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RENEWABLE DIESEL NEXBTL - GREENHOUSE GAS (GHG) DATA HANDLING

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1 Changes

This is an updated version of the GHG data handling instruction. Due to many changes in the structure and contents of the text, no highlighting is provided.

2 Purpose of the instruction

This document describes Neste Oil's greenhouse gas data handling practices and methodology used in fulfillment of requirements given in the European Union Renewable Energy Directive (RED).

3 Scope and effective date

This instruction is applied in Neste Oil Corporation. This instruction is applicable from 9.3.2012.

Once the HVO renewable diesel Voluntary Scheme gets recognized by the European Commission this instruction can also be applied by other biofuel producers to calculate their supply chain GHG emissions for hydrotreated biofuels in order to meet sustainability requirements in the EU.

4 Definitions

The definitions given in DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC **(RED)** are applied.

Additionally the following definitions apply:

Carbon dioxide equivalent (CO_2e) is a unit for comparing the radiative forcing of a GHG to carbon dioxide. The carbon dioxide equivalent is calculated using the mass of a given GHG multiplied by its global warming potential (SFS-EN ISO 14064-1).

Global warming potential (GWP) describes the radiative forcing impact of one mass-based unit of a given GHG relative to an equivalent unit of carbon dioxide over a given period of time (SFS-EN ISO 14064-1).

Greenhouse gas (GHG) gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at the specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) (SFS-EN ISO 14064-1). Only CO_2, CH_4 and N_2O are included in the GHG calculations according to this instruction.

Life cycle means consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal (SFS-EN ISO 14040).

Life cycle assessment (LCA) means compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (SFS-EN ISO 14040).

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Life cycle inventory analysis (LCI) is one phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle (SFS-EN ISO 14040).

NExBTL is the commercial name for Neste Oil's hydrotreated renewable diesel; the production is based on proprietary technology developed by Neste Oil.

5 Related documents

Documents related to this instruction:

1. HVO renewable diesel Scheme for Verification of compliance with the sustainability criteria for Biofuels
2. ISCC 205 GHG Emissions Calculation Methodology and GHG Audit, 15.3.2011 V 2.3. The calculation methodology described in this instruction follows the guidelines of both RED and ISCC 205. Both of the documents have been used as templates when forming this instruction.

6 Responsibilities

Responsible person for updating this instruction is the Director, Sustainability and Supplier Compliance.

7 Methodology for greenhouse gas data gathering and calculations

NExBTL supply chain greenhouse gas calculation methodology is built up by using systems approach and life cycle assessment as described in international standards (SFS-EN ISO 14040, 2006 and 14044, 2006). As an example the calculation system boundary of one of Neste Oil's production sites is described in Annex A. Correct allocation procedures are explained in Annex B.

Guidance given in international greenhouse gas verification standard (SFS-ISO 14064-1, 2006) and international carbon footprint standard (ISO 14067, under development) and WRI/WBCSD The Greenhouse Gas Protocol Initiative (GHG Protocol) Product Life Cycle Accounting and Reporting Standard (draft November 2009) as well as in ISCC 205 have been taken into account when developing this greenhouse gas calculation methodology. All direct and indirect emissions (note: does not include ILUC) or avoided emissions that are the result of the production of the hydrotreated biofuel are taken into account. Three different gases are recognized as greenhouse gases within this calculation methodology. These gases are fossil carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). Global warming potentials for the above gases are given in Annex D, Table D.5.

Land use change is dealt as a separate issue by following the rules given in the RED directive.

7.1 GHG emission calculation methodology

The GHG calculation methodology described in this instruction can be applied for hydrotreated biofuels and all sustainable feedstocks. According to the RED, ISCC and this instruction there are three options for providing GHG information:

Use of default values: RED contains default values for different types of biofuels and bioliquids. These values depend on both feedstock and process used. Each operator may use them to demonstrate compliance with the GHG saving requirements provided that no

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land use change has taken place and the requirements of Article 19(3) of the Renewable Energy Directive are met. RED includes both overall default values for different final products and disaggregated default values for cultivation, processing, transportation and distribution. The disaggregated default values can be used in the respective module of the supply chain. The default values are subjected to changes by the Commission. Such updates will become valid within this voluntary scheme with immediate effect

Use of calculated actual values: calculated values for specific modules of the supply chain can be used whether there exists a default value or not. Actual values shall be calculated according to the methodology described in section 7.1.1 of this instruction. This methodology has been developed by using the RED and ISCC 205 GHG Emissions Calculation Methodology as templates.

Combination of default and actual values: Combining default and actual values in the supply chain is possible between modules. Alternatively, the cultivation emissions can be based entirely on default emissions. However, the default cultivation emissions can only be applied for material cultivated outside the European Union, or on restricted areas as defined in the RED Article 19(2), (3).

In Neste Oil greenhouse gas emission calculations, all these options are used. Detailed information on how these values are applied is given in section 7.3.

7.1.1 Calculation of actual values

When actual values are used for certain raw materials or processes, they are always generated in cooperation between the biofuel producer and its suppliers. The calculation of actual values includes on-site data gathering where supplier's assistance is needed. On-site data includes e.g. previous land use, fertilizer and other chemical inputs, yields and other outputs.

The calculation of actual GHG values for the different modules of supply chains can rely partly on external data sources. The following data sources are preferred above others:

• Official data from government offices or bodies e.g. statistical data

• If not available, statistical data published by independent bodies may be used

• Scientific literature or studies which are peer-reviewed and data lies within the commonly accepted data range when available.

• Individual emission factors for different inputs and outputs e.g. fertilizers, fuels and electricity shall be based first and foremost on:

- Ecoinvent database
- BioGrace Standard Values
  (Available at: http://www.biograce.net/content/ghgcalculationtools/standardvalues)
- the "ISCC list of emission factors"
- when no other reliable data is available, verified information provided by the supplier may be used

A set of emissions factors which can be used when calculating actual values are presented in annex D of this instruction.

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All relevant information related to raw materials or processing should be gathered to enable the GHG assessments. Calculations are to be based on periods of 12 months, preferably the previous calendar year. The previous fiscal period is also accepted when the economic operators' fiscal year differs from the calendar year. In the case of oil palm cultivation, supplier's fiscal period is predominantly from July to June.

When calculating actual values all relevant emission sources throughout the production process shall be considered. Inputs and outputs with little or no effect on total emissions can be neglected. These are emission sources which have an impact of less than 0,5% on the overall emissions of the respective module.

7.1.1.1 Calculation of emissions from raw material production

GHG emissions from the cultivation of raw materials include emissions from cultivation process itself; from harvesting of raw materials; and from production of chemicals or other products used during the cultivation. (See RED, ANNEX V, C, 6 and example in Annex A of this document).

The variables that affect GHG emissions of cultivation typically include seeds, fuels, fertilizers, pesticides, yield and field N_2O emissions (2010/C 160/02). The data collection period is 12 months as described in 7.1.1.

GHG information passes into the next module as kg CO_2e per tonne of cultivated product i.e. the product that is passed on in the supply chain.

GHG emissions related to the production of raw materials are to be calculated according to the following equation:

$$e_{ec} = \frac{EM_{fertilizer} + EM_{diesel} + EM_{electricity} + EM_{inputs}}{crop\ yield_{main\ product}}, \qquad (1)$$

where:

$$[EM_i] = \frac{kgCO_{2e}}{yr}$$ EM is emission; [EM] is unit of emission

$$[crop\ yield] = \frac{t\ crop}{yr},$$

$$EM_{fertilizer} = \sum (\dot{m}_{fertilizer} * (EF_{field} + EF_{production})), \qquad (1a)$$

$$[\dot{m}_{fertilizer}] = \frac{kg_{fertilizer}}{yr}$$

$$[EF_i] = \frac{kgCO_{2e}}{kg_{fertilizer}},$$

$$EM_{diesel} = \dot{V}_{diesel} * EF_{diesel}, \qquad (1b)$$

$$[\dot{V}_{diesel}] = \frac{l_{diesel}}{yr}$$

$$\left[EF_{diesel}\right] = \frac{kgCO_{2e}}{l_{diesel}},$$

$$EM_{electricity} = el_{electricity} * EF_{regionalelectricity\ mix}, \tag{1c}$$

$$[el_{electricity}] = \frac{kWh}{yr}$$

$$\left[EF_{electricity}\right] = \frac{kgCO_{2e}}{kWh},$$

$$EM_{input} = \sum (\dot{m}_{input} * EF_{input}), \tag{1d}$$

$$[\dot{m}_{input}] = \frac{kg_{input}}{yr}$$; e.g. pesticides and seeds for annual crops

$$\left[EF_{input}\right] = \frac{kgCO_{2e}}{kg_{input}}.$$

Emission factors EF come primarily from Annex D, or from sources listed in 7.1.1.

