Draft baseline methodology AM00XX

"Production of sugar cane-based anhydrous bio-ethanol for transportation using Life-cycle analysis (LCA)"

Source

This methodology is based on the project activity "Khon Kaen fuel ethanol project", proposed by Khon Kaen Alcohol Company Limited, whose baseline study and project design document were prepared by Agrinergy Ltd.

For more information regarding the proposal and its consideration by the Executive Board please refer to case NM082-rev: "Production of sugar cane based anhydrous bio-ethanol for transportation using LCA" on http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

This methodology also refers to the latest version of the "Tool for the demonstration and assessment of additionality".[1]

Selected approach from paragraph 48 of the CDM modalities and procedures

"Actual or historical emissions, as applicable"

Applicability

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 methodology:

- The implementation of the project activity shall not lead to national production beyond the maximum national potential demand level, defined here as the lower of 20% of the gasoline demand or any nationally imposed ceiling on bio-ethanol/gasoline mix;
- No mandate exists on the use of anhydrous bio-ethanol fuel in transportation in the relevant national market and, if exists, is not effectively enforced;
- It can be readily verified that the anhydrous bio-ethanol will be used as a transportation fuel within the relevant national market;
- The anhydrous bio-ethanol will be blended with gasoline at a maximum level of 20%;
- The project activity will not result in other alternative fuel vehicles (such as LPG, LNG, CNG and bio diesel) switching to gasohol;
- Investing in capacity to produce another alternative fuel (such as LPG, LNG, CNG or bio diesel) is not a feasible option for the project proponent;

[1] Please refer to: < http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>

- The project activity shall include the production of the sugar cane used for production of the anhydrous bio-ethanol.

This baseline methodology shall be used in conjunction with the approved monitoring methodology AM00XX ("Production of sugar cane based anhydrous bio-ethanol for transportation using Life-cycle analysis (LCA)").

Identification of the baseline scenario

The baseline scenario shall be established for the project activity level and transportation fuel used in absence of the proposed project activity .

Project proponents must consider the following potential baseline scenarios for project activity level:
- No investment in bio-ethanol production capacity;
- The project activity implemented without CDM revenues; and
- Investment in capacity for production of another alternative fuel.

The latest version of the "Tool for the demonstration and assessment of additionality" shall be used to determine the most likely baseline scenario.

The project proponents may use barrier analysis if bio-ethanol production is undertaken by a sugar factory. Investment analysis, taking into account barriers to investment, shall be undertaken if bio-ethanol production is carried out by, for example, an oil company.

Project proponents shall use the following steps to establish the baseline fuel that will be displaced by anhydrous bio-ethanol produced by the project activity:

- Identify the fuel alternatives to gasoline available in the national market. Considered fuels shall include LPG and CNG;

- Undertake a cost-benefit analysis of the fuel alternatives identified in step 1. The analysis shall include consideration of vehicle conversion costs, fuel costs and fuel availability;

- If cost-benefit analysis determines that the project activity will result in motorists switching from an alternative fuel identified in step 1 to gasohol, the baseline fuel is the identified fuel alternative.

This methodology is applicable only if the baseline is (i) no ivestment in bioethanol production capacity; and (ii) the baseline fuel is gasoline.[2]

Additionality

The additionality of the project activity shall be demonstrated and assessed using the latest version of the ***"Tool for the demonstration and assessment of additionality"*** *agreed by the CDM Executive Board, available at the UNFCCC CDM web site*[3].

[2] 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.
[3] Please refer to: < http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>

Where Step 2 of the "Tool for the demonstration and assessment of additionality" (Investment Analysis) is used, sensitivity analysis should include sensitivity of investment to feedstock and fuel costs. Further, sensitivity of investment analysis to bio-ethanol sales price should be evaluated, this may be done by correlating bio-ethanol price to gasoline prices.

Project boundary

The methodology follows a lifecycle approach and, therefore, the project boundary encapsulates the production and combustion of bio-ethanol fuel. The methodology includes emissions relating to, both, the cultivation of the sugar cane feedstock and its further processing to bio-ethanol. The main greenhouse gas considered is CO_2, however, N_2O and CH_4 emissions from crop burning, if any, are also considered, as are N_2O from soil emissions.

The project boundary covers 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.

The boundary for baseline fuel emissions is national, i.e. only emissions which occur in the host country are considered. Thus a full life-cycle emissions factor is used if the gasoline is produced in the host country, whereas, tank-to-wheel emissions factor is used for imported gasoline.

Baseline emissions

The baseline fuel is gasoline, so lifecycle emissions for gasoline are used to estimate the baseline emissions.

