil pH, soil type and type of liming material. The accompanying CO2 emissions shall be calculated using points 1 and 2 of the procedure above. However, the subtraction specified in point 3 shall not be applied in this case, since the recommended use of aglime does not include aglime used to neutralize fertilizer applied in the same year, so there is no possible double counting of fertilizer neutralization emissions.

1.5. Soil (nitrous oxide/N_2O) emissions from crop cultivation

The calculation of N_2O emissions from managed soils shall follow the IPCC methodology. The use of disaggregated crop-specific emission factors for different environmental conditions (corresponding to Tier 2 of the IPCC methodology) shall be used to calculate the N_2O emissions resulting from crop cultivation. Specific emission factors for different environmental conditions, soil conditions and different crops should be taken into account. Economic operators could use validated models to calculate those emission factors provided that the models take these aspects into account. In line with the IPCC guidelines[2], both direct and indirect N_2O emissions shall be taken into account. The GNOC tool shall be used, which is based on the formulas below, following the naming conventions in the IPCC (2006) guidelines:

$$N_2O_{total}-N = N_2O_{direct} - N + N_2O_{indirect} - N$$

Where:

For mineral soils: $N_2O_{Direct}-N = [(F_{SN} + F_{ON}) \bullet EF_{1ij}] + [F_{CR} \bullet E_{F1}]$

For organic soils: $N_2O_{Direct}-N = [(F_{SN} + F_{ON}) \bullet EF_1] + [F_{CR} \bullet E_{F1}] + [(F_{OS,CG,Temp} \bullet EF_{2CG,\ Temp}] + [F_{CROS,CG,Trop} \bullet E_{2CG,Trop}]$

For both mineral and organic soils: $N_2O_{Direct}-N = [((F_{SN} \bullet Frac_{GASF}) + (F_{ON} \bullet Erac_{GASM}) \bullet EF_4] + [(F_{SN} + F_{ON} + F_{CR}) \bullet Frac_{Leach-(H)} \bullet EF_5]$

1.5.1 Crop residue N input

It must be calculated for:

(a) sugar beet, sugar cane according to IPCC (2006) Vol. 4 Chapter 11 Eq. 11.6, not considering below-ground residues and with the addition of N input from vignasse and filter cake in the case of sugar cane;

[2] IPCC (2006), Vol. 4, Chapter 11: N2O emissions from managed soils, and CO2 emissions from lime and urea application.

$F_{CR} = Yield \cdot DRY \cdot (1\text{-}Frac_{Burnt} \cdot C_f) \cdot [R_{AG} \cdot N_{AG} \cdot (1 - Frac_{Remove})] + F_{VF}$

(b) coconut and oil palm plantations applying a fixed N input based on literature as IPCC (2006) provides no default calculation method for standard emission factors, pursuant toAnnex IX;

(c) for all other crops according to IPCC (2006) Vol. 4 Chapter 11 Eq. 11.7a 11, 12, as
$F_{CR} = (1\text{-}Frac_{Burnt} \cdot C_f) \cdot AG_{DM} \cdot N_{AG} \cdot (1\text{-}Frac_{Remove}) + (AG_{DM} + Yield \cdot DRY) \cdot R_{BG\text{-}BIO} \cdot N_{BG}$

Where:

N_2O_{total} - N = direct and indirect annual N_2O–N emissions produced from managed soils; kg N_2O–N ha^{-1} a^{-1}

N_2O_{direct} - N = annual direct N_2O–N emissions produced from managed soils; kg N_2O–N ha^{-1} a^{-1}

$N_2O_{indirect}$ - N = annual indirect N_2O–N emissions (that is to say, the annual amount of N_2O–N produced from atmospheric deposition of N volatilised from managed soils and annual amount of N_2O–N produced from leaching and run-off of N additions to managed soils in regions where leaching/run-off occurs); kg N_2O–N ha^{-1} a^{-1}

F_{SN} = annual synthetic nitrogen fertiliser input; kg N ha^{-1} a^{-1}

F_{ON} = annual animal manure N applied as fertiliser; kg N ha^{-1} a^{-1}

F_{CR} = annual amount of N in crop residues (above ground and below ground); kg N ha^{-1} a^{-1}

$F_{OS,CG,Temp}$ = annual area of managed/drained organic soils under cropland in temperate climate; ha^{-1} a^{-1}

$F_{OS,CG,Trop}$ = annual area of managed/drained organic soils under cropland in tropical climate; ha^{-1}

$Frac_{GASF}$ = 0.10 (kg N NH_3–N + NOx–N) (kg N applied)$^{-1}$. Volatilisation from synthetic fertiliser

$Frac_{GASM}$ = 0.20 (kg N NH_3–N + NOx–N) (kg N applied)$^{-1}$. Volatilisation from all organic nitrogen fertilisers applied

$Frac_{Leach\text{-}(H)}$ = 0.30 kg N (kg N additions) -1. N losses by leaching/run-off for regions where leaching/run-off occurs

EF_{1ij} = Crop and site-specific emission factors for N_2O emissions from synthetic fertiliser and organic N application to mineral soils (kg N_2O–N (kg N input)$^{-1}$);

EF_1 = 0.01 [kg N_2O–N (kg N input) $^{-1}$]

$EF_{2CG,Temp}$ = 8 kg N ha^{-1} a^{-1} for temperate organic crop and grassland soils

$EF_{2CG,Trop}$ = 16 kg N ha^{-1} a^{-1} for tropical organic crop and grassland soils

EF_4 = 0.01 [kg N_2O–N (kg N NH3–N + NOx–N volatilised) $^{-1}$]

EF_5 = 0.0075 [kg N_2O–N (kg N leaching/run-off) $^{-1}$]

Yield = annual fresh yield of the crop (kg ha^{-1})

DRY = dry matter fraction of harvested product [kg d.m. (kg fresh weight)$^{-1}$] (see Table 1)

$Frac_{Burnt}$ = Fraction of crop area burnt annually [ha (ha)-1]

C_f = Combustion factor [dimensionless] (see Table 1)

R_{AG} = Ratio of above-ground residues, dry matter to harvested dry matter yield, for the crop [kg d.m. (kg d.m.)$^{-1}$] (see Table 3)

N_{AG} = N content of above-ground residues [kg N (kg d.m.)-1] (see Table 1)

$Frac_{Remove}$ = Fraction of above-ground residues removed from field [kg d.m. (kg AGDM)$^{-1}$]

F_{VF} = Annual amount of N in sugar cane vignasse and filter cake returned to the field [kg N ha^{-1}], calculated as Yield * 0.000508.
AG = Above-ground residue dry matter [kg d.m. ha^{-1}]

1.5.2 Crop and site-specific emission factors for N_2O emissions from synthetic fertiliser and organic N application

N_2O emissions from soils under agricultural use, in different agricultural fields under different environmental conditions and agricultural land use classes can be determined following the Stehfest and Bouwman (2006) statistical model (hereinafter referred to as ‘the S&B model’):

$$E = exp(-1.516 + \sum ev)$$

Where:
E = N_2O emission (in kg N_2O-N ha^{-1} a^{-1})

ev = effect value for different drivers (see Table 2)

The EF_{1ij} for the biofuel crop i at location j is calculated (S&B model) as:

$EF_{1ij} = (E_{fert,ij} – E_{unfert,ij}) / N_{appl,ij}$

The IPCC (2006) factor (EF1) for direct N_2O emissions from fertiliser input based on a global mean shall be replaced by the crop- and site-specific EF1ij for direct emissions from mineral fertiliser and manure N input, based on the crop- and site-specific EF1ij, applying the S&B model.