The short carbon cycle uptake of carbon dioxide in the plants is not taken into account; to balance this, the emissions related to biofuel combustion are not taken into account. (2010/C 160/02, ANNEX II)

For cultivation module the methodology allows for – as an alternative to actual values – the use of averages for smaller geographical areas than those used in the calculation of the default values in the RED. The default values were (with one exception) calculated for a global level. However, within the EU, the Directive places restrictions on their use. These restrictions operate at the level of NUTS 2 areas. The averages operate at the level of NUTS 2 areas (or equivalent level outside Europe) or a more fine-grained level (2010/C 160/02). Member States shall submit to the Commission a report including a list of those areas on their territory (Nuts 2 level or more disaggregated) where emissions from cultivation are equal to or lower than the disaggregated default value for cultivation as reported in the RED, Annex V, D. Cultivation default values for feedstocks grown in the EU can only be used if crops have been grown on the above mentioned areas.

The respective Member State reports are available on:

http://ec.europa.eu/energy/renewables/transparency_platform/emissions_en.htm

If co-products are produced in the cultivation module, the allocation of emissions to the main product and co-products takes place in the cultivation module.

GHG emissions related to residue or waste feedstocks are considered to be zero up to the first collection point of the specific material. Waste and residue definition can be found from the scheme's main document in section 2.2., point 9.Regarding processing residues, proof of other sustainability requirements than GHG requirements is not needed. For agricultural, aquaculture, fisheries and forestry residues all sustainability requirements must be met. Minimum GHG emission savings must be fulfilled in either case.

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7.1.1.2 Calculation of emissions from processing

All parties or individual processing units involved in the supply chain must guarantee that all emission sources are covered by the calculations. These emission sources are processing inputs and outputs including possible waste streams. Emissions related to inputs have to include the respective supply chain emissions as well. Calculations are to be based on periods of 12 months as described in 7.1.1.

Functional unit for the GHG calculations is mass of the main product. The final result can also be converted into other formats if necessary e.g. emissions per MJ of main product.

Calculation of emissions from processing is based on the following equation:

$$e_p = \frac{EM_{electricity\ consumption} + EM_{heat\ production} + EM_{inputs} + EM_{waste\&wastewater}}{yield_{main\ product}} \tag{2}$$

where:

$$yield_{main\ product} = \frac{t_{main\ product}}{yr}$$

$$EM_{electricity\ consumption} = el * EF_{regional electricity\ mix}, \tag{2a}$$

$$\left[EM_{electricity\ consumption}\right] = \frac{kgCO_{2e}}{yr}$$

$$[el] = \frac{kWh}{yr}$$

$$\left[EF_{regional electricity\ mix}\right] = \frac{kgCO_{2e}}{kWh}$$

$$EM_{heat\ production} = f_{fuel\ consumption} * EF_{fuel} \tag{2b}$$

$$\left[EM_{heat\ production}\right] = \frac{kgCO_{2e}}{yr}$$

$\left[f_{fuel\ consumption}\right] = \frac{kg_{fuel}}{yr}$ (or $\frac{MJ_{fuel}}{yr}$); overall fuel consumption

$\left[EF_{fuel}\right] = \frac{kgCO_{2e}}{kg_{fuel}}$ (or $\frac{kgCO_{2e}}{MJ_{fuel}}$);

$$\left[EM_{inputs}\right] = \sum(\dot{m}_{input} * EF_{input}), \tag{2c}$$

$$\left[EM_{inputs}\right] = \frac{kgCO_{2e}}{yr}$$

$\left[\dot{m}_{input}\right] = \frac{kg_{input}}{yr}$; e.g. raw materials and process chemicals

$$[EF_{input}] = \frac{kgCO_{2e}}{kg_{input}}$$

$$EM_{waste\&wastewater} = \sum \left(\dot{V}_{waste/wastewater} * EF_{waste/wastewater}\right) \quad (2d)$$

$$[EM_{waste\&wastewater}] = \frac{kgCO_{2e}}{yr}$$

$[\dot{V}_{waste/wastewater}] = \frac{kg_{waste/wastewater}}{yr}$; the amount of waste / waste water

$$[EF_{waste/wastewater}] = \frac{kgCO_{2e}}{kg_{waste/wastewater}} \text{ ;}$$

Emissions related to external electricity consumption are calculated by using emission factors. Acceptable source for emission factors are listed in section 7.1.1 of this document.

Feedstock emissions related to agricultural residues such as straw, bagasse, husks, cobs and nut shells as well as processing residues including e.g. crude glycerine are considered to be zero up to the point of their collection.

Emission savings from carbon capture and geological storage is limited to emissions avoided through the capture and sequestration of CO_2 emitted directly within the production chain.

Emission savings from carbon capture and replacement are limited to emissions avoided through the capture of CO_2 originating from biomass and used to replace fossil-derived CO_2 in commercial products or services.

The operator responsible for a specific module passes on GHG information together with the product. The GHG information is to be passed on in kg CO_2e per tonne of main product.

Any allocation of emissions to co-products must take place before the GHG information is passed on into the next module of the supply chain.

Processing: measured values

Actual values for emissions from all processing steps (e_p in the methodology) in the production chain must be measured or based on technical specifications of the processing facility.

When a range of emission values for a group of processing facilities to which the facility concerned belongs to is available, the most conservative emission value of the group shall be used. Thus, no averaging of measured emission values is allowed.

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7.1.1.3 Calculation of emissions from transport and distribution

GHG calculations shall include all transportation steps related to the supply chain. Transportation emissions accounted for inside the cultivation step do not have to be considered here.

For smallholder operators processing palm, as an exception, an estimate of the shares of diesel used in the transportation of fresh fruit bunches to the mill and by generators at the mill can be made in order to undertake actual value calculations. The estimate will be based on relevant industry experience, checked annually and updated as required.

GHG emissions due to distribution of biofuels have to be taken into account. The final operator or interface of the supply chain is responsible for the calculation of distribution emissions. He determines the emissions and states how far the products can be transported considering the fulfillment of the GHG savings thresholds.

Emissions related to fuel depots and fillings stations can be calculated by using BioGrace assumptions for electricity consumption (Table D.3) and region specific emission factors for electricity production. Primary source for the BioGrace values is the Joint Research Centre, JRC (2008): Input data relevant to calculating default GHG emissions from biofuels according to RE Directive Methodology, in the case of electricity consumption at depots and filling stations the original reference is Dautrebande, O., TotalFinaElf, January 2002. JRC values used in BioGrace can be found at:

http://re.jrc.ec.europa.eu/biof/html/input_data_ghg.htm.

Calculation of emissions from transport and distribution are based on equation 3:

$$e_{td} = \frac{s_{distance} * m_{load} * f_{fuel\,consumption} * EF_{fuel}}{m_{intermediate\,product}} \qquad (3a)$$

or $$e_{td} = \frac{s_{distance} * m_{load} * EF_{tkm}}{m_{intermediate\,product}} \qquad (3b)$$

where:

$$[s] = km$$

$$[m] = t$$

$$[f_{fuel\,consumption}] = \frac{kg_{fuel}}{tkm}$$; (tkm = tonne-kilometer)

$$[EF_{fuel}] = \frac{kgCO_{2e}}{kg_{fuel}}$$

$$[EF_{tkm}] = \frac{kgCO_{2e}}{tkm}$$; the emission factor shall reflect the average load of the vehicle i.e. empty return trips have to be included in the emission factor

$$[m_{intermediate product}] = t_{intermediate product}.$$

Emission factors EF come primarily from Annex D, or from sources listed in 7.1.1.