Project participants shall calculate lifecycle emissions for the specific country where the project activity is located. However, in absence of such data the project proponents can use the default values provided below:

Table: Default values for emissions from gasoline production and consumption[4]

Life-Cycle Stage	**GHG emissions**
Tank-To-Wheel (emission factor for imported gasoline)	2.26 tCO_2e/Kilo litre
Well-To-Wheel (emission factor for gasoline produced within the country)	**2.5 tCO_2e/Kilo** litre

If a proportion of gasoline is imported, a weighted emission factor is calculated for each year, as outlined in the monitoring methodology.

The baseline fuel emissions factor should be re-calculated at the end of each crediting period based on current analysis and/or studies available at that time.

The volume of gasoline displaced by use of a unit of bio-ethanol is estimated as follows:[5]

[4] See Annex 1 for details of emission factor.
[5] 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

$$Q = \frac{(FEP - (FEG \bullet X))}{(FEG - (FEG \bullet X))} \tag{1}$$

where:

Q	=	Factor showing volume of gasoline that is displaced by bio-ethanol when bio-ethanol is blended in gasoline
FEG	=	Fuel efficiency of gasohol (l/km)
FEP	=	Fuel efficiency of gasoline (l/km)
X	=	Blend of gasoline in gasohol ($0.8 \geq X < 1$)

The reason for using the above equation is that the bio-ethanol will be blended with gasoline to make gasohol. Thus using a figure of FEG/FEP would not indicate how much gasoline would be displaced by a litre of bio-ethanol. Rather it would indicate how much gasoline would be replaced by a litre of gasohol (FEG is the fuel efficiency of gasohol NOT bio-ethanol).

Tests to determine FEG and FEP

The tests that underlie the data on the fuel efficiency of gasohol and gasoline (FEG and FEP) should have been carried out specifically for the host country and on a sample of vehicles that is representative of those vehicles in use in the host country. Moreover, the blend of bio-ethanol in gasohol (1-X) used to determine FEG should be the same as that which will be applicable following implementation of the project activity.

Project proponents may commission such a test if data on FEG and FEP are not available. If such tests are commissioned, they should follow the above guidance on a representative sample and should be completed by a respected independent entity. Evaluation of the procedures for these tests and the subsequent results should form part of the project validation.

Where FEG and FEP are not provided in the host country, and where project proponents select not to commission such tests, a value for Q may 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).[6]

$$Q = \frac{ECE}{ECP} \tag{2}$$

where:

Q	=	Factor showing volume of gasoline that is displaced by bio-ethanol when bio-ethanol is blended in gasoline
ECE	=	Energy content of bio-ethanol (MJ/l)
ECP	=	Energy content of gasoline (MJ/l)

increase fuel efficiency. Comparing LCA GHG emissions on an energy content basis will ignore this element. 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.

[6] This equation is extremely conservative as it ignores the important benefit bio-ethanol provides in increasing combustion efficiency.

Total baseline emissions are thus determined as:

$$BE_y = AH_y \bullet Q \bullet EFP \quad \textbf{(3)}$$

where:

BE_y	=	Baseline emissions (tCO_2e)
AH_y	=	Volume of anhydrous bio-ethanol produced by the project activity and used in transportation in host country (kl)
Q	=	Factor showing volume of gasoline that is displaced by bio-ethanol when bio-ethanol is blended in gasoline as estimated in equation (l)
EFP	=	Gasoline lifecycle emissions coefficient (tCO_2e/kl)

Where the host country imports gasoline, the baseline emissions factor must be adjusted to take account of the share of national gasoline supply provided for by imports. Thus:

$$EFP = M.TTW + (1 - M) \bullet WTW \quad \textbf{(4)}$$

where:

M	=	Share of total gasoline supply provided for by imports (%)
TTW	=	Tank-to-Wheel baseline coefficient (2.26 tCO2e/kl)
WTW	=	Well-to-Wheel baseline coefficient (2.5 tCO2e/kl)

Project Emissions

Project emissions are 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. The following categories of GHG emissions have been identified:

1. Emissions from 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- CO_2
5. Emissions from the industrial production of bio-ethanol - CO_2
6. Emissions associated with the transport of bio-ethanol to the place of blending/distribution - CO_2

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.