Where:

$E_{fert,ij}$ = N_2O emission (in kg N_2O-N ha_{-1} a^{-1}) based on S&B, where the fertiliser input is the actual N application rate (mineral fertiliser and manure) to the crop i at location j

$E_{unfert,ij}$ = N_2O emission of the crop i at location j (in kg N_2O-N ha_{-1} a^{-1}) based on S&B. The N application rate is set to 0, all the other parameters are kept the same.

$N_{appl,ij}$ = N input from mineral fertiliser and manure (in kg N ha^{-1} a^{-1}) to the crop i at location j

Table 1 Crop-specific parameters to calculate N input from crop residues[3]

Crop	Calculation method	DRY	LHV	N_{AG}	slope	intercept	R_{BG_BIO}	N_{BG}	Cf	R_{AG}	Fixed amount of N in crop residues (kg N ha^{-1})	Data sources*
Barley	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.865	17	0.007	0.98	0.59	0.22	0.014	0.8			1, 2
Cassava	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.302	16.15	0.019	0.1	1.06	0.2	0.014	0.8			1, 2
Coconuts	Fixed N from crop residues	0.94	32.07								44	1, 3
Cotton	No inform. on crop residues	0.91	22.64									
Maize	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.86	17.3	0.006	1.03	0.61	0.22	0.007	0.8			1, 2
Oil palm fruit	Fixed N from crop residues	0.66	24								159	1, 4
Rapeseed	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.91	26.976	0.011	1.5	0	0.19	0.017	0.8			1, 5
Rye	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.86	17.1	0.005	1.09	0.88	0.22	0.011	0.8			1, 6
Safflower seed	No inform.on crop residues	0.91	25.9									
Sorghum (grain)	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.89	17.3	0.007	0.88	1.33	0.22	0.006	0.8			1, 7
Soybeans	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.87	23	0.008	0.93	1.35	0.19	0.087	0.8			1, 8
Sugar beets	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.6	0.25	16.3	0.004					0.8	0.5		1, 9
Sugar cane	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.6	0.275	19.6	0.004					0.8	0.43		1, 10
Sunflower seed	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.9	26.4	0.007	2.1	0	0.22	0.007	0.8			1, 11
Triticale	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.86	16.9	0.006	1.09	0.88	0.22	0.009	0.8			1, 2
Wheat	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.84	17	0.006	1.51	0.52	0.24	0.009	0.9			1, 2

[3] Data source: JRC report "Definition of input data to assess GHG default emissions from biofuels in EU legislation" JRC 2019 (EUR 28349 EN). https://op.europa.eu/en/publication-detail/-/publication/7d6dd4ba-720a-11e9-9f05-01aa75ed71a1

Table 2 Constant and effect values for calculating N_2O emissions from agricultural fields based on the S&B model

Constant value	-1.516	
Parameter	**Parameter class or unit**	**Effect value (ev)**
Fertilizer input		0.0038 * N application rate in kg N ha^{-1} a^{-1}
Soil organic C content	<1 %	0
	1-3 %	0.0526
	>3 %	0.6334
pH	<5.5	0
	5.5-7.3	-0.0693
	>7.3	-0.4836
Soil texture	Coarse	0
	Medium	-0.1528
	Fine	0.4312
Climate	Subtropical climate	0.6117
	Temperate continental climate	0
	Temperate oceanic climate	0.0226
	Tropical climate	-0.3022
Vegetation	Cereals	0
	Grass	-0.3502
	Legume	0.3783
	None	0.5870
	Other	0.4420
	Wetland rice	-0.8850
Length of experiment	1 yr	1.9910

EMISSIONS FROM THE COLLECTION, DRYING AND STORAGE OF RAW MATERIALS

Emissions from the collection, drying and storage of raw materials include all emissions related to fuel use in the collection, drying and storage of raw materials.

Emissions from collection

Emissions from the collection of raw materials include all the emissions resulting from the collection of raw materials and their transport to storage. The emissions are calculated using appropriate emission factors for the type of fuel used (diesel oil, gasoline, heavy fuel oil, biofuels or other fuels).

Biomass drying

The cultivation emissions shall include emissions from drying before storage as well as from storage and handling of biomass feedstock. Data on energy use for drying before storage shall include actual data on the drying process used to comply with the requirements of storage, depending on the biomass type, particle size, moisture content, weather conditions, etc. Appropriate emission factors, including upstream emissions, shall be used to account for the emissions from the use of fuels to produce heat or electricity used for drying. Emissions for drying include only emissions for the drying process needed to ensure adequate storage of raw materials and does not include drying of materials during processing.

ACCOUNTING FOR EMISSIONS FOR ELECTRICITY USED IN FARMING OPERATIONS

When accounting for the consumption of electricity not produced within the fuel production plant, the GHG emissions intensity of the produced and distributed electricity shall be assumed to be equal to the average emission intensity of the produced and distributed electricity in a defined region, which can be at a NUTS2[4] region or a national level. In case national electric emission coefficients are used, the values from Annex IX shall be used. By way of derogation from this rule, producers may use an average value for an individual electricity production plant for electricity produced by that plant if it is not connected to the electricity grid and sufficient information are available to derive an emission factor.

[4] Nomenclature of territorial units for statistics

ANNEX VIII

MINIMUM REQUIREMENTS ON THE PROCESS AND METHOD FOR CERTIFYING LOW INDIRECT LAND-USE CHANGE (ILUC) RISK BIOMASS

A. Process of low ILUC risk certification

To start the certification process, an economic operator has to submit an application to a certification body recognised by a voluntary scheme for low ILUC risk biomass certification. The applicant may be a farm, a first gathering point or a group manager, acting on behalf of a group of farmers.

The low ILUC risk certification application shall contain at least the following information:

(a) the name and contact details of the applicant or applicants, including where relevant the members of a group for group certification[5];

(b) a description of the low ILUC risk additionality measures envisaged, including:

(i) details on the delineated plot where the additionality measure will be implemented, including current land use, current management practices, current plot yield data, and if applicable a statement on whether the land is unused, abandoned or severely degraded;

(ii) description of the additionality measures and an estimate of the additional biomass that will be produced following its application (either through a yield increase or production on unused, abandoned or severely degraded land);

(c) information on any existing Commission-recognised voluntary scheme certification (name of the voluntary scheme, certificate number, status and validity period).

If the application is made after the additionality measures have been implemented, only the additional biomass produced after the date of low ILUC risk certification may be claimed as low ILUC risk.

1. Content of the management plan

Once the low ILUC risk application is accepted, the economic operator shall develop a management plan and submit it to the certification body. The management plan shall build on the information in the certification application, and include:

(a) a definition of the delineated plot of land;

(b) a description of additionality measures;

(c) check on sustainability of the additionality measure against the requirements of Directive (EU) 2018/2001;

[5] If applying for group certification, the application must include the name and contact details of the group manager and the name, contact details and locations of the farms/plantations that are part of the group.

(d) where relevant, demonstration of additionality assessment (either financial attractiveness or non-financial barrier test);

(e) determination of the dynamic yield baseline, including:

(i) for yield increase measures: at least 3 years of historical crop yield data related to the delineated plot of land;

(ii) for cultivation on unused, abandoned or severely degraded land: proof of land status (the baseline yield for cultivation on unused, abandoned or severely degraded land is considered to be zero)

(f) estimate of the additional biomass yield per year, with reference to the dynamic yield baseline for the delineated plot.

The management plan must allow a comparison to be made between the use of the delineated plot before and after implementation of the additionality measure.

2. Non-exhaustive list of additionality measures

Table 1. Non-exhaustive list of yield increase additionality measures.