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7.1.1.4 Allocation procedures

Allocation is used to divide GHG emissions between the main product and co-products. The allocation is done in proportion to the lower heating values of the products. Lower heating value or net calorific value takes into account the moisture content of the products. Heating values for only the dry fractions of products are not approved. In case of surplus electricity generation the allocation is to be based on the actual amount of supplied electricity.

Allocation takes place in every module of the supply chain where co-products are formed in addition to the main product which is passed on in the supply chain. All emissions up the point where the specific co-product is separated from the process are allocated between the main product and the co-product based on their lower heating values. The GHG value shall not be passed on in the supply chain before all relevant allocations are done.

Allocation of emissions to residues or wastes is strictly prohibited. If these streams were to be used in any other supply chain they would be considered to have zero emissions up till the point of collection. The material streams which the owner wants or is obligated to get rid of are considered as waste. However; raw materials that have been intentionally modified to be counted as waste (e.g. by adding waste material to a material that was not waste), shall not be considered as qualifying.

The allocation procedures are explained in more detail in Annex B.

7.1.1.5 Ensuring the quality of actual values

The following text describes how Neste Oil ensures the quality of calculated actual values. Similar approach can be used by other producers who intend to use this instruction as a guideline on how to calculate actual GHG values.

Currently, Neste Oil uses actual values for several raw materials, for the company’s own processing units, for certain transportation steps and for emissions related to fuel depots and fillings stations. The quality and accuracy of input data and the calculations made based on this data are verified during systematic third-party audits to ensure the compliance with the requirements of the RED.

In the case of crude palm oil based raw materials, GHG data from a new supplier is verified by GHG experts in Neste Oil. GHG data related to the new consignments from existing suppliers is compared to their earlier GHG data by operators. If there are significant changes, the GHG calculations will be verified again. The same approach will be used in the future regarding to other feedstocks as well; once actual calculations related to the future feedstocks have been made.

When delivering actual values, Neste Oil’s suppliers can use third-party verified GHG-datasheets provided by Neste Oil. An alternative option is that suppliers make the calculations independently, in which cases they have to third-party verify their calculations to ensure that they meet the requirements of the RED.

7.1.2 Use of default values

Default values for the entire supply chain or disaggregated default values for different modules of the supply chain given in RED Annex V, Table D can be used.

It should be noted that the default values are subject to change by the EC. Should the EC make any changes to the default values then these new values will be included in the HVO voluntary scheme latest on the date that the changes are effective from.

7.1.3 Land-use change in GHG emission calculations

Land-use change happening after the cut-off date of January 1, 2008 is taken into account. Land-use data is dealt with separately and taken into account during greenhouse gas calculations by following the rules given in the RED. The rules and land-use change calculations are further described in Annex C. See also Communication from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability scheme and on counting rules for biofuels (2010/C 160/02).

Land-use change is understood as referring to changes in terms of land cover between the six land categories used by the IPCC:

- forest land
- grassland
- cropland
- wetlands
- settlements; and
- other land;

plus a seventh category:

- perennial crops = multi-annual crops whose stem is usually not annually harvested such as short rotation coppice and oil palm (because such land has features of both cropland and forest land).

This means, for example, that a change from grassland to cropland is a land-use change, while a change from one crop (such as maize) to another (such as rapeseed) is not. Cropland includes fallow land (i.e. land set at rest for one or several years before being cultivated again). A change of management activities, tillage practice or manure input practice is not considered land-use change. (2010/C 160/02, Annex II)

The bonus e_B of 29 gCO_2e/MJ biofuel if obtained from restored degraded land according to RED Annex V, C is not yet applicable. Please see Annex C.

For land that may be converted to agricultural use according to RED, the total GHG emissions can be calculated by adding the net GHG emissions due to the land-use change on top of the other emission values. For calculating purposes the land-use category on January 1, 2008 must be determined.

If no land-use change took place after the cut-off date, the land-use change emissions equal zero. Only in this case, the overall default values or default values for cultivation can be applied.

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7.2 Greenhouse gas emission calculations

Rules for calculating the greenhouse gas impact of biofuels and their fossil fuel comparators given in RED directive annex V, C are followed.

Greenhouse gas emissions are calculated by following the equation:

$$\mathbf{E = e_{ec}+e_{l}+e_{p}+e_{td}+e_{u}- e_{sca} - e_{ccs} - e_{ccr}-e_{ee}}$$

E = total emissions from use of the fuel (gCO_2e/MJ)

e_{ec}= emissions from the extraction or cultivation of raw materials

e_{l}= annualised emissions from carbon stock change caused by land-use change

e_{p}= emissions from processing

e_{td}= emissions from transport and distribution

e_{u}= emissions from the fuel in use (shall be taken to be zero)

e_{sca}= emission saving from soil carbon accumulation via improved agricultural management

e_{ccs}= emission saving from carbon capture and geological storage

e_{ccr}= emission saving from carbon capture and replacement

e_{ee}= emission saving from excess electricity from cogeneration

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

By following the calculation rules, the flowchart of supply chain greenhouse gas emissions can be formed - see figure 1.

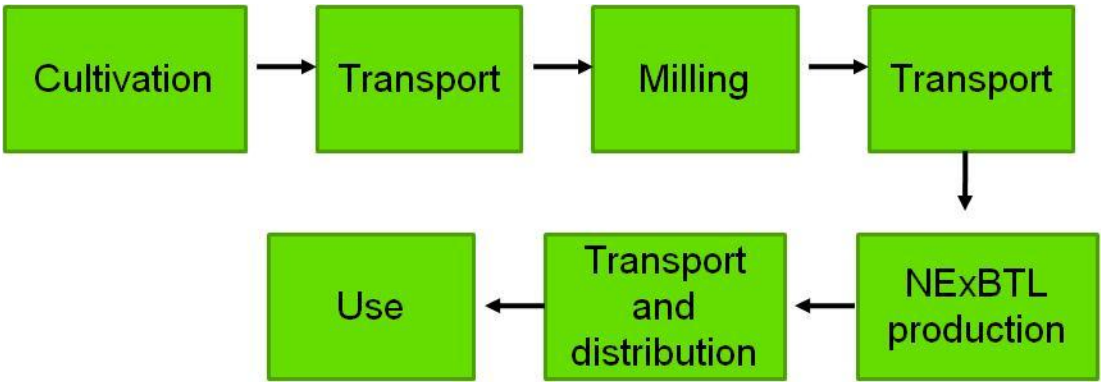

Figure 1. Flowchart of NExBTL supply chain greenhouse gas management

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7.3 Characteristics of GHG values used in Neste Oil's supply chain

In greenhouse gas calculations both actual and default values can be used. As an example the current status (actual or default) of specific values in Neste Oil's supply chains is indicated in the following tables (Table 1 and Table 2) which include both Porvoo and Singapore supply chains.

Table 1. Example of the current status of greenhouse gas values used in NExBTL Porvoo supply chain

Supply chain phase	NExBTL from crude palm oil	NExBTL from rapeseed oil	NExBTL from waste or residues	NExBTL from soybean oil	Comments
Emissions from carbon stock change (land-use change) e_l	No land-use change	No land-use change		No land-use change	All plantations in operation before January 2008
Emissions from raw material cultivation (e_{ec})	Actual value supplier specific cultivation data GHG-sheet for oil palm cultivation and weighted average between estates calculated as instructed in ISCC 205	RED, Annex V, table D default value for HVO		Actual value GHG-sheet for soya cultivation	Supplier specific data for Porvoo supply chain Total cultivation emissions as described in Annex A. If supplier specific data is not available, RED, Annex V, table D default value 15 is used for oil palm cultivation. For rapeseed cultivation the default value is used. First collection point for waste or residues depends on the feedstock type. There are no associated emissions before the transportation from the first collection point.
Emissions from raw material transport to first processing unit (e_{td1})	Actual value supplier specific transport data GHG-sheet for oil palm cultivation	Actual value raw material specific transport data taken from Neste Oil study 2008	Actual value Feedstock specific GHG-sheet for transport	Actual value supplier specific transport data	
Emissions from raw material processing (e_{p1})	Actual value GHG-sheet for crude palm oil milling	Actual Value GHG-sheet for rapeseed oil extraction	Actual Value Feedstock specific GHG-sheet	Actual value GHG-sheet for soybean oil extraction	Actual emissions from oil separation or milling are based on data gathered from producers providing raw material –see section 7.1.1.2.

