Indicative programme, baseline, and monitoring methodology for

Small Scale Biodigester

Voluntary Gold Standard

Table of Contents

Section I: SOURCE AND APPLICABILITY

This methodology is applicable to programmes of activities involving the implementation of biodigesters in households within the project's boundaries. The project activity is implemented by a project coordinator who acts as the project participant. The individual households will not act as project participants. The consumption of biogas from the biodigesters replaces the consumption of fossil fuel and/or biomass.

Furthermore, the following conditions apply to the methodology:

- The biodigester programme promotes the wide-scale use of biogas as substitute for wood, agricultural residues, animal dung and fossil fuels that are presently used for the cooking, space heating and lighting needs of most rural households.
- The methodology applies to project with biodigesters with a maximum total biodigester volume of 20 m^3.
- The biodigesters in the programme are not included in another CDM or voluntary market project, (i.e. no double counting takes place).
- If more than one climate zone is included in the project, the project should make a distinction per climate zone.

In many developing countries the level of energy service is not sufficient to meet human development needs due to lack of financial means and/or access to modern energy infrastructure. The methodology therefore proposes different options for the baseline calculation depending on whether the project activity is implemented under a situation where energy services provided are sufficient or insufficient to meet the needs of stakeholders. Where stakeholder's energy services are insufficient, the methodology allows the project developer to include emissions that would result from an increase in energy use to satisfy basic human development needs.

Section II: BASELINE METHODOLOGY

1. Project boundary

The physical, geographical site of the renewable energy generation delineates the project boundary.

Emissions sources included in or excluded from the project boundary [add/delete gases and sources as needed]

It is recommended that Project proponents include all the green-house gases marked below, and assess on a project-by-project basis whether or not their measurement or estimation is feasible or their quantitative impact is significant. In cases of doubt they may be omitted, and an estimate made of the level of conservativeness their omission implies.

	Source	Gas	Included?	Justification / Explanation
Baseline	Thermal energy need	CO_2	Yes	Major source of emissions
		CH_4	No	Excluded for simplification, this is conservative
		N_2O	No	Excluded for simplification, this is conservative
	Animal waste handling and storage	CO_2	No	Excluded as CO_2 emissions from animal waste are CO_2 neutral.
		CH_4	Yes	Major source of emissions
		N_2O	No	Excluded for simplification.
Project Activity	Direct emissions from the biodigester	CO_2	No	Excluded as CO_2 emissions from biogas incineration are CO_2 neutral.
		CH_4	Yes	Emissions from physical leakage and incomplete combustion of biogas
		N_2O	No	Excluded for simplification

2. Procedure for selection of the most plausible baseline scenario

The baseline scenario is one of the following options:

a. The situation before implementation of the biodigesters (i.e. **pre-project situation**).
b. The situation where fossil fuels are used to meet energy service needs (even if they are not currently being used).

3. Additionality

Additionality shall be demonstrated using the latest version of the "*Tool for the demonstration and assessment of additionality*" that is available on the UNFCCC website[1].
The "Tool for the demonstration and assessment of additionality" should be applied from the perspective of the project coordinator undertaking the project activity.

[1] http://cdm.unfccc.int/methodologies/PAmethodologies/AdditionalityTools/Additionality_tool.pdf

Possible barriers could include (among others):

- Investment barrier: the programme cannot be implemented as the initial investment in the biodigester is too high for individual households;
- The costs for large scale distribution of biodigesters, their related maintenance and training are too high for the project coordinator; and
- Sufficient knowledge is not available locally about the technology to enable autonomous uptake.

Evidence to show additionality could include (among others):

- National feasibility studies about biodigester dissemination in the host country;
- Comparison of biodigesters cost with annual income of targeted households; and
- Statistics on sale and availability of biodigesters in the region where the programme will be implemented.

4. Baseline emissions

The baseline emissions involve emission from use of fossil fuel and non-renewable biomass for cooking and heating, and emissions from the handling of animal waste in the baseline situation.

If project participants can identify the emissions from animal waste these can be included in the baseline emission calculations; if not, these are excluded.

In order to determine total baseline emissions, the baseline emissions per household are calculated as:

$$BE_h = BE_{th,h} + BE_{aw,h} \qquad \textbf{(1)}$$

Where:

BE_h = Baseline emissions of household h (tCO_2e/yr)
$BE_{th,h}$ = Baseline emissions from fuel consumption for thermal energy needs of household h (tCO_2e/yr)
$BE_{aw,h}$ = Baseline emissions from animal waste handling of household h (tCO_2e/yr)

In many developing countries the level of satisfied energy service demand is not reached, due to lack of financial means and/or access to modern energy infrastructure. In order to consider such a situation in the baseline calculation, the concepts of 'suppressed demand' and 'satisfied demand' are therefore introduced and defined as below:

<u>Concept of "suppressed demand" and "satisfied demand"</u>

"Suppressed demand" is the situation where energy services provided are insufficient – due to poverty or lack of access to modern energy infrastructure – to meet the needs of stakeholders given their human development needs.
"Satisfied demand" is the situation where suppressed demand is satisfied through an increase in energy use (i.e. from an accessible and/or more affordable energy source).

Where stakeholder's energy services are insufficient to meet their human development needs (suppressed demand), the baseline emissions may include emissions that would result from meeting this suppressed demand – that is, emissions resulting from an increase in energy use to satisfy basic human development needs (satisfied demand).

4.1 Baseline emissions from fuel consumption for thermal energy demand

Baseline emissions caused by the consumption of fuel for thermal energy demand can be determined in three separate ways:

1. Pre-project situation (section 4.1.1)
2. Project level energy service demand using a fossil fuel and appliance as in situation with satisfied demand (section 4.1.2)
3. Satisfied demand with fossil fuel mix and technology different from pre-project (section 4.1.3).

The below table summarises the approach considered for each of the baseline options.

Table 1 Overview of baseline options

Baseline option	**Level of consumption**	**Fuel technology**	**Approach for data gathering**
1: Pre-project situation	Pre-project	Pre-project situation	Questionnaire among households
2: Project level energy service demand with fossil fuel (and/or charcoal) technology	Project level	Technologies using fossil fuel/s and/or charcoal (one or more of charcoal, LPG, electricity, coal, kerosene, etc.)	Questionnaire among households with a higher standard of living outside the project boundary, to assess type of fuel and technology. Questionnaire among households using biogas to estimate level of fuel consumption.
3: Satisfied demand with different fuel mix and/or technology as pre-project	Satisfied demand	Satisfied demand (from one or more fossil fuels such as LPG, diesel, electricity, coal, kerosene, etc.)	Questionnaire among households with a higher standard of living outside the project boundary to assess type and level of demand for cooking and space heating services. Apply model to assess satisfied demand for heating.

4.1.1 Baseline Option 1: baseline emission from thermal energy demand in the pre-project situation

The following steps need to be followed to determine baseline emissions from thermal energy demand:

1. Determine baseline emissions from fuel consumption
2. Adjust baseline emissions for the share of non-renewable biomass

The baseline emissions from the thermal energy demand will be determined from fossil fuel and non renewable biomass use in the baseline situation. For guidelines on the determination of the share of Non-Renewable Biomass (NRB), please refer to Annex 1.

