CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY: BASELINE (CDM-NMB)
Version 01 - in effect as of: 1 July 2004

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SECTION A. Identification of methodology

A.1. Proposed methodology title:

>> Grasim baseline methodology for the energy efficiency improvement in the heat conversion and heat transfer equipment system[1].

A.2. List of category(ies) of project activity to which the methodology may apply:

>> This methodology is applicable to energy efficiency improvement projects for heat transfer equipment and heat conversion equipment, where the energy is saved in heat conversion equipment as a result of energy efficiency project taken up in heat transfer and/or heat conversion equipment. Such equipment can be categorised, but not limited to following;

Heat Transfer Equipment

1. Gas to gas heat exchangers
2. Liquid to liquid heat exchangers
3. Solid to liquid heat exchangers
4. Liquid to solid heat exchangers
5. Gas to liquid heat exchangers
6. Gas to solid heat exchangers

Heat Conversion Equipment

Fuel fired or electrically heated steam generators, hot water generators, furnaces, ovens, dryers.

Following are few practical examples of the equipment system, which are available in industry or manufacturing set up, where this methodology is applicable. The energy supplied to these equipment system may be by electrical or thermal energy sources.

- Boilers and hot water generators
- Thermic fluid (hot oil) heaters
- Hot air / water generators,
- Heat exchangers like shell and tube, plate type heat exchangers
- Fuel /electricity fired ovens, dryers, evaporators, furnaces, kilns
- Distillation columns, where heating takes place by steam used through direct injection or in reboilers.
- Reaction vessels, steam jacketed vessels or vessels with limpet coils.
- Series of heat exchangers like series of pre heaters *etc.*

The methodology is not applicable for the equipment system, where the efficiency can be more than unity. For example; it is not applicable to Vapour Compression and Vapour Absorption Refrigeration System (this include chiller compressor, generator of vapour absorption system, evaporator of chiller) where heat is transported from low temperature body to high temperature body with a coefficient of performance being more than unity.

[1] System means the series of heat transfer and heat conversion equipment.

A.3. Conditions under which the methodology is applicable to CDM project activities:
>>
The methodology is applicable in following conditions:

1. The methodology is applicable for constant useful heat output conditions of equipment. Constant output levels means that quantity of output per shift/batch should be relatively constant (whether continuous process or batch process), because in absence of constant output it becomes difficult to establish a baseline of consistent and reliable efficiency.
2. The methodology is applicable to heat energy conversion equipment and heat energy transfer equipment, which are connected in series, such that the energy efficiency project taken up in any heat transfer equipment, which is connected in series with heat energy conversion equipment, will save energy in later.
3. Where the historical and current data is available for heat balance parameters vis-à-vis equipment useful heat output. This is for defining the baseline criteria and emission reduction estimation.
4. The regular monitoring and/or estimation of heat energy transfer and heat conversion equipment efficiency and/or effectiveness[2] is estimated by direct (Output heat / Input heat) method.
5. The efficiency improvement may result into addition/elimination of some electrical loads or increase /reduction in electrical energy consumption for existing loads. The net emission of CO_2 as a result of energy efficiency project should take into account such electrical load while calculating project emission.

A.4. What are the potential strengths and weaknesses of this proposed new methodology?
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Strengths
1. It follows UNFCCC guidelines
2. Baseline calculation procedure is not complicated and can be used by industries proposing CDM projects with energy efficiency and thereby reducing the fossil fuel consumption as well as GHG reduction
3. The methodology has focus on determination of 'energy efficiency' and improvement in it. This helps in standardisation of calculations, which can be performed for heat conversion/ heat transfer equipment, to which this methodology is applicable.
4. The methodology addresses the minimisation of influence of 'proportional relationship' of output vs. energy efficiency and eliminates the possibilities of false emission reduction claims due to reduction in specific heat consumption, as a result of increased output.
5. Methodology provides provision for regular monitoring and estimation of efficiency by direct (Output heat/Input heat) method.
6. The methodology has the provision for proactive monitoring of impact of retrofits (such as change in output level, equipment changes) on equipment energy efficiency, affecting emission reduction claims.

[2] For the purpose of this methodology, the term 'efficiency' is used for 'effectiveness' of heat transfer equipment.

7. The methodology addresses the additional electricity consumption issues, if any, due to project activity and provides separate computational methods in case of captive generation and supply of electricity from grid. The methodology provides the option of considering 'nameplate data' of kW or HP rating of motor or other electrical equipment as additional electricity consumption per hour.
8. The assumptions used in the methodology are based on proper reasoning and adopt conservative basis of CO_2 reduction claims.
9. The methodology suggests use of realistic and recorded data, which can be readily verified.
10. The methodology can be applied to many energy efficiency project activities.