"Field" emissions

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

1. *Diesel consumption during agricultural operations.*

$$PED_y = EFD \bullet \frac{ACD_y}{Y_y} \quad \textbf{(5)}$$

where:

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

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 fertiliser used.

$$PEFy = \sum_i EFP_i \bullet \frac{ACFy_i}{Yy} \quad \textbf{(6)}$$

where:

PEF_y	=	Project emissions from production of fertiliser used ($kgCO_2e$/tonne cane)
EFP_i	=	Emissions factor Fertiliser Production ($kgCO_2e$/kg fertiliser) for fertiliser i[7]
$ACF_{y,i}$	=	Fertiliser application rate (kg/ha) for fertiliser I
Y_y	=	Average yield on land agricultural supplying project activity (tonnes cane per ha)

2b. Direct Soil N_2O emissions from organic and synthetic fertiliser use.
The following equation, as per IPCC 1996 guidelines, should be used to estimate the emissions:

$$N_2O_{direct} = (F_{SN} + F_{AM}) \bullet EF_1 \quad \textbf{(7)}$$

where:

N_2O_{Direct}	=	Emissions of N_2O in units of Nitrogen (Kg-N)
F_{SN}	=	Annual amount of synthetic fertiliser nitrogen applied per hectare adjusted for the amount that volatilises as NH_3 and NO_X, calculated as outlined below
F_{AM}	=	Annual amount of animal manure nitrogen intentionally applied per hectare adjusted to account for the amount that volatilises as NH_3 and NO_X, calculated as outlined below

[7] Project participants use the review of emission factors for fertiliser production produced by Wood and Cowie (A Review of Greenhouse Gas Emission Factors for Fertiliser Production, Sam Wood and Annette Cowie for IEA Bioenergy Task 38, June 2004). 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.

EF_1 = Emission factor for emissions from N inputs (kgN_2O-N/kg N input), taken from IPCC (Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual Volume 3 Table 4-18, or latest data if updated)

and:

$$F_{SN} = N_{FERT} \times (1 - Frac_{GASF}) \tag{8}$$

where:

N_{FERT} = Annual mass of synthetic fertilizer applied per hectare (kgN/ha)
$Frac_{GASF}$ = Fraction of synthetic fertilizer nitrogen applied that volatises as NH_3 and NO_X.

and:

$$F_{AM} = N_{AM} \times (1 - Frac_{GAAM}) \tag{9}$$

where:

N_{AM} = Annual mass of animal manure applied per hectare (kgN/ha)
$Frac_{GAAM}$ = Fraction of animal manure nitrogen applied that volatises as NH_3 and NO_X.

Unless country specific data are available, the IPCC default values for $Frac_{GASF}$ and $Frac_{GAAM}$, 0.1 and 0.2 respectively, are to be used.

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

$$N_2O_{fert,D} = \frac{N_2O_{direct} \bullet 44/28}{Yy} \bullet 310 \tag{10}$$

where:

$N_2O_{fert,D}$ = Direct N_2O emissions from Nitrogen fertilizer use (kgCO_2e/tonne cane)
Y_y = Average yield agricultural land supplying the project activity (tonnes cane per ha)

2c. Indirect N_2O emissions from atmospheric deposition

Taking IPCC 1996 Guidelines guidance, indirect N_2O emissions from atmospheric deposition on soils of NO_X and ammonium from volatisation of N inputs must be considered, as must indirect N_2O emissions from leaching/runoff:

$$N_2O_{INDIRECT} = N_2O_{(G)} + N_2O_{(L)} \tag{12}$$

where:

$N_2O_{INDIRECT}$ = Emissions of N_2O in units of Nitrogen (kgN)
$N_2O_{(G)}$ = N_2O produced from volatisation of applied synthetic fertilizer and animal manure N, and its subsequent atmospheric deposition as NO_X and NH_4 (kgN)
$N_2O_{(L)}$ = N_2O produced from leaching and runoff of applied fertiliser and animal manure N (kgN)

and:

$$N_2O_{(G)} = \left[(N_{FERT} \bullet Frac_{GASF}) + (N_{AM} \bullet Frac_{GAAM})\right] \bullet EF_4 \quad \textbf{(13)}$$

where:

N_{FERT} = Annual mass of synthetic fertilizer applied per hectare (kgN/ha)
$Frac_{GASF}$ = Fraction of synthetic fertilizer nitrogen applied that volatises as NH_3 and NO_X..
N_{AM} = Annual mass of animal manure applied per hectare (kgN/ha)
$Frac_{GAAM}$ = Fraction of animal manure nitrogen applied that volatises as NH_3 and NO_X..
EF_4 = Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces (kg N_2O-N/kg N input) taken from IPCC (Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual Volume 3 Table 4-23, or latest data if updated)

and:

$$N_2O_{(L)} = \left[N_{FERT} + N_{AM} * \%_N\right] \bullet Frac_{LEACH} \bullet EF_5 \quad \textbf{(14)}$$

where:

N_{FERT} = Annual mass of synthetic fertilizer applied per hectare (kgN/ha)
N_{AM} = Annual mass of animal manure applied per hectare (kg/ha)
$\%_N$ = Percentage of nitrogen in the animal manure
$Frac_{LEACH}$ = Fraction of N input that is lost through leaching and runoff
EF_5 = Emission factor for N_2O emissions from leaching and runoff (kg N_2O-N/kg N leaching/ runoff) taken from IPCC (Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual Volume 3 Table 4-23, or latest data if updated)

Indirect N_2O per tonne of cane are estimated as follows:

$$N_2O_{fert,I} = \frac{N_2O_{INDIRECT} \bullet 44/28}{Y_y} \bullet 310 \quad \textbf{(15)}$$

where:

$N_2O_{fert,I}$ = Indirect N_2O emissions from Nitrogen fertilizer use (kgCO_2e/tonne cane)

Y_y = Average yield agricultural land supplying the project activity (tonnes cane per ha)

3. Emissions associated with the field burning of crop residues

CH_4 and N_2O emissions from the burning of cane trash are estimated using IPCC default for emissions from the burning of agricultural residues (IPCC GPG, 1996), as follows:

$$Carbon\_released = 0.14 \cdot CT\_burned \cdot fraction\ oxidised \cdot CF \quad \textbf{(16)}$$

where:

Carbon_released	=	Carbon released (tonne per tonne of cane)
0.14	=	default fraction dry matter per tonne of cane
CT_burned	=	fraction of cane trash burned in the field
CF	=	Carbon fraction (0.45)

CH_4 and N_2O emissions per tonne of cane are then calculated (CO_2e) in line with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual Volume 3 chapter 4.4.3 (page 4.83) as:

$$CH_4trash = Carbon\_released \bullet 0.007 \bullet \frac{16}{12} \quad \textbf{(17)}$$

where:

CH_4 trash	=	CH_4 emissions per tonne of cane
Carbon_released	=	Carbon released (tonne per tonne of cane)
0.007	=	the upper estimate of CH_4 emission ratio provided in Table 4-16 of the above IPCC guidelines (page 4.84).

and:

$$N_2Otrash = Carbon\_released \bullet 0.015 \bullet 0.009 \bullet \frac{44}{28} \quad \textbf{(18)}$$

where:

N_2O trash	=	N_2O emissions per tonne of cane
Carbon_released	=	Carbon released (tonne per tonne of cane)
0.015	=	the default N-C ratio for crop residues provided by the above IPCC guidelines (page 4.83)
0.009	=	the upper estimate of N_2O emission ratio provided in Table 4-16 of the above IPCC guidelines (page 4.84).

and therefore:

$$ETB_y = CH_4trash \bullet 21 + N_2Otrash \bullet 310 \quad \textbf{(19)}$$

where:

ETBy	=	Emissions from the field burning of crop residues ($kgCO_2e$/tonne cane)
21, 310	=	GWP for CH_4 and N_2O respectively

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

Emissions from transporting the cane to the sugar or bio-ethanol factory must be accounted for:

$$TEF_y = \frac{2 * D_y \bullet CEF_i \bullet \beta \bullet FE}{TC} \quad \textbf{(20)}$$

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 distance between field and factory (km)
FE	=	Fuel efficiency of transporter (l/km)
CEF_t	=	CO_2 emissions factor ($kgCO_2$/l)
ß	=	fraction of cane transported to factory by truck
TC	=	Truck capacity (tones)

The calculation for emissions from the transportation of sugar cane from the field to the bio-ethanol factory requires the percentage of cane transported by truck for the following reasons: Firstly, the variable TEF feeds in to the calculation of an emission factor per tonne of cane (EFF). EFF is required (rather than a total transport figure) because it is used in the situation where bio-ethanol is produced from molasses. Where molasses is the feedstock, emissions per tonne of cane must be divided between sugar and molasses. (NB molasses is a by product of sugar production). Secondly, where sugar cane is not transported to the factory by truck, it is transported by animal and cart, which does not involve GHG emissions.