Additionality category	Additionality measure	Example
Mechanisation	Machinery	Adoption of machinery that reduces/complements existing workforce input to boost output or reduce losses. This could include sowing, precision farming, harvesting machinery or machinery to reduce post-harvest losses.
Multi-cropping	Sequential cropping	Introduction of second crop on same land in the same year.
Management	Soil management	Mulching instead of ploughing, low tillage.
	Fertilisation	Optimisation of fertilisation regime, use of precision agriculture.
	Crop protection	Change in weed, pest and disease control.

Additionality category	Additionality measure	Example
	Pollination	Improved pollination practices.
	Other	Leaves room for innovation, combinations of measures and unforeseen developments.
Replanting (for perennial crops)[6]	Choice of crop varieties	Higher yield variety, better adaptation to eco-physiological or climatic conditions.

Additionality measures are measures that go beyond common agricultural practices. Table 1 contains a non-exhaustive list of the types of yield increase additionality measures that economic operators can apply. Measures, or combinations of measures, shall boost output without compromising sustainability. The additionality measure shall not compromise future growing potential by creating a trade-off between short-term output gains and mid/long-term deterioration of soil, water and air quality and pollinator populations. The additionality measures shall not result in homogenisation of the agricultural landscape through removal of landscape elements and habitats such as solitary trees, hedgerows, shrubs, field edges or flower strips.

Only additional yield above the dynamic yield baseline may be claimed as low ILUC risk. Furthermore, an additionality measure may only be certified if it aims to achieve additional yields as a result of an improvement in agricultural practice. If a measure is applied that only aims to improve the sustainability of the plot, without improving yields, it is not deemed an additionality measure. This is not the case with cultivation on unused, abandoned or severely degraded land, in which case the cultivation itself is the additionality measure.

The economic operator will have to demonstrate that the management plan sets reasonable expectations on the yield increase by referring to, for example, scientific literature, experience from field trials, information from agronomy companies, seed/fertiliser developers or simple calculations. Satisfactory evidence supporting the expected yield increase of the additionality measure applied is needed for the project to be certified.

In the case of agricultural improvements, the agricultural practices applied, machinery and means before and after the additionality measure has been applied shall be documented in detail as part of the management plan. This shall allow a comparison in order to (i) determine whether an additionality measure has been implemented; (ii) evaluate if that additionality measure may be considered to be additional compared to a 'business as usual' development.

B. Additionality assessment: Financial attractiveness or barrier analysis tests

[6] Replanting at the end of the crop lifetime is always necessary for a perennial crop. For replanting to count as an additionality measure, the economic operator must prove that their replanting goes beyond 'business as usual'.

1. Financial attractiveness test

The financial attractiveness test shall demonstrate that the investment required for the additionality measure becomes financially attractive only if the resulting additional yield is certified as low ILUC risk. The analysis shall consist of a simple financial analysis of the envisaged low ILUC risk additionality measure investment.

The test shall include only those costs and yields that are directly related to the additionality measure investment. Normal operating costs of the entire farm shall therefore not be included in the analysis. The costs and revenues included in the test shall be related to the preparation, implementation, maintenance and decommissioning of the additionality measure that would not have been otherwise incurred.

Financial attractiveness arises from a business case in which the net present value ('NPV')[7] of the investment is positive, which means that the investment may be conducted by the economic operator itself. As a result, only measures for which the business case analysis is negative (without the inclusion of a premium) shall pass the financial additionality test and become eligible to be certified as low ILUC risk. Outcomes above zero (a positive NPV) may still be eligible only if they pass the non-financial barrier test.

Formula to calculate the NPV of an investment:

$$NPV = \sum \frac{P - L}{(1 + i)^t}$$

Where:

P = expected income from additional biomass (estimate of additional biomass x feedstock sales price without low ILUC premium)

L = cost of additionality measure (CAPEX and OPEX)

i = discount rate

t = time period

The parameters used in the NPV calculation shall be in line with the data included in the management plan.

The following parameters shall be included in the NPV calculation:

(a) estimate of additional biomass volume;

(b) feedstock sales price [currency/tonne]:

(i) the feedstock sales price may be a single number extrapolated over the lifetime of the additional yield investment;

(ii) this single number may be based on an average of actual historical feedstock sales values achieved by the economic operator. The average value shall be based

[7] NPV is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyse the profitability of a future investment or project. Source: https://www.investopedia.com/terms/n/npv.asp

on data for the same 3 years that the historical yield data used to set the dynamic yield baseline;

(iii) in the event of introducing a new crop for which the economic operator does not have actual price data, this value may be based on price data from FAOSTAT[8];

(c) discount rate to be used: 3.5% for high income countries[9] and 5.5% for all other countries;

(d) lifetime of the investment:

(i) a lifetime of up to 10 years shall be used in conformity with the lifetime of the low ILUC risk certification (baseline validity);

(ii) in some cases, the maximum lifetime of the investment may be set at 25 years based on the typical lifetime of perennial crops (that is to say, oil palm tree, in the case of oil palm replanting);

(e) investment cost related to the additionality measure [CAPEX + OPEX].

2. Non-financial barrier test

The non-financial barrier analysis shall only cover non-financial project barriers that prevent the implementation of the additionality measures in case of no low ILUC risk certification. Any barrier whose cost can be estimated shall be included in the financial attractiveness analysis rather than in the non-financial barrier analysis.

The economic operator that plans the additionality measure is responsible for justifying the existence of non-financial barriers. The justification shall consist of a clear, verifiable description of the situation that prevents the uptake of the additionality measure. The economic operator shall provide all the necessary verifiable evidence to support the claim and demonstrate how low ILUC risk certification would ensure that the non-financial barrier is overcome.

The validity of the operator's claim shall be assessed and validated by the baseline audit before issuing a low ILUC risk certificate.

C. Setting the dynamic yield baseline and calculation of the actual volume of low ILUC risk biomass

The dynamic yield baseline shall be set individually for each delineated plot based on the crop and the type or combination of additionality measures applied. Plot-specific historical crop yield data from at least the 3 years preceding the application of an additionality measure shall be used to calculate the starting point of the dynamic yield baseline. This shall be combined with a global crop-specific trend line for expected yields based on historical data of actual yields over the past decade, or longer if data is available. For perennial crops, the dynamic yield baseline also takes into account the yield curve over the lifetime of the crop.

[8] FAOSTAT producer prices. Source: http://www.fao.org/faostat/en/#data/PP
[9] OECD countries

1. Setting the dynamic yield baseline for annual crops

Where a farm rotates crops between fields and the crop whose yield will be increased ('target crop') has been planted in different fields on the same farm in previous years, two options are envisaged for gathering the historical yield data in order to calculate the dynamic yield baseline:

Option 1: The economic operator calculates an average of the yields for the 3 most recent years that the target crop was grown on the specific delineated plot prior to implementation of the additionality measure. As crops are grown in rotation, this may mean using data that is more than 5 years old.

Option 2: The economic operator calculates a weighted average of the yields of the 3 most recent years that the target crop was grown on the farm prior to implementation of the additionality measure, even if those yields were obtained from different plots of different sizes on the same farm.

If historical data for the 3 most recent years of crop yields is not available, whether inaccessible or not representative as per the auditor's judgement, or if crop yield data is of insufficient quality, additional data may be obtained for earlier years or data from a neighbouring field growing the same crop under the same management plan. If 1 of the 3 years of historical data represents an exceptionally good or bad harvest (for example, discrepancy of 30% or more compared to the other reference years), the outlier crop yield shall not be included in the calculation to avoid skewing the three-year average[10].

