CDM: Proposed New Methodology
Meth Panel recommendation to the Executive Board
(version 03)
(To be used by the Meth Panel to make a recommendation to the Board regarding a proposed new methodology)

Date of Meth Panel meeting:	8-9 September, 2003
Related F-CDM-NM document ID number *(electronically available to EB members)*	NM 0019 A.T. Biopower Rice Husk Power Project
Related F-CDM-NMex document ID number(s) *(electronically available to EB members)*	F-CDM-NMex0019: Deepak Mawandia/Yvonne Hofman
Related F-CDM-NMpu document ID number(s) *(electronically available to EB members)*	F-CDM-NMpu0019: Ralph Harthan/Lambert Schneider: Oeko-Institut Larry Lohmann Ben Pearson, CDM Watch

Note to those completing this form, as applicable: Please provide recommendations on the proposed new baseline and monitoring methodologies based on an assessment of annexes 3 and 4 and of their application in sections A to E of the draft CDM PDD, desk reviews and public input. Please ensure that the form is entirely filled and that arguments and expert judgements are substantiated.

A. Final recommendations by the Meth Panel

I. Recommendation on the proposed new baseline methodology: *(highlight choice made in bold)*

Title of proposed new baseline methodology:>>Grid-connected biomass power generation that avoids uncontrolled burning of biomass

a. To approve this proposed methodology with minor changes

☒

i. Conditions under which this proposed methodology is applicable to other potential CDM project activities (e.g. project type, region, data availability):

>>Applicability restricted to biomass-fired power generation project actvities displacing grid electricity that:

- Face an abundant supply of biomass that is unutilised and is too dispersed to be used for grid electricity generation under business as usual (BAU);
- Use biomass that would otherwise be dumped/burned uncontrollably;
- Have a negligible impact on plans for construction of new power plants;
- Have a negligible impact on the average grid emissions factor;
- Where the grid average carbon emission factor (CEF) is lower (and

therefore more conservative as the baseline) than the CEF of the most likely operating margin candidate .

ii. Minor changes:

>> Minor changes are proposed in the annex 3 attached and detail comments below. In addition some minor edits will be required to remove repetitive paragraphs, improve syntax and incorporate "methodology-specific" information from Annex 5 of the draft CDM-PDD.

b. To reconsider this proposed methodology, subject to required changes

☐

i. Conditions under which the proposed methodology is applicable to other potential projects (e.g. project type, region, data availability):

>>

ii. Required changes:

>>

(Project participants shall make required changes in the proposed new methodology and send it back to the Meth Panel. The proposed new methodology will be reconsidered by the Meth Panel if changes required are correctly made by the project participants. The Executive Board will only consider this proposed new methodology after required changes proposed have been made and the revised proposed methodology has been reconsidered by the Meth Panel)

c. Not to approve the proposed methodology

☐

i. Reasons for non-approval:

>>

(A new proposal should be submitted in accordance with the procedures for submission and consideration of proposed new methodologies of the Executive Board.)

II. Recommendation on the proposed new monitoring methodology: *(highlight the choice made in bold)*

Title of new proposed monitoring methodology: >>Monitoring greenhouse gas emission reductions for biomass power generation using direct measurements and commercial records

a. To approve this proposed methodology with minor changes

☒

i. Conditions under which methodology is applicable to other potential projects (e.g. project type, region, data availability):

>> Applicable where:

Data on the grid carbon emission factor (or fuel inputs and electricity output by fuel for the grid) is available, and where imports/exports from other electricity grids are limited. (further details given below). This monitoring methodology is applicable only to project activities eligible for using the baseline methodology above.

ii. Minor changes:

>>Minor changes are outlined in the detailed analysis below. The annexes may require minor edits to remove repetitive paragraphs, improve syntax.

b. To reconsider this proposed methodology, subject to required changes

☐

i. Conditions under which the proposed methodology is applicable to other potential projects (e.g. project type, region, data availability):

>>

ii. Required changes:

>>

(Project participants shall make required changes in the proposed new methodology and send it back to the Meth Panel. The proposed new methodology will be reconsidered by the Meth Panel if changes required are correctly made by the project participants. The Executive Board will only consider this proposed new methodology after required changes proposed have been made and the revised proposed methodology has been reconsidered by the Meth Panel)

c. Not to approve the proposed methodology

☐

i. Reasons for non-approval:

>>

(A new proposal should be submitted in accordance with the procedures for submission and consideration of proposed new methodologies of the Executive Board.)

B. Details of the evaluation of the proposed new methodology by the Meth Panel:

I. Proposed new baseline methodology *(specify title here):* >> Grid-connected biomass power generation that avoids uncontrolled burning of biomass

(1) Short description of the methodology, including an assessment of which approach from paragraph 48 of the CDM modalities and procedures was used:

a) Describe the methodology:

>> The baseline methodology is structured in 3 main steps:

Step 1 is aimed at checking that the project technology and/or biomass collection system is different to BAU using a barriers analysis based on the same barriers as those provided for small-scale CDM project activities (see Annex 3, pages 53-54).

Step 2 is aimed at selecting the baseline scenario for grid emissions avoided (a) between displacing operating margin or displacing build margin. The methodology provides a rationale to select operating margin in case of relatively small renewable energy based power generation and to adopt the grid average CEF (excluding the project except when it is deemed to have a negligible impact) when it can be considered a conservative estimate of the operating margin CEF. Ex post official data is used to update ex ante baseline emission estimates (see Annex 3, pages 55-56).

Step 3 is aimed at checking that the surplus of biomass is large enough to prevent any leakage by diverting current or future biomass users to a fossil fuel. The methodology provides an algorithm to calculate a supply-demand ratio that is required to be greater than 2:1 (see Annex 3, pages 56-58).

Then the baseline emission are calculated as a sum of (a) avoided emissions from the Grid and (b) the computed methane emissions on account of uncontrolled burning of the rice husk to be used (conservative assumption : 100% is burnt), using IPCC values for methane emission from wood/wood waste combustion as ex ante default value and then direct ex post spectroscopic measure of boilers methane emissions if more conservative.

b) State the approach selected:

>>Approach outlined in paragraph 48 (b) of the CDM modalities and procedures: "Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment;"

c) Indicate (in summary form) why the approach selected is the most appropriate. Please provide your expert judgement on the appropriateness of the selected approach to the project category:

>>There are in fact two different parts in the baseline emissions: one (a) is related to the electricity displaced, the other (b) refers to the avoided methane emissions from rice husk burning.

For part (a) (emissions related to grid electricity displaced) the proposed methodology uses official projections for the national/regional/local electricity grid to calculate the annual grid average carbon emission factors (CEFs) for the crediting period. Such method could reasonably be considered as being based on technology that represents an economically attractive course of action, taking into account barriers to investment if official projections are based on least cost planning or any similar common sectoral practice. One could also argue that continuing to dump/burn rice husk represents "an economically attractive course of action".

If other power generation plants using the same fuel source (rice husks) and collection methods already exist in the country and seem to be economically viable using a more conventional technology (that is the case for Thailand, according to the draft CDM-PDD associated to NM0019), such conventional technology would represent an economically attractive course of action and could be used consistently with approach 48 (b) to calculate the baseline emission associated to methane avoidance. In that case, unless any investment barrier prevents to implement it, the same technology should also be taken into account in the calculation of the emission reductions due to grid electricity displaced: only the difference in electricity displaced by the two technologies (the conventional technology and the project technology) and corresponding difference in emission avoided should lead to CERs issuance[1]

Thus, the 48 (b) approach selected can be considered the most appropriate.

[1] Art 12, para 5 (c) of Kyoto Protocol stipulates that only "Reductions in emissions that are additional to any that would occur in the absence of the certified project activity" shall be certified.

(2) Basis for determining the baseline scenario:

a) State whether the documentation explains how the baseline scenario is to be chosen and identified:

>>According to the documentation (Annex 3 and illustrative draft CDM-PDD associated), the methodology proposes to check that the project is not BAU mainly on the basis of a double investment and technology barrier analysis. This analysis checks two aspects of the project's additionality, namely 1) the technological aspect (the more innovative power generation plant) and 2) the biomass collection element.

The documentation clearly describes how the baseline scenario is to be chosen and identified.

b) State the basic underlying rationale for algorithms/formulae used (e.g. marginal vs. average basis (see also section 4 below):

>> **Baseline emissions:**

- For part (a) (grid electricity displaced):

The global grid emissions are recalculated using official consumption data of the different fuels consumed by the whole grid in the year and corresponding emission factors (see Annex 3, page 3). Then the annual grid emissions are rated by MWh generated by all generation plants connected to the grid. Multiplying this result by the total volume of electricity (MWh) exported by the proposed CDM project activity to the grid during the considered year gives the emission reduction achieved through grid electricity displacement.

- For part (b) (methane avoidance):

First the amount of carbon released from open air burning is determined by multiplying the amount of biomass used by the project with the carbon fraction of biomass . Second, the carbon released as CH_4 is calculated as a percentage of it and is multiplied by the GWP of CH_4 (see Annex 3, page 64).

Project emissions:

- Methane emissions by the project:

Annual CH_4 released by the project is calculated by application of a Methane emission factor for biomass combustion on the volume of biomass burnt by the project (see Annex 3, page 64)

- Emissions associated to transportation of biomass (CO_2, N_2O, CH_4):

First the total annual distance travelled by trucks carrying biomass used by the project is calculated, and second, emission factors per km are applied for each of the three considered gases.

- Emissions associated to start-up/auxiliary fuels (CO_2, N_2O, CH_4):

First a weighted emission factor representing the global GWP of the 3 gases associated to the fuel used as start-up fuel equivalent is calculated (expressed in CO_2), and is then multiplied by the corresponding fuel consumption.

c) State whether the documentation explains how, through the use of the methodology, it can be demonstrated that a project activity is additional and therefore not the baseline scenario. If so, what are the tools provided by the project participants?