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

$$EFF_y = PED_y + PEF_y + N_2O_{fert,D,y} + N2O_{fert\,I,y} + ETB_y + TEF_y \quad \textbf{(21)}$$

where:

EFF_y	=	Emissions from "Field" operations ($kgCO_2e$ per tonne cane)
PED_y	=	Project emissions from diesel consumption in agricultural operations ($kgCO_2e$/tonne cane)
PEF_y	=	Project emissions from production of fertiliser used ($kgCO_2e$/tonne cane)
$N_2O_{fert,D,y}$	=	Direct N_2O emissions from Nitrogen fertilizer use ($kgCO_2e$/tonne cane)
$N_2O_{fert,I,y}$	=	Indirect N_2O emissions from Nitrogen fertilizer use ($kgCO_2e$/tonne cane)
ETB_y	=	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 emissions are estimated on the basis of anhydrous bio-ethanol produced, the above emissions factor, estimated as per tonne of cane, must be converted to per kilolitre anhydrous bio-ethanol:

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

$$EFA_{sug,y} = CC \bullet EFF_y \qquad \textbf{(22)}$$

where:

$EFA_{sug,y}$	=	Total "Field" emissions factor where bio-ethanol feedstock is sugar cane ($kgCO_2e/kl$)
CC	=	Cane to anhydrous bio-ethanol conversion factor (t/kl). The sugar cane to anhydrous bio-ethanol conversion factor (CC) is to be calculated from factory input (cane) to output (bio-ethanol) data.
EFF_y	=	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:

$$EFM_y = \frac{SM}{M*SM + S*SS} \bullet EFF_y \qquad \textbf{(23)}$$

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

M and S (the molasses and raw sugar recovery rates from cane respectively) are to be calculated from factory input (cane) to output (molasses and raw sugar) data. SM and SS (the TRS content of molasses and raw sugar produced) are to be provided from factory analysis.

and:

$$EFA_{mol,y} = MC \bullet EFM_y \qquad \textbf{(24)}$$

where:

$EFA_{mol,y}$ = 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)

MC (the molasses to bio-ethanol conversion factor) is to be calculated from factory input (molasses) to output (bio-ethanol) data.

"Industrial" emissions

5. *Emissions from the industrial production of bio-ethanol*

Emissions from the industrial production of bio-ethanol have to be taken into account:

$$PPE_y = FF_y \bullet CEFF + GM_y \bullet CEFG + FF_{CP,y} \bullet CEF_{CP} \qquad \textbf{(25)}$$

where:

PPE_y = Total emissions from the industrial production process of bio-ethanol (tCO_2e)
FF_y = Fossil fuel for providing non-electrical energy to the bio-ethanol factory (tonnes)
CEFF = Emission factor for fossil fuel (tCO_2e/tonne)
GM_y = Electricity imports from the grid to the bio-ethanol factory (MWh)
CEFG = Combined margin grid emission factor (tCO_2e/MWh) estimated as per ACM0002.
$FF_{CP,y}$ = Fossil fuel consumed at captive electrical energy generation for the bio-ethanol factory (TJ)
CEF_{CP} = Carbon emission factor for fuel used at captive generation plant (tCO_2e/TJ). The factor should be based on data from fossil fuel supplier. If such data is not available it should be based on local or national values.

If molasses is used as a feedstock, emissions from non-biogenic energyused to crush the sugar cane must be allocated between molasses and raw sugar. It is recommended that this allocation is done on the basis of sugar content.

"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. As these transport emissions are only to be included if the current distribution of gasoline does not involve 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:

$$TE_y = D_y \bullet CEF_t \bullet TEC_y \bullet FE \qquad \textbf{(26)}$$

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 (l/km)
CEF_t	=	CO_2 emissions factor (tCO_2/l) for transport fuel
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:

$$PE_y = \frac{AH_y \bullet EFA_{sug,y}}{1000} + PPE_y + TE_y \qquad \textbf{(27)}$$

where:

PE_y	=	Project emissions (tCO_2e)
AH_y	=	Volume of anhydrous bio-ethanol produced and used in transportation (kl)
$EFA_{sug,y}$	=	Emissions from agricultural operations ($kgCO_2e$/kl)
PPE_y	=	Emissions from the industrial production of bio-ethanol (tCO_2e)
TE_y	=	Additional emissions from the transportation of bio-ethanol to the blend/distribution location (tCO_2e)

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

$$PEy = \frac{AH_y \bullet EFA_{mol,y}}{1000} + PPE_y + TE_y \qquad \textbf{(28)}$$

where:

PE_y	=	Project emissions (tCO_2e)
AH_y	=	Volume of anhydrous bio-ethanol produced and used in transportation (kl)
$EFA_{mol,y}$	=	Emissions from agricultural operations ($kgCO_2e$/kl)
PPE_y	=	Emissions from the industrial production of bio-ethanol (tCO_2e)
TE_y	=	Additional emissions from the transportation of bio-ethanol to the blend/distribution location (tCO_2e)

Leakage (LE_y)

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.

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 are unlikely to be available. Therefore project proponents must evaluate the following:

- Will the project activity result in an increase in the area of sugar cane planted?
- If yes, over the last 5 years for which data are available, has deforestation occurred in the host country?
- If yes, then the conservative assumption is that the increase in sugar cane area that will result from the project activity will lead to 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 for the calculation of project emissions. 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 biomass dry matter stock of forest before conversion is available in Annex 3A.1 of the GPG-LULUCF, 2003. This should be multiplied by 0.5 to obtain the carbon stock and by 44/12 to arrive at CO_2e.

