CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY: BASELINE (CDM-NMB)
Version 02 - in effect as of: 15 July 2005

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SECTION A. Methodology title and summary description

Methodology title:

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Baseline methodology for the production of sugar cane based anhydrous[1] bio-ethanol for transportation using LCA.
Version 2
Completed 29/06/05

Summary description:

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The first step in the methodology is to determine the applicability conditions outlined below apply.

Having determined that the methodology is applicable, the next step of the methodology is to outline the feasible baseline scenarios. Baseline determination consists of two elements. The first element is the baseline at the site that will produce the bio-ethanol. Options considered consist of no investment, investment in other transport fuel capacity and the project activity not carried out as a CDM project activity. Where investment in other transport fuel capacity is found to be a feasible alternative, the methodology does not apply. The methodology then uses the additionality tool developed by the EB to evaluate whether investment in anhydrous bio-ethanol production capacity at the project site is a plausible baseline scenario.

The second element of the baseline is the **baseline fuel** that will be displaced by the anhydrous bio-ethanol produced by the project activity. Project proponents must demonstrate that the project activity will not result in a fuel switch from an identified other alternative fuel (such as LPG, LNG etc.) to gasohol, and therefore that the baseline fuel is gasoline.

The determination of baseline emissions and project emissions in the methodology follows a fuel life-cycle assessment (LCA) approach. This is deemed complete and addresses specific concerns that may be raised over bio-ethanol life-cycle emissions. Baseline emissions are defined as the emissions that would result from the production and combustion of the substituted non-renewable fuel, whilst project emissions are defined as net emissions from the production and combustion of the bio-ethanol used. Carbon uptake during the growth of the bio-ethanol feedstock (sugar-cane) will cancel out CO_2 emissions from its combustion, and hence project emissions are restricted to those related to the cultivation of sugar cane, industrial production of bio-ethanol and transportation to the place of blending/distribution.

[1] Anhydrous ethanol undergoes a dehydration process and hence typically contains an ethanol content exceeding 99%. Anhydrous ethanol can be blended with gasoline and used by conventional gasoline vehicles without modification. Hydrous ethanol contains 95-96% ethanol and can only be used in transportation by specifically designed vehicles. (These vehicles are essentially only sold in Brazil).

As the methodology utilises a life-cycle approach, leakage is restricted to emissions relating to any land –use change resulting from the project activity. (See section D.8.).

If this methodology is a based on a previous submission, please state the previous reference number (NMXXXX/AMXXXX) here:

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NM0082

SECTION B. Applicability/ project activity

Methodology procedure:

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The project activity applies to the following category: Transport

The methodology is applicable to project activities that reduce emissions through the production and sale of anhydrous bio-ethanol fuel for use in transportation. The following conditions apply to the proposed methodology:

1. The relevant national anhydrous bio-ethanol fuel market is production constrained, and therefore the factor prohibiting the use of anhydrous bio-ethanol fuel is lack of supply.

2. There does not exist an effectively enforced mandate on the use of anhydrous bio-ethanol fuel in transportation in the relevant national market.

3. It can be readily verified that the anhydrous bio-ethanol will be used as a transportation fuel within the relevant national market.

4. The anhydrous bio-ethanol will be blended with gasoline at a maximum level of 20%. (This ensures that use of the subsequent bio-ethanol/gasoline mix (gasohol) does not require vehicle modifications, and hence will assist in baseline determination.)

Explanation/justification:

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No approved methodology exists for the same, or similar, project activity conditions.

The methodology is applicable to circumstances where a lack of supply of anhydrous bio-ethanol fuel is the factor constraining its use. This ensures that it is the act of producing anhydrous bio-ethanol that leads to emission reductions - a project activity that produces anhydrous bio-ethanol fuel that will substitute for a non-renewable fuel in transportation will result in emission reductions. As a guideline for a production constrained system, a 75% rule is proposed. Under this rule, if existing capacity for anhydrous bio-ethanol fuel production within the national market exceeds 75% of the maximum demand level, the system is not deemed production constrained. The maximum demand level for anhydrous bio-ethanol is defined in litres and is

derived from the maximum blend of anhydrous bio-ethanol in gasoline and total gasoline consumption in the national market. The maximum blend of anhydrous bio-ethanol is the lower of any national imposed ceiling and the commonly applied 20% technical ceiling. It should be noted that this applicability criteria is distinct from the determination of common practice, which is a separate step contained in the additionality tool.

The second applicability condition relates to a mandate. Whilst the determination of additionality contains an analysis of regulatory conditions, the importance of a mandate deems that its absence be a specific applicability condition. Where an effectively enforced mandate on anhydrous bio-ethanol fuel use exists, market mechanisms should ensure its production up to the level of the mandate without the assistance of the CDM. Although a mandate may be lower than a maximum demand level, the difficulty of separating out which production units supply the mandate level suggests the existence of a mandate should rule out use of this methodology. This is conservative. (This applicability condition may need to be revised at a later date in line with EB guidance on an approach to deal with L- type national policies).