Fossil fuel and biomass use will be determined through surveys at the household, which will be held:

a) In the total population (all households planning to implement biodigesters); or
b) In a sample of the total population.

The surveys should be held before the implementation of the biodigester or within 3 months after the implementation of the biodigester.

Project proponents may choose which option (a or b) they prefer. As households need to be visited for the installation of the biodigester, option (a) may be feasible.
The advantage of option (a) is that no margin of error needs to be subtracted from the average CO_2 emission in the baseline situation. Thus more baseline emission can be claimed.

In the event that option (a) is not feasible, option (b) will be applied.

Survey Option (a): Survey in total population
The calculation of baseline emissions is based on the results of the questionnaire. After collecting the questionnaires at all households covered by the project, total baseline emissions for the total number of households is calculated as the sum of individual household baselines given by formula (2).

Survey Option (b): Survey in sample of the total population
The calculation of baseline emissions is based on the results of the questionnaire. After collecting the questionnaires at all households included in the sample group, the mean and standard deviation of household project CO_2 emissions from fuel consumption should be calculated. These variables will be inputs for calculating total CO_2 emission from fuel consumption for the total number of households in the baseline situation as per formulas (2) to (5).

$$BE_{th,h,option1} = \Sigma((F_{i,bl,h}) \cdot NCV_i \cdot EF_{CO2i}) \qquad \textbf{(2)}$$

Where:

$BE_{th,h,\ option1}$	=	The baseline emissions used to meet the thermal energy need of one household
$F_{i,bl,h}$	=	The total amount of fuel i in the baseline situation (mass or volume) of one household
NCV_i	=	The net calorific value (energy content) per mass or volume unit of a fuel *i*,
$EF_{CO2,i}$	=	The CO2 emission factor per unit of energy of the fuel *i*.

Where available, local values of NCV_i and $EF_{CO2,i}$ should be used. If no such values are available, country-specific values or IPCC default values are to be used.

The mean of household baseline CO_2 emission is calculated as follows:

$$\mu BE = \frac{\sum BE_h}{n_{bl}} \qquad \textbf{(3)}$$

Where:

μBE	=	Mean of CO_2 emission of households included in the baseline sample group
BE_h	=	The amount of CO_2 emission in household h included in the baseline sample group in the baseline situation
n_{bl}	=	Total number of households included in the baseline sample group

The standard deviation of CO_2 emission in the baseline situation is calculated as follows:

$$\sigma_{BE,th} = \sqrt{\frac{\sum \left(BE_{th,h} - \mu BE_{th}\right)^2}{n_{bl} - 1}} \qquad \textbf{(4)}$$

Where:

$\sigma_{BE,th}$	=	Standard deviation of CO_2 emission in the baseline situation
μBE_{th}	=	Mean of CO_2 emission of households included in the baseline sample group
$BE_{th,h}$	=	The amount of CO_2 emission in household h included in the baseline sample group in the baseline situation
n_{bl}	=	Total number of households included in the baseline sample group

The total CO_2 emission in the pre-project situation can than be calculated as follows:

$$BE = n_{hh,y}\left(\mu_{BE} - z \cdot \frac{\sigma_{BE}}{\sqrt{n_{bl}}}\right) \qquad \textbf{(5)}$$

Where:

BE	=	The total amount of CO_2 emission in the pre-project situation
$n_{hh,y}$	=	Total number of households participating in the program for the monitoring interval y
σ_{BE}	=	Standard deviation of CO_2 emission in the baseline situation
μ_{BE}	=	Mean of CO_2 emission of households included in the baseline sample group
n_{bl}	=	Total number of households included in the baseline sample group
z	=	Standard normal for a confidence level of 95% (1.96)

4.1.2 Baseline option 2: project level energy service demand using a fossil fuel and appliance as in situation with satisfied demand

In this baseline option the energy service demand considered is the one of the project situation and the type of fuel and technology used are the ones of the satisfied demand situation. This will in most cases involve a fossil fuel and appliance mix rather than biomass, though charcoal could be included. Eligibility for this approach requires the establishment of improved standard of living as per step 1 below. The identification of the fuels and technologies is made as per step 2.

Step 1: Show that a suppressed demand exists by providing evidence that the standard of living of the households is increasing. This should be done in at least two of the following ways:

- Show that the heat demand after implementation of the biodigester is higher than before its implementation. This can be done through a questionnaire in a sample before and after the implementation of the project;
- Show that the biodigester was fully purchased by the household; and/or
- Show that level of income has increased in the last three years.

Step 2: Set a default baseline scenario for the <u>baseline fuel source</u> for heat supply at project level energy service demand as in a situation with satisfied demand

The type of fuel and appliance in a situation with satisfied demand should be determined through recognised practice or by survey from a sample among households in the same area as project participant that are more affluent members of the community.

The level of energy service is the same as that delivered by the project level consumption of biogas.

To calculate baseline emission under option 2, first the share in energy supply of each of the fuels in the project situation needs to be calculated:

$$S_{i,BL,option2} = \frac{F_i * NCV_i}{\sum_i F_i * NCV_i} \quad \textbf{(8)}$$

Where:

$S_{i,BL,\ option\ 2}$ = Share of each fuel i in the project situation (%).

F_i = Average fuel consumption in the sample of households with project level consumption for type of fuel and technology (in a mass or volume unit per year) for fuel *i*.

NCV_i = Net calorific value (energy content) per mass or volume unit of fuel *i*.

Baseline emissions for baseline option (2) with project level energy service demand (using a fossil fuel and appliance as in situation with satisfied demand) are then calculated as follows:

$$BE_{th,h,option2} = \sum_i \left(\frac{\sum_j \left(\mathrm{F}_{\mathrm{j,bl,h}} \cdot NCV_j \cdot \eta_{bl1} \right)}{\eta_{bl2}} \right) \cdot S_{i,BL,option2} \cdot EF_{CO2i} \quad \textbf{(9)}$$

Where:

$\mathrm{BE}_{\mathrm{th,h,\ option\ 2}}$ = The baseline emissions used to meet the thermal energy need of one household in baseline option 2.

$S_{i,BL,\ option\ 2}$ = Share of each fuel *i* in the project situation for type of fuel and technology as in situation with satisfied demand (%).

$\mathrm{F}_{\mathrm{j,bl,h}}$ = The total amount of fuel *j* in the project situation (mass or volume) of one household for the situation.

NCV_j = The net calorific value (energy content) per mass or volume unit of a fuel *j*.

η_{bl1} = The average energy efficiency of the cooking and heating device applied in the situation that would have been used in the absence of the project activity to burn fossil fuels (and/or charcoal).

η_{bl2} = The average energy efficiency of the cooking and heating device applied in the situation with satisfied demand for type of fuel and technology (baseline option 2).

$EF_{CO2,i}$ = The CO_2 emission factor per unit of energy of the fuel i in the situation with satisfied demand for type of fuel and technology.

Where available, local values of *NCV* and $EF_{CO2,i}$ should be used. If no such values are available, country-specific values or IPCC default values are to be used.