>>Step 1 of the methodology provides a list of barriers, based on those applied for in under the Attachment A of Appendix B of the simplified modalities and procedures for small-scale CDM project activities. The methodology requires that ‘relevant barriers are identified to establish that the project would not have been implemented on a business as usual basis’

d) State whether the basis for determining the baseline scenario and for assessing additionality is appropriate and adequate:

>>This is in accordance with ‘Further clarifications on methodological issues’ provided by the Executive Board at its tenth meeting (see Annex 1, section A, paragraph 2 of the report of the Board),

which provides for four options of tools to be used to demonstrate that a project activity is additional and therefore not the baseline scenario, among which 'a qualitative or quantitative assessment of one or more barriers facing the proposed project activity (such as laid out for small-scale CDM projects).

However, the methodology does not give any precise criteria to assess the investment barrier applying IRR on the baseline.

(3) Assessment of the description of the proposed methodology and its applicability

a) State whether the methodology has been described in an adequate manner:

>>The methodology is considered as described in an adequate manner.

b) State whether the proposed methodology is appropriate for the referred proposed project activity and the referred project context (described in Sections A-E of the draft CDM-PDD and submitted along with Annex 3):

>>To the extent that the project developer can reasonably explain that (a) the biomass used for power generation would have either been dumped or burned uncontrollably and/or (b) that the BAU technology would not have been used in the absence of the CDM, the proposed methodology is appropriate for the referred proposed project activity. If not, the methodology is not appropriate, as explained in section B I. (1) c).

c) State whether the application of the methodology could result in a baseline scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity.

>>Yes.

Please explain:

>>The use of an average operating margin emissions factor that will be adjusted *ex post* if the value is lower than that projected *ex ante* ensures that the methodology is conservative.

(4) Assessment of algorithms/formulae and type of data needed:

a) State whether the description of the methodology includes algorithms and generic formulae that can be applied to other potential project activities (If not, the proposed new methodology will be considered as a project-specific methodology.):

>>All formulae can be applied to other project activities that meet the conditions for using this methodology

b) Explain the spatial scope of data used to determine the baseline and whether the scope is appropriate:

>><u>For the grid electricity displaced</u>: The methodology uses official projections/data for the national/regional/local grid to calculate the annual grid average carbon emission factors *ex ante* (see page 58 of the draft CDM-PDD). Whereas this is representative, it would be desirable to include provisions for accounting for changes in the weighted average emission (if any) due to supply of energy from/to other regional countries that may form part of the regional grid.

c) Explain the vintage of data used (in relation to the duration of the project crediting period) and whether the vintage of data is appropriate, indicating the period covered by data:

>>The data used in the project are official projections for 2001 – 2012 from 2001. Projected data, by its very nature, have a high uncertainty; especially as the project crediting period is up to ten years from now. In order to be conservative, the methodology mandates the annual collection of official data to monitor the grid CEF. Where the grid CEF calculated ex post will result in a downward revision of CERs, this will replace the CEF calculated ex ante (see section 5 of Annex 3).

(5) Definition of the project boundary related to the baseline methodology:

a) State how the project boundary is defined in terms of:

i) Gases and sources

>>Baseline: CO_2 - Grid Electricity Generation.

CH_4 – Open Air burning of the Rice Husk

N_2O - Assumed nil – a conservative view (see Note 2 to Annex 3, page 70)

Project : CO_2 - Transportation of Rice Husk from the rice mill to the project site, Onsite transportation of the Rice Husk, Start-up / auxiliary fuel.

CH_4 – Rice husk fuelled generation, Transportation of Rice Husk from the rice mill to the project site, Start-up / auxiliary fuel

N_2O - Rice husk fuelled generation, Transportation of Rice Husk from the rice mill to the project site, Onsite transportation of the Rice Husk, Start-up / auxiliary fuel

ii) Physical delineation

>>The physical project boundary is the project site with inclusion of fuel used to transport the rice husk to the project site.

b) Indicate whether this project boundary is appropriate:

>> The project boundary includes all emissions under control of the project participants and thus can be considered appropriate

(6) Key assumptions/parameters (including emission factors and activity levels) and data sources:

a) List the implicit and explicit key assumptions. Identify those, if any, which are problematic and explain:

>>**Explicit and implicit key assumptions regarding grid electricity displaced:**

1. The methodology assumes that the power produced by the project will displace an "average" kWh, rather than generation from one particular source even though the national generating company expect a particular source to be displaced. This assumption is acceptable where taking the "average" kWh results in a lower (more conservative) baseline. The method also assumes that official data on national/regional/local (according to project context) grid electricity generation and fuel consumption is available.

   However, an implicit key assumption is the scale or the grid to which the projected power plant will be connected: especially for developing countries and/or non-national grid (regionally limited, or to the contrary internationally interconnected) data on grid electricity generation and fuel consumption may not be released on a regular basis. In such cases, additional methodology development would be required to produce conservative estimates.

2. An important implicit key assumption is that no other technology of biomass-fired power generation using the same biomass could be implemented without CDM in place of the technology selected by the proposed CDM activity (for instance same barriers apply for both, or there is no less innovative alternative mastered in the country). If it is not the case (for instance less innovative technology alternative has already been implemented in the country, as it is the case in Thailand where other power plants burning rice husk already exist, and could be implemented again without being registered as a CDM project activity), the methodology might not apply since it may overestimate the emissions reductions, accounting not only the additional emission reductions but also the ones which would have been achieved by the less

innovative technology.

3. An important implicit key assumption is that the proposed CDM project activity is not located in a country/region which does not face suppressed demand/deficit grid. If there is suppressed demand, project participants may wish to use an emissions baseline based on the "build margin" instead of the grid average.

Explicit key assumptions regarding avoidance of baseline methane emissions:

4. Explicit key assumption : Uncontrolled burning of biomass is deemed as the mode of disposal for unwanted agricultural residues in the baseline situation. This is presented as a conservative approach as the emissions from dumped biomass are higher that than that for uncontrolled burning (see note 1 to Annex 3 page 68).
5. Explicit key assumption : Carbon released as CH4 in open-air burning of biomass. A unique IPCC guidelines value is proposed as default value (= 0.005 units of C-CH4 per unit of carbon released, see note 1 to Annex 3 page68).

b) State whether the key assumptions are arrived at in a transparent manner:

>>Yes – most are based on Official or IPCC data.

c) Give your expert judgement on whether the assumptions/parameters are adequate:

>>The explicit assumptions mentioned are described in an adequate manner.

d) Indicate which data sources are used and how the data are obtained (e.g. official statistics, expert judgement). Identify whether the data used are complete and state possible data gaps:

>>The data used are:

- IPCC default factors for various emission factors, calorific values and oxidised fractions (Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual)
- Official energy generation and fuel consumption forecast data (for instance from the Electricity Generating Authority.)
- Current use/disposal of biomass – based on official data (host country national inventory 1990).
- Lab analysis data for specific biomass data.

No gaps in data are identified.

e) Give your expert judgement on whether the data used are adequate, consistent, accurate and reliable:

>>Official data regarding disposal of biomass may not be reliable, accurate or updated especially in certain developing countries (for the associated draft CDM-PDD, the vintage of the host country national inventory is 1990). But this uncertainty is related only to the calculation of the ratio between supply and demand of biomass which is very conservative (2:1)

(7) Assessment of uncertainties:

a) State whether the methodology includes an assessment of uncertainties regarding:

i) The basis for determining the baseline scenario:

>>Not included.

ii) Algorithms/formulae:

>>Not included.

iii) Key assumptions:

>>Key explicit assumptions uncertainties are addressed in a transparent and conservative manner. For implicit assumptions, see above section B I. (6) a).

iv) Data:

>>Yes, the accuracy of official projections is included as an uncertainty and is addressed by ex post calculation and a downward revision (page 61).

b) State whether the uncertainties presented are reasonable:

>>The uncertainties are reasonable or addressed in a conservative manner, except regarding the determination of the baseline. But this last point can be fixed by completing the methodology as required in section B I. (1) c) and B I. (3), and in section B I. (6) (a).

(8) Leakage:

a) State how the baseline methodology addresses any potential leakage due to the project activity:

>>Possible leakage may occur if the supply of biomass for the project leads to a shortage of supply of biomass for existing biomass energy plants, thus forcing them to divert to fossil fuel. The methodology uses a minimum ratio for surplus supply vs. demand of 2:1, where the surplus supply is the total available biomass minus the biomass used for electricity purposes other than generating grid electricity and the demand refers to the total biomass required by all plants using the same biomass. This will be monitored to ensure continuing applicability of the methodology. If the threshold is reached, a survey will be conducted addressing the occurrence of leakage. If leakage is identified, a discount factor will be developed and approved by the Executive Board.

b) Indicate whether the treatment for leakage is appropriate and adequate?

>>The treatment of leakage is globally appropriate and adequate, as long as the threshold has not been reached.

(9) Transparency and "conservativeness":

a) Indicate whether the baseline methodology was developed in a transparent way:

>>To the extent that an additional step is included to determine more precisely whether or not the biomass used in the project would have been used for energy purposes in the absence of the proposed CDM project activity, it can be considered that the baseline methodology was developed in a transparent way.

b) State whether the baseline methodology is conservative:

>> The methodology is conservative for the following reasons:

- The CEF will be monitored through the annual collection of official data. Where the grid CEF calculated ex post will result in a downward revision of CERs, this CEF will be revised.
- Transport is not taken into account in the baseline while it is taken into account in the project emissions.

- Uncontrolled burning is taken as the baseline for agricultural waste disposal, which results in lower emissions than dumping.
- Emission reductions from use of rice husk ash as a blending component for cement (displacing the GHG-intensive clinker) are not included.
- The average operating margin emission factor is lower than that of the marginal plant displaced.

(10) Potential strengths and weaknesses of the baseline methodology (please explain):

>>**Strengths**:

- Transparent as it is based on official data;
- Conservative as it contains a suitable mechanism for adjustments based on actual data ex post, should the results be more conservative;
- Easy to apply: as the proposed methodology does not require a great deal subjectivity.