The third applicability criterion is a simple procedural matter of ensuring the possibility of accurate verification that the bio-ethanol has been used as a transport fuel.

The fourth applicability criteria relates to the composition of the anhydrous bio-ethanol/gasoline fuel mix. This is important to determine the baseline fuel.

SECTION C. Project Boundary

Methodology procedure:

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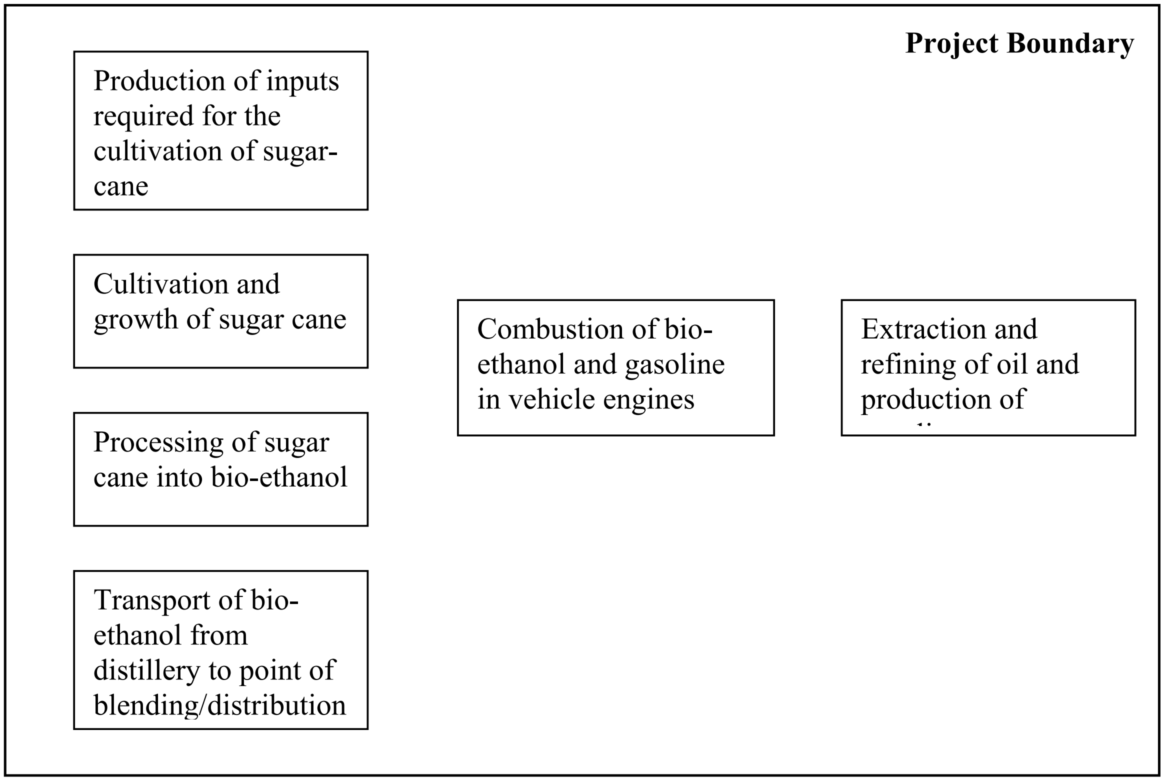
The boundary seeks to incorporate emissions from carbon dioxide through the combustion of gasoline and also nitrous oxide and methane in the production and cultivation of sugar cane. Whilst methane emissions may be slightly lower for bio-ethanol in comparison to gasoline when combusted in engines this difference is small and for the sake of conservatism we have not included these in the overall calculation of emission reductions.

The DNA approving the project activity is to be clearly informed of the wide project boundary. To ensure that the DNA does not approve another fuel switch project that conflicts with the project activity and boundary and therefore which could result in double counting of emissions reductions project proponents must obtain from the host DNA written confirmation that it is willing and able to ensure that no fuel switch projects are approved that use the same anhydrous bio-ethanol produced by the project activity. The monitoring methodology includes monitoring of all CDM projects approved in the host country to further ensure that no double counting occurs.



Explanation/justification:

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The methodology used follows a lifecycle approach, and therefore the project boundary encapsulates all emissions related to the production and combustion of both bio-ethanol and gasoline.

The project boundary extends to cover the final use in transportation of the anhydrous bio-ethanol produced by the project activity. This ensures that the bio-ethanol actually displaces the calculated volume of baseline fuel and that no double-counting of emissions reductions occurs.

D. Baseline Scenario

Methodology procedure:

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The methodology is applicable to situations where the anhydrous bio-ethanol fuel market is production constrained and where therefore it is the production of anhydrous bio-ethanol fuel which leads to emissions reductions. The methodology requires two elements of the baseline scenario to be established. The first element is the appropriate baseline at the project activity level, whilst the second element relates to the baseline transportation fuel i.e. the fuel that would be used under the considered baseline where the volume of bio-ethanol produced by the project activity is not produced and used in transportation.

