CLEAN DEVELOPMENT MECHANISM

AM0089

Large-scale Methodology

Production of diesel using a mixed feedstock of gasoil and vegetable oil

Version 03.0

Sectoral scope(s): 05, 13 and 15

United Nations
Framework Convention on
Climate Change

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1. Introduction

1. The following table describes the key elements of the methodology:

Table 1. Methodology key elements

Typical project(s)	Production of petro/renewable diesel by switching the feedstock of hydrodesulphurization process (HDS) unit from 100 % gasoil to a mixture of gasoil and vegetable oil in an existing refinery, where the vegetable oil comes from oilseeds from plants that are cultivated on dedicated plantations established on lands that are degraded or degrading at the start of the project
Type of GHG emissions mitigation action	• Renewable energy; • Feedstock switch; • Displacement of more-GHG-intensive feedstock for the production of diesel.

2. Scope, applicability, and entry into force

2.1. Scope

2. This methodology applies to project activities that produce petro/renewable diesel, by switching the feedstock from 100% gasoil to a mixture of gasoil and vegetable oil in an existing refinery.

2.2. Applicability

3. The methodology is applicable under the following conditions:

(a) Production of petro/renewable diesel:

(i) The project activity is carried out in a refinery that was producing only petrodiesel and no renewable diesel during the last three years prior to the start of the project activity. Under the project activity, the feedstock of the hydrodesulphurization process (HDS) unit is changed from 100 % gasoil to a mixture of gasoil and vegetable oil in the production of diesel. In case the project activity is introduced in new HDS unit, the project participants must have historical data of three years prior to the implementation of CDM project activity related to the petrodiesel produced by the refinery and the existing HDS unit;

(ii) The energy consumption in the HDS unit under the project activity is lower or equal to the baseline scenario;

(iii) Natural gas[1] is used as feedstock and fuel to produce hydrogen (H_2) in both the baseline scenario and under the project activity;

[1] The project participants can request for the revision of this methodology if they use different types of fuel in project scenario than baseline scenario and use other types of fuel than natural gas.

(iv) Under the project activity, any combustible gases and off-gases formed during the hydrogenation of vegetable oil are flared and/or used in the refinery as fuel.

(b) Consumption of petro/renewable diesel:

(i) The petro/renewable diesel produced under the project activity is not exported to the Annex I country;

(ii) Only petro/renewable diesel consumed in excess of mandatory regulations is eligible for the purpose of the project activity.[2]

4. In addition, the applicability conditions included in the tools referred to below shall apply.

5. Finally, the methodology is only applicable if the most plausible baseline scenario, as identified per the section “Selection of the baseline scenario and demonstration of additionality” hereunder, is:

(a) For production of diesel (P): scenario P1; and

(b) For land used for plantations (L): scenario L1.

2.3. Entry into force

6. The date of entry into force is the date of the publication of the EB 113 meeting report on 11 March 2022.

3. Normative references

7. This baseline and monitoring methodology is based on the following approved baseline and monitoring methodologies and proposed new methodologies:

(a) ACM0017 “Production of biodiesel for use as fuel” (hereinafter referred as ACM0017);

(b) NM0312 “Production of diesel using a mixed feedstock of gasoil and vegetable oil at the inlet of Hydrotreatment Units” prepared by Alberto Pasqualini REFAP S.A.

8. This methodology also refers to the latest approved versions of the following tools:

(a) “TOOL01: Tool for the demonstration and assessment of additionality” (hereinafter referred as “TOOL01”);

(b) “TOOL06: Project emissions from flaring” (hereinafter referred as “TOOL06”);

(c) “TOOL15: Upstream leakage emissions associated with fossil fuel use” (hereinafter referred as “TOOL15”);

(d) “TOOL16: Project and leakage emissions from biomass” (hereinafter referred as “TOOL16”);

[2] Regulations that have been implemented since the adoption by the COP of the CDM M&P (decision 17/CP.7, 11 November 2001) need not be taken into account.

(e) “TOOL25: Apportioning emissions from production processes between main product and co and by-product” (hereinafter referred as “TOOL25”).

9. For more information regarding the proposed new methodologies and the tools as well as their consideration by the Executive Board please refer to < http://cdm.unfccc.int/methodologies/PAmethodologies/approved >.

3.1. Selected approach from paragraph 48 of the CDM modalities and procedures

10. “Existing actual or historical emissions, as applicable”.

3.2. Applicability of sectoral scopes

11. For validation and verification of CDM projects and programme of activities by a designated operational entity (DOE) using this methodology, the following sectoral scopes are mandatory:

(a) If biofuel is produced from biomass residues as a feedstock for:

(i) Stationary applications, then sectoral scope 5 and 1 apply;

(ii) Transportation, then sectoral scopes 5 and 7 apply.

(b) If biofuel is produced from anything other than biomass residues as a feedstock for:

(i) Stationary applications, then sectoral scopes 1, 5 and 15 apply;

(ii) Transportation, then sectoral scopes 5, 7 and 15 apply.

4. Definitions

12. The definitions contained in the Glossary of CDM terms shall apply.

13. For the purpose of this methodology, the following definitions apply:

(a) **Biogenic** - means that the oils and/or fats originate from either vegetable or animal biomass, but not from mineral (fossil) sources;

(b) **Dedicated plantations** - plantations that are newly established as part of the project activity for the purpose of supplying oils seeds to project activity;

(c) **Degraded or degrading lands** - lands that can be identified as degraded or degrading as per the “Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities”;

(d) **Refinery** - a plant which produces petrodiesel and/or renewable diesel from gasoil or vegetable oil;

(e) **Existing refinery** - a refinery which started commercial operation at least three years prior to the start of the CDM project activity;

(f) **Gasoil** - a mixture of middle distillates from various refinery streams for example: heavy and light atmospheric distillate and fluid catalytic cracking middle distillate

(light cycle oil or coking gasoil) that constitute the feedstock for the hydrodesulphurization (HDS) unit;

(g) **Hydrodesulphurization process (HDS)** - the process that consists of the addition of hydrogen to gasoil at high pressure and high temperature using a catalyst. This process, traditionally used in oil refineries for removal of sulphur, nitrogen, olefins and aromatic compounds from gasoil by means of several kinds of reactions, is also suitable for carrying out vegetable oil hydrogenation;

(h) **Petrodiesel** - diesel produced only from petroleum sources, such as gasoil;

(i) **Petrodiesel HS** - petrodiesel with high sulphur content;

(j) **Petrodiesel LS** - petrodiesel with low sulphur content;

(k) **Petro/renewable diesel** - the mixture of petrodiesel and renewable diesel and is produced through the hydrogenation of vegetable oil along with gasoil carried out in operating oil refineries, and with the same technical specification, according to national norms and regulations, to the diesel oil;

(l) **Renewable diesel** - fuel produced through hydrogenation of vegetable oil;

(m) **Vegetable oil** - oil of biogenic origin that is produced from oil seeds from plants.