Weaknesses:

Regarding the investment barrier (step 1), no element is given to assess whether the investment is attractive for investors in the absence of the CERs, and the methodology detailed in Annex 3 (page 54) doesn't give any precise criteria to assess this barrier. As a result each project applying this methodology will have to develop its own criteria to prove additionality.

(11) Other considerations, such as a description of how national and/or sectoral policies and circumstances have been taken into account *(please explain)*:

>>National and/or sectoral policies and circumstances are supposed to be taken into account in official projections (for grid electricity projections)

(12) Applicability of the proposed methodology across project types and regions *(please indicate)*:

>> See section A.I. (a) (i) (above).

Having taken into account these restrictions, the methodology can be applied for different types of biomass in different regions or countries, and for that reason will be very useful for future projects.

(13) Any other comments:

a) State whether any other source of information (i.e. other than documentation on this proposed methodology available on the UNFCCC CDM website) has been used by you in evaluating this methodology. If so, please provide specific references:

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- ECN, 2003, Phyllis Database, the composition of biomass and waste, URL: http://www.ecn.nl/phyllis/dataTable.asp, Accessed August 2003.

- Web site of the Energy Policy & Planning Office http://www.eppo.go.th/info/NT-T14.html; APEC Energy Demand and Supply Outlook 2002; Bangkok Post – 22nd February 2003 http://search.bangkokpost.co.th/bkkpost/2003/feb2003/bp20030222/news/22Feb2003_news10.html

b) Indicate any further comments:

>>1. **Comments regarding the goal of the submission of this methodology together with the associated project:**

The demonstration that the project is not Baseline insists mainly on the additional risk that the choice of a state-of-the-art technology (suspension-fired-boilers) creates for investors when compared to more conventional rice husk power generation projects (see draft CDM-PDD pages 14 and 15). The choice of such technology, which is transferred for the first time in Thailand by foreign industrial and energy investors (see draft CDM-PDD page 5), is justified by the ability of this technology to produce high quality ash product, which will be suitable as a substitute ingredient for cement. This will reduce GHG emissions from cement manufacturing. The rationale seems to be robust enough to prove additionality of emissions reductions in cement factories when compared to conventional rice husk power generation plants. But neither the methodology elaborated in that direction, nor the proposed project is claiming for these reductions in cement industries.

2. The proposed methodology can serve as a very useful basis to elaborate a more complete methodology that could apply :

- for projects achieving additional emission reduction by substituting cement clinker by ashes resulting from biomass combustion in biomass-fired power plants
- for projects using innovative biomass combustion technology that allows to achieve additional emission reduction when compared to BAU biomass combustion technology using the same biomass

II. **Proposed new monitoring methodology *(specify title here):* >>** Monitoring GHG emission reductions for biomass power generation using direct measurements and commercial records.

In respect of the proposed new monitoring methodology, evaluate each section of Annex 4. Please provide your comments section by section:

(1) Brief description of new methodology:

Describe new methodology:

>>The proposed methodology is based on measurements and use of official data. The monitoring methodology involves monitoring of the following:

- Baseline emissions from grid electricity generation
- Baseline emissions from biomass disposal (uncontrolled combustion)
- Project emission from biomass electricity generation
- Project emission from fossil fuel use
- Project emission from transportation (including transportation distance)
- Biomass supply and demand for the biomass sources used by the proposed project.

(2) Key assumptions/parameters:

a) List the implicit and explicit key assumptions. Identify those, if any, which are problematic and explain:

>>The explicit assumption is that official data are readily available. This may be problematic in some developing countries, as some countries do not release these data on a regular basis.

b) State whether the key assumptions are arrived at in a transparent manner:

>>Yes, the assumption is also mentioned in the baseline methodology.

c) Give your expert judgement on whether the assumptions/parameters are adequate:

>>The assumptions are adequate.

(3) Data sources and data quality:

a) Indicate which data sources are used and how the data are obtained (e.g. official statistics, expert judgement). Identify whether the data used are complete and state possible data gaps:

>>Data sources consist of a combination of official statistics (grid electricity generation related), IPCC norms and expert judgment based on lab testing. No data gaps are identified.

b) Give your expert judgement on whether the data used are adequate, consistent, accurate *and reliable:*

>>As already explained in section B. I. (6) (a) and (e):

- For non national grid (regionally limited, or to the contrary internationally interconnected) data on grid electricity generation and fuel consumption may not be released on a regular basis. In such cases, additional methodology development would be required to produce conservative estimates.

- Official data regarding disposal of biomass may not be reliable, accurate or updated especially in certain developing countries (for the associated draft CDM-PDD, the vintage of the host country national inventory is 1990). But this uncertainty is related only to the calculation of the ratio between supply and demand of biomass which is very conservative (2:1)

(4) Assessment of the description of the proposed methodology and its applicability:

a) State whether the proposed methodology has been described in an adequate manner:

>>The draft CDM-PDD provides information on all issues included in Annex 4 of the UNFCCC's CDM-PDD and is described in a transparent and adequate manner.

b) State whether the proposed methodology is appropriate for the referred proposed project activity and the referred project context (described in Sections A-E of the draft CDM-PDD and submitted along with Annex 4):

>>The monitoring methodology is appropriate to the referred proposed project and the referred project context, only to the extent that the conditions of applicability of the baseline methodology expressed in section A I. (a) above are not violated. To the contrary, additional variables will have to be monitored, in accordance with complementary baseline methodology development that would be also required.

c) State whether this proposed monitoring methodology is compatible with the proposed baseline methodology described in annex 3 of the draft CDM-PDD:

>>Yes, the monitor methodology addresses all information and parameters that are needed to monitor a CDM project activity that is developed according to the proposed baseline methodology, to the extent that the conditions of applicability of the baseline methodology expressed in section A I. (a) are respected by the considered CDM project activity.

(5) Leakage *(please elaborate, if appropriate)***:**

>>Leakage will be monitored as described in Section 8 of the Baseline Methodology review above.

(6) Quality assurance and control procedures *(please explain)***:**

>>Quality assurance and control procedures are undertaken for all variables. The procedure involves the double-checking of the measured data against commercial data, e.g. biomass weightings will be checked with purchase receipts and inventory data. All metering devices involved will be maintained according to appropriate industrial standards. The QA/GC procedure seems appropriate for the proposed monitoring methodology.

(7) Potential strengths and weaknesses of the methodology *(please explain)***:**

>>**Strength**: The methodology is transparent, easy to implement, reliable and conservative.

Weakness: It is not applicable to projects that:

- do not have access to sufficient supply of biomass that would have been disposed (burnt/land filled), as it assumes that there will not be any 'leakages' on account of a tight supply of biomass to be monitored;

- are connected to grid for which the required official data are not available.

(8) Applicability of the proposed methodology across project types and regions *(please indicate)***:**

>>The monitoring methodology is applicable to all primarily biomass to energy projects, but only where

there is sufficient quantity of biomass that is unutilised/wasted and in countries where required official data are provided in a regular basis.

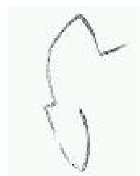
(9) Any other comments:

a) State whether any other source of information (i.e. other than documentation on this proposed methodology available on the UNFCCC CDM website) has been used by you in evaluating this methodology. If so, please provide specific references:

>> None.

b) Indicate any further comments:

>> No further comments.



Signature of Meth Panel Chair ………… ……………………………………..

Date: 16/09/2003 *(Jean-Jacques Becker)*

Signature of Meth Panel Vice-Chair

……………………………………………… ..

Date: 16/09/2003 *(Franz Capra Tattenbach)*

Information to be completed by the secretariat	
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Annex 3

NEW BASELINE METHODOLOGY

1. Title of the proposed methodology:

*Grid-connected biomass power generation **from projects avoiding emissions from biomass burning/dumping**.*

2. Description of the methodology:

2.1. General approach

- ☐ Existing actual or historical emissions, as applicable;
- X☐ 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.

The adoption of 48(b) as the baseline approach for this project is based on the view that in the absence of the CDM project, the most economically attractive course of action will be pursued for the grid, subject to relevant factors such as host country energy policies and environmental regulations. **It can also be considered that continued dumping/uncontrolled burning of biomass is also an "economically attractive course of action" if it is currently occurring.** Moreover, neither 48(a) nor 48(c) will be an appropriate approach to determine the project's baseline due to the reasons given below:

- From official power generation forecasts by the relevant power generation company, it is clear that existing actual or historical emissions will not be representative of the future emission patterns.
- There are no data to determine and analyse the top 20 percent of the projects similar to the project in social, economic, environmental and technological circumstances.

2.2. Overall description (other characteristics of the approach):

The proposed methodology is an application of 48(b) of the CDM modalities and procedures. It looks at the plausible scenarios from an investment perspective to arrive at a baseline scenario for electricity generation.

The methodology firstly determines whether the project is plausible as a business-as-usual project (Step 1). It then determines what will happen in the absence of the project – the baseline scenario in Steps 2.1-2.2. The supply and demand balance for the biomass and the issue of leakage will be considered in Step 3. The steps provided below are to be followed in Section B.3 of the CDM-PDD on a project-specific basis. If any of the questions posed in the following steps are answered with a no, this methodology is not applicable, and another methodology shall be applied to the project.

Step 1: Is the project different to BAU?

Some grid-connected biomass power generation projects can be implemented as BAU and therefore constitute the baseline. However, a great many of them do not materialize due to the presence of barriers. Step 1 of the proposed baseline methodology ascertains what barriers exist **at the biomass collection level as well as the technology level** to prevent the project under consideration**, or a similar project but using less advanced technology,** from being implemented on a BAU basis. There being no guidelines currently available on the appropriate barriers to be considered, this methodology uses the same barriers as those provided for small-scale CDM project activities[15]. These are:

(a) Investment barrier
(b) Technological barrier
(c) Barrier due to prevailing practice
(d) Other barriers

This methodology requires that ~~one or more of these~~**relevant** barriers be identified, to establish that the project would not have been implemented on a BAU basis. Should relevant guidance be provided in future, it will be used either in conjunction with or in lieu of these barriers.