Project proponents must consider the following potential project level baseline scenarios:

- No investment in bio-ethanol production capacity
- The project activity not carried out as a CDM project activity
- Investment in capacity for production of another alternative fuel

The additionality tool developed by the EB is used to determine whether the project activity not carried out as a CDM project activity is a plausible baseline. However, project proponents must also demonstrate that investment in capacity for production of another alternative fuel is not a plausible alternative. Where the project activity is undertaken by a sugar factory, this will normally be straightforward as a sugar factory is unlikely to have the technical expertise and access to raw materials to install other alternative fuel capacity. However where the project activity is carried out by, for example, an oil company, an economic evaluation (taking account of barriers to investment) other the attractiveness of investing in capacity to produce other alternative fuels (such as LPG, LNG, CNG or Bio diesel) should be carried out. If such an investment is considered as an economically realistic and plausible alternative then the methodology does not apply.

Turning to the fuel element of the baseline, project proponents are required to follow the following steps to establish the baseline fuel that will be displaced by anhydrous bio-ethanol:

1. Outline alternative fuels to gasoline available in the national market. Considered fuels shall include of LPG, CNG, bio diesel and Electricity (this list is not exhaustive).

2. Project proponents shall present a cost-benefit analysis of the fuel choice decision facing motorists. This shall include consideration of vehicle conversion costs, fuel costs and fuel availability.

3. Through this evaluation project proponents should determine whether increased availability of anhydrous bio-ethanol (and hence gasohol) will result in motorists switching from an identified alternative fuel (such as LPG, CNG or bio diesel) to gasohol.

Where the above evaluation determines that the project activity will result in motorists switching from an identified alternative fuel to gasohol, the baseline fuel is that identified and this methodology is not applicable. Otherwise the baseline fuel is gasoline and the methodology is applicable. (In this circumstance it may be that anhydrous bio-ethanol will also displace MTBE in gasoline. MTBE has higher lifecycle emissions than gasoline, and therefore taking gasoline as the basis for baseline emissions is conservative.)

Explanation/justification:

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See above.

SECTION E. Additionality

Methodology procedure:

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The methodology uses the tool for the demonstration and assessment of additionality developed by the EB (Annex 1 EB16) to asses whether the specific project activity investment in an anhydrous bio-ethanol production facility is part of the baseline. Where Step 2 (Investment Analysis) is followed, an analysis of the sensitivity to feedstock and fuel costs should be included. The bio-ethanol sales price is a key variability that will impact the financial performance of a project. This may be correlated with the gasoline price and the impact of this correlation should be accounted for in the sensitivity analysis.

Explanation/justification:

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There was some mention in reviewers' comments on the original submission (NM0082) on the need to include in the additionality evaluation end fuel costs faced by the motorist. However we do not feel this is necessary. As outlined in the applicability conditions, the methodology does not apply where there is an effectively enforced mandate on anhydrous bio-ethanol use in transportation. Motorists in developing countries will make fuel choice decisions on an economic basis – it is unrealistic to consider that any statistically significant number of motorists in a developing country will choose to purchase a gasoline/anhydrous bio-ethanol fuel mix (gasohol) because of lower associated GHG emissions if this is uneconomic. Thus gasohol must be priced below or on a par with conventional gasoline at the retail level (usually with the assistance of tax concessions, although the need for these is dependant on prevailing oil prices). Thus in a production constrained system, if the actual investment in a production facility is demonstrated to be additional this is all that is required to determine that in the absence of the CDM, the emission reductions would not occur. If the investment is not made, motorist will continue to use gasoline; if the investment is made, they will be able to switch to gasohol (and the monitoring methodology ensures that the bio-ethanol is actually used in transportation). In short, although use of gasohol in transportation may be economic, its production may not be (taking account of barriers). The CDM is therefore used to overcome the barriers to production in a production constrained (or under supplied) market.

SECTION F. Baseline emissions

Methodology procedure:

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Baseline emissions are derived from the volume of bio-ethanol produced and used in transportation, the relative fuel efficiency of anhydrous bio-ethanol and the gasoline lifecycle emissions coefficient:

$$BE_y = AH_y \bullet Q \bullet EFP$$

Where:

BE_y = Baseline emissions, $kgCO_2e$

AH_y = Volume of anhydrous bio-ethanol produced by the project activity and used in transportation, kl
Q = Relative fuel efficiency of anhydrous bio-ethanol
EFP = Gasoline lifecycle emissions coefficient, kgCO_2e/kl

Determination of EFP
Lifecycle emissions for gasoline must be established. The use of lifecycle baseline emissions is concomitant to the lifecycle approach used to evaluate project emissions.