5. Baseline methodology

5.1. Project boundary

14. The **spatial extent** of the project boundary encompasses:

(a) The HDS plant;

(b) The hydrogen production plant;

(c) The vegetable oil production plant(s);

(d) The dedicated plantations.

15. Simplified diagrams of the baseline scenario and project activity are presented in Figures 1 and 2.

Figure 1. Baseline Scenario

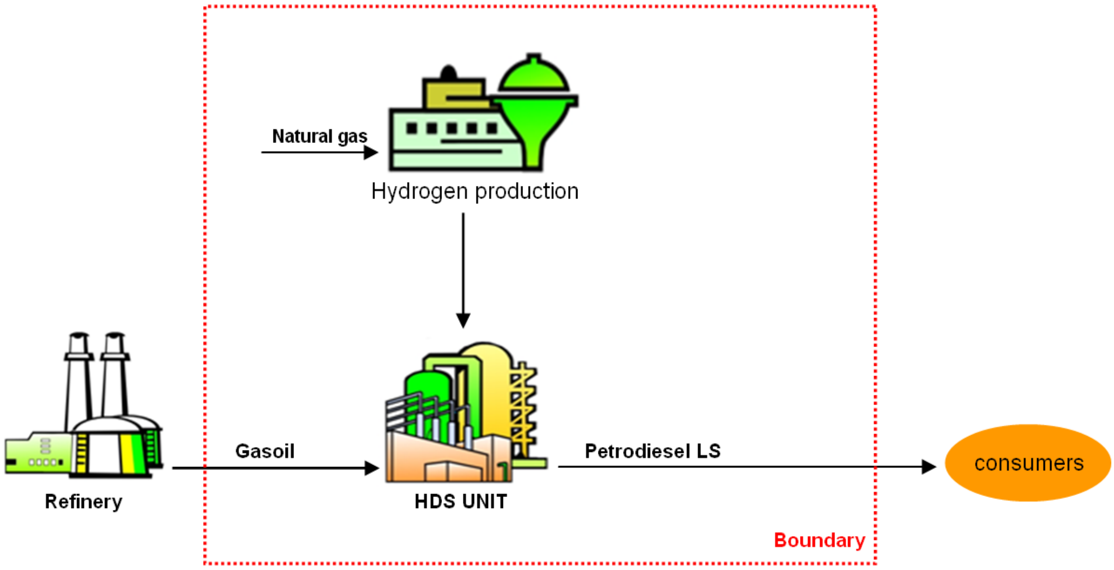
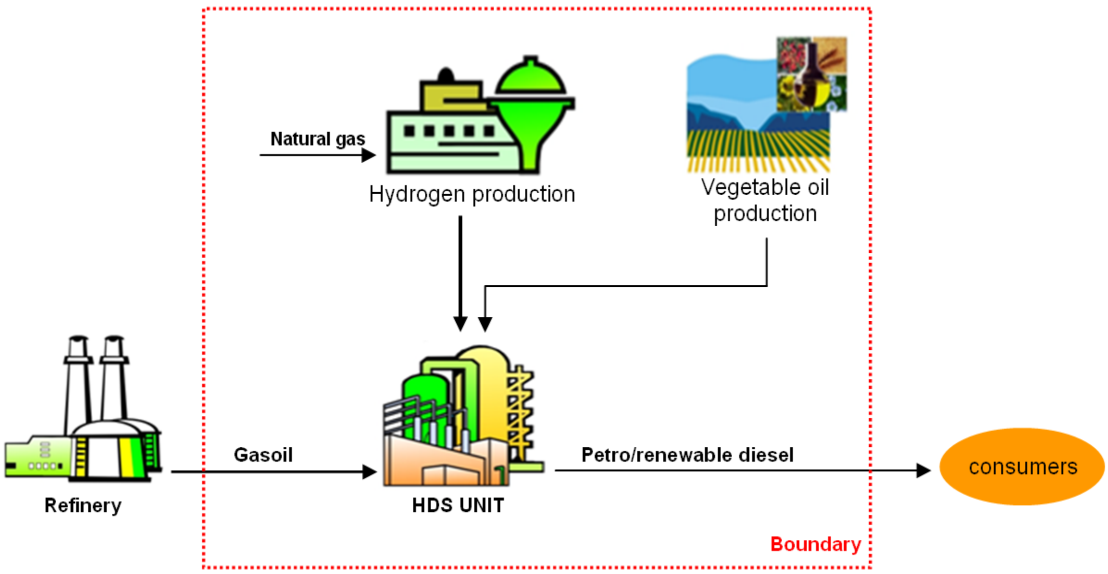


Figure 2. Project activity



16. The greenhouse gases included in or excluded from the project boundary are shown in Table 2.

Table 2. Emission sources included in or excluded from the project boundary

Source		Gas	Included	Justification/Explanation
Baseline	Consumption of petrodiesel	CO_2	Yes	Main emission source
		CH_4	No	Excluded for simplification. This is conservative

Source		Gas	Included	Justification/Explanation
		N_2O	No	Excluded for simplification. This is conservative
Project activity	Production of excess hydrogen (H_2)	CO_2	Yes	Main emission source
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
	Transportation of oil seeds and vegetable oil	CO_2	Yes	Main emission source
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
	Energy consumption for production of vegetable oil	CO_2	Yes	Main emission source
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
	Anaerobic treatment of wastewater from the production of vegetable oil	CO_2	No	Excluded for simplification
		CH_4	Yes	Main emission source
		N_2O	No	Excluded for simplification
	Cultivation of land to produce oil seeds in dedicated plantations	CO_2	Yes	Main emission source
		CH_4	Yes	Main emission source
		N_2O	Yes	Main emission source

5.2. Selection of the baseline scenario and demonstration of additionality

17. The baseline scenario should be separately determined for the following elements:

(a) Production of diesel (P); and

(b) Land used for plantations (L).