The project will be credited with CERs only when calculated cumulative emission reductions from the production and use of anhydrous bio-ethanol exceed the one-off GHG emissions from deforestation land. any further CERs will only be issued when the emissions increase has been compensated by subsequent emission reductions by the project activity. (See EB 21, item 18)

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.

Emission Reductions

Emission reductions are calculated as:

$$ER_y = BE_y - PE_y - LE_y \qquad \textbf{(29)}$$

where:

ER_y = Emission reductions in year *y* (tCO_2e)
BE_y = Baseline emissions in year *y* (tCO_2e) as outlined above
PE_y = Project emissions in year *y* (tCO_2e) as outlined above
LE_y = Leakage emissions in year *y* (tCO_2e) as outlined below

Draft approved monitoring methodology AM00XX

"Production of sugar cane-based anhydrous bio-ethanol for transportation using LCA"

Source

This methodology is based on the project activity " Khon Kaen fuel ethanol project", proposed by Khon Kaen Alcohol Company Limited, whose baseline study and project design document were prepared by Agrinergy Ltd.
For more information regarding the proposal and its consideration by the Executive Board please refer to case NM082rev: "Production of sugar cane based anhydrous bio-ethanol for transportation using LCA" on http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

This methodology also refers to the latest version of the "Tool for the demonstration and assessment of additionality".[8]

Applicability

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM00XX (Production of sugar cane-based anhydrous bio-ethanol for transportation using LCA). The same applicability conditions as in baseline AM00XX apply.

Monitoring Methodology

The key element of the monitoring methodology is the determination of ex-post LCA GHG emissions from the production of anhydrous bio-ethanol at the project activity. The LCA of GHG emissions covers the following activities:

- Emissions associated with diesel consumption from agricultural operations in the cane fields supplying cane to the project activity;
- Emissions relating to the production of synthetic fertiliser that is used on the cane fields supplying the project activity;
- Soil N_2O emissions from synthetic and organic fertiliser use on the cane fields supplying the project activity;
- Non CO_2 GHG emissions from the field burning of crop residues;
- Transportation of sugar cane from the field to the sugar/bio-ethanol factory;
- Fossil fuel combustion in the industrial production of bio-ethanol;
- Electrical energy consumption in the industrial production of bio-ethanol.

[8] Please refer to: < http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>

Project emissions parameters

The following table illustrates the data to be collected or used in order to monitor emissions from the project activity:

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1	AH_y Volume of anhydrous bio-ethanol produced and used in transportation in host country	Factory and purchaser records	l	M	Annual	100%	Electronic	The verifier must obtain confirmation from the buyer that the volume of fuel has been used in transportation in host country
1	Bio-ethanol feedstock (sugar cane juice or molasses)	Factory data	feedstoc k name	M	Annual	100%	Electronic	Qualitative Variable
2	Tonnes of sugar cane required to produce 1 kilolitre of bio-ethanol	Factory data	t/kl	C	Annual	100%	Electronic	Estimated total sugar cane used divided by production of bio-ethanol
3	Raw sugar recovery rate from cane	Factory data	%	C	Annual	100%	Electronic	Is required if Molasses is the feedstock. From sugar producing unit that supplies Molasses.
4	Molasses recovery rate from cane	Factory data	%	C	Annual	100%	Electronic	Is required if Molasses is the feedstock. From sugar producing unit that supplies Molasses.

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
5	Total reducing sugars content of molasses	Factory data	%	C	Annual	100%	Electronic	Estimated by project participants using standard industry practice
6	Total reducing sugars content of raw sugar	Factory data	%	C	Annual	100%	Electronic	Sourced by project participants from industry supplying Molasses where this is estimated using standard industry practice
7	Tonnes of molasses required to make 1 kilolitre of bio-ethanol	Factory data	t/kl	C	Annual	100%		Is required if Molasses is the feedstock. From sugar producing unit that supplies Molasses.Estimated using procured Molasses and Bio-ethanol production.
8	Molasses yield from tonne of sugar cane	Factory data	Kg/t	C	Annual	100%	Electronic	
9	Sugar cane yield per hectare	Factory data	t/ha	C	Annual	100%	Electronic	