Project participants have the opportunity to calculate lifecycle emissions for the specific country of the project activity. However, this may be difficult in many countries, and may increase transaction costs. Therefore the methodology suggests use of a proxy based on a reputable study carried out by L-B-Systemtechnik GmbH (http://www.lbst.de/gm-wtw/) "GM well-to-wheel analysis of energy use and greenhouse emissions of advanced fuel/vehicle systems – a European study". GM, BP, ExxonMobil, Shell and TotalFinaElf participated in the study, the results of which were presented in 2002. The study is based on the situation in Europe, and its applicability to the emerging markets that host CDM projects is considered conservative. If local data are available, these can be combined with the findings of the LBST study as applicable. The LBST study breaks well-to-wheel (WTW) emissions down into well-to-tank (WTT) and tank-to-wheel (TTW). For a conventional gasoline car, the following key data are provided:

Life-Cycle Stage	Product/vehicle	GHG emissions
Well-To-Tank	Gasoline (sulphur content <10 ppm), crude based pathway	13.2 gCO_2e/MJ
Tank-To-Wheel	Gasoline (MTA)	185 gCO_2e/km (best estimate)

Fuel economy in the LBST study is given as 8.15 l/100 km, whilst a Net Calorific Value for gasoline is given as 31.756 MJ/l. The use of these conversion factors allows for the following calculation of a lifecycle carbon dioxide emission factor for gasoline.

Life-Cycle Stage	GHG emissions
Well-To-Tank	419.18 gCO_2e/litre
Tank-To-Wheel	2269.93 gCO_2e/litre
Well-To-Wheel	**2689.11 gCO_2e/litre**

The total lifecycle carbon dioxide emissions factor for gasoline, (Well-to-Wheel), is therefore 2.68911 tonnes CO_2e/kilolitre of bio-ethanol. The full LCA figure for gasoline is applicable to gasoline that is produced within the host country. The emissions factor applicable for imported gasoline is the Tank-to-Wheel factor (2.26993 tonnes CO_2e/kilolitre). Where a proportion of gasoline supplying the host country is imported, a weighted emission factor is calculated each year as outlined in the monitoring methodology.

Determination of Q

The methodology provides a formula to calculate the relative volumetric fuel efficiency of anhydrous bio-ethanol and gasoline:

$$Q = \frac{FEP - FEG \bullet X}{FEG - FEG \bullet X}$$

Where:

Q = Relative volumetric fuel efficiency coefficient of anhydrous bio-ethanol
FEG = Fuel efficiency of gasohol (l/km)
FEP = Fuel efficiency of gasoline (l/km)
X = Blend of gasoline in gasohol ($0.8 > X < 1$)

FEG and FEP will be typically available from national oil company or authority data. However, where FEG and FEP are not provided in the host country, a value for Q must be derived based solely on energy content as below. (FEG and FEP must be country specific variables as they are at least partially related to country specific factors such as vehicle types).

$$Q = \frac{ECE}{ECP}$$

Where:

Q = Relative volumetric fuel efficiency coefficient of anhydrous bio-ethanol
ECE = Energy content of ethanol (MJ/km)
ECP = energy content of gasoline (MJ/km)

Explanation/justification:

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The first step in determining the baseline scenario and associated emissions is identification of the baseline fuel. As outlined earlier this is gasoline. In terms of determination of EFP as mentioned above, the project participant may use local data if available, or may combine local data with the above LBST data. However at all times the principle of conservativeness should be adhered to. The baseline fuel emissions factor should be re-calculated at the end of each crediting period based on up to date analysis and/or studies.

LCA GHG emissions factors for both bio-ethanol and gasoline are presented in **volumetric** terms rather than in **energy content** terms. This is because although bio-ethanol has a lower energy content than gasoline, when anhydrous bio-ethanol is blended with gasoline the resultant mix (gasohol) has a higher combustion efficiency, which acts to increase fuel efficiency.

Comparing LCA GHG emissions on an energy content basis will ignore this element[2]. Therefore concomitantly, Q is determined as the relative **volumetric** fuel efficiency.

The key potential uncertainties are the extent to which the production of bio-ethanol will lead to reduced emissions and the level of emissions associated with the production of ethanol. The applicability criteria for the methodology and the use of a lifecycle approach we believe deal with these uncertainties in a conservative manner.

The selection of the study for baseline LCA GHG emissions is a potential area of uncertainty. However the LBST study selected is academically respected and widely used. We selected a second study as a comparison, which is J.J.J. Louis, Well-to-Wheel Energy Use and Greenhouse Emissions for Various Vehicle Technologies, 2001 (Shell Global Solutions). This study gives a figure, based on a Mercedes A-class 1.6L engine, for well-to-wheel gasoline emissions of 220g/km. Using the 8.15 l/100km fuel economy outlined in the LBST study, this gives an emissions factor of 2699gCO_2e/litre, higher than the LBST figure outlined in the methodology. (Taking a more realistic fuel economy for a Mercedes A-Class of 7/100km, we arrive at a figure of 3143 gCO_2e/litre). This suggests use of the LBST study is conservative.