18. For the **production of diesel (P)**, the baseline scenario should be determined as follows:

5.2.1. Step 1.1: Identify all realistic and credible alternatives for the production of diesel

19. Project participants should at least consider the following alternatives with respect to the production of diesel, inter alia:

(a) P1: Production of diesel from 100% gasoil in the existing refinery and the existing HDS unit;

(b) P2: Production of diesel from different mix of vegetable oil and gasoil than project activity;

(c) P3: The proposed project activity not undertaken as a CDM project activity.

5.2.2. Step 1.2: Eliminate alternatives that are not complying with applicable laws and regulations

20. Eliminate alternatives that are not in compliance with all applicable legal and regulatory requirements. Apply Sub-step 1b of the latest version of the TOOL01.

5.2.3. Step 1.3: Compare economic attractiveness of remaining alternatives

21. Compare the economic attractiveness for all the remaining alternatives by applying Step 2 of the latest version of the TOOL01. Provide all the assumptions in the CDM-PDD.

22. Include a sensitivity analysis applying Sub-step 2d of the latest version of the TOOL01. If the sensitivity analysis is conclusive (for a realistic range of assumptions), then the most cost effective scenario is the baseline scenario. In case the sensitivity analysis is not fully conclusive, select the baseline scenario alternative with least emissions among the alternatives that are the most economically attractive according to the investment analysis and the sensitivity analysis.

23. For the **land use where the dedicated plantations are established (L)**, the baseline scenario should be determined as follows:

5.2.4. Step 2.1: Identify all realistic and credible alternatives for the land use

24. Project participants should at least consider the following alternatives with respect to the baseline scenario for the use of the land where the dedicated plantations are established, inter alia:

    (a) L1: Continuation of current land use;

    (b) L2: Conversion to another plantation (annual or perennial);

    (c) L3: Conversion to oil plant plantations without CDM.

5.2.5. Step 2.2: Eliminate alternatives that are not complying with applicable laws and regulations

25. Eliminate alternatives that are not in compliance with all applicable legal and regulatory requirements. Apply Sub-step 1b of the latest version of the TOOL01.

5.2.6. Step 2.3: Eliminate alternatives that face prohibitive barriers

26. Scenarios that face prohibitive barriers (e.g. technical barrier) should be eliminated by applying Step 3 of the latest version of the TOOL01.

5.2.7. Step 2.4: Compare economic attractiveness of remaining alternatives

27. Compare the economic attractiveness for all the remaining alternatives by applying Step 2 of the latest version of the TOOL01. Provide all the assumptions in the CDM-PDD.

28. Include a sensitivity analysis applying Sub-step 2d of the latest version of the TOOL01. If the sensitivity analysis is conclusive (for a realistic range of assumptions), then the most cost effective scenario is the baseline scenario. In case the sensitivity analysis is not fully conclusive, select the baseline scenario alternative with least emissions among the alternatives that are the most economically attractive according to the investment analysis and the sensitivity analysis.

29. The project participants should demonstrate that the most plausible scenario is the “continuation of current land use (L1)”, by assessing the attractiveness of the plausible alternative land uses in terms of benefits to the project participants, consulting with stakeholders for existing and future land use, and identifying barriers for alternative land

uses. This can be done by demonstrating that similar lands in the vicinity are not planned to be used for alternative land uses other than L1. Show that apparent financial and/or other barriers, which prevent alternative land uses can be identified.

5.3. Additionality

30. The additionality of the project activity shall be demonstrated and assessed using the latest version of the TOOL01.

31. Where Step 2 of the TOOL01 (Investment Analysis) is used, the investment analysis shall include a sensitivity analysis of the petro/renewable diesel sales price, the feedstock costs and fuel costs.

5.3.1. Guidance for the Barriers Analysis when the dedicated plantation (or part of) is covered under an A/R CDM project activity

32. If the A/R CDM activity and the activity covering the production, sale and consumption of petro/renewable diesel are two independent project activities (which may imply also that project proponents are different) then:

    (a) A barrier related to the implementation of the plantation cannot be used for the project activity covering the production, sale and consumption of petro/renewable diesel;

33. If the A/R CDM project activity and the project activity covering the production, sale and consumption of petro/renewable diesel are part of an integrated development project (which means that the same project proponents are to be involved in the two CDM activities) then:

    (a) A barrier related to the implementation of the plantation can also be used by the production, sale and consumption of petro/renewable diesel.

34. Investment in the establishment of dedicated plantations must be considered, whether or not the establishment of such plantations is part of an A/R CDM project activity, if there is no market for the oil seeds. By definition, tCERs from A/R CDM activities, whose plantations are part of the project activity, implemented under this methodology and CERs accruing from CDM project activities under this methodology must not be included in the investment analysis performed in order to identify the baseline scenario.

5.4. Emission reductions

35. Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \text{Equation (1)}$$

Where:

ER_y	=	Emission reductions in year *y* (tCO_2)
BE_y	=	Baseline emissions in year *y* (tCO_2)
PE_y	=	Project emissions in year *y* (tCO_2)
LE_y	=	Leakage emissions in year *y* (tCO_2)

5.5. Baseline emissions

36. Baseline emissions include the emissions associated with the consumption of petrodiesel by the consumers which is displaced by the use of renewable diesel. The baseline emissions are calculated as follows:

$$BE_y = Q_{VO,y} \times R_{RD} \times d_{RD} \times NCV_{PD,y} \times EF_{CO2,PD} \times 10^{-6}$$ Equation (2)

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2)
$Q_{VO,y}$	=	Amount of vegetable oil fed to HDS unit in year *y* (m^3)
R_{RD}	=	Ratio between the amount of renewable diesel produced per vegetable oil fed into the HDS unit (m^3 renewable diesel / m^3 vegetable oil)
d_{RD}	=	Density of renewable diesel (tonne/m^3)
$NCV_{PD,y}$	=	Average net calorific value of petrodiesel in year *y* (MJ/tonne)
$EF_{CO2,PD}$	=	CO_2 emission factor of petrodiesel (tCO_2/TJ)

5.6. Project emissions

37. Project emissions are calculated as follows:

$$PE_y = PE_{Biomass,y} + PE_{H2,y}$$ Equation (3)

Where:

$PE_{Biomass,y}$	=	Project emissions associated with the biomass and biomass residues in year *y* (t CO_2)
$PE_{H2,y}$	=	Project emissions due to the excess hydrogen production in year *y* (tCO_2)