The auditor is responsible for determining a yield outlier, based on their expert judgement, experience on the ground and knowledge of the economic operator's practices over the long term. The auditor is also obliged to evaluate whether the crop yield data is of insufficient quality to be included as part of the baseline and annual audits, and to then decide whether a crop yield needs to be excluded or not.

The slope of the dynamic yield baseline shall be taken as the slope of a straight trend line fitted for yield developments of the target crop over the previous 10 years or longer if data is available. It is based on global data and shall be derived from the FAOSTAT World+ data for the relevant crop. This shall be done at the start of the certification period, and the slope shall be valid for the 10-year baseline validity period of the low ILUC certification.

Table 2 shows the slope of the dynamic yield baseline for the most common biofuel feedstock crops. These values are obtained by fitting a trend line over 20 years of global crop data obtained from FAOSTAT.

Table 2. Slope of the trend line obtained for FAOSTAT World+ crop yield data. Average improvement in yield (tonne/ha/year) per year.

Crop	Barley	Maize	Oil palm fruit	Rapeseed	Soybean	Sugar beet	Sugar cane	Sunflower seed	Wheat
Slope-20	0.035	0.074	0.200	0.036	0.028	1.276	0.379	0.035	0.04

Slope-20 is based on 2008-2017.

For any crop in the table, the dynamic yield baseline is determined by taking the starting point

[10] In line with Article 2(7) of Delegated Regulation (EU) 2019/807, yield fluctuations should be excluded.

(three-year average of historical yields prior to application of the additionality measure) and adding the global trend line (slope) from Table 2. The following formula shall be used, starting at the year the additionality measure is implemented:

$$DYBx = (starting\ point\ DYB) + (slope_{20})x$$

Where:

DYB_x = dynamic yield baseline in year x after implementation of the additionality measure

x = year(s) after implementation of additionality measure

If the additionality measure is to replace the existing crop with a different (higher yielding) crop on a delineated plot, the counterfactual situation is the cultivation of the existing crop. The dynamic yield baseline shall be determined based on historical yield and trend line data for the existing crop.

The starting point of the baseline shall be the 3-year average of the crop yield obtained for the lower performing existing crop. The trend line is based on the global FAOSTAT trend line data for the existing crop (see Table 2). This approach shall only be used if it can be demonstrated that the better performing crop could be introduced due to changes in the biofuel market, as demonstrated in the additionality assessment.

2. Setting the dynamic yield baseline for perennial crops

Depending on the yield variation observed over the lifetime of different types of perennial crop, different methodological approaches shall be possible.

For palm trees, the following data may be used by economic operators of oil palm plantations when determining their dynamic yield baseline:

(a) the historical crop yields obtained prior to implementation of an additionality measure;

(b) the planting year of palm trees on the delineated plot of land and/or their age profile;

(c) the cultivars of palm trees on the delineated plot, if applicable;

(d) the area of land replanted each year on a plantation, if applicable.

That data is combined with a growth curve to determine the dynamic yield baseline. The key characteristic from the growth curve shall be the shape, not the magnitude of the yield.

The growth curve gives the shape and it needs to be combined with the historical yield data and age of the trees, as set out in points (a) and (b), to adjust the magnitude of the dynamic yield baseline curve to the specific plot.

The following three options are available for determining the dynamic yield baseline for palm trees.

For each option, the data required to set the dynamic yield baselines must include:

(a) Option 1a: Standard growth curve

(i) three most recent years of historical crop yields for palm trees grown on the delineated plot;

(ii) age of trees on the delineated plot / planting year;

(b) Option 1b: Economic operator provides growth curve[11]

(i) three most recent years of historical crop yield for palm trees grown on the delineated plot;

(ii) age of trees on the delineated plot/planting year;

(iii) the cultivars of palm trees on the delineated plot;

(iv) economic operator's own reference growth curve.

(c) Option 2: Group certification approach

(i) for the three most recent years, the total hectares and total yield in fresh fruit bunches (FFB) for palm trees grown on the delineated plot/plantation(s), producing palm as part of the group.

Options 1a and 1b apply where an additionality measure is taken on a stand of trees that are the same age, or if the age profile of the trees on the delineated plot(s) is known and does not remain constant year after year.

Option 2 may be applied when the age profile of the trees on the delineated plots is mixed and remains relatively constant year after year, that is to say in a group certification approach or if a consistent percentage of a plantation area is replanted each year, resulting in a constant age profile for the trees.

Option 2 shall not be used if more than 20% of the volume in the group comes from the same plantation, or if more than 5% of the total area in the group is being replanted in the same year. In that case, option 1a or b shall be used to determine the baseline.

Option 1a: Standard growth curve

The first option uses the shape of a pre-established "standard" growth curve (based on existing scientific evidence) to determine the dynamic yield baseline for a delineated plot. The standard curve has been normalised and is shown in Figure 1 and Table 3 below.

[11] To use this option, economic operators have to show that the correlation between the standard growth curve and their baseline growth curve is less than 0.8.

The dynamic yield baseline is determined by using the 3 most recent years of historical crop yield data for the specific plot and the age of the palm trees when that yield was observed, and using the annual percentage yield change from the standard curve to form a "business-as-usual" yield curve relevant to the specific plot.

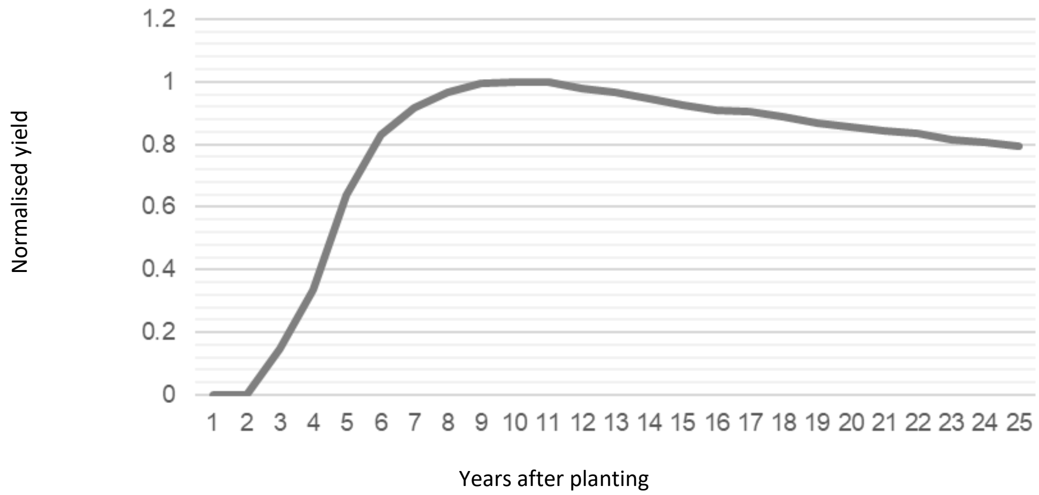

Figure 1 Normalised standard growth curve palm yield

Table 3. Normalised standard growth curve palm yield data

Years after planting	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Normalised yield	0	0	0.147	0.336	0.641	0.833	0.916	0.968	0.996	1	0.999	0.980	0.965
Years after planting	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**≥ 26***
Normalised yield	0.945	0.926	0.910	0.906	0.888	0.870	0.858	0.842	0.836	0.815	0.806	0.793	0.793

* After 25 years, the yield would be expected to continue to decline. However, as the typical lifetime of an oil palm tree is around 25 years, there is a lack of data to support the magnitude of the decline after 25 years. Therefore, a conservative approach is taken to assume that the yield curve would remain at the 25-year level.