Data sources:

Data	Type	Source	Reference	Appropriateness
EFP	Baseline (gasoline) lifecycle emissions coefficient	LBST Report. Data taken from pages 42, 80, 86, 91	GM well-to-wheel analysis of energy use and greenhouse emissions of advanced fuel/vehicle systems – a European study. (http://www.lbst.de/gm-wtw/)	This study is based on European data, and its use for CDM host countries is deemed conservative.
FEP	Fuel efficiency of gasohol	National authority/oil company statistics		Directly applicable
FEG	Fuel efficiency of gasoline	National authority/oil company statistics		Directly applicable
AH_y	Volume of bio-fuel produced and sold for use in transportation	Proprietary data		Primary data used to calculate baseline emissions, verified annually.

SETION G. Project activity emissions

[2] Use of volumetric relative fuel efficiency is also consistent with monitoring, which is focused on the volume of bio-ethanol produced and used in transportation. Fuel efficiency data will also be expressed on a volumetric l/km basis or similar.

Methodology procedure:

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As outlined, the project activity using this methodology will displace gasoline with anhydrous bio-ethanol. Project emissions are therefore the lifecycle emissions of sugar-cane based anhydrous bio-ethanol and any additional emissions from the transport of bio-ethanol to the place of blending of bio-ethanol and gasoline in the gasohol fuel mix. As part of the monitoring plan, an annual ex-post GHG LCA for the bio-ethanol produced at the project activity is carried out. In terms of the calculation of these GHG LCA emissions and the associated monitoring requirements, the following categories have been identified. (In developing this methodology we have drawn on LCA literature and in particular the study by Macedo et al, 2004 and the ISO guidelines on life cycle assessment, ISO 14041 and ISO 14040[3].):

1. Diesel consumption during agricultural operations (preparation, planting, harvesting etc) - CO_2
2. Emissions associated with fertiliser production and use - CO_2,CH_4 and N_2O
3. Emissions associated with the field burning of crop residues – CH_4 and N_2O
4. Emissions associated with the transport of cane to the sugar/bio-ethanol factory
5. Emissions from the industrial production of bio-ethanol
6. Emissions associated with the transport of bio-ethanol to the place of blending/distribution

Categories 1-4 can be classified as "**Field**" emissions and are the emissions related to the production and transport of the bio-ethanol feedstock. Category 5 can be termed "**Industrial**" emissions and relate to the processing of the feedstock into anhydrous bio-ethanol. Finally, category 5 can be classified as "**Transportation to end use**" emissions.

In order to monitor and calculate the above emissions, project proponents must collect on an annual basis the following core data variables:

- Tonnes of sugar cane or sugar cane molasses required to produce 1 kilolitre of anhydrous bio-ethanol
- Raw sugar and molasses recovery rates from cane
- Total reducing sugars contents of raw sugar and molasses
- Diesel consumption in tractors for agricultural operations
- Percentage of land where sugar cane trash is burned
- Sources of energy supply to bio-ethanol factory
- Distance travelled by cane trucks from field to sugar/bio-ethanol factory and efficiency of vehicles

[3] It should be remembered that CO_2 flows associated with the uptake of atmospheric carbon by photosynthesis and its release by oxidation (which includes uptake during crop growth, release during combustion of crop residues and release during combustion of the bio-fuel in vehicle engines) have a net impact of zero due the renewable nature of bio-fuels.

- Distance travelled to place of blending/distribution of bio-ethanol and efficiency of vehicles

The above information and variables will be collected as part of the normal activities of the agricultural extension operation servicing the farmers or the bio-ethanol factory.

"Field" emissions

The first step is to calculate emissions on a kgCO_2e/tonne cane basis :

1. *Diesel consumption during agricultural operations.*

$$PEDy = EFD \bullet \frac{ACDy}{Yy}$$

Where:
PEDy = Project emissions from diesel consumption in agricultural operations (kgCO_2e/tonne cane)
EFD = Emissions factor for diesel (kgCO_2e/kilolitre)
ACD_y = Average diesel consumption per hectare on agricultural land supplying project activity (kilolitre/ha)
Y_y = Average yield on land agricultural supplying project activity (tonnes cane per hectare)

2. *Emissions associated with fertiliser production and use.*

GHG emissions relating to fertiliser use originate from two sources: those associated with the production of fertiliser and direct soil N_2O emissions from nitrogen fertiliser use.

2a. Emissions from the production of synthetic fertilser used.

Fertiliser production utilises significant energy resources and therefore the bio-ethanol LCA should encompass these associated emissions. The IPCC does not provide emission factors for the production of fertiliser and therefore the methodology recommends project participants use the review of emission factors for fertiliser production produced by Wood and Cowie[4]. This review contains a summary of a number of studies and outlines emission factors (on a gCO_2e/kg product basis) for the major fertiliser types. Project proponents should use the most conservative (i.e. highest) emission factor presented in the report for each type of fertiliser used.

$$PEFy = EFP \bullet \frac{ACFy}{Yy}$$

[4] A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie for IEA Bioenergy Task 38, June 2004.