Examples of typical barriers in the context of grid-connected biomass power generation that the project must be shown to face are provided below:

(a) Investment barrier

- Return on equity is too low compared to conventional projects.
- Real and/or perceived risk associated with the unfamiliar technology or process is too high to attract investment.
- There is a lack of support from funding sources to promote innovative projects.

(b) Technological barrier

- The project represents the first or one of the first cases of its kind in the country, leading to technological concerns even when the technology to be employed is proven in other countries.
- There is a lack of skilled labour and/or proper training to operate and maintain state-of-the art technologies, leading to equipment disrepair and malfunctioning.

(c) Barrier due to prevailing practice

- There is a lack of will to change the current practice in biomass disposal, with or without regulations. **If so, indicate how the biomass used for power generation by the project would be used in the baseline scenario.**
- Developers lack familiarity with all available technological options, in particular state-of-the-art technologies, and are reluctant to use them.

(d) Other barriers

[15] Attachment A to Appendix B of the Simplified Modalities and Procedures for Small-Scale Clean Development Mechanism Project Activities

- There is a lack of previous experience using the latest technologies, requiring too much of precious management resources. This puts the project low in management priorities.
- Many local communities fail to see the environmental friendliness of biomass power generation and are opposed to the project, equating it with environmentally more controversial conventional power stations.
- **There is a lack of experience/procedures to collect the biomass used in the project activity from dispersed sources.**

Section B.3 of the accompanying PDD identifies the barriers on a project-specific basis.

Step 2.1: Is the baseline the operating margin?

In this step, the methodology determines whether the project activity will displace the operating margin or build margin after evaluating major relevant factors such as the host country's energy policy and the characteristics of the Project.

It is generally said that the build margin is the appropriate baseline to gauge the long-term impact of a new facility particularly in an environment of increasing electricity demand, which is the case for most countries. However, for most biomass power plants, the operating margin is often more relevant as the baseline even under the circumstances of growing electricity demand.

To determine between build margin and operati**ng**~~ve~~ margin displacement, the methodology proposes an analysis on the factors including the following two:

- Size of the project relative to the total capacity growth planned for the grid and
- Host country energy policies

For grid-connected biomass energy projects, the analysis will typically show:

- The relatively small size of the biomass power generation project means that it has little impact on plans for constructing major new power stations.
- In view of the importance of renewable energy sources emphasized in energy policies in the host country, the project is unlikely to cause the cancellation of planned construction (build margin displacement) of another renewable energy plant of similar size. They will both be built.

The only exception to the second point above is when the supply-demand condition for the biomass to be used by the project is so tight that the two plants cannot both be built. This aspect is assessed as part of the suitability test stipulated in Step3.

Nevertheless, in situations of known suppressed demand, ***project participants can use an emissions baseline based on the "build margin" instead of the grid average.***

Step 2.2: Is the operating margin a combination of all generation types?

Having established the operating margin as the baseline scenario in the previous step, the most likely marginal fuel needs to be identified in this step. The two major factors that must be considered to identify the marginal fuel are:

- Host country energy priorities and

- Operating economy of the different types of power plants.

There are normally two leading candidates for the operating margin. One is single-cycle natural gas which is often marginal due to its low efficiency. The other is imported oil-fuelled power generation, a frequent target of reduction in an effort to curb oil imports and curtail current account deficit.

Sometimes the operating margin can be identified with a fair amount of certainty by close examination of available data. At other times, it is possible to determine the operating margin on the basis of the government's clear policies (e.g. let renewables displace diesel). If a generation type can be definitively singled out as being the operating margin, this will be identified as the baseline scenario.

However, in great many cases, a clear identification of the operating margin is not feasible due to a lack of sufficient data or definite government policy. In this case, this methodology views the grid average excluding the project as the operating margin to be displaced by the project. This view is based on the fact that the grid average without the project signifies the combination of all the economically attractive courses of action for grid power generation in a particular country or region. While admittedly not perfect, it is the most reasonable representation of the operating margin, in the absence of the data (such as well developed dispatch information) that allows precise determination of the operating margin. The use of the grid average as the operating margin is contingent on the following three conditions being met:

- The project under consideration is grid-connected.
- For conservatism, the grid average includes hydro which is often excluded from the operating margin as "must run".
- The grid average carbon emission factor (CEF) is lower (and therefore more conservative as the baseline) than the CEF of the most likely operating margin candidate rejected due to the lack of convincing evidence.

As the baseline is counterfactual, the grid average as the operating margin should be the average excluding the project emissions. However, for the purpose of simplification, the exclusion is deemed unnecessary in cases where the project emissions have only a negligible impact on the value of overage grid emissions. In other words, the grid average including the project will be used as a very close approximation of the grid average without the project, which is conceptually more accurate as the baseline. For biomass generation, the inclusion of the project in the grid average will in fact lead to conservatism.

It is noted that when the supply-demand condition is tight for the biomass fuel to be used by the project, there is a possibility that the diversion of the biomass fuel to a new plant constructed by the project leads to be a decline in the output at existing power plants fuelled by the same biomass. In such a case, the existing power generation must be viewed as the operating margin, instead of the grid average this methodology proposes The methodology has a suitability test against its application to a tight supply-demand environment. Please refer to Step 3.

<u>Step 3: Is there a large surplus supply of biomass?</u>

The following must be ascertained to determine that the application of this methodology is appropriate for a project:

a) The project will not deplete the supply of the biomass in question to the extent that it will affect the construction of biomass power plants pipelined.

b) There is no competition for supply of the biomass that will result in a decrease in the load factor of other biomass-fuelled plants. Thus, biomass-fuelled generation is not the operating margin.
c) The project will not deplete the supply of biomass to drive current users, using the biomass for energy generation purposes, to divert to a fossil fuel to generate the equivalent energy. Thus there is no leakage.

It is thus crucial that there is an abundance of biomass that is not utilised. This methodology thus introduces a supply and demand test. A ratio of more than 2:1 in the following formula is required for the methodology to be applied.

Supply:Demand	=	Surplus amount of biomass, for which there is no use	÷	Biomass required to fuel all plants using same biomass
	=	**greater than 2:1**		

The "supply" referred to in this methodology is equivalent to the total biomass minus biomass consumed for conventional purposes (i.e. other than for grid electricity generation). The amount of surplus supply is to be obtained from the host country's national inventory.

The relevant input values and time span for the factors outlined above differ. For a) and b), which affect the baseline selection, it is necessary to include in the "demand" biomass necessary to fuel not only existing but also planned biomass plants. However the test need only be carried out once, when preparing the CDM-PDD, as they are both baseline issues. If the resulting supply-demand ratio is less than 2:1, supply will be considered tight and the baseline scenario deduced by this methodology incorrect. Then, this methodology will not be applicable to the project.

c) is of both immediate and on-going concern. It is necessary that the supply-demand ratio is greater than 2:1 for the duration of the crediting period. Unlike a) and b) however, the "demand" here includes only the demand at that point in time, and does not include future demand. For the initial supply-demand assessment, the test carried out for a) and b) will automatically test for c).

An assumption made is that there is minimal change in demand for conventional purposes. This assumption is necessary to make use of the official, national inventory data for this analysis. The appropriateness of this assumption is discussed in Section 3.

Having ascertained for the project that there is enough biomass to fuel all plants pipelined, including the project plant, monitoring will be carried out to ensure the continuing applicability of the methodology to the project. As outlined in Annex 4, once the 2:1 threshold is reached, an independent survey will be conducted targeting the region encompassing the project's procurement area. Depending on the survey result, an appropriate measure such as a discount factor will be planned and submitted to the Methodology Panel (or any other relevant authority) for approval. This will ensure leakage is dealt with in an appropriate manner, without unnecessarily increasing transaction costs by mandating comprehensive surveys even in situations where there is a clear abundance of biomass.

The calculation method for supply and demand is illustrated below.

Firstly, the host country’s national inventory is used to deduce the amount of surplus biomass.

Total surplus supply (national inventory)	=	Total supply of biomass	−	Biomass used for grid-electricity generation	−	Biomass used for conventional purposes (e.g. own heating)
	=	Biomass burned (as given in national inventory)	+	Biomass disposed (as given in national inventory)		

As can be seen from the above relationship, the inventory will give the amount of major agricultural crop residues burned or disposed, which represents the surplus biomass factoring in the biomass used for conventional purposes as well as for grid-electricity generation. The amount required for grid-electricity generation is added back to the surplus supply to provide the “supply” as defined in this methodology.

Surplus supply (defined in methodology)	=	Total surplus supply	+	Biomass used to fuel existing plants using same biomass

The amount of biomass necessary to fuel power plants is determined from the amount biomass-fuelled electricity generated for the grid, multiplied by the per unit biomass required. The biomass required by all plants is deemed equivalent to the project plant, as biomass plants are typically of similar scale and efficiency. Thus:

Per unit biomass required to fuel plants (t/MWh)	=	Biomass used to fuel project plant (t/yr)	÷	Electricity exported by project (MWh/yr)

Demand (t/yr)	=	Grid electricity generated by power plants using same biomass as the project, including the project plant* (MWh/yr)	x	Per unit biomass required to fuel plants (t/MWh)

*existing and planned

If there is no data on the amount of electricity generated, but plant capacity is available, a calculation based on the amount of biomass required per unit of installed capacity instead will give a reasonable estimation.

It is noted that where abundance of unused biomass is ascertained, the biomass fuel the project uses would, in the absence of the project, be disposed of in the regular manner, which is the combination of dumping and open air burning or burning in simple incinerators. Since the combustion of the biomass in a controlled environment of a newly-built power station results in much lower GHG emissions, the project will contribute to the reduction of GHG emissions from biomass disposal.