Option 1a involves the following methodological steps:

1. To determine the average historical crop yield, collect the three most recent historical crop yields observed on the delineated plot prior to implementation of the additionality measure, as well as the corresponding age of the trees when those yields were observed;

2. Calculate an average (mean) of the three historical crop yields;

3. Based on the age of the trees when the historical yield data is from, determine where this average historical crop yield shall be on the standard growth curve (e.g. if the yield data is from trees aged 7, 8 and 9 years, the average historical yield should be considered to be year 8);

4. To determine the next point of the dynamic yield baseline, multiply the average historical crop yield from step 2 by the corresponding calculated annual percentage change, derived from the standard growth curve (Table 4 below). Repeat this for each subsequent point to plot the dynamic yield baseline;

Table 4 Annual percentage change in yield derived from standard growth curve

Years after planting	1 to 3	4	5	6	7	8	9	10	11	12	13	14
Annual percentage change	-	128.0%	90.6%	30.0%	10.0%	5.6%	2.9%	0.4%	-0.1%	-1.9%	-1.6%	-2.0%
Years after planting	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**≥ 26***
Annual percentage change	-2.1%	-1.7%	-0.5%	-1.9%	-2.0%	-1.4%	-1.8%	-0.8%	-2.5%	-1.1%	-1.6%	0%

* After 25 years, the yield would be expected to continue to decline. However, as the typical lifetime of an oil palm tree is around 25 years, there is a lack of data to support the magnitude of the decline after 25 years. Therefore, a conservative approach is taken to assume that the yield curve would remain at the 25-year level.

5. To incorporate the global yield trend in the dynamic yield baseline, apply the compound annual growth rate (CAGR) calculated from FAOSTAT World+ yield data (Table 5 below), to each point of the dynamic yield baseline to obtain the CAGR corrected dynamic yield baseline.

Table 5 Compound annual growth rate palm (20-year)

Annual performance increase palm - business as usual	**1.37%**

Based on FAOSTAT World+ 2008-2017

Option 1b: Economic operator provides the growth curve

This option may be used in exceptional cases, if the economic operator can demonstrate that option 1a is not appropriate for their specific case. In such a case, if the economic operator has an expected growth curve determined based on the available data of palm seedlings (that relates to their 'business-as-usual' scenario), that curve may be used as the basis for the dynamic yield baseline instead of using the standard growth curve. All steps described in Option 1a shall be followed, replacing the standard growth curve with the economic operator's own curve. The economic operator shall therefore calculate the annual percentage change.

The plot-specific growth curve shall still be corrected for global yield development using the CAGR calculated FAOSTAT World+ yield data (Table 5).

Option 2: Group certification approach

In the case of group certification, or when a first gathering point or mill acts as the unit of certification, the dynamic yield baseline may be set using a similar “straight line” dynamic yield baseline approach as used for annual crops. This approach may be used if a group manager, first gathering point or mill is seeking to certify a group that is taking the same additionality measure, and when the plantation or area supplying the mill contains a mix of ages of trees meaning that the annual yield supplying the mill has remained relatively constant.

To determine the dynamic yield baseline, the group manager needs to record the total plantation area (ha) supplying the mill and the total yield (fresh fruit bunches) that corresponds to that area in each of the last 3 years. This is used to determine the yearly yield per hectare for each of the last 3 years (in tonnes/ha). These data points are then averaged and used as the starting point for the dynamic yield baseline. The starting point is combined with the global trendline slope for oil palm from FAOSTAT World+ data (Table 2) to determine the dynamic yield baseline.

Sugar cane shall be treated as an annual crop when setting the dynamic yield baseline.

3. Setting the dynamic yield baseline for sequential cropping

If multi-cropping practices such as sequential cropping are used, the economic operators have three options to calculate the additional biomass:

1. Demonstrate that the second crop does not lower the yield of the main crop.
2. If the second crop lowers the yield of the main crop:
    a. Determine a dynamic yield baseline for a system in which the main crop is the same each year;
    b. Determine a compensation factor for a system in which the main crop is different each year;

Option 1. Demonstrate that the second crop does not lower the yield of the main crop

If an economic operator can demonstrate that the introduction of the second crop does not lower the yield of the main crop, the whole yield of the second crop can be claimed as additional biomass.

This may be demonstrated, for example, by comparison of the observed yield of the main crop before (3-year historical average) and after introduction of the second crop.

Option 2a. Determine a dynamic yield baseline for a system in which the main crop is the same each year

The dynamic yield baseline shall be based on the 'business as usual' situation for the delineated plot of land. When the main crop is the same each year, the baseline shall be determined based on at least the 3-year average historical yield of the main crop on that plot, combined with the global trend line for the main crop, as is done for annual crops.

This approach may also be used when the crop rotation follows a clearly defined rotation pattern that can be observed from historical data, which enables the business-as-usual situation to be clearly determined. In this case, it may be necessary to use data older than 3 years to determine the average historical yield of the main crop.

After implementation of sequential cropping, the net additional biomass shall be calculated as the difference between the total annual yield from the delineated plot of land (that is to say, the yield of the main crop plus the yield of the second crop) and the main crop dynamic yield baseline.

If the main and second crops are different feedstocks that produce a different combination of crop components (for example, oil, protein meal, starch, fibre), when the main crop and second crop yields are added together, the calculation shall be based on appropriate units of measurement to allow for the calculation of a single representative figure for the net additional biomass produced. Respectively, the methodology shall allow for an effective compensation of the biomass loss of the main crop. For example, the calculation can be done on a simple weight (tonnes) basis or an energy content basis (e.g. if the full second crop is used for energy, such as for biogas). The choice of methodology shall be justified by the economic operator and validated by the auditor.

Option 2b. Determine a compensation factor for a system in which the main crop is different each year

When the main crop differs each year in the crop rotation and does not follow a regular pattern, the economic operator needs to assess any loss in yield of the main crop due to the second crop and to take it into account in the volume of additional biomass claimed.

The economic operator needs to compare the observed yield of the main crop after introduction of the second crop with the historical yield of the same (main) crop. That comparison may be done based on observed yields in neighbouring fields (e.g. if the same farm grows the same crops on rotation but in different fields), or on the basis of justified scientific literature that describes the impact of sequential cropping on those crops in that region.

The impact on yield of the main crop shall be translated into a compensation factor that shall be deducted from the volume of the second crop to calculate the additional biomass. As for Option 2a, the factor can be based on weight or energy content and shall allow for an effective compensation of the biomass loss of the main crop. The choice of methodology shall be justified by the economic operator and validated by the auditor.

4. Calculating additional biomass volume

After implementation of the additionality measure, the economic operator shall determine the volume of low ILUC risk biomass that can be claimed by comparing the actual crop yield achieved on the delineated plot with the dynamic yield baseline. The auditor must verify in the annual audit that the volume of additional biomass achieved is in line with the projections in the management plan, and seek justification if there are discrepancies of more than 20% compared to the estimates in the management plan.

If certification is sought for an additionality measure applied in the past, the additional biomass yield may be calculated and recorded in the management plan. While this allows the actual volume of low ILUC risk biomass to be precisely calculated, low ILUC risk biomass may only be claimed after low ILUC risk certification has been awarded. Retrospective claims cannot be made for biomass supplied in the past.

To calculate the additional biomass volume, the economic operator must record the full crop yield from the delineated plot for each year, from the start of the implementation of the additionality measure. The economic operator must prove the link between the specific delineated plot and the crop yield achieved (tonne/ha).

If the harvested volume is only measured (weighed) at a first gathering point where products from multiple farms or plots arrive, then the documentation from the first gathering point may be used as proof of the harvested volume (yield) for the farms and plots involved.