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Emissions from raw material transport from first processing unit to harbor (e_{td2})	Actual value GHG-sheet for crude palm oil milling		Actual value Feedstock specific GHG-sheet for transport	Actual value GHG-sheet for soybean oil extraction	
Emissions from raw material transport to Europe (e_{td3})	Actual value GHG-sheet for sea transport		Actual value Feedstock specific GHG-sheet for transport	Actual value GHG-sheet for sea transport	Crude palm oil is transported from Malaysia to Rotterdam by big tanker ship and from Rotterdam to Porvoo by smaller tanker ships
Emissions from raw material transport from Europe to Porvoo (e_{td4})	Actual value GHG-sheet for sea transport	Actual value GHG-sheet for sea transport	Actual value Feedstock specific GHG-sheet for transport	Actual value GHG-sheet for sea transport	Rapeseeds are first transported from Europe to Raisio by ship and rapeseed oil is transported from Raisio to Porvoo by truck or ship Crude palm oil is transported from Rotterdam to Porvoo with tanker ships.
Emissions from raw material transport inside Finland (e_{td5})		Actual value GHG-sheet for road transport	Actual value GHG-sheet for road transport		
Emissions from hydrotreatment process in Porvoo plant (e_{p2})	Actual value GHG-sheet for biofuel production at Porvoo	Actual value GHG-sheet for biofuel production at Porvoo	Actual value GHG-sheet for biofuel production at Porvoo	Actual value GHG-sheet for biofuel production at Porvoo	Includes pretreatment, hydrotreatment, hydrogen production and production of relevant process chemicals. Regardless of feedstock, production emissions from this multi-feedstock process are same
Emissions from depots and filling stations to domestic markets (e_{td6})	Actual value GHG-sheet for depots and filling	Actual value GHG-sheet for depots and filling	Actual value GHG-sheet for depots and filling	Actual value GHG-sheet for depots and filling	Includes electricity consumption in fuel depot at Porvoo and any filling station in Finland
Emissions from product transport from Porvoo to European market by ship (e_{td7})	Actual value GHG-sheet for sea transport	Actual value GHG-sheet for sea transport	Actual value GHG-sheet for sea transport	Actual value GHG-sheet for sea transport	Sea transport from Porvoo to Rotterdam
Emissions from depots and filling stations to European markets (e_{td8})	Actual value GHG-sheet for depots and filling	Actual value GHG-sheet for depots and filling	Actual value GHG-sheet for depots and filling	Actual value GHG-sheet for depots and filling	Includes emissions from electricity consumption at fuel depot in Porvoo, import terminal in Rotterdam and filling station in Europe
Emissions from product distribution from Porvoo to domestic markets by truck (e_{td9})	Actual value GHG-sheet for road transport	Actual value GHG-sheet for road transport	Actual value GHG-sheet for road transport	Actual value GHG-sheet for road transport	Road transport from Porvoo

Emissions from product distribution in Europe (e_{td10})	Actual value GHG-sheet for distribution	Actual value GHG-sheet for distribution	Actual value GHG-sheet for distribution	Actual value GHG-sheet for distribution	Includes road transport in Europe, emissions from depots are calculated separately

Table 2. Example of the current status of greenhouse gas values used in NExBTL Singapore supply chain

Supply chain phase	NExBTL from crude palm oil	NExBTL from rapeseed oil	NExBTL from waste or residues	NExBTL from soybean oil	Comments
Emissions from carbon stock change (land-use change) e_l	No land-use change	No land-use change		No land-use change	All plantations in operation before January 2008
Emissions from raw material cultivation (e_{ec})	Actual value supplier specific cultivation data GHG-sheet for oil palm cultivation	RED, Annex V, table D default value		Actual value GHG-sheet for soya cultivation	Supplier specific data for Singapore supply chain. Total cultivation emissions as described in Annex A If supplier specific data is not available or it is not valid, RED, Annex V, table D default value is used for oil palm cultivation. For rapeseed the default values for cultivation and transport are used
Emissions from raw material transport to first processing unit (e_{td1})	Actual value supplier specific transport data GHG-sheet for oil palm cultivation	RED default for transport	Actual value Feedstock specific GHG-sheet for transport	Actual value supplier specific transport data	First collection point for waste or residues depends on the feedstock type. There are no associated emissions before the transportation from the first collection point.
Emissions from raw material processing (e_{p1})	Actual value GHG-sheet for crude palm oil	Actual Value GHG-sheet for rapeseed oil extraction	Actual Value Feedstock specific GHG-sheet	Actual value GHG-sheet for soybean oil extraction	Actual emissions from oil separation or milling are based on data gathered from producers providing raw material –see section 7.1.1.2.
Emissions from raw material transport from first processing unit to harbor (e_{td2})	Actual value GHG-sheet for crude palm oil	RED default for transport of HVO used	Actual value Feedstock specific GHG-sheet for transport	Actual value GHG-sheet for soybean oil extraction	

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Emissions from raw material transport to Singapore (e_{td3})	Actual value GHG-sheet for sea transport	RED default for transport of HVO used	Actual value Feedstock specific GHG-sheet for transport	Actual value GHG-sheet for sea transport	Crude palm oil is transported from different location in Indonesia and Malaysia to Singapore by tanker ships. The transport data calculations were verified during ISCC audit in January 2011. For rapeseed the RED default values for transport and cultivation are used.
Emissions from hydrotreatment process in Singapore plant (e_{p2})	Actual value GHG-sheet for biofuel production at Singapore	Actual value GHG-sheet for biofuel production at Singapore	Actual value GHG-sheet for biofuel production at Singapore	Actual value GHG-sheet for biofuel production at Singapore	Includes pretreatment, hydrotreatment, hydrogen production and production of relevant process chemicals.. Regardless of feedstock, production emissions from this multi-feedstock process are same
Emissions from product transport from Singapore to European market by ship (e_{td4})	Actual value GHG-sheet for sea transport	RED default for transport of HVO used	Actual value GHG-sheet for sea transport	Actual value GHG-sheet for sea transport	Sea transport from Singapore to Rotterdam. Same value as crude palm oil transport from Malaysia to Rotterdam is used.
Emissions from depots and filling stations to European markets (e_{td5})	Actual value GHG-sheet for deports and filling	RED default for transport of HVO used	Actual value GHG-sheet for deports and filling	Actual value GHG-sheet for deports and filling	Includes emissions from electricity consumption at fuel depot in Singapore, import terminal in Rotterdam and filling station in Europe
Emissions from product distribution in Europe (e_{td6})	Actual value GHG-sheet for distribution	RED default for transport of HVO used	Actual value GHG-sheet for distribution	Actual value GHG-sheet for distribution	Road transport in Europe, emissions from depots are calculated separately

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Table 3. Default values for hydrotreated vegetable oils given in the RED annex V.D. The RED also includes other HVO related default values, which can be used.

Supply chain phase	**HVO from crude palm oil** (gCO_2e/MJ)	**HVO from rapeseed oil** (gCO_2e/MJ)	**Comments**
Emissions from carbon stock change (land use change) el	0,00	0,00	All plantations in operation before January 2008
Emissions from raw material cultivation (eec)	15	30	
Emissions from processing (ep)	9-42	13	Default values do not separate raw material processing and biofuel production. For palm oil, default values are linked to milling process. There are two kinds of default values for processing in RED Annex V, depending on crude palm oil milling process. If there is evidence that crude palm oil mill has methane capture in operation, the default for processing is 9 and if process is not specified, the default value for processing is 42.
Emissions from transport (etd)	5	1	Default values do not separate raw material transport and product transport

7.4 Calculating the greenhouse gas savings

The calculation of greenhouse gas savings is done by using the equation given in RED directive Annex V C.