Where:
PEFy = Emissions from production of fertiliser used ($kgCO_2e$/tonne cane)
EFP = Fertiliser production emissions coefficient ($kgCO_2e$/kg fertiliser)
ACFy = Recommended fertiliser application rate (kg/ha)
Y_y = Average yield on land agricultural supplying project activity (tonnes cane per hectare)

2b. Soil N_2O emissions from organic and synthetic fertiliser use.

The IPCC 1996 Guidelines provide guidance on how to estimate direct N_2O emissions due to Nitrogen inputs (both artificial and organic). The following equation should be used:

$$N2Odirect - N = (FSN + FAM) \bullet EF1$$

Where
N_2O_{Direct} -N = Emissions of N_2O in units of Nitrogen
F_{SN} = Annual amount of synthetic fertiliser nitrogen applied per hectare adjusted for the amount that volatilises as NH_3 and NOx
F_{AM} = Annual amount of animal manure nitrogen intentionally applied per hectare adjusted to account for the amount that volatilises as NH3 and NOx
EF_1 = Emission factor for emissions from N inputs (kg N2O-N/kg N input)

Conversion of N_2O-N emissions to N_2O emissions per tonne of cane is then performed via the following equation:

$$N2Ofert = \frac{N2Odirect - N \bullet 44/28}{Yy} \bullet 310 \quad \text{or} \quad \frac{N2Odirect - N \bullet 487}{Yy}$$

Where
N2Ofert = Direct N_2O emissions from Nitrogen fertilizer use ($kgCO_2e$/tonne cane)
N2Odirect –N = Emissions of N_2O in units of Nitrogen
Yy = Average yield on agricultural land supplying the project activity (tonnes cane per hectare)

3. Emissions associated with the field burning of crop residues

CH_4 and N_2O emissions from the burning of cane trash must be accounted for. A default value for emissions from the burning of agricultural residues is taken from the IPCC GPG, 1996. First the carbon released from field burning must be calculated:

The methodology recommends use of a default residue fraction for sugar cane of 14% dry matter per tonne of cane (see: Macedo, Leal and Hassuani, 2001) and IPCC default emission rates for CH_4 and N_2O. Information on the percentage of land supplying the bio-ethanol factory on which cane trash is burned will be provided each year by the extension service.

Therefore in line with IPCC guidelines:

Carbon released/tonne cane = 0.14 • percentage of cane trash burned in field • fraction oxidised • carbon fraction (0.45)

CH_4 and N_2O emissions per tonne of cane are then calculated (in CO_2e) as:

$$CH4trash = Carbon\_released / tonne\_cane \bullet 0.005 \bullet \frac{16}{12}$$

$$N2Otrash = Carbon\_released / tonne\_cane \bullet 0.015 \bullet 0.007 \bullet \frac{16}{12}$$

And

$$ETBy = CH4trash \bullet 23 + N2Otrash \bullet 310$$

Where

ETBy = Emissions from the field burning of crop residues ($kgCO_2e$/tonne cane) and 23 and 310 are the GWP for CH_4 and N_2O respectively

4. Emissions associated with the transport of cane to the sugar/bio-ethanol factory

$$TEF_y = \frac{Dy \bullet CEFi \bullet \beta}{FE \bullet TC}$$

Where:

TEF_y = Emissions from the transportation of sugar cane from the field to the bio-ethanol factory ($kgCO_2e$ per tonne cane)

D_y = Average return distance from field to factory (km)

FE = Fuel efficiency of transporter (km/l)

CEF_t = CO_2 emissions factor ($kgCO_2$/l)

ß = percentage of cane transported to factory by truck

TC = Truck capacity, tonnes

Total "Field" emissions on a $kgCO_2e$ per tonne cane are thus:

$$EFFy = PEDy + PEFy + N2Ofert, y + ETBy + TEFy$$

Where:

EFFy = Emissions from "Field" operations ($kgCO_2e$ per tonne cane)

PEDy = Project emissions from diesel consumption in agricultural operations ($kgCO_2e$/tonne cane)

PEFy = Emissions from production of fertiliser used ($kgCO_2e$/tonne cane)

N2Ofert,y = Direct N_2O emissions from Nitrogen fertilizer use ($kgCO_2e$/tonne cane)

ETBy = Emissions from the field burning of crop residues (kgCO_2e/tonne cane)
TEF_y = Emissions from the transportation of sugar cane from the field to the sugar/bio-ethanol factory (kgCO_2e per tonne cane)

As part of the calculation of total project emissions, the above emissions factor must be converted from a kgCO_2e per tonne cane basis to a kgCO_2e per kilolitre anhydrous bio-ethanol basis:

i) Where anhydrous bio-ethanol is produced directly from sugar cane:

$$EFAsug, y = CC \bullet EFFy$$

Where
EFAsug,y = Total "Field" emissions factor where bio-ethanol feedstock is sugar cane (kgCO_2e/kl)
CC = Cane to anhydrous bio-ethanol conversion factor (t/kl)
EFFy = Emissions from "Field" operations (kgCO_2e per tonne cane)

ii) Where anhydrous bio-ethanol is produced from sugar cane molasses:

In cases where bio-ethanol is made from sugar cane molasses, emissions from cane production must be allocated between molasses and raw sugar. It is recommended that this allocation is done on the basis of sugar content. This has the benefits that it is in line with ISO 14041, the sugar content of both the molasses and raw sugar will be readily available, the key reason for growing sugar cane is to obtain sugars and the sugar content will correlate directly with energy content.