4.1.3 Baseline Option 3: baseline emission from a situation with satisfied demand for type of fuel and technology and level of energy service demand.

The determination of the baseline emissions under this option should be compatible with CDM methodology AMS-I.E. (available at http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html) and in accordance with the following steps:

Step 1: Show that a suppressed demand exists by providing evidence that the standard of living of the households is increasing. This should be done in at least two of the following ways:

- Show that the heat demand after implementation of the biodigester is higher than before its implementation. This can be done through a questionnaire in a sample before and after the implementation of the project;
- Show that the biodigester was fully purchased by the household; and/or
- Show that level of income has increased in the last three years.

Step 2: Set a default baseline scenario for the baseline energy fossil fuel source for heat supply in a situation where energy service levels are satisfactory i.e. where there is no suppressed demand for energy service.

Different fossil fuel energy sources may be identified for cooking and space heating. The fossil fuel energy sources could be fuels such as diesel, LPG, kerosene, coal, charcoal briquettes, electricity or other fossil fuel sources. This should be done in one of the following ways:

- Existing socio-economic data on what fossil fuels and appliance combinations are used for energy services for heating and cooking in households, in the same region or country as the proposed project; or
- If no socio-economic data exist for fossil fuels and appliance combinations, this information should be derived from questionnaires in a sample of households in the same region or country as the proposed project with a socio-economic level that is higher than the level of the project population and with satisfying energy service demand for space heating and cooking.

Step 3: Assess the level of baseline consumption for cooking and space heating.
The baseline energy consumption will be determined as follows for space heating and cooking respectively:

- The baseline level of energy consumption for space heating will be determined with a model that applies data derived from project monitoring of indoor and outdoor temperature in a sample of the project population and default data of the construction of the house. See annex 3 for an algorithm of such a model. Annex 4 provides an example of how this level can be conservatively estimated.
- The baseline level of consumption for cooking should be determined through questionnaires in a sample of households in the same region or country with a socio-economic level that is higher than the level of the project population and considered to have a satisfied energy service demand for cooking.

Step 4: Calculate the baseline emissions for each household in the sample as follows:

$$BE_{th,h,y} = \Sigma\left(\left(F_{i,bl\_us\_sh,h,y} + F_{i,bl\_us\_c,h,y}\right) \cdot NCV_i \cdot EF_{CO2i}\right) \qquad \textbf{(10)}$$

Where:

$BE_{th,h,y}$	=	The emissions from thermal energy used to satisfy thermal energy service requirements of one household in year y.
$F_{i,bl\_us\_sh,h,y}$	=	The total amount of fuel *i* in the situation with satisfied demand (mass or volume) for space heating of one household in year y.
$F_{i,bl\_us\_c,h,y}$	=	The total amount of fuel *i* in the situation with satisfied demand (mass or volume) for cooking of one household in year y.
$NCVi$	=	The net calorific value (energy content) per mass or volume unit of a fuel *i*,
$EF_{CO2,i}$	=	The CO2 emission factor per unit of energy of the fuel *i*.

The variables $F_{i,bl\_us\_sh,h,y}$ and $F_{i,bl\_us\_c,h,y}$ should be derived from one of the approach outlined above.

Where available, local values of NCV_i and $EF_{CO2,i}$ should be used. If no such values are available, country-specific values or IPCC default values are to be used.

4.2 Baseline emissions from handling of animal waste

Project participants can include baseline emissions from animal waste handling if these can be clearly identified. If this is not possible the baseline emissions from animal waste are to be excluded.

The baseline emissions from the handling of animal waste can be determined by one of the following three options:
- Use an IPCC TIER 1 approach.
- Use an IPCC TIER 2 approach
- Assume no baseline emissions from the handling of animal waste in the baseline situation.

4.2.1 IPCC TIER 1 approach

This approach is applicable on households without a distinctive animal waste management system, i.e. life stock is not kept at the household premises or in the very near vicinity. The animal waste will only be partially collected for utilisation.

The share of the total produced waste per animal, which is fed into the biodigester, is obtained from the surveys. This percentage is used to adjust the methane emission factor per animal obtained from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

$$BE_{aw,h,T1} = 365 \cdot \Sigma(MS_{T,S,k} \cdot VS_T \cdot EF_{aw,i}) \quad \textbf{(11)}$$

Where:

$BE_{aw,h,,T1}$	=	the baseline emission from handling of animal waste in year y for household h for TIER 1
365	=	basis for calculating annual VS production, days yr^{-1}
VS_T	=	daily volatile solid excreted for livestock category *T*, kg dry matter $animal^{-1}$ day^{-1}
$MS_{T,,h,k}$	=	fraction of livestock category *T*'s manure fed into the biodigester *of household h*, in climate region *k*, dimensionless
$EF_{T,,aw,i}$	=	the animal waste methane emission factor by average ambient temperature in $kgCH_4animal^{-1}yr^{-1}$ for livestock category *T*

In Annex 2 the relevant IPCC tables can be found for Manure animal waste methane emission factors by temperature in $kgCH_4head^{-1}yr^{-1}$.

4.2.2 IPCC TIER 2 approach

This approach is applicable to households with a distinctive animal waste management system, i.e. animals are kept in a confined area and the manure is collected following a specifically designed system. If animals leave the confined area, the percentage manure they excrement (MS) has to be estimated as a percentage from the total amount manure they produce.

$$BE_{aw,h,T2} = \sum_{T} \left(EF_{(T)} \cdot LC_{T,h} \right) \quad \textbf{(12)}$$

$BE_{aw,h,T2,}$ = the baseline emission from handling of animal waste for household h for TIER 2 in tCO_2 per year
$LC_{T,h}$ = Number of animals of livestock category Tin household h

$$EF_{(T)} = VS_{(T)} \cdot 365 \cdot GWP_{CH4} \left[Bo_{(T)} \cdot 0.67 kg/m^3 \cdot \sum_{k} \frac{MCF_{BL,k}}{100} \cdot MS_{(T,k)} \right] \quad \textbf{(13)}$$

Where:

$EF_{(T)}$ = annual CH_4 emission factor for livestock category *T*, tCO_{2eq} $animal^{-1}$ yr^{-1}
$VS_{(T)}$ = daily volatile solid excreted for livestock category *T*, kg dry matter $animal^{-1}$ day^{-1}
365 = basis for calculating annual VS production, days yr^{-1}
GWP_{CH4} = Global Warming Potential (GWP) of methane
$Bo_{(T)}$ = maximum methane producing capacity for manure produced by livestock category *T*, $m^3 CH_4$ $kg^{-1}$of VS excreted
0.00067 = conversion factor of m^3 CH_4 to tonne CH_4
$MCF_{(BL,k)}$ = methane conversion factors for the animal waste handling system in the baseline situation by climate zone *k*, %
$MS_{(T,S,k)}$ = fraction of livestock category *T*'s manure treated in the animal waste management system, in climate region *k*, dimensionless

If country-specific data are available for only a portion of these variables, project participants must calculate country-specific emission factors, using the data in Tables 10A-4 through 10A-9 from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories to fill gaps

Default methane conversion factors (MCFs) are provided in Table 10.17 from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories for different manure management systems and by annual average temperatures.