GHG emission savings = $(E_F - E_B)/E_F$

E_F = Total emissions from fossil fuel comparator (83,8 gCO_2e/MJ_{fuel}) (diesel)

E_B = Total emissions from biofuel

7.5 Management of changes

The accuracy and quality of greenhouse gas data is under continuous development. Data sets are checked annually and necessary changes to supply chain values are done by December of the year of checking.

7.6 Development of greenhouse gas data handling

The accuracy and quality of greenhouse gas data related to raw materials is developed together with raw material suppliers. The suppliers’ greenhouse gas data is updated annually and aligned with auditing procedures.

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Annex A. Example of a system boundary for greenhouse gas calculations

System boundary of the NExBTL life cycle inventory can be seen in Figure 3. Production of crude palm oil CPO includes material and energy use, discharges and emissions related to cultivation of fresh fruit bunches (FFB), transport of FFB to conversion mill and production of CPO from FFB at the mill. Production of rapeseed oil (RSO) includes material and energy use, discharges and emissions related to cultivation of rapeseeds, transport of rapeseeds to conversion mill and production of RSO at the mill. Cultivation emission sources include:

- seed production for annual crops
- agrochemicals e.g. fertilizers, pesticides, herbicides, fungicides and rodenticides
- field emissions from fertilizers
- machinery usage, e.g. sowing, planting, harvesting, tillage (fuel consumption)
- other fuel consumption
- electricity consumption, including storage and handling (e.g. drying) of crops

For waste and residues the calculation boundary begins at the transportation from the first collection point.

Energy use and emissions related to the transport of raw materials from conversion sites to Neste Oil's refinery located in Kilpilahti, Porvoo, Finland, are included in the calculations. Crude palm oil is transported by ships to Kilpilahti from Malaysia. Rapeseeds needed in rapeseed oil production are transported from different parts of the European Union to Raisio for processing. Processed rapeseed oil comes by road from Raisio to Pansio. Both are located in Finland. In Pansio rapeseed oil is loaded onto ships and transported to Kilpilahti. Material and energy use and emissions related to building and maintenance of ships and trucks are excluded from the calculations.

Emissions related to electricity consumption at fuel depots and filling stations have been included in the calculations. Calculations for biofuels consumed on domestic (Finland) markets include one depot and biofuels transported to the European markets are assumed to go through two depots, one in Porvoo or Singapore and one in Rotterdam

Data regarding the material and energy use, as well as emissions related to the pretreatment of feedstock and hydrotreatment process itself are generated with the aid of NExBTL production experts. Drying of solid waste from the pretreatment is included in the calculations. Dry-waste is transported by truck to a different site to be used for energy conversion, which is excluded from the calculations.

The production of hydrogen plays an important role. Hydrogen production process is the main source of fossil CO_2 emission during the biofuel production at Kilpilahti. Therefore material and energy use and emissions from the production of hydrogen are included in the emission calculations. Main process chemicals are also included in the calculations.

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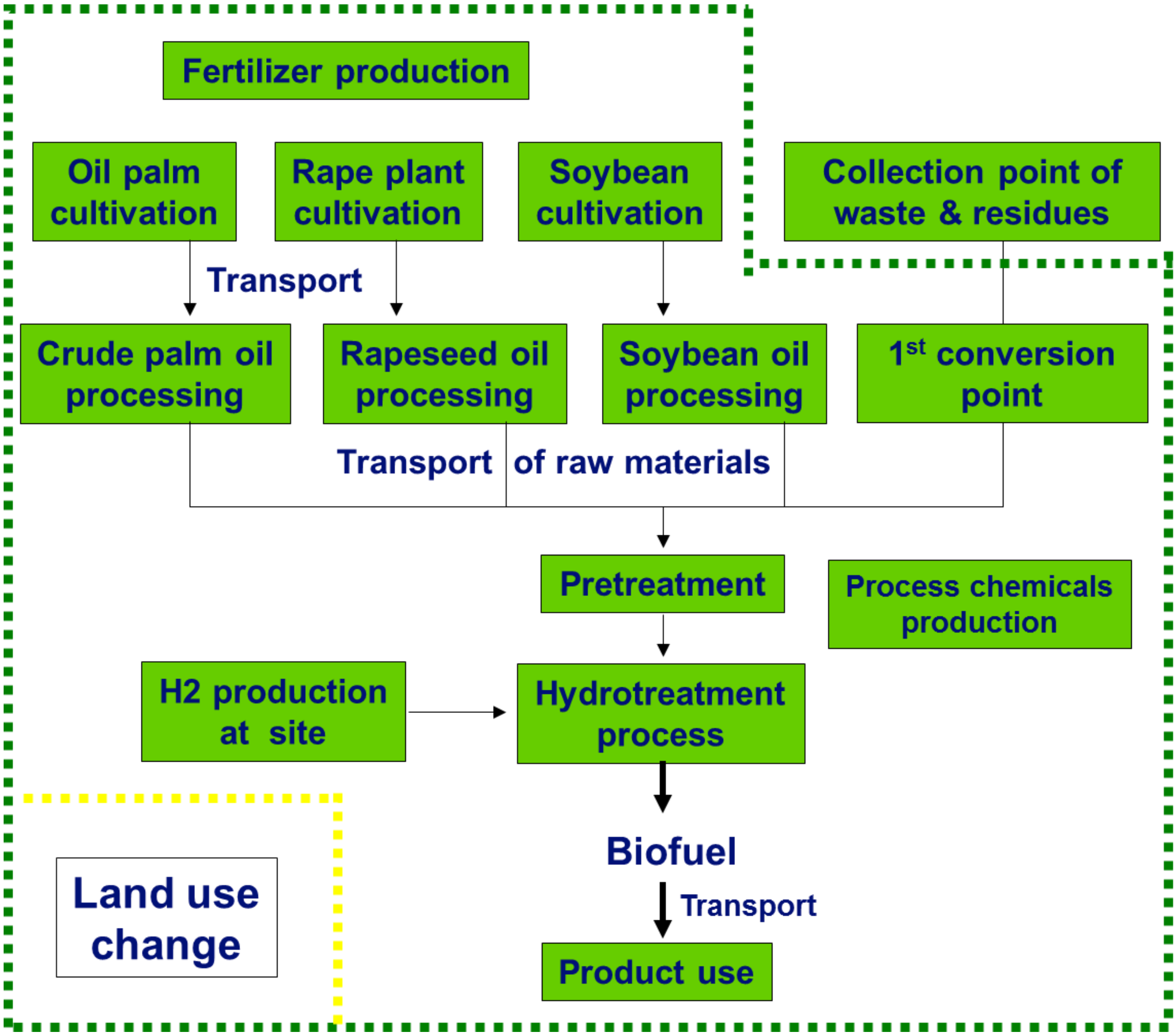

Figure 3*. System boundary of NExBTL life cycle inventory (green dotted-line). Land-use change emissions are calculated case-by-case when necessary. If the land-use has not changed after January 1, 2008 the land-use change emission calculations are not needed (yellow dotted-line).*

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Annex B. Allocation procedures used in greenhouse gas calculations

RED demands the use of energy allocation, which is required also by this instruction. The allocation shall be based on the lower heating values (LHV) of products and co-products. The lower heating values shall represent the entire (co-)product and not only the dry fraction. The below mentioned LHVs can be used for the respective products.

LHVs related to crude palm oil processing are:

- Crude palm oil (CPO) 39,3 MJ/kg
- Palm Kernel (PK) 21,1 MJ/kg

Source: Malaysian Energy Information Bureau, Renewable Energy Resource, Anders Evald et al.
As a major palm oil producer Malaysia has firsthand knowledge related to palm oil. Therefore, the above lower heating values are preferred.

LHVs related to biofuel production are:

- Renewable diesel (NExBTL) 44,09 MJ/kg
- Biogasoline or bionaphtha 44,87 MJ/kg
- Refinery Biogas or biofuel gas 50,00 MJ/kg

Source: Neste Oil ETS Reporting, third-party verified

- Hydrogen 120 MJ/kg

Source: Statistics of Finland, Fuel Classification and Emission Coefficients 2011

B.1. Allocations done during the supply chain

B.1.1 Allocations in raw material cultivation and processing

In the raw material cultivation and processing the allocation procedures follow material and energy flows along the biofuel supply chain. If wastes related to raw material production are left outside the supply chain, no emissions or other environmental impacts are to be allocated to the waste streams. If process or subsystem creates co-products or wastes which are used in the same subsystem or in a previous subsystem of the same supply chain, no environmental impacts are to be allocated to these co-products or waste fractions.