A record of the business transaction between the economic operator and the first gathering point may be used as evidence, as long as the link back to the specific delineated plot can be proven. In this case, the first gathering point is responsible for collecting and recording the crop yield data. It shall record yields of biomass collected per farm (and if necessary, for a specified delineated plot on a farm) based on a template to be issued by the voluntary scheme.

In the case of group auditing and if the first gathering point acts as the group lead, it shall be responsible for recording yield data for all delineated plots.

To calculate the additional biomass volume, the crop yield data obtained for a given year shall be compared to the dynamic yield baseline. The additional biomass yield is equal to the difference between the crop yield observed and the yield projected by the dynamic yield baseline for the same year, multiplied by the surface area A (ha) of the delineated plot in question. This additional volume can then be claimed as low ILUC risk biomass.

Additional biomass = $(Y_x - DYB_x) \times A$

Where:

Y_x = Observed yield in year x (in tonne/ha/yr)

DYB_x = Dynamic yield baseline in year x (in tonne/ha/yr)

A = Surface area of delineated plot (ha)

D. <u>Minimum content of the low ILUC risk certificate</u>
<u>Low ILUC-risk certificates must contain all the following information:</u>

(a) contact details of main certified entity (company name and address, details of the designated point of contact);
(b) scope of certification (type of additionality measure and additionality test applied as well as type of economic operator (if they are small holders));
(c) longitude and latitude coordinates (for farms and plantations certified as single entities);

(d) list of sites under the scope of certification (name and address);
(e) total volume of biomass certified as low ILUC risk;
(f) contact details of the certification body (name and address) and logo;
(g) (unique) certificate number or code;
(h) place and date of issuance;
(g) certificate valid from/to dates (and date certified, if applicable);
(h) stamp and/or signature of issuing party.

ANNEX IX

STANDARD VALUES OF EMISSIONS FACTORS

				GHG emission coefficient				Fossil energy input
	parameter							
		unit:	$gCO_{2,eq}$ / g	gCO_2/kg	gCH_4/kg	gN_2O/kg	gCO_{2-eq}/kg	MJ_{fossil}/kg
Global warming potential								
	CO_2		1					
	CH_4		28					
	N_2O		265					
Agro inputs:								
N-fertiliser (kg N)								
	Ammonium nitrate (AN)			2671	6,9	2,1	3469	
	Ammonium sulphate (AS)			2560	6,5	0,0	2724	
	Ammonium nitrate sulphate (ANS)			2561	8,9	1,3	3162	
	Anhydrous ammonia			2662	6,8	0,0	2832	
	Calcium ammonium nitrate (CAN)			2863	7,3	2,1	3670	

	parameter		GHG emission coefficient				Fossil energy input
	unit:	**$gCO_{2,eq}$ / g**	**gCO_2/kg**	**gCH_4/kg**	**gN_2O/kg**	**gCO_{2-eq}/kg**	**MJ_{fossil}/kg**
	Calcium nitrate (CN)		2653	7,0	5,1	4348	
	Urea		1703	9,3	0,0	1935	
	Urea ammonium nitrate (UAN)		2182	7,5	1,1	2693	
P2O5-fertiliser (kg P2O5)							
	Triple superphosphate (TSP)		517	0,9	0,0	544	
	Rock phosphate 21%P_2O_5 23%SO_3		95	0,0	0,0	95	
	Mono ammonium phosphate (MAP) 11%N 52%P_2O_5		967	2,5	0,0	1029	
	Di-Ammonium-Phosphate (DAP) 18%N 46%P2O5		1459	3,7	0,0	1552	
K2O-fertiliser (kg K2O)							
	Muriate of Potash (MOP) 60%K2O		409	0,17	0,0	413	
Other fertilisers							
	NPK 15-15-15		4261	10,0	1,7	5013	
	MgO (kg MgO)		769	0,0	0,0	769	
	Sodium (Na) fertiliser (kg Na)		1620	0,0	0,0	1620	
	Seeds- barley		189,5	0,08	0,4001	310,6	3,23
	Seeds- eucalyptus cuttings		0,0	0,00	0,0000	0,0	

	parameter		GHG emission coefficient				Fossil energy input
	unit:	$gCO_{2,eq}$ / g	gCO_2/kg	gCH_4/kg	gN_2O/kg	$gCO_{2\text{-}eq}$/kg	MJ_{fossil}/kg
	Seeds- maize		189,5	0,08	0,4001	310,6	3,23
	Seeds- poplar cuttings		0,0	0,00	0,0000	0,0	
	Seeds- rapeseed		451,0	0,27	1,0024	756,5	8,33
	Seeds- rye		191,0	0,08	0,4001	312,1	3,23
	Seeds- soy bean		0,0	0,00	0,0000	0,0	
	Seeds- sugar beet		2363,0	1,37	4,2096	3651,7	38,44
	Seeds- sugar cane		4,97	0,00	0,0000	5,0	0,06
	Seeds- sunflower		451,0	0,27	1,0024	756,5	8,33
	Seeds- triticale		180,0	0,04	0,4000	300,2	3,00
	Seeds- wheat		163,7	0,04	0,4000	283,9	2,76

	parameter		GHG emission coefficient				Fossil energy input
	unit:	$gCO_{2,eq}$ / g	gCO_2/kg	gCH_4/kg	gN_2O/kg	$gCO_{2\text{-}eq}$/kg	MJ_{fossil}/kg
Residues (feedstock or input):							
	Biogas digestate		0,0	0,00	0,0000	0,0	0,00
	EFB compost (palm oil)		0,0	0,00	0,0000	0,0	0,00
	Filter mud cake		0,0	0,00	0,0000	0,0	0,00

	parameter:	GHG emission coefficient				Fossil energy input		Density	LHV (lower heating value) MJ/kg
	unit:	gCO_2/MJ	gCH_4/MJ	gN_2O/MJ	$gCO_{2\text{-}eq}$/MJ	MJ_{fossil}/kg	MJ_{fossil}/MJ	kg/m^3	(on a dry basis)
Fuels- gases									
	Natural gas (EU mix)	66,00	0,0000	-	66,00		1,2000		49,2
	LPG	66,30	0,0000	0,0000	66,31		1,2000		46,0
	Methane								50,0

	parameter:	**GHG emission coefficient**				**Fossil energy input**		**Density**	**LHV (lower heating value)** MJ/kg
	unit:	**gCO_2/MJ**	**gCH_4/MJ**	**gN_2O/MJ**	**gCO_{2-eq}/MJ**	**MJ_{fossil}/kg**	**MJ_{fossil}/MJ**	**kg/m^3**	**(on a dry basis)**
Fuels- liquids (also conversion inputs)									
	Diesel	95,1	-	-	95,10		1,2300	832	43,1
	Gasoline	93,3	-	-	93,30		1,2000	745	43,2
	Heavy fuel oil	94,2	-	-	94,20		1,1600	970	40,5
	Ethanol							794	26,81
	Methanol	97,08	0,0001	0,0000	97,09		1,7639	793	19,95
	DME							670	28,4
	FAME							890	37,2
	HVO								44,0
	PVO							920	37,0
	Syn diesel (BtL)							780	44,0
	Palm oil							920	37,0
	Rapeseed oil							920	37,0
	Soybean oil							920	37,0
	Sunflower oil							920	37,0

	parameter:	GHG emission coefficient				Fossil energy input	Density	LHV MJ/kg
	unit:	**gCO2/MJ**	**gCH4/MJ**	**gN2O/MJ**	**gCO2-eq/MJ**	**MJfossil/MJ**	**kg/m3**	**(on a dry basis)**
Fuels- solids (also conversion inputs)								
	Hard coal	102,62	0,3854	0,0003	112,32	1,0909		26,5
	Lignite	116,68	0,0014	0,0001	116,73	1,0149		9,2
	Wood chips						155	19,0
	Wood pellets					0,0080	650	19,0