5. Project emissions

The project emissions involve emission from household fuel consumption after installation of the biodigester and emission from the biodigester in the statistically significant sampling group. Emission from the biodigester includes physical leakage of the biodigester and incomplete combustion of biogas, which are both calculated as a percentage of the produced methane.

$$PE_{y,h} = PE_{th,h,y} + PE_{biodigester,h,y} \quad \textbf{(14)}$$

Where:

$PE_{,y,,h}$ = Project emissions per household h in year y (tCO_2e/yr).
$PE_{,th,,h,y}$ = Project emissions from fuels used to meet the thermal energy need per household h in year y (tCO_2e/yr).
$PE_{,biodigester,,h,y}$ = Project emission from the biodigester per household h in year y (tCO_2e/yr).

$$PE_{th,h,y} = \Sigma((F_{i,pj,y}) \cdot NCV_i \cdot EF_{CO2i}) \quad \textbf{(15)}$$

Where:

$PE_{,th,,h,y}$ = Project emissions from fuels used to meet the thermal energy need per household h in year y (tCO_2e/yr).
$F_{i,pj,y}$ = The total amount of fuel i in the project situation (mass or volume) per household in year y.
NCV_i = The net calorific value (energy content) per mass or volume unit of a fuel *i*,
$EF_{CO2,i}$ = The CO_2 emission factor per unit of energy of the fuel *i*.

For the assessment of $EF_{CO2,i}$ for $F_{i,pj,y}$ where $F_{i,pj,y}$ is a biomass source, the assessment of non-renewable biomass (NRB), as elaborated in the section on baseline emissions should be applied.

In case the project proponent can not show that a share of the biomass was non-renewable, it has to be assumed that all biomass applied in the baseline is non-renewable, i.e. the CO_2 emissions from consumption of the biomass should be accounted for.

$$PE_{biodigester,y} = \sum (LC_{T,h,y} \cdot EF_T) \cdot PL_y + \sum (LC_{T,h,y} \cdot EF_T) \cdot (1-\eta_{biogastove})(1-PL_y) \quad \textbf{(16)}$$

Where:

$LC_{T,h,y}$ = Number of animals of livestock category T in year y in household h.
EF_T = Annual CH_4 emission factor for livestock category *T*, (tCH_4 $animal^{-1}$ yr^{-1}).
PL = Physical Leakage of the biodigester in year y (%).
$\eta_{biogastove}$ = Combustion efficiency of the most commonly used type of biogas stove.

EF_T is estimated using the IPCC TIER 2 approach. Formula (12) needs to be applied for the situation of the biodigester in the project situation.,

The physical leakage (PL) of the biodigester system is estimated using IPCC guidelines. The physical leakage from anaerobic digesters is estimated by the IPCC as 10% of total methane production. Where project participants use lower values or percentage of physical leakage, they should provide measurements proving that this lower value is appropriate for the project

Apart from leakage, also incomplete combustion results in the emission of methane to the atmosphere. This is accounted for by the inclusion of the combustion efficiency ($\eta_{biogastove}$) of the most commonly used type of biogas stove. This figure can be obtained form literature or a default value of 98% can be applied.

Project emissions will be determined for each household in the sample group. The mean of household project CO_2 emission is calculated as follows:

$$\mu PE = \frac{\sum PE_h}{n_{pj}} \quad \textbf{(17)}$$

Where:

μPE	=	Mean of CO_2 emission of households included in the project sample group.
$PE_{,h}$	=	The amount of CO_2 emission in household h included in the project sample group in the baseline situation.
n_{pj}	=	Total number of households included in the project sample group.

The standard deviation of CO_2 emission in the project situation is calculated as follows:

$$\sigma_{PE} = \sqrt{\frac{\sum (PE_h - \mu PE)^2}{n_{pj} - 1}} \quad \textbf{(18)}$$

Where:

$\sigma_{,PE,}$	=	Standard deviation of CO_2 emission in the project situation.
$\mu PE_{,}$	=	Mean of CO_2 emission of households included in the project sample group.
PE_{th}	=	The amount of CO_2 emission in household h included in the project sample group in the baseline situation.
N_{pj}	=	Total number of households included in the project sample group.

The total CO_2 emission in the project situation can than be calculated as follows:

$$PE = n_{hh,y}\left(\mu_{PE} + z \cdot \frac{\sigma_{PE}}{\sqrt{n_{pj}}}\right) \quad \textbf{(19)}$$

Where:

PE	=	The total amount of CO_2 emission in the project situation.
$n_{hh,y}$	=	Total number of households participating in the program for the monitoring interval y.
$\sigma_{PE,th}$	=	Standard deviation of CO_2 emission in the project situation.
$\mu PE_{,}$	=	Mean of CO_2 emission of households included in the project sample group.
n_{bl}	=	Total number of households included in the project sample group.
z	=	Standard normal for a confidence level of 95% (1.96).

6. Leakage

No significant sources of leakage are identified.

7. Emission reductions

The project implementation and determination of emission reductions involves the following steps:

Step 1: Determination of the project area(s) i
Step 2: Establishment of a project activity implementation plan
Step 3: Determination of the size of the project sample group
Step 4: Selection of the households to be included in the project sample group
Step 5: Establishment of a project database
Step 6: Perform baseline questionnaire

Step 7: Perform project questionnaire
Step 8: Calculation of the mean and standard deviation of project and baseline emissions
Step 9: Calculation of emission reductions

The replaced fuel consumption will be based on the difference between the baseline fuel consumption and the project fuel consumption. Actual baseline emission can therefore only be determined on the basis of the project questionnaire.

Step 1: Determination of the project area(s) i
The total project area should be divided into single project areas i for each climate region. In case the total project area involves one climate region, only one project area is identified. The project needs to be located in one country.

The distinct geographical boundary of each project area i should be clearly documented in the CDM-PDD using GPS data.

Step 2: Establishment of a project activity implementation plan
A project activity implementation plan which specifies how the project is implemented should be established and documented in the PDD, including, inter alia, information on:

- The type of biodigesters that are distributed or sold by the project coordinator, including information on the various manufacturers and the capacity of the digesters;
- The number of biodigesters by type that are planned to be distributed by the project activity in each project area i over the duration of the crediting period;
- Which households are eligible to participate in the project activity (e.g. households with a certain income, etc);
- How the biodigesters will be distributed or sold to household consumers, including a description of all measures employed under the project and a description how final consumers are motivated to participate in the project; and
- How households included in the sample groups will be selected randomly in a statistically representative manner.

Step 3: Determination of the size of the sample group
To yield statistically representative results, the sample group should have a minimum size. In this methodology, baseline and project emissions are adjusted by the margin of error at a 95% confidence interval from sampling fuel consumption in order to ensure that emission reductions are estimated in a conservative manner. Moreover, emission reductions can only be claimed if ≥ 60 households are sampled. It will be advisable to have a bigger sample group as the will decrease the margin of error.

Step 4: Selection of the households to be included in the project sample group
The households to be included in the pool of households should be selected randomly among the households that are participating in the programme. How the random selection is undertaken must be explained in the GS-PDD.