Calculation of baseline emissions

Having established the baseline scenario through the preceding steps, this methodology uses official projections for the national/regional/local electricity grid to calculate the annual grid average carbon emission factors (CEFs) for the crediting period. The annual average CEF is then multiplied by the amount of electricity displaced by the project activity to arrive at the baseline emissions, using the formulae described in Section 6. Methane emission from uncontrolled burning of agricultural residue, which will be displaced by the project, is deduced from the amount of biomass consumed as fuel by the project, multiplied by a methane emission factor.

It is important to emphasise that the baseline scenarios and algorithms and parameters for baseline emission calculations are all determined *ex ante*. Related emissions for both grid electricity and biomass disposal are also determined *ex ante* on the basis of currently available information. Activity related data such as fuel consumed and electricity exported by the project will be monitored and used in the actual computation of CERs, once the project activity starts.

One point of note is the calculation of the grid CEFs. The baseline scenario for electricity generation having being determined as the grid average generation, the definition of the baseline will dictate that the mix of generation types set *ex ante* remains unchanged, with only the CEFs (i.e. the efficiency of future plants) requiring monitoring. However, this approach is more applicable with baselines that specify a single generating type as the target for displacement. Taking into account the fact that biomass plants will have minimal impact on the grid fuel mix due to reasons delineated previously, it is appropriate for this methodology that both the mix of generation types and the respective CEFs – effectively the grid average CEF – be monitored.

For this methodology, in the interest of conservatism, the monitored *ex post* grid CEF will replace the grid CEF calculated *ex ante* only when they represent a lower value.

3. Key parameters/assumptions (including emission factors and activity levels), and data sources considered and used:

Key assumptions:

The inherent assumption in applying this methodology is availability of official grid data for the country/region in which the project is located. Specifically, it is assumed that official projection for annual grid CEFs is available, or, in the case where this cannot be obtained, official fuel consumption and generation plans for each year of the crediting period are available. Furthermore, for monitoring purposes, official actual data on the grid must be released regularly. **It is also assumed that the proposed CDM project activity is not located in a country/region which does not face suppressed demand/deficit grid. (However, if a there is suppressed demand, project participants may wish to use an emissions baseline based on the "build margin" instead of the grid average.)**

Uncontrolled burning is deemed as the mode of disposal for unwanted agricultural residue. This is a conservative assumption, in that emissions from dumped biomass will lead to higher emissions than that for uncontrolled burning. Calculations using IPCC default factors and biomass carbon fraction of 0.4 show that dumped biomass will emit five times more methane over a seven-year crediting period than uncontrolled burning. This figure will increase manifold if long-term effects spanning beyond the crediting period is considered. Please refer to Note 1 to Annex 3 for details.

An assumption is necessitated to make use of official data when conducting the suitability test (Step 3, Section 2.2), which is that biomass consumed for conventional use remains constant. The assumption is reasonable in that most if not all of the future change in demand will stem from biomass used to fuel industrial-scale plants that supply electricity to the grid. Nevertheless, the suitability of this assumption to a specific project is to be confirmed in Section B.3 of the CDM-PDD.

Data sources:

Grid trend – Official power development plans issued by the relevant electricity generating authority/company. This will be used as a primary indication of the national and sectoral circumstances, as the energy plan is typically a reflection of the energy sector priorities as well as the pertinent national policies.

Emission factor (grid electricity) – The relevant electricity generating authority/company is the preferred data source for obtaining grid emission factors. Where there is no official grid carbon emission factor, but fuel usage and generation data are available, the emission factor may be calculated using appropriate IPCC factors and density data.

Current use/disposal of biomass – The major source of data is official data, namely the host country national inventory. This may be strengthened with surveys carried out with producers of the agricultural waste, or by comparing with anecdotal evidence.

Emission factor (biomass) – Default IPCC emission factors are used to compute both baseline and project emissions. Where local data is available, this should be used in lieu of the default factor. The default factors are provided in Section 6 below:

Emission factor (other) – Where available, local data will be used. Otherwise, default IPCC emission factors will be used to compute baseline and/or project emissions. The default factors are also provided in Section 6.

4. Definition of the project boundary related to the baseline methodology:

The physical boundary is defined as the project site. However, emission related to transportation, which occurs outside the plant perimeter, is an exception, and is included in the project boundary.

The gases and sources related to both the baseline and project activities are summarised below. Where a source is not counted, justification is provided.

	Source	**Gas**	**Included in emission calculation? (Justification if not included)**
Baseline	Grid electricity generation	CO_2	Yes
		N_2O	No. For purpose of simplification. This is conservative*.
	Open air burning of surplus biomass	CO_2	No. CO_2 from biomass is carbon-neutral as per IPCC guidelines[16].
		CH_4	Yes

[16] p4.73, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual

		N_2O	No. For purpose of simplification. This is conservative*.
	Transportation of biomass (to disposal site)	CO_2	No. For purpose of simplification. This is conservative.
Project	Biomass electricity generation	CO_2	No. CO_2 from biomass is carbon-neutral as per IPCC guidelines.
		CH_4	Yes
		N_2O	No. For purpose of simplification. This is conservative*.
	Transportation of biomass (from rice mill to project site)	CO_2	Yes
		N_2O	Yes
		CH_4	Yes
	Transportation of biomass (on-site)	CO_2	Yes
		N_2O	Yes
		CH_4	Yes
	Biomass storage	CH_4	No. Biomass will be stored for only a short period of time and hence the emissions will be minor. Further, it should be noted that in the current (baseline) practice, biomass is piled until there is a substantial amount to be burned in the open air.
	Start-up/auxiliary fuel	CO_2	Yes
		N_2O	Yes
		CH_4	Yes

*Grid electricity generation and open air burning of biomass both lead to N_2O emissions, greater than that emitted by the project. For conservatism and simplification, this source is not included in emission calculations. Please refer to Note 2 to Annex 3 attached to this Annex for details.

The definition of the project boundary, as well as gases and sources, may differ slightly depending on the characteristics of the specific project to which the methodology is applied.

5. Assessment of uncertainties:

The most significant uncertainty is the accuracy of official projections which will be used for calculating future annual grid average CEFs to serve as the baseline CEFs. To minimize the risk of over-issuance of CEFs as a result of this uncertainty, the methodology mandates the annual collection of official data to monitor the grid CEF. Where the CEF calculated *ex post* will result in a downward revision of CERs, this will supplant the CEF calculated *ex ante*.

The proposed methodology deems the baseline for surplus biomass to be uncontrolled burning. The uncertainty lies in the assumption that all agricultural waste for which uses cannot be found will be burned, whilst in reality, a significant quantity of the agricultural waste is dumped. The methodology duly addresses this uncertainty by erring on the side of conservatism, as dumping of biomass will result in higher baseline emissions due to the larger quantities of methane – a potent greenhouse gas – produced.

The other uncertainty relates to the possibility of competing use of biomass. Should biomass supply become tight, different baseline scenarios as well as the issue of leakage will have to be considered. As per Step 4, Section 2.2, the methodology duly addresses this aspect by introducing initial and ongoing suitability tests. When the given threshold for supply:demand is crossed, a survey will be conducted by an independent party, the result of which will be used to determine an appropriate measure to account for any leakage.

6. Description of how the baseline methodology addresses the calculation of baseline emissions and the determination of project additionality:

In Step 1, Section 2.2, the project is established as not occurring under BAU. Then, in the subsequent steps, a scenario that is different to the project is established as the baseline scenario (i.e. BAU), taking into consideration factors such as host country energy plans and priorities, regulations and prevalent practice, and investment, technological, institutional and other barriers. This satisfies the latter of the two conditions given in Paragraph 43 of the CDM Modalities and Procedures[17], which states: "*A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity*".

The following formulae describe the calculation of baseline and project emissions, based on the relevant sections of the IPCC guidelines[18]. The difference between the two emission levels will be used to establish that the project will indeed lead to a decrease of emissions as compared to the baseline. This fulfils the other condition given in Paragraph 43.

6.1 Input variables

Where reliable local or project-specific data is available, these will be used in the formulae provided below. Where unavailable, the following IPCC default factors may be used.

Source	Variable	IPCC default	Reference[19]
Grid electricity generation	Net calorific value	Various	Table 1-2, 1-3
	C emission factor	Various	Table 1-1
	Fraction of C oxidised	Various	Table 1-6
	Grid fuel consumption		Electricity generating company
	Grid electricity generation		Electricity generating company
	Electricity exported by project		Project-specific
Open air burning of surplus biomass	C fraction of biomass	Various	Table 4-17
	CH_4 emission factor	0.005	Table 4-16
	Biomass used by project		Project-specific
Biomass electricity generation	Heat value of biomass	Various	Table 1-13
	CH_4 emission factor	30 kg/TJ	Table 1-7
Transportation emission	CO_2 emission factor	1097 g/km 3172.31 g/kg	Table 1-32

[17] Decision 17/CP.7 Modalities and procedures for a clean development mechanism as defined in Article 12 of the Kyoto Protocol, http://unfccc.int/resource/docs/cop7/13a02.pdf (accessed July 2003)
[18] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual
[19] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, unless otherwise stated

	CH_4 emission factor	0.06 g/km 0.18 g/kg	(US heavy duty diesel vehicles, uncontrolled – this is most conservative)
	N_2O emission factor	0.031 g/km 0.09 g/kg	
	Truck capacity		Project-specific
	Return trip distance		Project-specific
Start-up/auxiliary fuel use (assuming heavy oil)	C emission factor	21.1 t C/TJ	Table 1-1
	Fraction of C oxidised	0.99	Table 1-6
	CH_4 emission factor	3 kg/TJ	Table 1-7
	N_2O emission factor	0.6 kg/TJ	Table 1-8

Other data:

GWP CH_4	21
GWP N_2O	310
Mass conversion factor (tCO_2/tC)	44/12
Mass conversion factor (tCH_4/tC)	16/12

6.2 Baseline Emissions

<u>Grid electricity generation – CO_2</u>

Step 1:

For each generation type, fuel consumption data is obtained from official sources and used in the following calculation.