Actual recovery rates of sugar and molasses per tonne of cane will be available from factory records. These figures should then be adjusted by the actual sugar content of the raw sugar and molasses to allocate emissions accurately. Thus:

$$EFMy = \frac{M.SM}{M.SM + S.SS} \bullet \frac{1}{M} \bullet EFFy$$

Where:
EFM,y = Emissions from "Field" operations (kgCO_2e per tonne molasses)
M = Molasses recovery rate from cane (%)
S = Raw sugar recovery rate from cane (%)
SM = Total reducing sugars (TRS) content of molasses
SS = Total reducing sugars (TRS) content of raw sugar
EFFy = Emissions from "Field" operations (kgCO_2e per tonne cane)

And:

$$EFAmol,y = MC \bullet EFMy$$

Where:
EFAmol,y = Total “Field” emissions factor where bio-ethanol feedstock is sugar cane molasses ($kgCO_2e/kl$)
MC = Sugar cane molasses to anhydrous bio-ethanol conversion factor (t/kl)
EFM,y = Emissions from “Field” operations ($kgCO_2e$ per tonne molasses)

“Industrial” emissions

5. Emissions from the industrial production of bio-ethanol

$$PPEy = FFy \bullet CEFF + GMy \bullet CEFG + CPy \bullet CEFC$$

Where:
PPEy = Total emissions from the industrial production process of bio-ethanol ($kgCO_2e$)
FFy = Fossil fuel combusted to provide non-electrical energy to the bio-ethanol factory (tonnes)
CEFF = Emission factor for fossil fuel ($kgCO_2e/tonne$)
GMy = Imports from the grid to the bio-ethanol factory (kWh)
CEFG = Combined margin grid emission factor ($kgCO_2e/kWh$)
CPy = Captive electrical energy generation for the bio-ethanol factory (kWh)
CEFC = Captive generation emission factor ($kgCO_2e/kWh$)

“Transportation to end use” emissions

6. Emissions associated with the transport of bio-ethanol to the place of blending/distribution

The methodology states that these emissions are to be added to the project lifecycle emissions only if the current distribution of the displaced gasoline does not involve similar transport of fuel to a blend/distribution location. Transport emissions are calculated from the volume of bio-ethanol transported and the fuel efficiency and appropriate CO_2 emissions factor of the transport vehicle. (The CO_2 emissions factor is taken from the IPCC again adding to the conservatism of the methodology.) As these transport emissions are only be included if the current distribution of gasoline does not involves the transport of fuel to a blend/distribution location, the variable TEC_y is set to 1 if the calculation is required under this test and 0 if their calculation is not required, the calculation of transport emissions are carried out through the following equation:

$$TE_y = \frac{D_y}{FE}.CEF_t.TEC_y$$

Where:
TE_y = Additional emissions from the transportation of bio-ethanol to the blend/distribution location, tCO_2e
D_y = Distance travelled by transporters in year y, km

FE = Fuel efficiency of transporter, km/l
CEF_t = CO_2 emissions factor, tCO_2/l
TEC_y = whether the calculation of transport emissions required (value = 0 or 1)

Total Project Emissions

Total project emissions are thus calculated as:

i) Where bio-ethanol is produced directly from sugar cane:

$$PEy = AHy \bullet EFAsug, y + PPEy + TEy$$

Where:

PEy = Project emissions, $kgCO_2e$
AHy = Volume of anhydrous bio-ethanol produced and used in transportation, kl
EFAsug,y = Emissions from agricultural operations , $kgCO_2e/kl$
PPEy = Emissions from the industrial production of bio-ethanol, $kgCO_2e$
TEy = Additional emissions from the transportation of bio-ethanol to the blend/distribution location, $kgCO_2e$

ii) Where bio-ethanol is produced from sugar cane molasses:

$$PEy = AHy \bullet EFAmol, y + PPEy + TEy$$

Where:

PEy = Project emissions, $kgCO_2e$
AHy = Volume of anhydrous bio-ethanol produced and used in transportation, kl
EFAmol,y = Emissions from agricultural operations , $kgCO_2e/kl$
PPEy = Emissions from the industrial production of bio-ethano, $kgCO_2e$
TEy = Additional emissions from the transportation of bio-ethanol to the blend/distribution location, $kgCO_2e$

Explanation/justification:

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See above.