5.6.1. Determination of $PE_{Biomass,y}$

38. $PE_{Biomass,y}$ shall be determined by applying the provisions form the TOOL16 and involve the following emission sources:

(a) Project emissions resulting from the cultivation of biomass in a dedicated plantation if the biofuel is produced from feedstock that is cultivated in dedicated plantations (e.g. seeds) (PE_{BC});

(b) Project emissions resulting from the transportation of biomass (e.g. oil seeds) to from the cultivation site to the biomass processing facility (e.g. oil production plant(s)/mill(s)), and from the transportation of biomass (e.g. vegetable oil, waste oil/fats) from the biomass processing facility to the HDS unit (PE_{BT});

(c) Project emissions resulting from the biomass processing facility (e.g. the oil production plant(s) and/or mill(s)) (PE_{BP});

39. Where applicable, project emissions associated with the cultivation of land are allocated between the different products produced from the plants expressed through the allocation factor AF_y. The allocation factors are estimated as per the TOOL25.

$$PE_{Biomass,y} = PE_{BP,y} + PE_{BT,y} + \left(AF_y \times PE_{BC,y}\right) \quad \text{Equation (4)}$$

Where:

$PE_{BP,y}$	=	Project emissions resulting from the biomass processing facility and from the biodiesel production plant (tCO_2e)
$PE_{BT,y}$	=	Project emissions resulting from the transportation of biomass from the cultivation site to the biomass processing facility, and from the biomass processing facility to the biodiesel production plant (tCO_2e)
$PE_{BC,y}$	=	Project emissions resulting from the cultivation of biomass in a dedicated plantation (tCO_2e)

40. Project participants may alternatively choose a simplified approach to calculate $PE_{BC,y}$ using conservative **default values** for the emissions associated with the cultivation of lands. This approach can only be used for **palm or jatropha** based on the equation below:

$$PE_{BC,y} = \sum_{s} A_{s,y} \times EF_{s,y} \quad \text{Equation (5)}$$

Where:

$PE_{BC,y}$	=	Project emissions associated with the cultivation of land to produce biomass feedstock in year *y* (tCO_2)
$A_{s,y}$	=	Area in which feedstock type *s* is cultivated for use in the project plant in year *y* (ha)
$EF_{s,y}$	=	Default emission factor for the GHG emissions associated with the cultivation of land to produce feedstock type *s* (tCO_2e/ha). See Table 3 below for available values

Table 3. Conservative default emission factors for the GHG emissions associated with the cultivation of land to produce biomass feedstock

Feedstock type *s*	**Tropical Moist[3]**	**Tropical Wet[3]**
Palm	1.87 tCO_2e/ha	1.87 tCO_2e/ha
Jatropha	1.76 tCO_2e/ha	2.52 tCO_2e/ha

[3] See Appendix 2.

5.6.2. Determination of $PE_{H2,y}$

41. The project emission due to the excess hydrogen production shall include:

(a) The emissions due to the fossil fuel (in this case natural gas) combusted to produce excess hydrogen required to process vegetable oil in the HDS unit;

(b) The emissions due to the chemical reaction that forms the excess hydrogen required to process vegetable oil in the HDS unit.

42. The project emission due to the excess hydrogen production shall be calculated as follows:

$$PE_{H2,y} = PE_{NG,H2,y} + PE_{CO2,H2,y}$$ Equation (6)

Where:

$PE_{H2,y}$	=	Project emissions due to the excess hydrogen production in year *y* (tCO_2)
$PE_{NG,H2,y}$	=	Project emissions due to natural gas combusted to produce excess hydrogen required to process vegetable oil in the HDS unit in year *y* (tCO_2)
$PE_{CO2,H2,y}$	=	Project emissions due to the chemical reaction that forms the excess hydrogen required to process vegetable oil in the HDS unit in year *y* (tCO_2)

5.6.2.1. Determination of $PE_{NG,H2,y}$

43. Project emissions due to natural gas combusted to produce excess hydrogen required to process vegetable oil in the HDS unit shall be calculated as follows:

$$PE_{NG,H2,y} = VR_{H2,Es,y} \times r_{E,H2} \times EF_{CO2,NG} \times 10^{-6}$$ Equation (7)

Where:

$PE_{NG,H2,y}$	=	Project emissions due to natural gas combusted to produce H_2 required by the HDS unit during the year *y* (tCO_2)
$VR_{H2,Es,y}$	=	Volume of excess H_2 required in the HDS unit in year *y* (Nm^3 H_2)
$r_{E,H2}$	=	Rate of energy consumption for H_2 production (MJ/Nm^3 H_2)
$EF_{CO2,NG}$	=	CO_2 emission factor of natural gas consumed (tCO_2/TJ)

5.6.2.2. Determination of $VR_{H2,Es,y}$

$$VR_{H2,Es,y} = VC_{H2,y} - \left[Q_{PRD,y} \times \frac{\sum_{x=1}^{3} VC_{H2,x}}{\sum_{x=1}^{3} Q_{PD,x}}\right]$$ Equation (8)

Where:

$VR_{H2,Es,y}$	=	Volume of excess H_2 required in the HDS unit in year *y* (Nm^3 H_2)
$VC_{H2,y}$	=	Volume of H_2 consumed in the HDS unit in the year *y* (Nm^3 H_2)
$Q_{PRD,y}$	=	Total amount of petro/renewable diesel produced by the project activity in year *y* (m^3)

$VC_{H2,x}$	=	Volume of H_2 consumed in the HDS unit in year x (Nm^3 H_2)
$Q_{PD,x}$	=	Amount of petrodiesel produced in year x (m^3)
x	=	The most recent three years prior to the implementation of the project activity

5.6.2.3. Determination of $r_{E,H2}$

$$r_{E,H2} = \frac{\sum_{x=1}^{3} FC_{NG,H2,x} \times NCV_{NG,x}}{\sum_{x=1}^{3} VP_{H2,x}}$$ Equation (9)

Where:

$r_{E,H2}$	=	Rate of energy consumption for H_2 production (MJ/Nm^3 H_2)
$FC_{NG,H2,x}$	=	Amount of natural gas consumed as fuel for H_2 production in year x (Nm^3)
$NCV_{NG,x}$	=	Net calorific value of natural gas combusted in year x (MJ/Nm^3)
$VP_{H2,x}$	=	Volume of H_2 produced in the H_2 production facility in year x (Nm^3 H_2)
x	=	The most recent three years prior to the implementation of the project activity