Step 5: Establishment of a project database
Prior to the start of the distribution of biodigesters by the project coordinator, the project coordinator should establish a database containing all relevant information for sampling households, including, inter alia:

- A list of all project areas i, including the name or number of the project area and the GPS data to delineate the area;
- A list of the households that are taking part in the project sampling group, including information to identify the household (name, GPS coordinates, applicable project area i);
- For each household, information on when the biodigester has been implemented; and
- For each household that is selected for either the baseline or project sample a separate database needs to be made for the questionnaire results.

Step 6: Collect baseline questionnaire
A baseline questionnaire needs to be collected before the implementation of the biodigesters from all participating households. This can for example be done at the moment of installation of the biodigester. Baseline emissions are calculated on the basis of the questionnaire results.

Step 7: Collect project questionnaire
A project monitoring questionnaire needs to be collected at the end of each monitoring period from the sample group.

Step 8: Calculation of the mean and standard deviation of project and baseline emissions
After collecting the questionnaires from all households included in the baseline and project sample group, the mean and standard deviation of household project fuel consumption during the monitoring interval y (the time period between two spot checks) should be calculated as explained in section 4 and 5. Baseline emissions need to be calculated only in the first year, either for the whole group of project participants or a sample group.

Step 9: Calculation of fuel consumption and emission reductions
Project fuel consumption is calculated based on the sampling results and adjusted with the statistical margin of error at a 95% confidence level. The fuel savings as a result of the project are calculated as the difference of the mean household fuel consumption for the baseline and project situation multiplied with the total number of households participating in the project as in section 4.

Emission reductions are then calculated as follows:

$$ER_y = BE - PE_y \tag{20}$$

Where:

ER_y = Emission reduction in total household population in year y (tCO_2e/yr)
BE = Baseline emissions of total household population (tCO_2e/yr)
PE_y = Project emissions of total household population in year y (tCO_2e/yr)

8. Data and parameters not monitored

Data / Parameter:	**NCV_i**
Data unit:	GJ/kg
Description:	net calorific value (energy content) *i*, per mass or volume unit of a fuel
Source of data:	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Any comment:	

Data / Parameter:	**$EF_{CO2,i}$**
Data unit:	tCO2/GJ
Description:	CO_2 emission factor per unit of energy of the fuel *i*. THIS factor should be monitored annually if data available – if this is electricity use
Source of data:	
Any comment:	

Data / Parameter:	**NCV_{CH4}**
Data unit:	GJ/kg
Description:	Net Calorific Value CH_4
Source of data:	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Any comment:	

Data / Parameter:	**$VS_{(T)}$**
Data unit:	kg dry matter $animal^{-1}$ day^{-1}
Description:	daily volatile solid excreted for livestock category *T*
Source of data:	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Any comment:	365 = basis for calculating annual VS production, days yr^{-1}

Data / Parameter:	**$Bo_{(T)}$**
Data unit:	m^3CH_4 kg^{-1} of VS excreted
Description:	maximum methane producing capacity for manure produced by livestock category *T*
Source of data:	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Any comment:	

Data / Parameter:	**$MCF_{(S,k)}$**
Data unit:	[-] %
Description:	methane conversion factors for each manure management system *S* by climate region *k*
Source of data:	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Any comment:	

Data / Parameter:	**$EF_{aw,i}$**
Data unit:	$kgCH_4head^{-1}yr^{-1}$ for animal i.
Description:	animal waste methane emission factor by average temperature
Source of data:	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Any comment:	

Data / Parameter:	**$\eta_{biogastove}$**
Data unit:	[-] %
Description:	Incineration efficiency of the biogas stove
Source of data:	Literature
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	**η_{bl1}**
Data unit:	[-] %
Description:	Incineration efficiency of the devices used for cooking and heating in the situation before project implementation (baseline option 1)
Source of data:	Literature
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	η_{bl2}
Data unit:	[-] %
Description:	Incineration efficiency of the of the cooking and heating devices applied in the situation with satisfied demand (baseline option 2)
Source of data:	Literature
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	Only applicable for baseline option 2

Section III: MONITORING METHODOLOGY

During monitoring, the provisions as outlined in the baseline methodology apply.
Monitoring involves, inter alia, the collection of the following data:

- Ex-post identification of the number of households that took part in the programme at the beginning of the monitoring interval y.
- Identification of the households that are randomly selected for the project sample.
- Ex-post collection of data on fuel use and input of excrements and biomass into the digester.
- Ex-post calculation of the mean and standard variation of baseline and project emissions and ex-post calculation of emission reductions.
- All monitored data should be stored in the electronic database. A complete extract of the database should be made available to the DOE with each monitoring report.
- All measurement equipment should be calibrated and regularly maintained and checked for its functioning according to manufacturer's specification and relevant national or international standards.

For baseline scenario with modelled energy consumption of satisfied demand for energy services for heat supply, the following needs to be monitored:

- Check that biogas digester is in working order.
- Check whether biogas is being used for cooking.
- Check whether biogas is being used for space heating.

1. Quality Assurance of Questionnaire distribution and collection

As the emission reductions are based on questionnaires (or calibrated models), the quality assurance lies in the reliability of the estimates made on the basis of the questionnaire. It is therefore of importance that the questionnaires are distributed by specially trained personnel who have extensive knowledge about:

- Country or regional customs;
- Local farming practices;
- The technical design of the biodigester system;
- The amount and type of fuel used for each household; and
- How households handle their animal waste.

The surveys are to be performed by a survey team of at least two persons. It is estimated that in each working day 5 households can be surveyed by a team.

During the visit the survey team will also check if the biodigester is still operating according to the standard of the manufacturer, and if leaks can be discovered in the biodigester (using a methane detector).

2. Quality Control

The Quality control is to be performed by a DOE on a biannual basis. They will visit a select group of households which is part of the project sample group. They must at least fulfil the same knowledge requirements as the survey team. At the household they will assess the reliability of the questionnaire by checking the figures provided by the respondents. If deviations occur, the value will be adjusted accordingly.

3. Data and parameters monitored

Data / Parameter:	**ID 1 / $Area_i$**
Data unit:	km^2
Description:	Project area
Source of data:	Project participant
Measurement procedures (if any):	Identified by climate region *k*
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

These parameters have to be available for every household in the sample group

Data / Parameter:	**ID 2 / n_{bl}**
Data unit:	[-]
Description:	Number of households in baseline sample group
Source of data:	Project participant
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	**ID 3 / n_{pj}**
Data unit:	[-]
Description:	Number of households in project sample group
Source of data:	Project participant
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	**ID 4 / n_{bl2}**
Data unit:	[-]
Description:	Number of households in sample group with satisfied demand (baseline option 2)
Source of data:	Project participant
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	The sample group should be taken from households in the same region with a satisfied demand for energy services

Data / Parameter:	**ID 5 / $n_{hh,y}$**
Data unit:	[-]
Description:	Total number of households participating in the programme in year y
Source of data:	Project participant
Measurement procedures (if any):	All households' details need to be included in a database. The number of households should be derived from this database.
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	**ID 6 / $F_{i,bl1}$**
Data unit:	kg or m^3
Description:	amount of fuel i consumption in the baseline in baseline option 1
Source of data:	survey
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	**ID 7 / $F_{i,bl2}$**
Data unit:	kg or m^3
Description:	amount of fuel i consumption in the baseline in baseline option 2
Source of data:	survey
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	The sample group should be taken from households in the same region with a satisfied demand for energy services