Allocations related to palm oil
The processing of crude palm oil (CPO) produces palm kernels (PK) as a co-product. Kernels are further used to extract palm kernel oil (PKO). The extraction of PKO is outside of the system boundaries of the greenhouse gas calculations. This is due to the fact that palm kernel oil extraction is done at a separate production facility on a different site. The allocation means that a part of the emissions and discharges of oil palm cultivation and crude palm oil production is to be allocated to palm kernels leaving the system boundaries. The allocation is done based on the energy contents of products and co-products.

Allocation factors are calculated by using the following equations:

$$Allocation\ factor\,(CPO) = \frac{m_{CPO} * LHV_{CPO}}{m_{PK} * LHV_{PK} + m_{CPO} * LHV_{CPO}} \qquad \text{(B1)}$$

$$Allocation\ factor\,(PK) = \frac{m_{PK} * LHV_{PK}}{m_{PK} * LHV_{PK} + m_{CPO} * LHV_{CPO}} \quad \text{(B2)}$$

where:

$$[m] = \frac{kg}{yr}$$

$$[LHV] = \frac{MJ}{kg}$$; Lower heating value

The information above is based on actual data from suppliers. However, if palm kernel oil extraction is done at the same site as the milling, then emissions are to be allocated between palm kernel meal, palm kernel oil and crude palm oil. Lower heating values for palm kernel meal and palm kernel oil can be taken from external data sources as described in section 7.1.1 of this document.

The allocation factor shall be calculated by using actual data from mills. As a reference it can be stated that Schmidt (Schmidt 2007)* has calculated that processing 1 t FFB produces 0,1998 t CPO and 0,0532 t PK. By using LHVs for CPO and PK presented in Annex B of this instruction, the allocation gives a ratio of 0,875 for crude palm oil. This means that 12,5% of discharges and emissions would be allocated to PK and 87,5 % of discharges and emissions to CPO.

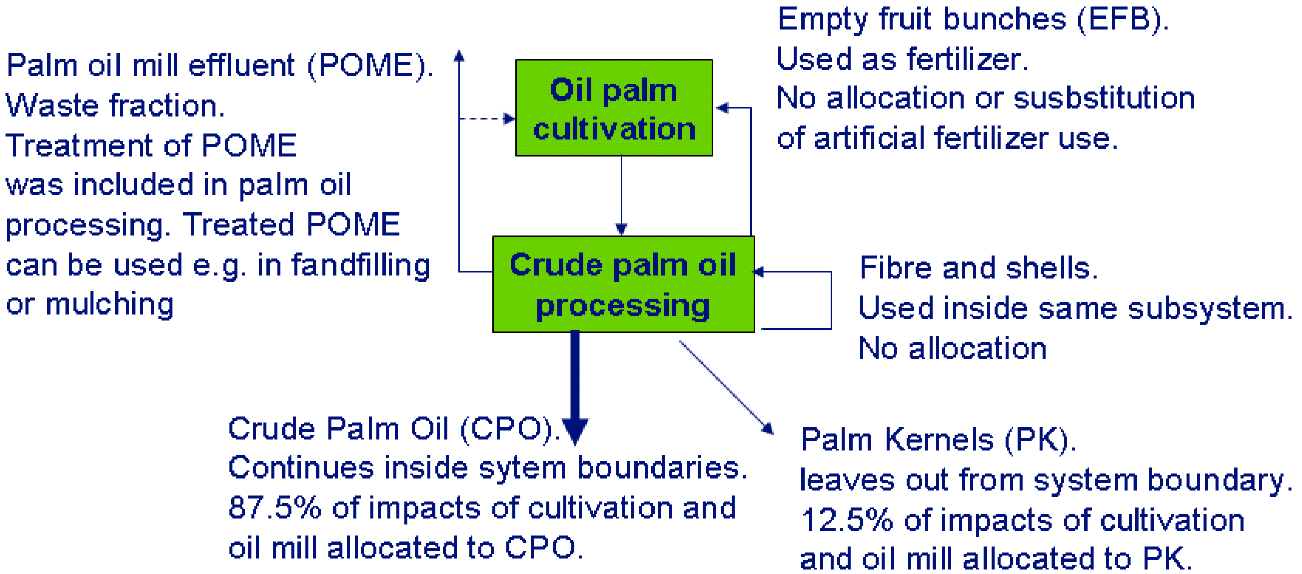

Figure 4. *Allocation procedure of crude palm oil cultivation and processing, data related to the operation of CPO mill is from Schmidt 2007.*

*Schmidt 2007, Life cycle assessment of rapeseed oil and palm oil, Ph.D. thesis, Part 3: Life cycle inventory of rapeseed oil and palm oil, Jannick H Schmidt, Department of Development and Planning, Aalborg University. Version for the assessment committee

B.1.2 Allocations in biofuel production

Currently, three different outputs from the hydrotreatment process can be identified. In addition to renewable diesel, biofuel gas and bionaphtha are formed.

Biofuel gas and bionaphtha can be used inside the system boundaries in which case the renewable diesel or NExBTL would be the only product leaving the system boundaries. In this case all emissions are allocated to the renewable diesel.

The biofuel gas which is comparable to refinery gases can be utilised in combined heat and power production, replacing natural gas as a fuel. If the generated electricity exceeds the consumption of the biofuel production unit, and this electricity leaves the system boundary, as a co-product, then part of the total emissions can be allocated to the excess electricity in proportion to the energy content of the electricity and other (co-)products.

The above allocation rule does not apply for CHP electricity when the CHP runs on fossil fuels, bioenergy other than a co-product of the biofuel production process or agricultural crop residues. Instead, a credit due to the surplus electricity generation can be calculated. The credit e_{ee}, in gCO_2e/MJ, is calculated by multiplying the excess electricity produced el_{ee} with a BioGrace standard value for CHP electricity production:

$$e_{ee} = el_{ee} * SV_{CHP} \qquad \text{(B3)}$$

where:

$[el_{ee}] = MJ$ of excess electricity

$SV_{CHP} = BioGrace\ S\tan dard\ Value\ \ for\ CHP$; see table D.4.

The chosen standard value has to reflect the life cycle emissions attributable to the production of electricity from the same type of fuel in a conventional power plant

If the CHP plant supplies heat to other customers besides the biofuel producer, before calculating the credit, size of the CHP should be notionally reduced to a size that is just sufficient to cover the heat requirements of the biofuel process.

If biofuel gas and bionaphtha are sold as transportation fuels and are therefore leaving the system boundary, they will be regarded as co-products. Total emissions of the entire production chain shall be allocated to all (co-)products according to their respective energy content.

When outputs are considered as co-products the allocation has to be done according to the energy contents of the respective products. Lower heating values for bionaphtha and refinery biogas can be found from Annex B of this instruction.

This calculation methodology supports the allocation of emission to other biofuel fractions as well; if these fractions are produced during the HVO process. One example could be the aviation biofuel. However, LHVs of the different biofuel fractions for allocation purposes have to be based on verified information as described in section 7.1.1.

The picture below illustrates how the three different outputs have been treated at one of Neste Oil's production units. The calculated carbon intensity of the renewable diesel production process is not feedstock dependent. In other words; the same value for processing is used for all feedstocks.