CO_2 emission from grid	=	Grid fuel consumption	x	Net Calorific Value	x	C emission factor	x	Fraction of C oxidized	x	Mass conversion factor
(tCO_2)		(10^3 t)		($TJ/10^3$ t)		(tC/TJ)				(tCO_2/tC)

The total grid CO_2 emission is obtained by summing for all generation types.

Step 2:

The total electricity generated is again obtained from official sources and used to obtain the CO_2 emission factor.

CO_2 emission factor	=	Sum of all CO_2 emission from grid	÷	Grid electricity generated
(tCO_2/MWh)		(tCO_2)		(MWh)

Step 3:

The CO_2 emission displaced by the project is calculated by multiplying the emission factor obtained in Step 2 by the amount of electricity exported by the project.

CO_2 emission	=	Electricity exported by project	x	CO_2 emission factor
(tCO_2/yr)		(MWh/yr)		(tCO_2/MWh)

Open air burning for biomass disposal – CH_4

Step 1:

The amount of carbon released from open air burning of biomass in the absence of the project is determined by multiplying the amount of biomass used by the project with the carbon fraction of biomass.

Carbon released	=	Biomass used as fuel	x	Carbon fraction of biomass
(tC/yr)		(t biomass/yr)		(tC/t biomass)

Step 2:

Annual CH_4 released	=	Carbon released in total	x	Carbon released as CH_4 in open-air burning	x	Mass conversion factor	x	GWP of CH_4
(tCO_2e/yr)		(tC/yr)		(%)		(tCH_4/tC)		(tCO_2e/tCH_4)

6.3 Project Emissions

Biomass electricity generation – CH_4

Methane released by the project is calculated using the following equation. The actual heat value of biomass is relatively easy to obtain and is preferred over the IPCC default factor. After the commencement of the project activity, the actual methane emission factor is to be deduced from stack gas measurements.

Annual CH_4 released	=	Heat value of biomass used by project	x	Methane emission factor for biomass combustion	x	GWP of CH_4
(tCO_2e/yr)		(TJ/yr)		(tCH_4/TJ)		(tCO_2e/tCH_4)

Transportation of biomass – CO_2, N_2O, CH_4

As off-site transportation is often contracted out, this methodology uses the distance between the project plant and biomass supply site as the basis for the calculations. If fuel consumption data can be obtained, the basis for the calculation can be changed from emission per unit distance to emission per unit of fuel. For on-site transportation, where fuel consumption data can be easily obtained, this is usually the case.

Step 1:

$$\underset{(km/yr)}{\text{Distance travelled}} = \underset{(t/yr)}{\text{Total biomass consumed by project}} \div \underset{(t)}{\text{Truck capacity}} \times \underset{(km)}{\text{Return trip distance to supply site}}$$

Step 2:

$$\underset{(tCO_2e/km)}{\text{Emission factor}} = \underset{(tCO_2/km)}{CO_2 \text{ emission factor}} + \underset{(tCH_4/km)}{CH_4 \text{ emission factor}} \times \underset{(tCO_2e/tCH_4)}{\text{GWP of } CH_4} + \underset{(tN_2O/km)}{N_2O \text{ emission factor}} \times \underset{(tCO_2e/tN_2O)}{\text{GWP of } N_2O}$$

Step 3:

$$\underset{(tCO_2e/yr)}{\text{Annual Emission}} = \underset{(tCO_2e/km)}{\text{Emission factor}} \times \underset{(km/yr)}{\text{Distance travelled}}$$

<u>Start-up/auxiliary fuel use – CO_2, N_2O, CH_4</u>

Step 1:

The CO_2 emission factor is calculated using IPCC default values.

$$\underset{(tCO_2/TJ)}{CO_2 \text{ emission factor}} = \underset{(tC/TJ)}{\text{C emission factor}} \times \text{Fraction of C oxidised} \times \underset{(tCO_2/tC)}{\text{Mass conversion factor}}$$

Step 2:

The CO_2 emission factor from above is summed with the CO_2 equivalent values for CH_4 and N_2O emission factors to obtain the total emission factor for fuel use.

$$\underset{(tCO_2e/TJ)}{\text{Emission factor}} = \underset{(tCO_2/TJ)}{CO_2 \text{ emission factor}} + \underset{(tCH_4/TJ)}{CH_4 \text{ emission factor}} \times \underset{(tCO_2e/tCH_4)}{\text{GWP of } CH_4} + \underset{(tN_2O/TJ)}{N_2O \text{ emission factor}} \times \underset{(tCO_2e/tN_2O)}{\text{GWP of } N_2O}$$

Step 3:

The above value is multiplied with the project fuel consumption expressed in energy equivalent.

$$\underset{(tCO_2e/yr)}{\text{Annual Emission}} = \underset{(tCO_2e/TJ)}{\text{Emission factor}} \times \underset{(TJ/yr)}{\text{Fuel consumption in energy equivalent}}$$

7. Description of how the baseline methodology addresses any potential leakage of the project activity:

For biomass energy projects, a potential leakage source is the diversion from biomass to a more carbon-intensive fuel as it begins to be used for power generation. To address this, the methodology has as part of its criteria a suitability test, which assesses whether leakage from this source will occur, either immediately or in the future. It is necessary to ascertain that there is an abundant source of biomass. Where tight biomass supply is an immediate concern, the test deems the methodology unsuitable for a project. If and when tight supply is detected through monitoring, a discount factor is to be introduced to duly account for possible leakage. It should be noted that the definition of "tight" supply for this methodology – 2:1 supply to demand ratio – means that potential leakage will be identified prior to it becoming a real issue.

8. Criteria used in developing the proposed baseline methodology, including an explanation of how the baseline methodology was developed in a transparent and conservative manner:

In determining the baseline for grid electricity generation, the first criterion is transparency. The methodology is clearly transparent in that it requires the use of official grid data sourced from a relevant power generating company. Official projections and stated host country energy priorities is used as an indicator of the baseline scenario. Moreover, the official grid CEF is used to determined the emissions associated with the displacement of grid electricity. All data used is readily available to the public and can easily be double-checked by the DOE.

The possibility of competing use of biomass is also discussed transparently, relying again on official data – the national inventory and grid biomass electricity data. The methodology clearly discusses whether the baseline determination is appropriate, and the possibility of fuel diversion to a more carbon-intensive fuel based on variables that can be easily examined. The use of a supply-demand ratio gives a straightforward and transparent assessment of the issues relating to competing use of biomass.

The baseline selection is carried out in a conservative manner. The selection of the grid average electricity as the baseline scenario for biomass electricity generation projects is conservative in most cases, as it includes in the calculation hydro- and renewable power with zero or very low emission. The approach thus avoids overestimation of the baseline, which may arise from prematurely selecting, as the target of displacement, more carbon-intensive power generation such as coal-fuelled or oil-fuelled electricity, which are the typical targets for displacement.

Due to the uncertainty relating to the disposal method of agricultural waste identified in Section 5 above, transparency and conservatism was given precedence over accuracy in determining the baseline scenario for surplus biomass. There are two methods of disposing biomass for which no use is found – dumping and uncontrolled burning. As the methodology applies to situations where there is no reliable data on the ratio of the respective modes of disposal, it selects as the baseline scenario uncontrolled field burning, which results in a considerable conservative estimation of emissions in comparison to when dumping is selected as the baseline. Therefore, the baseline methodology is clearly conservative.

The methodology also includes in the calculation of project emissions even minor emission sources, such as start-up fuel use and transportation, whilst neglecting emission reduction sources such as N_2O from field burning, which will ensure that emission reductions are not over-stated.

9. Assessment of strengths and weaknesses of the baseline methodology:

The strength of the proposed methodology is in the transparency of the grid average CEFs used for calculating CERs for each year. Also, by recalculating the weighted average CEF for the grid based on official actual data *ex post*, to supplant *ex ante* calculations only when it leads to a conservative CER amount, the methodology has in effect a built-in automatic update function that concurrently ensures conservatism. The transparency and conservatism related to this methodology is discussed in length in Section 8 above.

The weakness of the methodology lies not in the methodology itself but in the possibility of misguided application of the methodology. If it is reasonable to predict a specific fuel(s) that will be replaced by the project activity, this methodology is not pertinent. However, when the displacement of a carbon-intensive fuel is likely but inconclusive, the use of this methodology may be preferable for the sake of conservatism. The same applies to biomass disposal, which is assumed to be uncontrolled burning. If the prevalent mode of disposal can be ascertained as dumping, the calculation of emissions will change drastically and this methodology is therefore not suitable.

Applicability is limited to those projects where official grid data can be readily obtained, not only for current data, but also the grid projection and periodic, future actual data. As official data must be obtained from the relevant local generating company, this methodology is not suitable in regions where official data cannot be obtained, or the reliability of the data is suspect. This is a weakness given that many developing countries lack the sufficient capacity to produce such reliable periodic grid data.

Applicability will also be limited to those projects that specifically have as its baseline emission the grid average emission. The methodology, with some modification, may be adapted to other projects where the baseline fuel mix can be to some extent verified *ex post*, such as those that involve dispatch order analysis. This methodology and accompanying monitoring methodology, which will monitor the actual fuel mix and emission factors, is not applicable to those projects that involve fixing a priori a specific technology(ies) that the project will displace.

10. Other considerations, such as a description of how national and/or sectoral policies and circumstances have been taken into account:

For electricity generation, the official energy plan is central in setting the baseline. This implicitly takes into account all national and sectoral policies and circumstances surrounding electricity generation in that the actual fuel mix is a reflection of these circumstances.

For biomass, an important consideration is the degree to which the agricultural waste is currently utilised. Sectoral policies and circumstances are to be discussed as part of the baseline “tests” provided in Step 4, Section 2.2, to assess the prevailing practice for biomass disposal. In monitoring supply and demand, future sectoral policies will be implicitly but accurately taken into account.