5.6.2.4. Determination of $PE_{CO2,H2,y}$

44. Project emissions due to the chemical reaction that forms the excess hydrogen required to process vegetable oil in the HDS unit shall be determined as follows:

$$PE_{CO_2,H_2,y} = F \times VR_{H_2,Es,y} \times 10^{-6}$$ Equation (10)

With

$$F = 490.6 \times \eta_{H_2,react,y}$$ Equation (11)

Where:

$PE_{CO2,H2,y}$	=	Project emissions due to the chemical reaction that forms the excess hydrogen required to process vegetable oil in the HDS unit in year y (tCO_2)
F	=	Factor used to relate the volume of H_2 produced to the mass of CO_2 emitted in the reaction (gCO_2/Nm^3 H_2), refer to Appendix 2
$VR_{H2,Es,y}$	=	Volume of excess H_2 required in the HDS unit in year y (Nm^3 H_2)
$\eta_{H2,react,y}$	=	Reaction efficiency of H_2 formation in year y

5.7. Leakage

45. Leakage emissions (LE_y) include the upstream emissions of excess natural gas required for the production of hydrogen and the positive leakage associated with the avoided production of petrodiesel.

46. Leakage emissions in year *y* (LE_y) shall be determined using the latest version of the TOOL15 where $LE_{US,y}$ *refers to* LE_y, $FC_{PJ,x,y}$ refers to $Q_{NG,Es,y}$ and $FC_{BL,x,y}$ refers to $Q_{RD,y}$ in this methodology.

47. Where total net leakage effects from upstream emissions are negative ($LE_y < 0$), project participants should assume $LE_y = 0$.

5.7.1. Determination of $Q_{NG,Es,y}$

$$Q_{NG,Es,y} = VR_{H_2,Es,y} \times \frac{\sum_1^3 \left(Q_{NG,FS,x} + FC_{NG,H_2,x}\right)}{\sum_1^3 VP_{H_2,x}}$$ Equation (12)

Where:

$Q_{NG,Es,y}$	=	Amount of excess of natural gas used as feedstock and fuel for H_2 production between baseline scenario and project activity in year *y* (Nm^3)
$VR_{H2,Es,y}$	=	Volume of excess H_2 required in the HDS unit in year *y* (Nm^3 H_2) (Calculated following the equation 6 above)
$Q_{NG,FS,x}$	=	Amount of natural gas used as feedstock for H_2 production in year *x* (Nm^3)
$FC_{NG,H2,x}$	=	Amount of natural gas consumed as fuel for H_2 production in year *x* (Nm^3)
$VP_{H2,x}$	=	Volume of H_2 produced in the H_2 production facility in year *x* (Nm^3 H_2)
x	=	The most recent years prior to the implementation of the project activity

5.7.2. Determination of $Q_{RD,y}$

$$Q_{RD,y} = Q_{VO,y} \times R_{RD} \times d_{RD}$$ Equation (13)

Where:

$Q_{RD,y}$	=	Amount of renewable diesel (tonnes)
$Q_{VO,y}$	=	Amount of vegetable oil fed to HDS unit in year *y* (m^3)
R_{RD}	=	Ratio on volume basis of renewable diesel produced to vegetable oil fed to in the HDS unit (determined by carrying out a mass balance around the HDS unit or a laboratory test using relevant national or international standards)
d_{RD}	=	Density of renewable diesel ($tonne/m^3$)

5.8. Data and parameters not monitored

48. In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

Data / Parameter table 1.

Data / Parameter:	R_{RD}
Data unit:	m^3 renewable diesel / m^3 vegetable oil
Description:	Ratio between the amount of renewable diesel produced per vegetable oil fed into the HDS unit
Source of data:	Onsite measurements and calculations by the project participants
Measurement procedures (if any):	This parameter is to be determined by carrying out a mass balance around the HDS unit or a laboratory test using relevant national or international standards

Monitoring frequency:	This parameter is determined once and fixed throughout the crediting period
QA/QC procedures:	
Any comment:	

Data / Parameter table 2.

Data / Parameter:	d_{RD}
Data unit:	tonne/m³
Description:	Density of renewable diesel
Source of data:	Onsite measurements and calculations by the project participants
Measurement procedures (if any):	This parameter is to be estimated from (i) the density of the petrodiesel, (ii) the density of the petro/renewable diesel, and (iii) the volume fraction of renewable diesel (obtained by multiplying $Q_{VO,y}$ and R_{RD}) against petrodiesel (obtained by running the HDS unit only with gasoil)
Any comment:	This parameter is determined once and fixed throughout the crediting period

Data / Parameter table 3.

Data / Parameter:	$EF_{CO2,PD}$
Data unit:	tCO_2/TJ
Description:	CO_2 emission factor of petrodiesel
Source of data:	IPCC default value at the lower limit of the confidence interval with 95% confidence level, as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 4.

Data / Parameter:	$EF_{CO2,i}$
Data unit:	tCO_2/TJ
Description:	CO_2 emissions factor for fossil fuel type *i*

<table>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table><tr><th>Data source</th><th>Conditions for using the data source</th></tr><tr><td>(a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source</td></tr><tr><td>(b) Measurements by the project participants</td><td>If a) is not available</td></tr><tr><td>(c) Regional or national default values</td><td>If a) is not available.
These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances)</td></tr><tr><td>(d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If a) is not available</td></tr></table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>For (a) and (b): Measurements should be undertaken in line with national or international fuel standards</td></tr>
<tr><td>Any comment:</td><td>-</td></tr>
</table>

Data / Parameter table 5.

Data / Parameter:	$VC_{H2,x}$
Data unit:	Nm^3
Description:	Volume of H_2 consumed in the HDS unit in year *x*
Source of data:	Plant historical data
Measurement procedures (if any):	Flow meter at the inlet of the unit
Any comment:	-

Data / Parameter table 6.

Data / Parameter:	$Q_{PD,x}$
Data unit:	m^3
Description:	Amount of petrodiesel produced in year *x*
Source of data:	Plant historical data
Measurement procedures (if any):	Flow meter at the outlet of the unit
Any comment:	-

Data / Parameter table 7.

Data / Parameter:	$FC_{NG,H2,x}$
Data unit:	Nm^3
Description:	Amount of natural gas consumed as fuel for H_2 production in year *x*
Source of data:	Plant historical data
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 8.