Data / Parameter:	**ID 8 / $F_{i,y,\,pj}$**
Data unit:	kg or m^3
Description:	amount of fuel I consumption in the project in year y
Source of data:	survey
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	**ID 9 / I**
Data unit:	tons/year
Description:	Annual biomass increment on the project area$_i$.
Source of data:	Obtained from field surveys or a GIS
Measurement	

procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	**ID 10 / H**
Data unit:	tons/year
Description:	Annual biomass harvest on the project area$_i$.
Source of data:	Obtained from field surveys or a GIS
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	**ID 11/ $MS_{(T,S,k)}$**
Data unit:	[-] %
Description:	fraction of livestock category *T*'s manure fed into the biodigester, *S* in climate region *k*
Source of data:	survey
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	**ID 12 / PL**
Data unit:	[-] %
Description:	Physical Leakage of the biodigester
Source of data:	Survey or other measuring method, default values of 2006 IPCC Guidelines for National Greenhouse Gas Inventories is 10%.
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	**ID 13 / LC**
Data unit:	[-]
Description:	Number of life stock of category K
Source of data:	Survey.
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter:	ID 14 / T_{in}
Data unit:	C
Description:	Indoor temperature
Source of data:	Survey.
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Only applicable for Baseline option 3

Data / Parameter:	ID 15 / T_{out}
Data unit:	[-]
Description:	Outdoor temperature
Source of data:	Survey.
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	Only applicable for Baseline option 3

Data / Parameter:	ID 16 / GWP_{CH4}
Data unit:	tCO_2e / t CH_4
Description:	Global Warming Potential (GWP) of methane
Source of data:	Most recent IPCC guidelines
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

- - - - -

Section IV: Annexes

Annex 1 – Determination of share of Non-Renewable Biomass (NRB)

The determination of the baseline emissions from biomass consumption requires the determination of the share of non-renewable biomass (NRB) in the baseline.

For the definition of NRB, the Executive Board decision EB 23 Annex 18 is followed. From the inversion of EB23 decision it follows that biomass is NRB if:

1) In the project area the consumption of wood exceeds the renewable wood production; or
2) Fuel wood consumption by households constitutes a significant share of total wood consumption.

Project proponents must demonstrate that the biomass used in the baseline is indeed non-renewable, by using the following steps[2]:

Step 1: identify a "woody biomass production area" (area) which should be the larger of the following two areas: a) all forests and woodlands from which the project participants derive their wood fuel in the baseline, b) all forests and woodlands from which project participants could realistically obtain biomass, given means of transport, accessability and daily time available for transporting biomass.

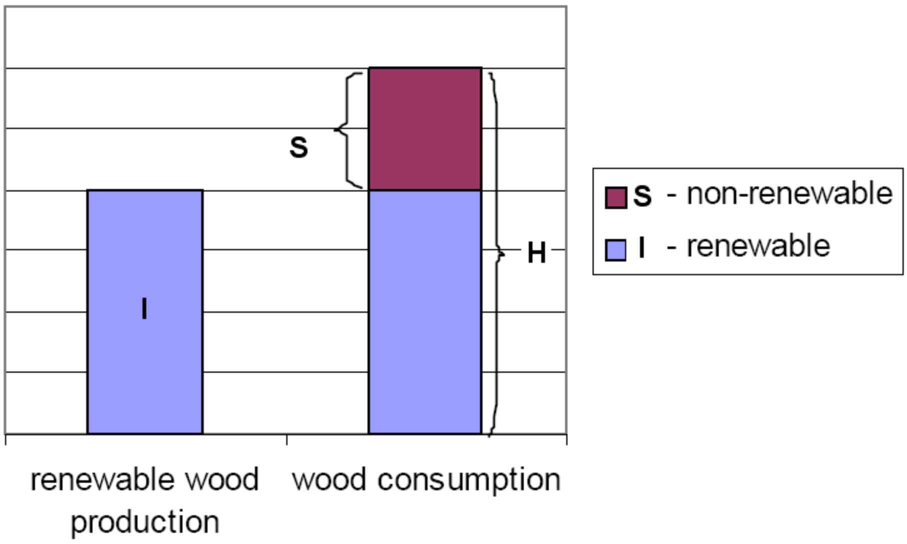
Step 2: For the area estimated in step 1, estimate the average annual wood fuel increment (I) which could be harvested, consistent with the definition of "renewable biomass". For this purpose, tools like satellite data, regional statistics, regional or IPCC allometric equations to estimate the above ground biomass increment etc. may be used.

Step 3: Estimate the average harvest of wood fuels derived from this area (H)

Step 4: Calculate the shortage of woody biomass in the area: S = H – I.

Step 5: Demonstrate that the amount of woody biomass used in the project baseline, at time zero, is less than S. If this is not the case, set the amount of woody biomass that can be included in the baseline to S.

Figure 2: overview of the definitions.



[2] Based on submission of Bernard Schlamadinger to the UNFCCC

Where:

A	Area from which woody biomass is produced (the larger of the following two areas: a) all forests and woodlands from which the project participants derive their wood fuel in the baseline, b) all forests and woodlands from which project participants could realistically obtain biomass, given means of transport, accessibility, and daily time available for transporting biomass).
I	Annual biomass increment (tons/year) on area A
H	Annual biomass harvest (tons/year) on area A
S	Net shortage of wood on area A, which is considered non-renewable

The share of non-renewable biomass can now be calculated according to:

$$S_{NRB} = \frac{S}{H} \qquad \textbf{(6)}$$

Where:

S_{NRB}	=	Share of non-renewable biomass
S	=	Non renewable biomass harvest (tons/year) on the project $area_i$.
H	=	Annual biomass harvest (tons/year) on the project $area_i$.

The amount of non-renewable biomass displaced can now be calculated according to:

$$F_{NRB,y} = S_{NRB} \cdot F_{Bio,y} \qquad \textbf{(7)}$$

Where:

$F_{NRB,y,h}$	=	the amount of non renewable biomass in year y in household h
S_{NRB}	=	the share of non-renewable biomass obtained from the total project $area_i$
$F_{bio,y}$	=	the amount of baseline biomass consumption in household h

That a share of the biomass was non-renewable, it has to be assumed that all biomass applied in the baseline is renewable, i.e. no baseline emission can be accounted to biomass consumption.

The proposed methodology for estimating NRB shares is based upon the limited body of existing work. The Gold Standard Technical Advisory Committee is prepared to review and endorse new methodologies for estimating NRB and to incorporate them into this baseline and monitoring methodology.
Such proposals would need to consider the following elements:

- Methodologies must be demonstrably conservative, ensuring a high probability that over-crediting of emissions reductions will not occur
- Datasets required by the methodology must be reliably obtained from proposed sampling methods
- Use of generic datasets must be clearly justified and adjusted for local relevance
- Methodologies ought to be practical and simple enough for widespread usage

Proposals for new NRB methodologies should be submitted independently to the Gold Standard TAC for consideration using the email address info@cdmgoldstandard.org and will be subject to a reduced assessment fee of 1250 USD per proposal.