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
10	Artificial fertiliser application by cane farmers supplying bio-ethanol factory	Extension service/ Individual Farmers	t/ha	M	Annual	100%	Electronic	The extension service is an organisation of agronomists, managed by the sugar factory, that assists the farmers to optmise their cane yield. The extension service will therefore collect data from each farmer on their use of agricultural inputs. If extension data are not available/applicable data is collected from individual farmers
11	Animal manure fertiliser application by cane farmers supplying bio-ethanol factory	Extension service/ Individual Farmers	Kg/ha	M	Annual	100%	Electronic	The extension service is an organisation of agronomists, managed by the sugar factory, that assists the farmers to optmises their cane yield. The extension service will therefore collect data from each farmer on their use of agricultural inputs. If extension data are not available/applicable data is collected from individual farmers
11A	Nitrogen content of manure	Extension service	%	M	Annual	100%	Electronic	

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
12	Average diesel consumption in tractors from agricultural operations for cane farmers supplying bio-ethanol factory	Extension service/ Individual Farmers	l/ha	C	Annual	100%	Electronic	The extension service is an organisation of agronomists, managed by the sugar factory, that assists the farmers to optmise their cane yield. The extension service will therefore collect data from each farmer on their use of agricultural inputs. If extension data are not available/applicable data is collected from individual farmers
13	Percentage of sugar cane land where trash is burned before harvest	Extension service/ Individual Farmers	%	E	Annual	100%	Electronic	The extension service is an organisation of agronomists, managed by the sugar factory, that assists the farmers to optmise their cane yield. The extension service will therefore collect data from each farmer on their use of agricultural inputs. If extension data are not available/applicable data is collected from individual farmers

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
14	Fossil fuel combusted on site to supply non-electrical energy to the bio-ethanol factory	Factory data		M	Annual	100%	Electronic	Qualitative Variable
15	Emissions factor for fossil fuel combusted	IPCC	tCO_2e/t	M	Annual	100%	Electronic	
16	Electricity utilised by bio-ethanol factory	Factory data	MWh	M	Annual	100%	Electronic	
17	Shares of electricity supplied by grid and captive	Factory data	%	M	Annual	100%	Electronic	
18	Source of captive power	Factory data		M	Annual	100%	Electronic	
19	Emissions factor for captive power source	IPCC	tCO_2e/ MWh	C	Annual	100%	Electronic	
20	Grid combined margin emissions factor	National generation data	tCO_2e/ MWh	C	Annual or ex-ante	100%	Electronic	As per ACM0002

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
21	Average distance travelled by trucks transporting cane from fields to sugar factory	Extension service	Km	E	Annual	100%	Electronic	
22	Share of cane transported by truck to factory	Extension service	%	E	Annual	100%	Electronic	
23	Average truck capacity	Extension service	%	E	Annual	100%	Electronic	
24	Truck Fuel efficiency	Manufacturer's data	km/l	M	Annual	100%	Electronic	This will be taken from vehicle records.
25	Truck fuel carbon emission factor	IPCC	CO_2/l	M	Annual	100%	Electronic	
26	Average return distance travelled from bio-ethanol factory to place of blending	Proprietary data	Km	E	Annual	100%	Electronic	Distance is measured if the contract is for delivered bio-ethanol by the project activity and will be estimated if the project activity has a factory gate contract.
27	Bio-ethanol transporter capacity	Manufacturer's data	l	M	Annual	100%	Electronic	

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
28	Bio-ethanol transporter fuel efficiency	Manufacturer's data	km/l	M	Annual	100%	Electronic	This will be taken from vehicle records.
29	Transporter fuel carbon emission factor	IPCC	CO_2/l	M	Annual	100%	Electronic	
30	TEC_y Operator	Determined from evaluation of gasoline supply at blending/ distribution points	0/1	C	Annual	100%	Electronic	If value is set to 1 then transport emissions are calculated, if it is set to zero then transport emissions do not apply.

Baseline emission parameters

The following table illustrates the data to be collected or used in order to estimate emissions from the baseline activity.

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
32	AH_y Volume of anhydrous bio-ethanol produced and used in transportation in host country	Factory and purchaser records	l	M	Annual	100%	Electronic	The verifier must obtain confirmation from the buyer that the volume of fuel has been used in transportation in host country
33	X share of gasoline blended with bio-ethanol in gasohol	Oil company/national fuel specifications	0.8>X<1	M	Annual	100%	Electronic	
34	FEG Fuel efficiency of gasohol	Tests as ourlined in NMB	l/km	M	Annual			Factor to be agreed at validation. However monitoring will allow for review of factor at renewal of crediting period.
35	FEP Fuel efficiency of gasoline	Test as ourlined in NMB	l/km	M	Annual			Factor to be agreed at validation. However monitoring will allow for review of factor at renewal of crediting period.