Note 1 to Annex 3: Emission from Biomass Disposal

GHG emissions stemming from the two modes of biomass disposal – open air burning and dumping – are compared. Using the formulae provided in the IPCC guidelines, the emissions were calculated for 1000 tonnes of biomass assuming the following typical properties:

Variable	Value
Degradable Organic Carbon (DOC)	0.45 (typical value for biomass)
Fraction of degradable organic carbon dissimilated (DOC_F)	0.77 (default)
Methane generation rate constant (k)	0.05 (default)
Methane correction factor (MCF)	0.6 (for piles over 5 metres deep)
Fraction of CH_4 in landfill gas (F)	0.5 (default)
Oxidation factor (OX)	0 (value for uncovered piles)
Mass of biomass (M)	1000 t

For the calculation of CH_4 emission from dumping, the following first-order-decay model was used:

$$\text{Methane emissions} = \left(\sum_x \left(A \times M(x) \times MCF(x) \times DOC(x) \times DOC_F \times F \times \frac{16}{12}\right) \times e^{-k(t-x)}\right) \times (1 - OX)$$

where t and x represent the year of emission and year of disposal, respectively.

When 1000 tonnes of biomass is dumped in year 1, 2.4 tonnes of CH_4 is released in the same year. With a GWP of 21, this translates to 51 tonnes CO_2e. As the release of CH_4 from piles occur over a long time span, by year 7, the emission accumulates to 327 tonnes CO_2e. It can be seen from the ensuing table that when long-term effects are accounted for, emission from dumping is significantly higher again.

Year	CH_4 emission (t CH_4)	CO_2 equivalent (tCO_2e)
1	2.4	51
2	2.4	49
3	2.3	48
4	2.2	47
5	2.2	45
6	2.1	44
7	2.0	43
8	2.0	41
9	1.9	40
10	1.9	39

In comparison, according to IPCC guidelines, field burning of biomass is said to release 0.005 units of CH_4 as a fraction of carbon released. Assuming the same properties, 1000 tonnes of biomass will release 56 tonnes CO_2e when burned:

Carbon released = 1000 t biomass x 0.4 tC/t biomass = 400 tC

CH_4 released as CO_2e = 400tC x 0.005 x 16 tCH_4/12 tC x 21 tCO_2e/tCH_4 = 56 tCO_2e

Thus, the GHG effects of both disposal methods over a 7-year span can be summarised as follows:

Year	**Biomass disposed (t)**	**Emission if dumped (tCO_2e)**	**Emission if burned (tCO_2e)**	**Difference (tCO_2e)**
1	1000	51	56	-5
2	0	49	0	49
3	0	48	0	48
4	0	47	0	47
5	0	45	0	45
6	0	44	0	44
7	0	43	0	43
Total	**1000**	**327**	**56**	**271**

Clearly, dumping of biomass will result in higher emissions as compared to burning.

Note 2 to Annex 3: N_2O Emission from Biomass Combustion

N_2O is released when biomass is combusted, both in controlled and uncontrolled burning. Generally, N_2O emission is indirectly proportional to combustion temperature. Thus, it can be stated that with the high boiler temperatures, N_2O emission from biomass-fuelled power generation is lower than that for open air burning.

The same conclusion can be drawn when using IPCC default values, as shown below.

Variable	IPCC default value	Reference
Energy		
N_2O emission factor for biomass	4 kg/TJ	Table 1.8
Net calorific value (bagasse/agriculture)	8.8 TJ/kt	Table 1.24
Agricultural residue burning		
Dry matter fraction (for rice)	0.83 (taking the middle of the range of 0.78 ~ 0.88)	Table 4.17
Carbon fraction (%dm)	0.4144	Table 4.17
N:C	0.014	Table 4.17
Fraction oxidised	0.9	p4.83
N_2O emission ratio	0.007	Table 4.16

Assuming 1000 tonnes of biomass, for power generation,

N_2O emission = amount of biomass x net calorific value x N_2O emission factor
= 1000 t x 8.8TJ/10^3 t x 4 kgN_2O/TJ
= 35 kgN_2O or 0.035 tN_2O

With the same amount of biomass, for field burning,

C released = amount of biomass x dry matter fraction x fraction of C x oxidation factor
= 1000 t x 0.83 x 0.4144 x 0.9
= 310 tC

N_2O emission = C released x ratio N:C x N_2O emission factor x mass conversion factor
= 310 tC x 0.014 tN/tC x 0.007 x 44 tN_2O/28 tN_2
= 0.048 tN_2O

It can be seen that biomass combustion for power generation will result in 0.035 tN_2O, which is lower than the 0.048 tN_2O emitted from field burning. Thus, it is concluded that not counting N_2O emission from biomass combustion will contribute to conservatism when calculating CERs.

Annex 4

NEW MONITORING METHODOLOGY

Proposed new monitoring methodology

Monitoring GHG emission reductions for biomass power generation using direct measurements and commercial records.

1. Brief description of new methodology

In this monitoring methodology, the emissions related to the following sources will be monitored:

- Baseline emission from grid electricity generation
- Baseline emission from biomass disposal (uncontrolled combustion)
- Project emission from biomass electricity generation
- Project emission from fossil fuel use
- Project emission from transportation

In addition, biomass supply and demand will be monitored, as per the accompanying baseline methodology.

2. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived

The following table represents data that will be collected in order to calculate project emissions.

ID number	Data type	Data variable	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)	For how long is archived data kept?
1	Quantitative	Methane in stack gas	%	m	minimum of four times per year	-	electronic	minimum of two years after last issuance of CERs
2	Quantitative	Amount of biomass combusted	t fuel	m	monthly (aggregate)	100%	electronic	minimum of two years after last issuance of CERs
3	Quantitative	Fuel oil use	L	m	continuous	100%	electronic	minimum of two years after last issuance of CERs
4	Quantitative	On-site use of transport fuel	L	m	continuous	100%	electronic	minimum of two years after last issuance of CERs
5	Quantitative	Off-site transport distance	km	m (by a third party)	monthly (aggregate)	100%	electronic	minimum of two years after last issuance of CERs

Spectroscopic measurements (Data 1) will be carried out quarterly to obtain the proportion of methane in the stack gas emitted to the atmosphere. This data, together with the aggregated monthly report on biomass usage (Data 2), will be used to calculate the total methane emission from biomass combustion. Where spectroscopic or equivalent measuring instruments are not available, particularly for small projects, methane emission can be calculated using IPCC default factors, as given in the accompanying baseline methodology.

Emissions from fuel oil used as supplementary and start-up fuel are expected to be insignificant, but will be monitored and included in project emissions regardless. Flow meters will continuously record the amount of fuel being fed into the boilers (Data 3). This will be double-checked against fuel purchase receipts.

Transportation of biomass will occur both on- and off-site. On-site emissions can be calculated by obtaining the amount of fuel used (Data 4). Off-site emissions can be calculated by recording the distance travelled by the trucks (Data 5). This is based on the assumption that fuel consumption data is readily available for on-site transportation, whereas off-site transportation is contracted out. However, either mode of monitoring is acceptable for both on- and off-site transportation emissions.

Baseline emissions will be monitored through the following variables:

ID number	Data type	Data variable	Data unit	Will data be collected on this item? (If no, explain).	How is data archived? (electronic/ paper)	For how long is data archived to be kept?
6	Quantitative	Electricity exported by project	MWh	yes	electronic	minimum of two years after last issuance of CERs
7	Quantitative	Grid CEF	tCO_2e/ MWh	yes	electronic	minimum of two years after last issuance of CERs
8	Quantitative	Amount of biomass combusted	t fuel	yes	electronic	minimum of two years after last issuance of CERs

Emission from grid electricity generation will be obtained by multiplying the amount of electricity exported by the project (Data 6) with the grid CEF (Data 7). The grid CEF, if not obtained directly, can be calculated from grid fuel consumption and generation data.

The amount of biomass consumed by the plant (Data 8) will be used together with the carbon content of biomass and the IPCC default factor for methane emission to calculate methane emitted from open-air burning.

An electronic spreadsheet file will be kept in which all monitored variables are accumulated. This will be presented to the DOE for verification. All hardcopy material relating to these variables will also be stored for reference.

3. Potential sources of emissions which are significant and reasonably attributable to the project activity, but which are not included in the project boundary, and identification if and how data will be collected and archived on these emission sources

In the accompanying baseline methodology, an analysis is conducted to firstly establish that there is a significant surplus of biomass. Hence, there is no leakage associated with the project. To ensure that there is a continuing surplus, the methodology mandates on-going monitoring of a surplus indicator.

ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived?	For how long is archived data kept?

							(electronic/ paper)	
9	Quantitative	Amount of grid electricity generated using same biomass as project	t	n/a (official data)	annually	100%	electronic	minimum of two years after last issuance of CERs
10	Quantitative	Biomass required for grid electricity generation	t	c	annually	100%	electronic	minimum of two years after last issuance of CERs
11	Quantitative	Surplus biomass supply	t	n/a (official data)	annually	100%	electronic	minimum of two years after last issuance of CERs

As per Annex 3, biomass supply must be abundant – the ratio of biomass surplus (unused biomass) and biomass used for grid electricity generation is to be greater than 2:1. This will be determined using the formulae provided below. The amount of electricity generated from the specific biomass (Data 9) will be obtained from the electricity generating company, the surplus biomass supply (Data 11) from the national inventory.

$$\text{Supply:Demand} = \text{Surplus amount of biomass, for which there is no use} \div \text{Biomass required to fuel all plants using same biomass}$$

$$= \textbf{greater than 2:1}$$

where:

$$\underset{(t/yr)}{\text{Demand}} = \underset{(MWh/yr)}{\text{Electricity generated by power plants using same biomass}} \times \underset{(t/MWh)}{\text{Per unit biomass requirement}}$$

and:

$$\underset{(t/MWh)}{\text{Per unit biomass requirement}} = \underset{(t/yr)}{\text{Biomass used by project}} \div \underset{(MWh/yr)}{\text{Electricity exported by project}}$$

Supply as defined by the accompanying baseline methodology is:

$$\text{Surplus supply (defined in methodology)} = \text{Total surplus supply (national inventory)} + \text{Biomass used to fuel existing plants using same biomass}$$

Once the threshold for “tight” supply is reached, a survey will be commissioned to an independent party. As the above calculation provides an indication of the national situation, the survey to be conducted will target the region that is affected by the project, that is, the area within the project’s procurement distance, and the immediate surrounding regions (say, an area within 200% of the project's maximum procurement distance).