Annex 2 – Emissions factors for livestock

TABLE 10.14
MANURE MANAGEMENT METHANE EMISSION FACTORS BY TEMPERATURE FOR CATTLE, SWINE, AND BUFFALO[a]
(KG CH_4 $HEAD^{-1}$ YR^{-1})

Regional characteristics	Livestock species	CH_4 emission factors by average annual temperature (°C)[b]																	
		Cool					Temperate											Warm		
		≤ 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28
North America: Liquid-based systems are commonly used for dairy cows and swine manure. Other cattle manure is usually managed as a solid and deposited on pastures or ranges.	Dairy Cows	48	50	53	55	58	63	65	68	71	74	78	81	85	89	93	98	105	110	112
	Other Cattle	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Market Swine	10	11	11	12	12	13	13	14	15	15	16	17	18	18	19	20	22	23	23
	Breeding Swine	19	20	21	22	23	24	26	27	28	29	31	32	34	35	37	39	41	44	45
Western Europe: Liquid/slurry and pit storage systems are commonly used for cattle and swine manure. Limited cropland is available for spreading manure.	Dairy Cows	21	23	25	27	29	34	37	40	43	47	51	55	59	64	70	75	83	90	92
	Other Cattle	6	7	7	8	8	10	11	12	13	14	15	16	17	18	20	21	24	25	26
	Market Swine	6	6	7	7	8	9	9	10	11	11	12	13	14	15	16	18	19	21	21
	Breeding Swine	9	10	10	11	12	13	14	15	16	17	19	20	22	23	25	27	29	32	33
	Buffalo	4	4	5	5	5	6	7	7	8	9	9	10	11	12	13	14	15	16	17
Eastern Europe: Solid based systems are used for the majority of manure. About one-third of livestock manure is managed in liquid-based systems.	Dairy Cows	11	12	13	14	15	20	21	22	23	25	27	28	30	33	35	37	42	45	46
	Other Cattle	6	6	7	7	8	9	10	11	11	12	13	14	15	16	18	19	21	23	23
	Market Swine	3	3	3	3	3	4	4	4	4	5	5	5	6	6	6	7	10	10	10
	Breeding Swine	4	5	5	5	5	6	7	7	7	8	8	9	9	10	11	12	16	17	17
	Buffalo	5	5	5	6	6	7	8	8	9	10	11	11	12	13	15	16	17	19	19
Oceania: Most cattle manure is managed as a solid on pastures and ranges, except dairy cows where there is some usage of lagoons. About half of the swine manure is managed in anaerobic lagoons.	Dairy Cows	23	24	25	26	26	27	28	28	28	29	29	29	29	29	30	30	31	31	31
	Other Cattle	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Market Swine	11	11	12	12	12	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	Breeding Swine	20	20	21	21	22	22	23	23	23	23	23	24	24	24	24	24	24	24	24
Latin America: Almost all livestock manure is managed as a solid on pastures and ranges. Buffalo manure is deposited on pastures and ranges.	Dairy Cows	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
	Other Cattle	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Swine	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
	Buffalo	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2

TABLE 10.15
MANURE MANAGEMENT METHANE EMISSION FACTORS BY TEMPERATURE FOR SHEEP, GOATS, CAMELS, HORSES, MULES AND ASSES, AND POULTRY[a] (KG CH_4 HEAD^{-1} YR^{-1})

Livestock	CH_4 emission factor by average annual temperature (°C)		
	Cool (<15°C)	Temperate (15 to 25°C)	Warm (>25°C)
Sheep			
Developed countries	0.19	0.28	0.37
Developing countries	0.10	0.15	0.20
Goats			
Developed countries	0.13	0.20	0.26
Developing countries	0.11	0.17	0.22
Camels			
Developed countries	1.58	2.37	3.17
Developing countries	1.28	1.92	2.56
Horses			
Developed countries	1.56	2.34	3.13
Developing countries	1.09	1.64	2.19
Mules and Asses			
Developed countries	0.76	1.10	1.52
Developing countries	0.60	0.90	1.20
Poultry			
Developed countries			
Layers (dry)[b]	0.03	0.03	0.03
Layers (wet)[c]	1.2	1.4	1.4
Broilers	0.02	0.02	0.02
Turkeys	0.09	0.09	0.09
Ducks	0.02	0.03	0.03
Developing countries	0.01	0.02	0.02

The uncertainty in these emission factors is ±30 %.

Sources: Emission factors developed from: feed intake values and feed digestibilities used to develop the enteric fermentation emission factors (see Annex 10A.1); Except for poultry in developed countries, methane conversion factor (MCF), and maximum methane producing capacity (B_o) values reported in Woodbury and Hashimoto (1993). Poultry for developed countries was subdivided into five categories. Layers (dry) represent layers in a "without bedding" waste management system; layers (wet) represent layers in an anaerobic lagoon waste management system. For layers, volatile solids (VS) are values reported in USDA (1996); typical animal mass values are from ASAE (1999); and B_o values for Layers are values reported by Hill (1982). For broilers and turkeys, B_o values are from Hill (1984); typical animal mass values are from ASAE (1999); and VS values are those reported in USDA (1996). B_o values for ducks were transferred from broilers and turkeys; typical animal mass values are from MWPS-18; and VS values are from USDA, AWMFH. Typical mass of sheep, goats and horses, and VS and B_o values of goats and horses for developed countries updated according to the analysis of GHG inventories of Annex I countries. All manure, with the exception of Layers (wet), is assumed to be managed in dry systems, which is consistent with the manure management system usage reported in Woodbury and Hashimoto (1993).

[a] When selecting a default emission factor, be sure to consult the supporting tables in Annex 10A.2 for the distribution of manure management systems and animal waste characteristics used to estimate emissions. Select an emission factor for a region that most closely matches your own in these characteristics.

[b] Layer operations that manage dry manure.

[c] Layer operations that manage manure as a liquid, such as stored in an anaerobic lagoon.

TABLE 10.16 MANURE MANAGEMENT METHANE EMISSION FACTORS FOR DEER, REINDEER, RABBITS, AND FUR-BEARING ANIMALS	
Livestock	**CH_4 emission factor (kg CH_4 head^{-1} yr^{-1})**
Deer[a]	0.22
Reindeer[b]	0.36
Rabbits[c]	0.08
Fur-bearing animals (e.g., fox, mink)[b]	0.68

The uncertainty in these emission factors is ±30 %.
[a] Sneath *et al.* (1997)
[b] Estimations of Agricultural University of Norway, Institute of Chemistry and Biotechnology, Section for Microbiology.
[c] Judgement of the IPCC Expert Group