<table>
<tr><td>Data / Parameter:</td><td>$NCV_{NG,x}$</td></tr>
<tr><td>Data unit:</td><td>MJ/Nm^3</td></tr>
<tr><td>Description:</td><td>Net calorific value of natural gas combusted in year x</td></tr>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>(a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source</td></tr>
<tr><td>(b) Measurements by the project participants</td><td>If a) is not available</td></tr>
<tr><td>(c) Regional or national default values</td><td>If a) is not available.
These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances)</td></tr>
<tr><td>(d) IPCC default values at the upper limit of the confidence interval with 95% confidence level, as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If a) is not available</td></tr>
</table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>For (a) and (b): Measurements should be undertaken in line with national or international fuel standards</td></tr>
<tr><td>Any comment:</td><td>-</td></tr>
</table>

Data / Parameter table 9.

Data / Parameter:	$VP_{H2,x}$
Data unit:	Nm^3
Description:	Volume of H_2 produced in the H_2 production facility in year *x*
Source of data:	Plant historical data

Measurement procedures (if any):	Flow meter at the outlet of the facility
Any comment:	-

Data / Parameter table 10.

Data / Parameter:	GWP_{CH4}
Data unit:	tCO_2/tCH_4
Description:	Global warming potential of methane
Source of data:	IPCC
Measurement procedures (if any):	Default to be applied: 21 for the first commitment period
Any comment:	This parameter shall be updated according to any future COP/MOP decisions

Data / Parameter table 11.

<table>
<tr><th>Data / Parameter:</th><th>EF_{CO2,NG}</th></tr>
<tr><td>Data unit:</td><td>tCO_2/TJ</td></tr>
<tr><td>Description:</td><td>CO_2 emission factor of natural gas consumed</td></tr>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>(a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source</td></tr>
<tr><td>(b) Measurements by the project participants</td><td>If (a) is not available</td></tr>
<tr><td>(c) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If (a) is not available</td></tr>
</table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>For (a) and (b): Measurements should be undertaken in line with national or international fuel standards</td></tr>
<tr><td>Any comment:</td><td>-</td></tr>
</table>

Data / Parameter table 12.

Data / Parameter:	$Q_{NG,FS,x}$
Data unit:	Nm^3
Description:	Amount of natural gas used as feedstock for H_2 production in year *x*
Source of data:	Plant historical data

Measurement procedures (if any):	Flow meter at the inlet of the facility for feedstock
Any comment:	-

6. Monitoring methodology

49. Describe and specify in the CDM-PDD all monitoring procedures, including the type of measurement instrumentation used and the responsibilities for monitoring and QA/QC procedures that will be applied. Where the methodology provides different options (e.g. use of default values or on-site measurements), specify which option will be used. Meters should be installed, maintained and calibrated according to equipment manufacturer instructions and be in line with relevant standards. If such standards are not available, use national standards. If a national standard is not available, then use international standards.

50. All monitoring should be attended to by appropriate and adequate personnel, as assessed by the project developer. All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last crediting period. 100% of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards. In addition, the monitoring provisions in the tools referred to in this methodology apply.

6.1. Data and parameters monitored

Data / Parameter table 13.

Data / Parameter:	$Exp_{PRD,An-I}$
Data unit:	-
Description:	Export of the petro/renewable diesel to Annex I country
Source of data:	Sales records from the project participants
Measurement procedures (if any):	The DOE should verify that the petro/renewable diesel produced under the project activity are not exported to the Annex I country throughout the crediting period
Monitoring frequency:	-
QA/QC procedures:	-
Any comment:	The source of verification can be based on mass balance or sales records

Data / Parameter table 14.

Data / Parameter:	$NCV_{PD,y}$
Data unit:	MJ/tonne
Description:	Average net calorific value of petrodiesel in year *y*

<table>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table><tr><td>Data source</td><td>Conditions for using the data source</td></tr><tr><td>(a) Measurements by the project participants</td><td>This is the preferred source</td></tr><tr><td>(b) Regional or national default values</td><td>If (a) is not available.
These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances)</td></tr><tr><td>(c) IPCC default values at the upper limit of the confidence interval with 95% confidence level, as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If (a) is not available</td></tr></table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>For (a): Measurements should be undertaken in line with national or international fuel standards</td></tr>
<tr><td>Monitoring frequency:</td><td>For (a): Monthly, averaged for the year.
For (b) and (c): Annually</td></tr>
<tr><td>QA/QC procedures:</td><td>Verify that the values under (a) and (b) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values out of this range, collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in (a) or (b) should have ISO17025 accreditation or justify that they can comply with similar quality standards</td></tr>
<tr><td>Any comment:</td><td>-</td></tr>
</table>

Data / Parameter table 15.

Data / Parameter:	$Q_{VO,y}$
Data unit:	m^3
Description:	Amount of vegetable oil fed to HDS unit in year *y* (m^3 VO)
Source of data:	Onsite measurements by the project participants
Measurement procedures (if any):	The volume of vegetable oil fed into HDS unit shall be monitored by the flow meter at the inlet of the unit
Monitoring frequency:	Continuously, data is presented as hourly average
QA/QC procedures:	The flow meter will be calibrated according to the suppliers' specifications and following the refinery QA/QC procedures
Any comment:	In case the production of renewable/petrodiesel is seasonal, such parameter will be monitored continuously only when vegetable oil is introduced in the HDS unit

Data / Parameter table 16.

Data / Parameter:	$NCV_{NG,y}$
Data unit:	MJ/Nm³
Description:	Average net calorific value of the natural gas combusted in year *y*
Source of data:	The following data sources may be used if the relevant conditions apply: **Data source** / **Conditions for using the data source**: (a) Values provided by the fuel supplier in invoices — This is the preferred source (b) Measurements by the project participants — If (a) is not available (c) Regional or national default values — If (a) is not available. These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances) (d) IPCC default values at the upper limit of the confidence interval with 95% confidence level, as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories — If (a) is not available
Measurement procedures (if any):	For (a) and (b): Measurements should be undertaken in line with national or international fuel standards

Monitoring frequency:	For (a): Each batch of fuel supplied, averaged for the year.
	For (b): Monthly, averaged for the year.
	For (c) and (d): Annually

QA/QC procedures:	Verify that the values under (a), (b) and (c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values out of this range, collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in (a), (b) or (c) should have ISO17025 accreditation or justify that they can comply with similar quality standards
Any comment:	-

Nested table in "Source of data":

Data source	Conditions for using the data source
(a) Values provided by the fuel supplier in invoices	This is the preferred source
(b) Measurements by the project participants	If (a) is not available
(c) Regional or national default values	If (a) is not available. These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances)
(d) IPCC default values at the upper limit of the confidence interval with 95% confidence level, as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If (a) is not available

Data / Parameter table 17.