	parameter:	**Density**	**LHV** MJ/kg
	unit:	**kg/m^3**	**(on a dry basis)**
Fuels / feedstock / co-products / residues / wastes			
	Agricultural residue bales		18,0
	Animal fat (tallow)		38,8
	Bagasse		17,0
	Bagasse exit mill (dry)	120	17,0
	Bagasse bales (dry)	165	17,0
	Bagasse pellets (dry)	650	17,0
	Barley		17,0
	Biogasoline		44,0
	Biowaste		20,7
	DDGS (barley)		17,8
	DDGS (maize)		19,2
	DDGS (rye)		17,8
	DDGS (triticale)		18,0
	DDGS (wheat)		18,1
	Eucalyptus (SRC)		19,0
	Fatty acids		37,0
	FFB		24,0

	parameter:	Density	LHV MJ/kg
	unit:	**kg/m^3**	**(on a dry basis)**
Fuels / feedstock / co-products / residues / wastes			
	Forestry residues		19,0
	Glycerol		16,0
	Industry residues (wood)		19,0
	Manure		12,0
	Maize (grain only)		17,3
	Maize whole crop		16,9
	Palm kernel meal	570	18,5
	Palm kernel oil		37,0
	Poplar (SRC)		19,0
	Rapeseed		27,0
	Rapeseed oil cake		18,4
	Rye		17,1
	Sawdust		19,0
	Soybeans		23,0
	Soybean oil cake		19,1
	Stemwood (Pine)		19,0
	Straw		17,2

	parameter:	**Density**	**LHV** MJ/kg
	unit:	**kg/m^3**	**(on a dry basis)**
Fuels / feedstock / co-products / residues / wastes			
	Straw bales	125	17,2
	Straw chopped	50	17,2
	Straw pellets	600	17,2
	Sugar beet		16,3
	Sugar beet pulp		16,1
	Sugar cane		19,6
	Sunflower seed		27,2
	Sunflower oil cake		18,2
	Triticale		16,9
	Vinasse		14,0
	Waste cooking oil		37,0
	Wheat		17,0
	Wheat straw		17,2

parameter:	GHG emission coefficient								Fossil energy input		LHV MJ/kg
unit:	**gCO_2/kg**	**gCH_4/kg**	**(at 0% water)**	**$gCO_{2\text{-}eq}$/kg**	**gCO_2/ MJ**	**gCH_4/MJ**	**gN_2O/ MJ**	**$gCO_{2\text{-}eq}$/MJ**	**MJ_{fossil}/kg**	**MJ_{fossil}/MJ**	**(on a dry basis)**
Conversion inputs											
Ammonia	2350,6	0,00	0,0022	2351,3					42,50		
Ammonium sulphate ($(NH_4)_2SO_4$)	420,9	1,29	0,0002	453,2					7,56		
Antifoam (assumed to be propylene glycol)	3119,5	4,96	0,105	3274,8					34,97		
Alpha-amylase	1000,0	0,00	0,0000	1000,0					15,00		
Gluco-amylase	7500,0	0,00	0,0000	7500,0					97,00		
Calcium chloride ($CaCl_2$)	38,6	0,002	0,001	38,8					0,50		
Cyclohexane	723,0	0,00	0,0000	723,0					9,90		
Diammonium phosphate (DAP)	653,2	0,81	0,004	674,4					10,23		
Fuller's earth	197,0	0,04	0,0063	199,8					2,54		
n-Hexane					80,08	0,0146	0,0003	80,53		0,3204	45,1
Hydrochloric acid (HCl)	977,1	2,91	0,0376	1061,1					14,84		
Lubricants	947,0	0,00	0,0000	947,0					53,28		

parameter:	GHG emission coefficient								Fossil energy input		LHV MJ/kg
unit:	**gCO_2/kg**	**gCH_4/kg**	**(at 0% water)**	**gCO_{2-eq}/kg**	**gCO_2/MJ**	**gCH_4/MJ**	**gN_2O/MJ**	**gCO_{2-eq}/MJ**	**MJ_{fossil}/kg**	**MJ_{fossil}/MJ**	**(on a dry basis)**
Conversion inputs											
Magnesium sulphate ($MgSO_4$)	191,4	0,04	-0,002	191,8					-3,24		
Monopotassium phosphate (KH_2PO_4)	238,7	0,91	0,012	264,9					4,43		
Nitrogen	52,6	0,12	0,0024	56,4					1,08		
Phosphoric acid (H_3PO_4)	2808,9	11,36	0,1067	3124,7					28,61		
Potassium hydroxide (KOH)	403,0	0,40	0,0208	419,1					11,47		
Pure CaO for processes	1188,5	0,10	0,0080	1193,2					7,87		
Sodium carbonate (Na_2CO_3)	1133,5	4,39	0,0060	1245,1					14,92		
Sodium chloride (NaCl)	12,7	0,02	0,001	13,3					0,23		
Sodium hydroxide (NaOH)	485,5	1,45	0,0271	529,7					10,16		
Sodium methoxide ($Na(CH_3O)$)	2207,7	7,56	0,0965	2425,5					45,64		
SO_2	52,0	0,03	0,001	53,3					0,78		
Sulphuric acid (H_2SO_4)	210,2	0,24	0,0046	217,5					4,02		

parameter:		GHG emission coefficient								Fossil energy input		LHV MJ/kg
unit:		**gCO_2/kg**	**gCH_4/kg**	**(at 0% water)**	**gCO_{2-eq}/kg**	**gCO_2/MJ**	**gCH_4/MJ**	**gN_2O/MJ**	**gCO_{2-eq}/MJ**	**MJ_{fossil}/kg**	**MJ_{fossil}/MJ**	**(on a dry basis)**
Conversion inputs												
	Urea	1790,9	1,92	0,027	1846,6					31,71		

parameter:		Fuel Efficiency	Transport exhaust gas emissions	
unit:		**MJ/t.km**	**gCH4/t.km**	**gN2O/t.km**
Transport efficiencies - Trucks				
	Truck (40 tonne) for dry product (Diesel)	0,81	0,003	0,0015
	Truck (40 tonne) for chips (and similar size dry product) (Diesel)	0,84	0,004	0,0016
	Truck (40 tonne) for liquids and pellets (Diesel)	0,87	0,004	0,0016
	Truck (40 tonne) for manure (Diesel)	0,88	0,004	0,0016
	Truck (40 tonne) for biowaste (Diesel)	0,84	0,004	0,0016
	Truck (40 tonne) for sugar cane transport	1,37	0,001	0,0039
	Truck (12 tonne) for FFB transport (Diesel)	2,24	0,002	0,0015
	Dumpster truck MB2213 for filter mud transport	3,60	0,000	0,0000