Annex 3 – Thermal Performance Algorithm

Thermal Performance Algorithm

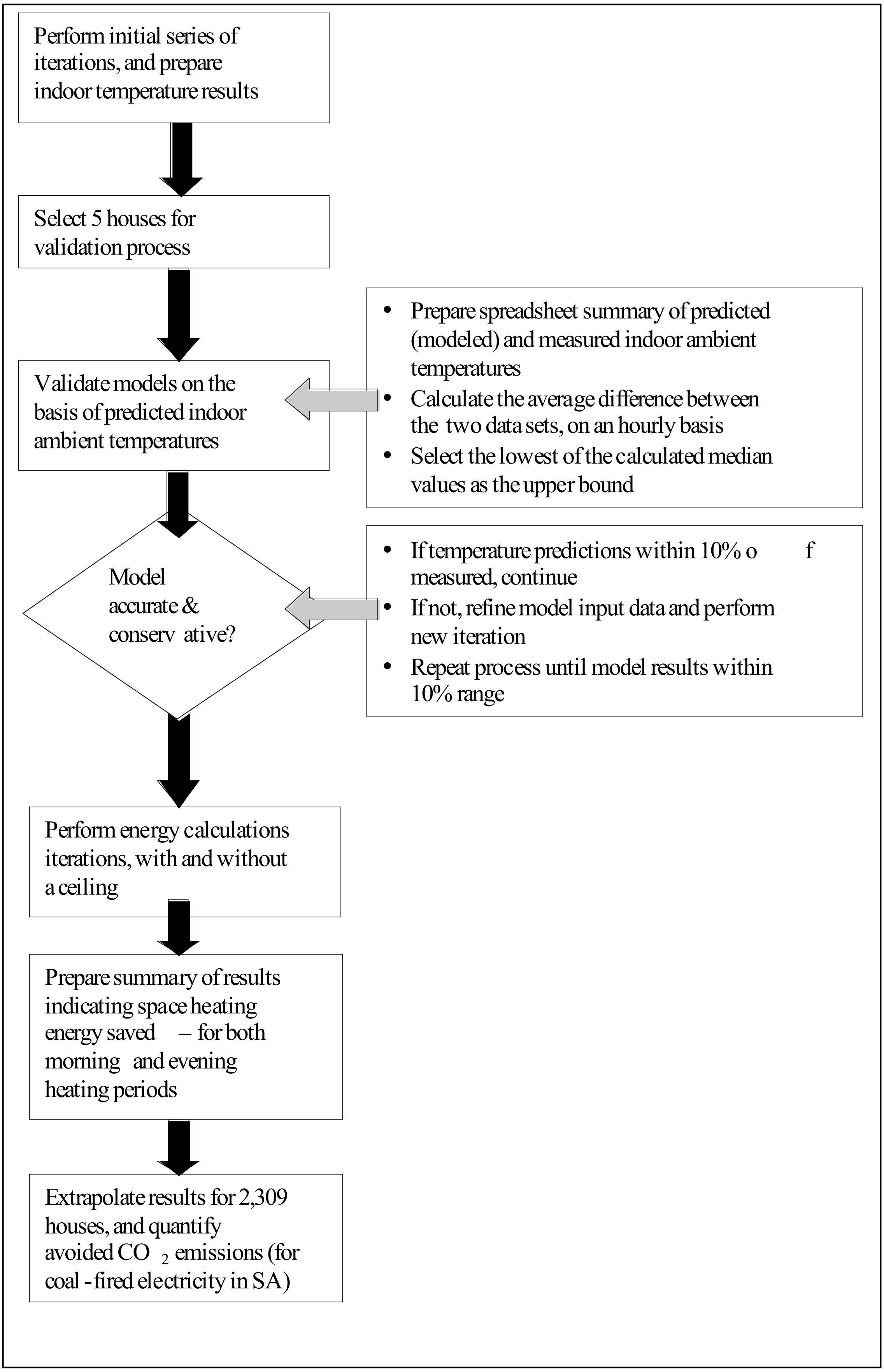
Model input data to QUICK Ver 3.0 thermal performance modeling software

- Household physical dimensions
  - Walls and windows: length x height x depth
  - Orientation
  - Overhangs
  - Plaster (Y/N)
  - Pai nt (Y/N) & paint colour
  - Door position and size
  - Internal floor coverings
  - Internal partition sizes
  - Floor slab thickness
- Meteorological data
  - Used data from the 5% probability design data for Cape Town locations as reported in WB40 (a publication by the SA Wea ther Bureau that details meteorological data from 1900 to 1984)
- Materials thermal performance data
  - Density (kg/m ^{3}) and conductivity (W/m $^\circ$C)
- Internal heat load data – to reflect existing non -electrical heat loading
  - Derived from social study wherein specific questionnaires were developed for this input
  - Occupancy rates and activity levels
- Clothing worn by occupants
- **Ventilation – measured in air -changes**

Model assumptions and constraints

- No cooling energy required during summer months
- Space heating required during the colder six months of the year (April through September)
- A diurnal use of energy for space heating was required
  - Defined for each house
  - ON/OFF times assessed from monitored data
- Definition of thermal comfort level @ 21 degrees Celsius

Annex 3 – Thermal Performance Algorithm (continued)



Annex 4 – Determination of the satisfied level of service
Example of the thermal energy services

To determine satisfied levels of service, observations of what this constitutes in circumstances where suppressed demand does not exist, will be required. To translate this level of energy service into fuels consumed and hence emissions, it may be required to build a model that predicts the quantity of energy required. Theoretical models should be calibrated against primary data, gathered on or near the site to ensure accuracy and conservativeness.

Such a model would be based on indoor and outdoor temperatures over time, heat loads inside the dwelling, the fabric (type and thickness), orientation, color, placement of windows and doors, and other attributes of the structure, air changes, wind rates and solar radiation, etc. Existing internationally recognized software packages can be used, or the model could be built from first principles.

To determine the space heating required in a dwelling to satisfy residents level of service, one first needs to determine when the service is required and at what temperature it should be maintained to satisfy residents. The time that heating would be required is most likely to be in the coldest months of the year in temperate climates when residents are in their dwellings and not sleeping. The duration of the “heating season” can be determined using seasonal average diurnal temperature logs. The diurnal non-sleeping occupancy period can be determined by monitoring electricity use (if available) longitudinally and checking when appliances are turned on and off, alternatively, behavioral studies/interviews can be undertaken.

The next parameter required in fixing the level of service, is the temperature at which thermal comfort or a satisfied level of service is achieved. The parameter needs to be determined using behavioral studies, which include the indoor temperature when heating is switched off or removed, when outer clothing is removed etc. The temperature at which that happens will be related to the climatic zone and the ranges of temperature which people are accustomed to. This temperature could be considered as the satisfied level of service. In temperate climates this temperature is typically around 19 to 22 Degrees Centigrade.

These data parameters are then fed into the model to predict heat requirements to achieve the level of thermal comfort for non sleeping occupancy during the coldest 4 to 6 months of the year.

In instances where dwellings are of a regular size and fabric the model can be based on energy for each dwelling. In instances where floor sizes differ, the model can be developed on square meter of heated space basis.

It is essential that predictive models are calibrated against real data, monitored on site though electronic monitoring and/or using interviews providing longitudinal data in a statistically relevant sample. Typically this would require logging indoor thermal services, indoor and outdoor temperatures to test whether the dwelling performs thermally as predicted. In order to maintain conservativeness, the model must be calibrated downwards in its prediction of energy requirements to achieve thermal comfort.