Data / Parameter:	$VC_{H2,y}$
Data unit:	Nm^3
Description:	Volume of H_2 consumed in the HDS unit in the year *y*
Source of data:	Onsite measurements by the project participants

Measurement procedures (if any):	The volume of H_2 consumed in the HDS unit shall be monitored by the flow meter at the inlet of the unit
Monitoring frequency:	Continuously, data is presented as hourly average
QA/QC procedures:	The flow meter will be calibrated according to the suppliers' specifications and following the refinery QA/QC procedures
Any comment:	In case the production of petro/renewable diesel is seasonal, such parameter will be monitored continuously only when vegetable oil is introduced in the HDS unit

Data / Parameter table 18.

Data / Parameter:	$Q_{PRD,y}$
Data unit:	m^3
Description:	Total amount of petro/renewable diesel produced by the project activity in year *y* (m^3)
Source of data:	Onsite measurements by the project participants
Measurement procedures (if any):	Total amount of petro/renewable diesel produced shall be monitored by the flow meter at the outlet of the HDS unit
Monitoring frequency:	Continuously, data is presented as hourly average
QA/QC procedures:	The flow meter will be calibrated according to the suppliers' specifications and following the refinery QA/QC procedures
Any comment:	In case the production of petro/renewable is seasonal, such parameter will be monitored continuously only when vegetable oil is introduced in the HDS unit

Data / Parameter table 19.

Data / Parameter:	$\eta_{H2,react,y}$
Data unit:	Fraction
Description:	Reaction efficiency of H_2 formation in year *y*
Source of data:	Default factor or onsite measurements by the project participants
Measurement procedures (if any):	The project participants can use a conservative default value of 1 or can calculate it considering the stoichiometry of the reaction to produce H_2 and the actual amount of end products obtained and document transparently in the CDM-PDD. Measurements should be undertaken in line with national or international standards
Monitoring frequency:	Monthly
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 20.

Data / Parameter:	$NCV_{i,y}$
Data unit:	MJ/tonne
Description:	Net calorific value of fossil fuel type *i* in year *y*

<table>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table><tr><td>Data source</td><td>Conditions for using the data source</td></tr><tr><td>(a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source</td></tr><tr><td>(b) Measurements by the project participants</td><td>If (a) is not available</td></tr><tr><td>(c) Regional or national default values</td><td>If (a) is not available.
These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances)</td></tr><tr><td>(d) IPCC default values at the upper limit of the confidence interval with 95% confidence level, as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If (a) is not available</td></tr></table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>For (a) and (b): Measurements should be undertaken in line with national or international fuel standards</td></tr>
<tr><td>Monitoring frequency:</td><td>For (a): Each batch of fuel supplied, averaged for the year.
For (b): Monthly, averaged for the year.
For (c) and (d): Annually</td></tr>
<tr><td>QA/QC procedures:</td><td>Verify that the values under (a), (b) and (c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values out of this range, collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in (a), (b) or (c) should have ISO17025 accreditation or justify that they can comply with similar quality standards</td></tr>
<tr><td>Any comment:</td><td>-</td></tr>
</table>

Data / Parameter table 21.

Data / Parameter:	$A_{s,y}$
Data unit:	ha
Description:	Area in which oil seed type *s* is cultivated for use in the project plant in year *y*
Source of data:	Onsite measurements by the project participants
Measurement procedures (if any):	Measure the area in which oil seed type *s* is cultivated for each plantations and use the largest area among all the plantations in year *y* for this parameter
Monitoring frequency:	Each plantation

QA/QC procedures:	-
Any comment:	-

Data / Parameter table 22.

Data / Parameter:	AF_y
Data unit:	Fraction
Description:	Allocation factor for the oil seeds cultivation in year *y*
Source of data:	-
Measurement procedures (if any):	Estimated as per the TOOL25
Monitoring frequency:	Annually
QA/QC procedures:	-
Any comment:	-

Appendix 1. Determination of factor F in the production of Hydrogen

1. Fuel is combusted to supply energy to the reactor where H_2 is generated by reforming natural gas with steam. The other emission source related to H_2 production is represented by the chemical reaction that occurs when H_2 is generated.

2. The reforming of natural gas with steam is the process used to generate H_2. The chemical reactions are:

$$CH_4 + H_2O \rightarrow CO + 3H_2 \qquad \text{Equation (1)}$$

$$CO + H_2O \rightarrow CO_2 + H_2 \qquad \text{Equation (2)}$$

3. The *F* factor used in Equation (9) is obtained as follows:

   (a) As the volume of H_2 required by the HDS unit to process a certain amount of vegetable oil is known in the refinery activity, the proposed methodology uses this value to obtain the mass of CO_2 produced in the chemical reaction that forms H_2.

   (b) To obtain the mass of CO_2 generated in the chemical reaction using the volume of H_2 required by the hydrogenation process, the *"ideal gas equation"* is applied as follows:

$$n_{H_2} = \frac{P_{H_2} \times V_{H_2}}{R \times T_{H_2}} \qquad \text{Equation (3)}$$

Where:

n_{H2}	=	Number of moles of H_2 produced in the reaction (mol)
R	=	8.314 (m^3 Pa/K mol)
V_{H2}	=	Volume of H_2 produced in the reaction (Nm^3)
T	=	273 (K), temperature of gases in normal conditions
P_{H2}	=	101,325 (Pa), pressure of gases in normal conditions

4. Naming *"a"* the constant that multiplies the volume of H_2, the abovementioned *"ideal gas equation"* yields:

$$n_{H_2} = a \times V_{H_2} \qquad \text{Equation (4)}$$

Where:

a	=	44.6 (mol/Nm^3)

5. Based on the stoichiometry of the reaction of H_2

$$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$$ Equation (5)

The number of moles of CO_2 emitted per mole of H_2 produced is:

$$n_{CO_2} = \frac{1}{4} \times n_{H_2}$$ Equation (6)

6. Substituting Equation (4) in Equation (6):

$$n_{CO_2} = \frac{a}{4} \times V_{H_2}$$ Equation (7)

7. To obtain the mass of CO_2 produced in the reaction, it is necessary to multiply Equation (7) by the molar mass of carbon dioxide, as follows:

$$n_{CO_2} = M_{CO_2} \times \frac{a}{4} \times n_{H_2}$$ Equation (8)

Where:

M_{CO2}	=	Molar mass of CO_2, equal to 44 g/mol

8. Thus, the *F* factor becomes:

$$F = \frac{44.6 \times 44}{4} = 490.6$$ Equation (9)

9. As the H_2 chemical formation reaction is not 100 per cent efficient the factor *F* must be multiplied by $\eta_{reaction}$, which is the efficiency of the H_2 formation reaction.