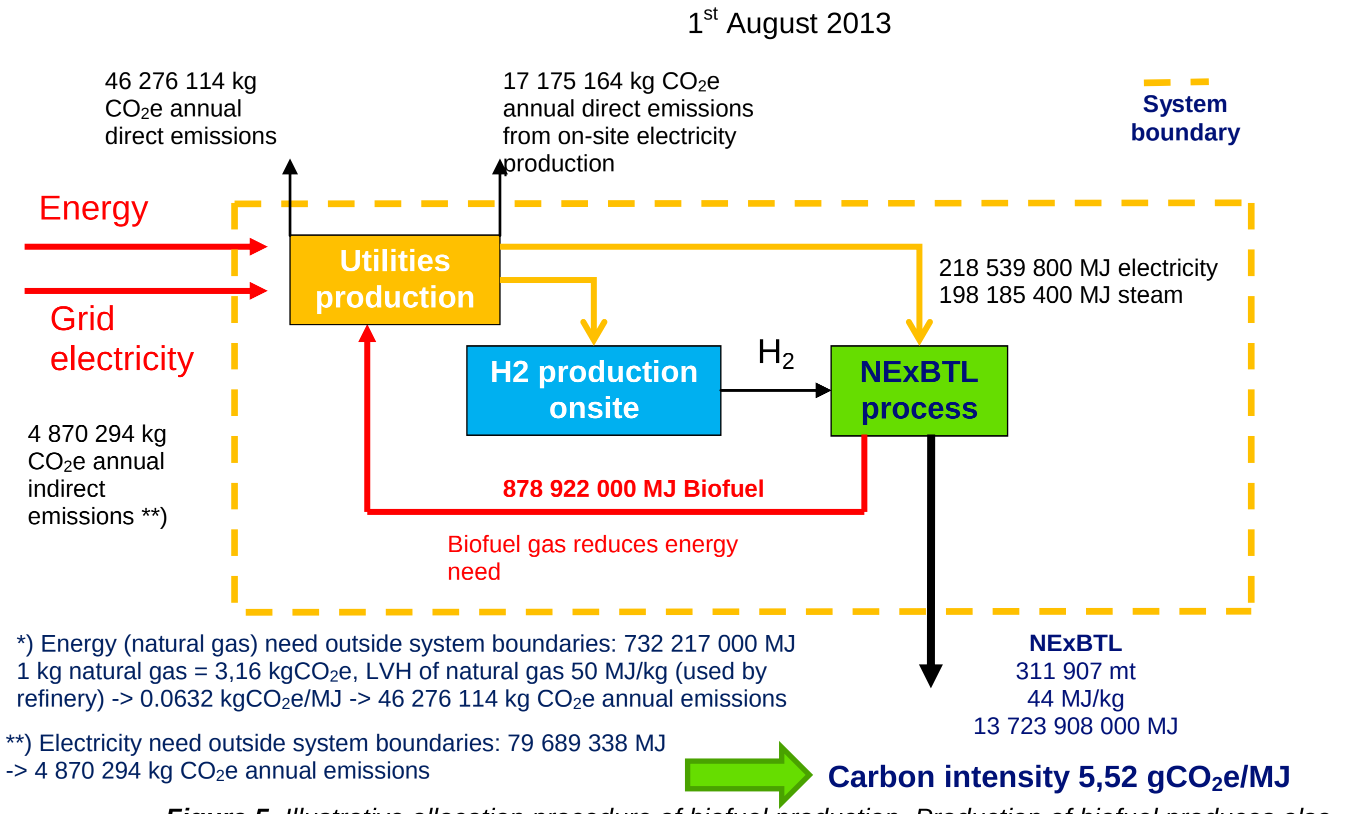

***Figure 5**. Illustrative allocation procedure of biofuel production. Production of biofuel produces also biofuel gas and bionaphtha. Biofuel gas is used as an energy source inside system boundaries and no emissions are allocated to it. Using the refinery biogas reduces fossil energy need outside of system boundaries. Bionaphtha is lead to conventional gasoline production of a nearby refinery. This gasoline reduces the fossil energy need in the gasoline production, but no emissions are allocated to the bionaphtha fraction. All emissions are allocated to the renewable diesel product. Total GHG emissions of NExBTL production in the example case are 5,5 gCO_2e/MJ NExBTL.*

Annex C. Land use change calculation

The calculation of emissions from land-use change are instructed to be done according to the following guidelines: (RED, Annex V, C, point 7)

Annualised emissions from carbon stock changes caused by land-use change, e_l , shall be calculated by dividing total emissions equally over 20 years. For the calculation of those emissions the following rule shall be applied:

- $e_l = (CS_R – CS_A) \times 3{,}664 \times 1/20 \times 1/P – e_B$ *(C1)*
    - The quotient obtained by dividing the molecular weight of CO_2 (44,010 g/mol) by the molecular weight of carbon (12,011 g/mol) is equal to 3,664.,

where
- e_l =annualised greenhouse gas emissions from carbon stock change due to land-use change (measured as mass of CO_2 -equivalent per unit biofuel energy),
- CS_R =the carbon stock per unit area associated with the reference land use (measured as mass of carbon per unit area, including both soil and vegetation). **The reference land use shall be the land use in January 2008 or 20 years before the raw material was obtained, whichever was the later;**
- CS_A =the carbon stock per unit area associated with the actual land use (measured as mass of carbon per unit area, including both soil and vegetation). In cases where the carbon stock accumulates over more than one year, the value attributed to CS_A shall be the estimated stock per unit area after 20 years or when the crop reaches maturity, whichever the earlier;

- P =the productivity of the crop (measured as biofuel or bioliquid energy per unit area per year); and
- e_B =bonus of 29 gCO_2e/MJ biofuel if biomass is obtained from restored degraded land under the conditions (a) and (b) listed below**. Definitions for “degraded land” are not yet available from the EC. Until such a time as the definition of degraded land is finalised, the Commission is unable to recognise allocation of the 29gCO_2/MJ biofuel bonus for degraded land (e_B). This bonus cannot be included in GHG calculations before the EC can provide necessary definitions.**
  (a) the land was not in use for agriculture or any other activity in January 2008; and
  (b) the land falls into one of the following categories:
    (i) severely degraded land, including such land that was formerly in agricultural use;
    (ii) heavily contaminated land.
- The bonus of 29 gCO_2e/MJ shall apply for a period of up to 10 years from the date of conversion of the land to agricultural use, provided that a steady increase in carbon stocks as well as a sizable reduction in erosion phenomena for land falling under (i) are ensured and that soil contamination for land falling under (ii) is reduced.
- The categories referred to in point (b) are defined as follows:
- ‘severely degraded land’ means land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded;
- ‘heavily contaminated land’ means land that is unfit for the cultivation of food and feed due to soil contamination.
- Such land shall include land that has been the subject of a Commission decision in accordance with the fourth subparagraph of Article 18(4).

The land use change needs to be calculated, if there has been land use change after January 1st 2008. If the raw material estate has been in operation before that date the value of change in soil carbon stock will be 0 gCO_2e/MJ.

Commission Decision of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC, (2010/335/EU), establishes rules for the calculation of land carbon stocks, completing the rules laid down in the Annex V. The rules established in 2010/335/EU include the calculation of land carbon stocks, both for the reference land use (CS_R , as defined in point 7 of Annex V to RED) and the actual land use (CS_A , as defined in point 7 of Annex V to RED) –see equation below.

CALCULATION OF CARBON STOCKS (2010/335/EU)

For the calculation of CS_R and CS_A the following rule shall apply:

$$CS_i = (SOC + C_{VEG}) \times A \qquad \text{(C2)}$$

where:
CS_I = the carbon stock per unit area associated with the land use i (measured as mass of carbon per unit area, including both soil and vegetation);

SOC = soil organic carbon (measured as mass of carbon per hectare), calculated in accordance with point 4;

C_{VEG} = above and below ground vegetation carbon stock (measured as mass of carbon per hectare), calculated in accordance with point 5 or selected from the appropriate values in point 8;

A = factor scaling to the area concerned (measured as hectares per unit area), EN L 151/22 Official Journal of the European Union 17.6.2010.

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Annex D. List of emission factors

The below presented emissions factors have been drawn from different sources. The origin of an individual emission factor is stated in the right most column of the table. Please note that these emission factors are subjected to change. These emission factors will be updated according to any possible changes made to the original sources.