We do not account for emissions associated with the manufacture and maintenance of equipment and the manufacture of agrochemicals. Conversely, we do not apportion any credit to bagasse production that exceeds the energy requirements of cane and bio-ethanol processing. It is reasonable to assume that these emissions flows are equivalent and cancel each other out (see Macedo et al, 2004). This assumption greatly eases the monitoring burden without materially impacting the accuracy of the calculation of emissions reductions.

Data Sources:

Data	Type	Source	Reference	Appropriateness
EFP	Fertilser production emission coefficient	Wood & Cowie, 2004	www.joanneum.ac.at/iea-bioenergy-task38/ publications/GHG_Emission_Fertilizer%20Production_July2004.pdf	Deemed conservative as methodology takes highest factor for fertiliser type

As outlined in the attached PDD, utilisation of this methodology yields an estimate of project emissions that is marginally higher than that outlined in the Macedo *et al* study that formed the basis of the original submission NM0082. The Macedo *et al* study is well respected and deemed conservative and thorough by academics. However it is the only LCA study available for sugar cane based bio-ethanol and demonstrating its conservativeness is not simple. Therefore to ensure accuracy and appropriateness of emission factors, individual project specific LCA evaluations is deemed appropriate in this revised methodology submission.

SECTION H. Leakage

Methodology procedure:

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The first element of the leakage treatment is to establish whether the project activity leads to land clearance/deforestation. Recent data on deforestation and its causes in a host country may not be available. Therefore project proponents must evaluate the following:

1. Will the project activity result in an increase in the area of sugar cane planted? (This may not always be the case – an increase in bio-ethanol production may lead to a reduction in sugar production, or may use existing molasses supplies).

2. If yes, over the last 5 years for which data are available, has deforestation occurred in the host country?

3. If yes, then the conservative assumption is that the increase in sugar cane area that will result from the project activity will lead an equivalent area to be deforested. The area of sugar cane required to meet the annual bio-ethanol production of the project activity can be calculated from the data collected as per Section D.7. above. Project proponents should assume a one-time emission of GHG as the carbon contained in the area of forest is released. This should be calculated as per IPCC good practice guidelines. The carbon stock of forest before conversion is available in Annex 3A.1 of the GPG-LULUCF, 2003.

The project is only to receive CERs when calculated cumulative emission reductions from the production and use of anhydrous bio-ethanol exceed the above one-off GHG emissions.

Land-use changes and the area of sugar cane supplying the project activity are monitored annually (See attached monitoring methodology) and any leakage penalty is to be applied as outlined in the methodology should the area of cane supplying the project activity have increased as a result of the project activity **and** the occurrence of deforestation cannot be ruled out in the host country.

Explanation/justification:

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The methodology covers GHG LCA emissions associated with the production and transportation of bio-ethanol. Leakage is therefore identified as any increase in emissions that may occur should the project activity result either directly or indirectly in deforestation.

SECTION I. Emission reductions

Methodology procedure:

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The derivation of **Project emissions** is outlined above, and thus **Emission reductions** in year *y* (ER_y) are thus calculated as

ERy = BEy - PEy - LEy

Explanation/justification:

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SECTION J. Changes required for methodology implementation in 2nd and 3rd crediting periods (if relevant / optional)

Methodology procedure:

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Applicability conditions should be re-evaluated at renewal of crediting periods. Moreover, studies on LCA emissions factors for gasoline should be reviewed at renewal of crediting period.

Explanation/justification:

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SECTION K. Selected baseline approach from paragraph 48 of the CDM modalities and procedures

Choose One (delete others):

☒ Existing actual or historical emissions, as applicable;

or

☒ Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment;

☐ The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category.

Explanation/justification of choice:

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Baseline emissions are taken as those associated with the substituted fuel (gasoline). In this case approach 48(a) is followed.

Equally however, the decision to invest in anhydrous bio-ethanol fuel production facilities is an economic decision (taking account of barriers to investment). The methodology is applicable to situations where there is insufficient supply of bio-ethanol and hence where an investment in bio-ethanol production facilities will lead directly to a reduction in conventional (gasoline) fuel consumption. Thus under approach 48(c), the selected baseline would also be use of gasoline.

SECTION I. Other Information

Explanation/justification:

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Strengths
The methodology is complete and accounts for all key emission flows. Project emissions are calculated via a project specific annual ex-post life cycle assessment (LCA).
The applicability conditions and additonality evaluation ensure that the baseline is robust.

A production-based approach to bio-fuel projects greatly assists monitoring, as well as being appropriate given the methodology applicability conditions (lack of supply as key factor constraining use). It is not really feasible to monitor individual motorists' actions, but monitoring the production of bio-fuels, and assuring only production that ends up in transportation fuel qualifies for CERs, is an efficient and accurate method of ensuring integrity.

Weaknesses
The monitoring requirements inherent in an ex-post LCA approach are substantial. However the data required should normally be collected as part of factory and extension standard practice.

The use of a pre-defined baseline emissions factor, an actual LCA for and the methodology panel's draft consolidated tools for additionality allow for conservative and transparent baseline determination.

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