10. Thus, the *F* factor used in Equation (9) is:

$$F = 490.6 \times \eta_{reaction}$$ Equation (10)

11. And, the mass of CO_2 produced in the chemical formation reaction of H_2 is:

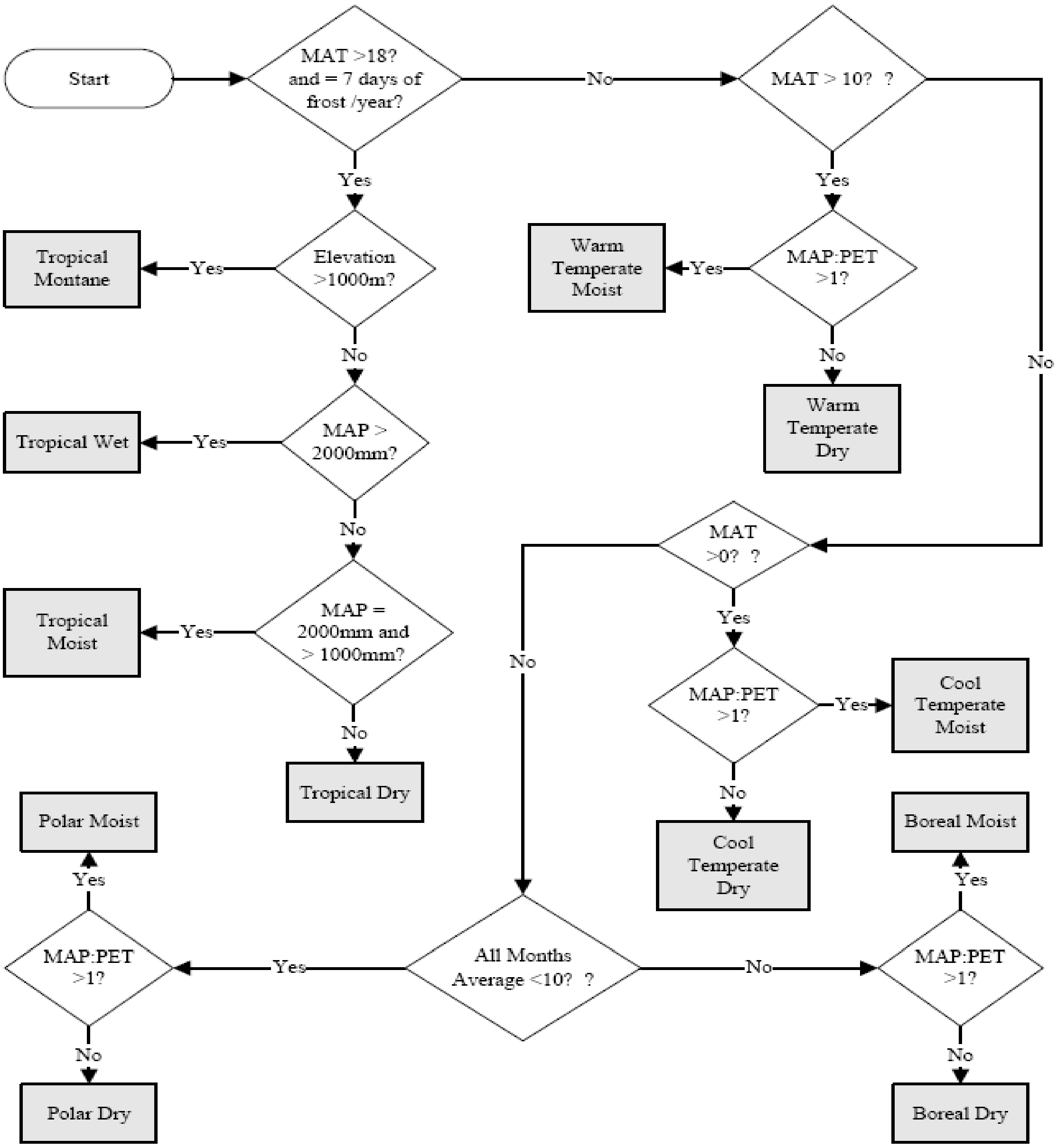
$$m_{CO_2} = 490.6 \times \eta_{reaction} \times V_{H_2}$$ Equation (11)

Where:

m_{CO2}	=	Mass of CO_2 (g)
V_{H2}	=	Volume of H_2 produced in the reaction (Nm^3)

Appendix 2. Climate Zone

Figure 3A.5.2 **Classification scheme for default climate regions. The classification is based on elevation, mean annual temperature (MAT), mean annual precipitation (MAP), mean annual precipitation to potential evapotransporation ratio (MAP:PET), and frost occurrence.**



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Document information

Version	*Date*	*Description*
03.0	11 March 2022	EB 113, Annex 13 Revision to indicate the emission sources that are relevant in the calculation of project emissions associated with biomass and biomass residues, in line with “TOOL16: Project and leakage emissions from biomass” (version 05.0).
02.0	24 July 2015	EB 85, Annex 7 Revision to: • Add a reference to the following methodological tools: (a) “Upstream leakage emissions associated with fossil fuel use”; (b) “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period”; (c) Project and leakage emissions from transportation of freight; (d) Project emissions from cultivation of biomass. • Clarify that net leakage should always be considered as zero when net leakage effects are negative; • Change the sectoral scope of the methodology from 01 and 05 to 05, 13 and 15; • Editorial improvement.
01.1	26 November 2010	EB 58, Annex 6 Revision to exclude the consumers from the project boundary.
01.0	17 September 2010	EB 56, Annex 3 Initial adoption.

Decision Class: Regulatory
Document Type: Standard
Business Function: Methodology
Keywords: biodiesel, plant oil, fuel switching, retrofit