***Table D.1**. Co-efficient factors related to oil palm cultivation*

Description	Co-efficient factor	Origin
Agro chemical production		
N-fertilizer production	5,8806 kg CO_2e per kg nutrient	BioGrace Standard Values, Version 4
P-fertilizer production (P_2O_5)	1,0107 kg CO_2e per kg nutrient	
K_2O-fertilizer production	0,5761 kg CO_2e per kg nutrient	
CaO-fertilizer production	0,1295 ka CO_2e per kg nutrient	
Pesticides, rodenticides and herbicides production	10,9713 kg CO_2e per kg substance	
Borate fertilizer production (sodium borate)	0,085096 kg CO_2e per kg nutrient	Ecoinvent database, IPCC 2007, GWP 20
Mg-fertilizer production (MgO)	1,0689 kg CO_2e per kg nutrient	Ecoinvent database, IPCC 2007, GWP 20
$ZnSO_4$-fertilizer production ($ZnSO_4$)	1,9978 kg CO_2e per kg	Ecoinvent database, IPCC 2007, GWP 20
Field emissions from agro chemical use		
N_2O from N fertilizer use as a CO_2e	6,16 kg CO_2e per kg nutrient applied	IPCC Guidance 2006 Tier 1. GHG emissions caused by N_2O are calculated by multiplying amount of used N in fertilizer by N_2O co-efficient of 0.01325 kg N_2O/kg N
Emissions from electricity and energy use		
CO_2 from machinery use	3,1 kgCO_2e per litre diesel fuel	JEC (2006). Well-to-wheels analysis of future automotive fuels and powertrains in the European context. Well to wheels report. CONCAWE, EUCAR and JRC.
CO_2 from grid electricity consumption in Indonesia	0,9 kgCO_2e/kWhel	ISCC emission factors, ISCC 11-05-15, V 2.3-EU. Calculations based on information according to composition of Indonesian electricity mix, LCI information of energy carriers taken from Ecoinvent, 2010
CO_2 from grid electricity consumption in Malaysia	0,89 kgCO_2e/kWhel	ISCC emission factors, ISCC 11-05-15, V 2.3-EU. IFEU, 2009; Ableitung von Defaultwerten für Anlage 2 der NachVBioSt für flüssige Biobrennstoffe, die in Anhang V der EE-RL nicht aufgeführt sind.

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Table D.2. Greenhouse gas co-efficient factors related to palm oil processing

Description	Co-efficient factor	Origin
CO_2e from diesel use	3,1 $kgCO_2e$ per litre diesel fuel	JEC (2006). Well-to-wheels analysis of future automotive fuels and powertrains in the European context. Well to wheels report. CONCAWE, EUCAR and JRC.
CO_2 from grid electricity consumption in Malaysia	0,89 $kgCO_2e/kWh_{el}$	ISCC emission factors, ISCC 11-05-15, V 2.3-EU. IFEU, 2009; Ableitung von Defaultwerten für Anlage 2 der NachVBioSt für flüssige Biobrennstoffe, die in Anhang V der EE-RL nicht aufgeführt sind.
POME open pond treatment	12,12 $kgCH_4$/t POME = 278,77 $kgCO_2e$/t POME	Methane emissions calculated based on POME composition (e.g. fats, fibres and proteins) and assumption of total anaerobic degradation according to stoichiometry. Ideal gas law used for mass – volume conversion.
POME open pond treatment (if amount of POME is not measured)	0,51 $kgCO_2e$/kg CPO	ISCC emission factors, ISCC 11-05-15, V 2.3-EU, BLE, 2010, Guideline Sustainable Biomass Production

Table D.3. Co-efficient factors related to transportation and distribution

Description	Co-efficient factor	Origin
CH_4 (road) Liquid products	0,00094 gCH_4/tkm	VTT LIPASTO 2006, Emissions of liquid fuel distribution http://lipasto.vtt.fi/liisa/index.htm
CO_2 (road) Liquid products	72 gCO_2/tkm	VTT LIPASTO 2006, Emissions of liquid fuel distribution http://lipasto.vtt.fi/liisa/index.htm
N_2O (road) Liquid products	0,002 gN_2O/tkm	VTT LIPASTO 2006, Emissions of liquid fuel distribution http://lipasto.vtt.fi/liisa/index.htm
CO_2e (road) Liquid products	72,61 gCO_2e/tkm	Calculated from the above (VTT LIPASTO 2006), using co-efficient factors from table D.5.
CO_2e (road) SE Asia	155,52 gCO_2e/tkm	Energy consumption of transport is estimated according to WBSCD/IEA (2004) Transport spreadsheet mode – Mobility 2030 Project. IEA/OECD and WBSCD by using value “Other Asia” 1,8 MJ/t-km. GHG emissions o FFB transport from field to mill are calculated by multiplying amount of use of energy (MJ) by co-efficient factor (0,0864) kgCO2e/MJ diesel. Source RTFO.
CO_2e (road) Dry products	80,87 gCO_2e/tkm	Fuel consumption of dry truck is 0,936 MJ/tkm, BioGrace Standard Values Version 4. GHG emissions are calculated by multiplying the fuel consumption with emission factor of 0,0864 kgCO2e/MJ diesel. Source RTFO.
CH_4 (sea)	0,3 $kgCH_4$/t fuel	IMO http://unfccc.int/files/methods_and_science/emissions_from_intl_transport/application/pdf/imoghgmain.pdf
CO_2 (sea)	3170 $kgCO_2$/t fuel	IMO http://unfccc.int/files/methods_and_science/emissions_from_intl_transport/application/pdf/imoghgmain.pdf
N_2O (sea)	0,08 kgN_2O/t fuel	IMO http://unfccc.int/files/methods_and_science/emissions_from_intl_transport/application/pdf/imoghgmain.pdf
CO_2e (sea)	3201 gCO_2e/t fuel	Calculated from the above (IMO), using co-efficient factors from table D.5.

Diesel consumption of oceanic tanker, smaller than 150kt	1,55 g/tkm	Tanker oceanic ETH U (ETH-ESU) data from early 1990´s gives value 1,8 g/tkm and is not ship specific. Transoceanic tanker/OCE (ecoinvent 2004) gives value 1,3 g/tkm and is specific to tankers 150 000 t capacity. Average of the two values can be used for oceanic tankers smaller than 150kt.
Electricity consumption at fuel depot	0,00084 MJ/MJ_{fuel}	BioGrace/JRC, Dautrebande O., TotalFinaElf 2002
Electricity consumption at filling station	0,0034 MJ/MJ_{fuel}	BioGrace/JRC, Dautrebande O., TotalFinaElf 2002

Table D.4 *Co-efficient factors related to biofuel processing*

Description	**Co-efficient factor**	**Origin**
Phosphoric acid production	3,0117 $kgCO_2e/kg$ chemical	BioGrace Standard Values, Version 4
Citric acid production	3,0117 $kgCO_2e/kg$ chemical	BioGrace Standard Values, Version 4 (value for sulphuric acid) Lack of data concerning citric acid
Sulphuric Acid	0,2077 $kgCO_2e/kg$ chemical	BioGrace Standard Values, Version 4
Sodium hydroxide production, NaOH	0,4693 $kgCO_2e/kg$ chemical	BioGrace Standard Values, Version 4
Silica production	0,29257 $kgCO_2e/kg$ chemical	Ecoinvent database, IPCC 2007, GWP 20
Bleaching earth	0,1997 $kgCO_2e/kg$ chemical	BioGrace Standard Values, Version 4
CO_2 from grid electricity use in Finland	220 $kgCO_2e/MWh$	Motiva http://www.motiva.fi/en/ http://www.motiva.fi/files/209/Laskentaohje_CO2_kohde_040622.pdf
CO_2 from grid electricity use in Singapore	536,1 $kgCO_2e/MWh$	The World Resource Institute (WRI) Singapore 0,5361 kg/kWh http://www.ghgprotocol.org/ calculation-tools/all-tools
CHP (NG CCGT) credit due to surplus electricity	125,16 gCO_2e/MJ	BioGrace Standard Values, Version 4b
CHP (Lignite ST) credit due to surplus electricity	287,73 gCO_2e/MJ	BioGrace Standard Values, Version 4b
CHP (Straw) credit due to surplus electricity	5,72 gCO_2e/MJ	BioGrace Standard Values, Version 4b

Table D.5*. Greenhouse gas emission factors for CO_2, CH_4 and N_2O*

Description	**Co-efficient factor**	**Origin**
CO_2	1	RED 2009/28/EC, Annex V, C, point 5
CH_4	23	RED 2009/28/EC, Annex V, C, point 5
N_2O	296	RED 2009/28/EC, Annex V, C, point 5