parameter:		Fuel Efficiency	Transport exhaust gas emissions	
unit:		MJ/t.km	gCH4/t.km	gN2O/t.km
	Tanker truck MB2318 for vinasse transport	2,16	0,000	0,0000
	Tanker truck MB2318 for cane seed transport	2,61	0,000	0,0000
	Tanker truck with water cannons for vinasse transport	0,94		
Transport efficiencies - Ships				
	‘Handymax’ bulk carrier (fuel oil) - Grains	0,10		
	‘Handysize’ bulk carrier (fuel oil) - wood chips with bulk density 221 kg/m^3	0,26		
	‘Supramax’ bulk carrier (fuel oil) - wood chips with bulk density 221 kg/m^3	0,16		
	‘Handysize’ bulk carrier (fuel oil) - pellets with bulk density 650 kg/m^3	0,10		
	‘Supramax’ bulk carrier (fuel oil) - pellets with bulk density 650 kg/m^3	0,07		
	‘Handysize’ bulk carrier (fuel oil) - agri-residues with low bulk density (125 kg/m^3)	0,43		
	‘Supramax’ bulk carrier (fuel oil) - agri-residues with low bulk density (125 kg/m^3)	0,27		
	‘Handysize’ bulk carrier (fuel oil) - agri-residues with high bulk density (300 kg/m^3)	0,20		
	‘Supramax’ bulk carrier (fuel oil) - agri-residues with high bulk density (300 kg/m^3)	0,13		
	‘Handysize’ bulk carrier (fuel oil) - PKM	0,13		
	‘Supramax’ bulk carrier (fuel oil) - PKM	0,07		
	Chemical/product tanker, 12.617 kt (fuel oil)	0,12		
	Chemical/product tanker, 15 kt (fuel oil) for ethanol transport	0,17		
	Chemical/product tanker, 15 kt (fuel oil) for FAME and HVO transport	0,16		
	Chemical/product tanker, 22.56 kt (fuel oil)	0,10		

	parameter:	Fuel Efficiency	Transport exhaust gas emissions	
	unit:	**MJ/t.km**	**gCH4/t.km**	**gN2O/t.km**
	Inland bulk carrier, 8.8 kt (diesel)	0,32	0,093	0,0004
	Inland ship for oil transport, 1.2 kt (diesel)	0,50	0,030	
Transport efficiencies - Pipeline and rail				
	Local (10 km) pipeline	0,00	0,000	0,0000
	Freight train USA (diesel)	0,25	0,005	0,0010
	Rail (electric, MV)	0,21		

Carbon Intensity of electricity produced and consumed in the EU in 2019 [gCO2eq / kWh]

With upstream emissions, without emissions from construction

	CI net electricity production	CI used electricity HV	CI used electricity MV	CI used electricity LV
Austria	153	238	240	245
Belgium	204	214	215	219
Bulgaria	493	504	510	532
Cyprus	757	768	772	787
Czechia	518	526	531	549
Germany	389	386	388	398
Denmark	100	135	136	139
Estonia	654	468	471	485
Greece	577	585	590	610
Spain	245	248	251	263
Finland	105	127	128	130
France	74	81	82	86
Croatia	208	329	333	349
Hungary	277	307	310	322
Ireland	349	357	360	374
Italy	352	331	333	343
Latvia	203	312	315	325
Lithuania	79	291	294	305
Luxembourg	93	311	312	316
Malta	455	437	441	454
Netherlands	430	415	417	426
Poland	742	715	720	741
Portugal	268	282	285	299
Romania	388	421	427	454
Slovakia	168	316	319	329
Slovenia	269	281	283	291
Sweden	20	25	25	26

EU27	288	295	298	308
Iceland	7	7	7	7
Norway	12	20	20	21
Switzerland	32	107	108	112
United Kingdom	271	277	280	292
Albania	0	302	308	332
Bosnia Herzegovina	799	766	776	818
Kosovo	1,099	1,067	1,097	1,224
Moldova	246	446	453	476
Montenegro	472	588	599	646
North Macedonia	794	760	774	831
Serbia	807	819	833	892
Turkey	487	508	516	546
Belarus	449	458	462	479
Russia	459	474	479	496
Ukraine	407	419	423	439

	parameter:	**GHG emission coefficient**		
	unit:	**gCH4/MJ**	**gN2O/MJ**	**gCO2-eq/MJ**
*Emissions from machinery operations incl. chipping (**per MJ diesel**)*				
	CH_4 and N_2O emissions from use of diesel (transport)	0,0008	0,0032	0,97
	CH_4 and N_2O emissions from use of diesel (forestry)	0,0008	0,0032	0,97
	CH_4 and N_2O emissions from use of diesel (agriculture)	0,0013	0,0032	0,97
*Emissions from boiler or CHP (**per MJ feedstock**)*				

	parameter:	GHG emission coefficient		
	unit:	**gCH4/MJ**	**gN2O/MJ**	**gCO2-eq/MJ**
	CH_4 and N_2O emissions from agricultural residue boiler	0,0017	0,0007	0,24
	CH_4 and N_2O emissions from agricultural residue CHP	0,0017	0,0007	0,24
	CH_4 and N_2O emissions from bagasse boiler	0,0025	0,0012	0,43
	CH_4 and N_2O emissions from bagasse CHP	0,0025	0,0012	0,43
	CH_4 and N_2O emissions from biogas CHP gas engine	0,3400	0,0014	8,92
	CH_4 and N_2O emissions from biogas boiler	0,0025	0,0010	0,36
	CH_4 and N_2O emissions from hard coal CHP	0,0018	0,0050	1,53
	CH_4 and N_2O emissions from lignite CHP	0,0007	0,0028	0,86
	CH_4 and N_2O emissions from NG boiler	0,0025	0,0010	0,36
	CH_4 and N_2O emissions from NG CHP	0,0042	0,0008	0,36
	CH_4 and N_2O emissions from NG gas engine	0,0030	0,0001	0,10
	CH_4 and N_2O emissions from palm shells and fibres boiler	0,0030	0,0040	1,27
	CH_4 and N_2O emissions from palm shells and fibres CHP	0,0030	0,0040	1,27
	CH_4 and N_2O emissions from PKM boiler	0,0017	0,0007	0,24
	CH_4 and N_2O emissions from PKM CHP	0,0017	0,0007	0,24
	CH_4 and N_2O emissions from sawdust boiler	0,0049	0,0010	0,41
	CH_4 and N_2O emissions from straw pellet boiler	0,0017	0,0007	0,24

	parameter:	GHG emission coefficient		
	unit:	gCH4/MJ	gN2O/MJ	gCO2-eq/MJ
	CH_4 and N_2O emissions from straw pellet CHP	0,0017	0,0007	0,24
	CH_4 and N_2O emissions from wood chip boiler	0,0049	0,0010	0,41
	CH_4 and N_2O emissions from wood chip CHP	0,0049	0,0010	0,41
	CH_4 and N_2O emissions from wood pellet boiler	0,0030	0,0006	0,25
	CH_4 and N_2O emissions from wood pellet CHP	0,0030	0,0006	0,25
	CH_4 and N_2O emissions from liquid fuel boiler	0,0009	0,0004	0,14
	CH_4 and N_2O emissions from wood pellet co-combustion (fluidised bed coal-fired power plant)	0,0010	0,0610	18,20
	CH_4 and N_2O emissions from wood pellet co-combustion (pulverised coal-fired power plant)	0,0009	0,0014	0,44
*Emissions from digestate storage (**per MJ biogas**)*				
	CH_4 and N_2O emissions from open biowaste digestate storage	0,4930	0,0319	21,82
	CH_4 and N_2O emissions from open maize digestate storage	0,4422	0,0082	13,51
	CH_4 and N_2O emissions from open manure digestate storage	1,9917	0,0663	69,56

	GHG emission coefficient

		gCO2/kg	gCH4/kg	gN2O/kg	gCO2-eq/kg	gCO2/MJ	gCH4/MJ	gN2O/MJ	gCO2-eq/MJ
*Manure methane credits (**per MJ biogas**)*									
	CH_4 and N_2O emission credits for manure						1,4700	0,0279	45,05
	No emissions	0,0	0,00	0,0000	0,0	0,00	0,0000	0,0000	0,00