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
33	Q Relative fuel efficiency of anhydrous bio-ethanol and gasoline	Calculated from variables 33 to 35	N/A	C	N/A	100%	Electronic	.
34	EFP Carbon emission factor	LBST study	tCO_2e/l	Constant	Annual	100%	Electronic	The data represents the baseline emissions constant in the baseline methodology. Although a constant, annual monitoring of new studies is to be carried out and these will be evaluated at renewal of the crediting period.
35	Gasoline production in host country	Reputable statistical sources	kl	M	Annual	100%	Electronic	
36	Gasoline imports into host country	Reputable statistical sources	kl	M	Annual	100%	Electronic	
37	Gasoline consumption in host country	Reputable statistical sources	kl	M	Annual	100%	Electronic	
38	M Share of national gasoline consumption imported	Calculated from variables 35-37	%	C	Annual	100%	Electronic	

Leakage

The main potential source of leakage for this project activity lies in an increase in deforestation as a result of the project activity. This condition is checked in the validation of the project.

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
39	All registered CDM project activities in host country	UNFCCC	N/A	M	Annual	100%	Electronic	
40	Area of cane supplying project activity	Factory records/extension service	ha	M	Annual	100%	Electronic	
41	Occurrence of deforestation in host country	National/ International independent organisation data	N/A	E	Annual	100%	Electronic	
42	Dry matter content of forests in host country	IPCC	t/ha		Annual		Electonic	Most recent data to be used.

Quality Control (QC) and Quality Assurance (QA) Procedures

All measurements should use calibrated measurement equipment that is maintained regularly and checked for its functioning. QA/QC procedures for the parameters to be monitored are illustrated in the following table.

Data	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
1-9	Low	Standard factory date.
10-12	Low	Standard extension service data.
13-19	Low	Factory data Cross-checked with receipts
20-22	Low	Factory /Extension service data.
23-24	Low	Manufacturers' data.
25-31	Low	Factory/Extension service data.

Annex 1: LCA emission factor for gasoline

The default emission factors present in the methodology are based on a study carried out by L-B-Systemtechnik GmbH (LBST, 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". 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). Table below gives WTT and TTW values from the study for a conventional gasoline car.

Life-Cycle Stage	**Product/vehicle**	**GHG emissions**
Well-To-Tank	Gasoline (sulphur content <10 ppm), crude based pathway	13.1[9] gCO_2e/MJ
Tank-To-Wheel	Gasoline (MTA)	185 gCO_2e/km (best estimate)

Fuel efficiency of gasoline cars, as reported in the LBST study, is 8.15 l/100 km, whilst a Net Calorific Value for gasoline is 31.756 MJ/l. Based on these two values, the WTT and TTW values are expressed in per litre of fuel, as shown in table below:

Life-Cycle Stage	**GHG emissions**
Well-To-Tank	416.00 gCO_2e/litre
Tank-To-Wheel	2269.93 gCO_2e/litre
Well-To-Wheel	**2689.11 gCO_2e/litre**

[9] We take the lower figure of 13.1, presented in page 36 of the Annex full background report and the "best estimate" presented in page 42 of the main report.

For conservativeness, and to reflect that fact that it may not be possible to account for every emission of the project activity, and to account for the fact that well-to-tank emissions used in the baseline study may be higher than corresponding emissions in developing countries, refining emissions are adjusted downwards by 50% and emissions associated with crude oil transport (international bunkers) are excluded. The LBST report splits WTT between crude oil production, crude oil transport, refining and distribution as follows:

Life cycle stage	**GHG emissions (gCO_2e/MJ) (LBST report)**	**GHG emissions (gCO_2e/MJ) (used for baseline calculation)**
Crude oil production	3.7	3.7
Crude oil transport	0.9	0
Refining	7.4	3.7
Distribution	1.1	0

Emissions from crude oil transport and distribution are excluded, reducing WTT emissions to 7.4 gCO_2e/MJ. Using these valuesthis gives the following revised emission factor:

Life-Cycle Stage	**GHG emissions**
Well-To-Tank	235 gCO_2e/litre
Tank-To-Wheel	2270 gCO_2e/litre
Well-To-Wheel	**2505 gCO_2e/litre**

The total lifecycle carbon dioxide emissions factor for gasoline (Well-to-Wheel) is, therefore, 2.51 tonnes CO_2e/kilolitre. This figure is applicable to gasoline that is produced within the host country. The emissions factor applicable for *imported* gasoline is the Tank-to-Wheel factor (2.27 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. To reflect uncertainties, these figures should be rounded down to **2.50** and **2.26** t CO_2e/kl respectively.

As mentioned, 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 data analysis and/or studies.