Depending on the results of the survey, an appropriate measure will be developed to account for potential leakage, whether it be a discount factor or otherwise. This will be submitted to the Methodology Panel (or the relevant authority at that time) for approval.

4. Assumptions used in elaborating the new methodology:

As is the case for the accompanying baseline methodology, this monitoring methodology assumes that official data necessary to calculate project and baseline emissions (given in Sections 2 and 3) are readily available.

Otherwise, no explicit assumptions are made.

5. Please indicate whether quality control (QC) and quality assurance (QA) procedures are being undertaken for the items monitored. *(see tables in sections 2 and 3 above)*

All except one variable – related to off-site transportation – used in calculating project and baseline emissions are either directly measured or are official data publicly available. In order to ensure the quality of the data, in particular those which are measured, the data are double-checked against commercial data.

The quality control measures planned for the Project are outlined in the following table.

Data	Uncertainty level of data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation why QA/QC procedures are or are not being planned.
1	Low	Yes	The sampling instruments will undergo maintenance subject to appropriate industry standards. The spectroscopy results will be compared to the IPCC default emission factor. The larger of the two values will be used to ensure conservatism.
2	Low	Yes	Trucks carrying biomass will be weighed twice, upon entry and exit. Meters at the weighing station will undergo maintenance subject to appropriate industry standards. This will be checked against purchase receipts and inventory data.
3	Low	Yes	Meters will undergo maintenance subject to appropriate industry standards. The meter readings will be checked against purchase receipts and inventory data.
4	Low	Yes	Fuel pump readings will be compared against fuel purchase invoices.
5	Low	Yes	The distance records submitted by the truckers will be compared to the average distance between the plant and the fuel supply site.
6	Low	Yes	Meters will undergo maintenance/calibration subject to appropriate industry standards. The accuracy of the meter readings will be verified by receipts issued by the purchasing power company, a national or regional authority in most cases.
7	Low	N/A	This involves the use of official data released by the power generating company. Quality control of this data is beyond the control of the project operators. However, the data, if considered unreasonable, may be supplanted by more accurate data according to methods verified by the DOE.
8	Low	Yes	As per 2-2
9	Low	N/A	This involves the use of official data released by the power generating company. Quality control of this data is beyond

			the control of the project operators.
10	Low	Yes	The fuel consumption per unit of electricity generated by the project will be a fair indication of the consumption for other grid-connected biomass plants, which are all likely to be similarly sized. Thus, quality control for the project activity will in effect be quality control for this data also.
11	Low	N/A	This involves the use of official data released by the national government and the power generating company. Quality control of this data is beyond the control of the project operators.

6. What are the potential strengths and weaknesses of this methodology?

The use of measured data will ensure high accuracy of the monitored variables. Also, the use of publicly available official data where necessary increases the transparency of the monitoring process. The use of commercial records as a quality control measure, which are directly or indirectly verified by independent outside parties, will ensure high accuracy for the monitored data. At the same time, the effective use of existing systems in place will streamline the monitoring and verification process and reduce the costs to be borne by the project operator. Another merit of using commercial data is that the proportion of data monitored will be high, in many cases being 100%.

Also, by monitoring project emissions from sources that have only minor impacts on the total project emissions such as start-up fuel use and on- and off-site transportation, this methodology eliminates potential sources of leakage and ensures a conservative calculation of emission reductions stemming from the project activity.

The downside of this, however, is that the monitoring and archiving of emissions from such minor sources will be a laborious process. Although the monitoring of these emission sources is desirable in the interest of conservatism, it is an added burden for project operators, who, particularly for biomass projects, may not have the sufficient capacity to carry this out.

7. Has the methodology been applied successfully elsewhere and, if so, in which circumstances?

This methodology has not been applied in the context of a CDM project.

Annex 5

TABLE: BASELINE DATA

Forecast of Total Energy Generation and Fuel Requirement in Thailand[20]

Type of fuel		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Hydroelectric	GWh	5052	3552	3552	4351	4303	4372	4414	4201	4260	4269	4281	4303
	%	5.0%	3.3%	3.1%	3.5%	3.3%	3.1%	2.9%	2.6%	2.5%	2.4%	2.2%	2.1%
Natural Gas	GWh	62999	72889	77086	83865	88454	87134	85878	81501	87113	87493	82921	74362
	%	62.8%	67.6%	66.9%	68.0%	67.2%	62.1%	57.4%	51.3%	51.2%	48.3%	43.2%	36.5%
	MMSCFD	1475	1603	1697	1769	1841	1810	1752	1642	1764	1760	1658	1472
Heavy Oil	GWh	4178	2787	4794	1070	1059	1061	1061	1050	1047	1047	1047	1051
	%	4.2%	2.6%	4.2%	0.9%	0.8%	0.8%	0.7%	0.7%	0.6%	0.6%	0.5%	0.5%
	MLitres	1063	684	1137	259	257	257	257	255	254	254	254	255
Diesel Oil	GWh	34	12	12	10	10	14	16	0	0	0	0	0
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	MLitres	36	39	37	75	75	76	76	71	71	71	71	71
Lignite	GWh	15213	14603	15106	17311	17257	17259	17255	17310	16251	16253	16252	15798
	%	15.2%	13.6%	13.1%	14.0%	13.1%	12.3%	11.5%	10.9%	9.5%	9.0%	8.5%	7.8%
	MTons	14.51	14.771	15.179	18.386	18.33	18.33	18.33	18.386	17.221	17.221	17.221	16.718
Imported Coal	GWh	0	0	0	0	3809	13979	23291	25170	25094	25094	25094	25170
	%	0.0%	0.0%	0.0%	0.0%	2.9%	10.0%	15.6%	15.8%	14.7%	13.9%	13.1%	12.4%
	MTons	0	0	0	0	1.523	5.342	8.803	9.503	9.473	9.473	9.473	9.503
Other Purchases													
SPP	GWh	10215	11232	12057	13786	13786	13786	14417	14417	14417	14417	14417	14417
	%	10.2%	10.4%	10.5%	11.2%	10.5%	9.8%	9.6%	9.1%	8.5%	8.0%	7.5%	7.1%
Lao PDR	GWh	2631	2690	2640	2921	2857	2810	3305	15332	18834	18784	18721	18698
	%	2.6%	2.5%	2.3%	2.4%	2.2%	2.0%	2.2%	9.6%	11.1%	10.4%	9.8%	9.2%
New IPP	GWh	0	0	0	0	0	0	0	0	3273	13626	29161	49732
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.9%	7.5%	15.2%	24.4%
Total	GWh	12846	13922	14697	16707	16643	16596	17722	29749	36524	46827	62299	82847
	%	12.8%	12.9%	12.8%	13.5%	12.7%	11.8%	11.8%	18.7%	21.4%	25.9%	32.5%	40.7%
Grand Total	GWh	100322	107765	115247	123314	131535	140415	149637	158981	170289	180983	191894	203531

[20] EGAT Power Development Plan PDP 2001, Electricity Generating Authority of Thailand, Appendix 8

Input variables

Source	Variable	Value	Reference[21]
Grid electricity generation	Net calorific value	(TJ/kt) Natural gas = 52.3 Heavy oil = 40.19 (residual fuel oil) Diesel oil = 43.33 Lignite = 12.14 (Thailand) Imported Coal = 26.38 (imported hard coal, Thailand)	Table 1-2, 1-3
	C emission factor	(tC/TJ) Natural gas = 15.3 (dry) Heavy oil = 21.1 (residual fuel oil) Diesel oil = 20.2 Lignite = 27.6 Imported Coal = 26.8 (anthracite)	Table 1-1
	Fraction of C oxidised	Gas = 0.995 Oil and oil products = 0.99 Coal (default) = 0.98	Table 1-6
	Grid fuel consumption	Refer to table above	EGAT PDP
	Grid electricity generation	Refer to table above	EGAT PDP
	Electricity exported by project	132,864 MWh/yr	Calculated
Open air burning of surplus biomass	C fraction of biomass	0.3713 t C/t biomass	Lab analysis
	CH_4 emission factor	0.005	Table 4-16,
	Biomass used by project	144,632 t/yr	Calculated
Biomass electricity generation	Heat value of biomass	0.013607 TJ/t	Lab analysis
	CH_4 emission factor	30 kg/TJ	Table 1-7
Transportation emission	CO_2 emission factor	1097 g/km 3172.31 g/kg	Table 1-32 (US heavy duty diesel vehicles, uncontrolled – this is most conservative)
	CH_4 emission factor	0.06 g/km 0.18 g/kg	
	N_2O emission factor	0.031 g/km 0.09 g/kg	
	Truck capacity	15 t	ATB data
	Return trip distance	120 km (average)	ATB data
Start-up/auxiliary fuel use (assuming heavy oil)	C emission factor	21.1 t C/TJ	Table 1-1
	Fraction of C oxidised	0.99	Table 1-6
	CH_4 emission factor	3 kg/TJ	Table 1-7
	N_2O emission factor	0.6 kg/TJ	Table 1-8

[21] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, unless otherwise stated

Other data:

GWP CH_4	21
GWP N_2O	310
Mass conversion factor (tCO_2/tC)	44/12
Mass conversion factor (tCH_4/tC)	16/12

In converting volume-based fuel consumption to mass-based, the following densities were used:

Natural gas = 0.774kg/m^3
Specific gravity is typically around 0.6 (density of nat. gas = density of air (1.29kg/m3) x 0.6 = 0.774)

Heavy oil = 0.89kg/m^3
Heavy oil densities are between 0.9 and 1.0 kg/m^3 at 15ºC. For a conservative calculation of baseline emissions, the lower limit was used, adjusted for higher temperatures (30ºC). For consistency, project emissions for on-site fuel use were calculated using the same value.