Weaknesses

1. The methodology relies on the historical (recorded) data for baseline determination, for which reliability check is a must.
2. The computation of representative data for output requires the good understanding of output capacity, normal range of output. Methodology prescribes the normal output range of ±5% of average rated output capacity of plant, which is applicable to most of the general output conditions (based on experience of project proponent). But in isolated cases, the relationship of output and energy efficiency of equipment might be extremely sensitive, which may even narrow down the 'normal output' range. In such cases, it is recommended that the output-efficiency relationship should be studied well before deciding 'normal output range'.
3. A clear understanding of heat balance of heat transfer and heat conversion equipment is important before using this methodology.

SECTION B. Overall summary description:

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This methodology is applicable for the energy efficiency projects implemented with an intention to save heat energy input in heat energy conversion and/ or heat transfer equipment. This methodology covers most of the heat conversion and transfer equipment, which are direct or indirect fuel fired or electrically heated. This methodology is primarily based on energy efficiency projects for heat energy savings but it also takes into account the electrical energy equipment within the system boundary for the purpose of heat balance. The approach for emission calculations is 48(a), i.e. historical emissions. The calculations are based on the efficiency of the equipment before and after the project activity. This methodology is applicable on constant output conditions i.e. the daily output should be within the limit of +/-5% of the normal daily output, this is important for baseline determination. The methodology requires regular monitoring of efficiency i.e. efficiency monitoring in each shift or in each batch. The calculation approach (efficiency approach) is transparent and absolute. This methodology will give the conservative actual emission reduction from the project activity.

SECTION C. Choice of and justification as to why one of the baseline approaches listed in paragraph 48 of CDM modalities and procedures is considered to be the most appropriate:

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C.1. General baseline approach:

☐ **Existing actual or historical emissions, as applicable;**

☐ 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.

C.2. Justification of why the approach chosen in 3.1 above is considered the most appropriate:

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Out of the three approach suggested, choice of the first one i.e. 48(a) is based on the view that the baseline determination depends on the verifiable data of the historical or existing emissions in absence of project activity. Approach 48(b) might have some overlap in case of economic analysis of the energy efficiency project; however, baseline determination of energy efficiency improvement system would definitely depend on the existing actual or historical data and therefore emissions. The third approach 48(c) is not an appropriate approach considering non-availability of data to analyse 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 percent of their category. Therefore, the suggested approach 48(a) is the best suitable for the suggested methodology.

SECTION D. Explanation and justification of the proposed new baseline methodology:

D.1. Explanation of how the methodology determines the baseline scenario (that is, indicate the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases (GHG) that would occur in the absence of the proposed project activity):

>> The methodology determines the representative baseline efficiency for the baseline scenario. The approach chosen is 48(a), which considers the historical emissions for calculations. The representative baseline efficiency is calculated for the pre-project activity. This methodology takes into account the minimum three months data before the project activity. The methodology suggests the use of single baseline value of efficiency of equipment, which makes it potentially conservative. This is because in absence of project activity, the efficiency of equipment would have deteriorated with time and use of dynamic baseline with reduced efficiency would have inflated emission reduction claims. Therefore, the consideration of single fixed value of baseline ensures conservativeness of methodology.

D.2. Criteria used in developing the proposed baseline methodology:

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The proposed baseline methodology is prepared based on the following criteria:

1. The baseline determination is based on historical data that are generated in the pre-project scenario and are verifiable as records. The parameters for equipment within the project boundary are recorded reducing possibility of errors.

2. The ISO-9001 /14001 (or similar systems) procedures and formats followed for monitoring and evaluation of parameters mentioned in monitoring plan. The procedure for selection of representative data of output and corresponding thermal energy, fuel and electricity consumption is also to be followed. The plant capacity documents and technical catalogue of proposed project studied for benchmarking the representative data of output and corresponding thermal and additional electrical consumption and the permissible tolerances to determine extreme values. For determination of additionality methodology uses guidance provided by CDM Executive Board (EB16).

3. The linked parameters for equipment energy efficiency calculations are monitored to evaluate its impact on emission reduction at regular intervals.

4. The monitoring of retrofits is done to estimate the impact on baseline, project emissions and emission reduction claims.

D.3. Explanation of how, through the methodology, it can be demonstrated that a project activity is additional and therefore not the baseline scenario (section B.3 of the CDM-PDD):

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The baseline methodology proposed is applicable for GHG reduction due to conservation in input thermal energy (supplied by fuel and/or electrical source) as a result of modification and/or retrofit measures in an established process. The methodology recommends the use of additionality tests as per Annex-1 of EB-16 meeting report on "Consolidated tools for Demonstration of Additionality"..

D.4. How national and/or sectoral policies and circumstances can been taken into account by the methodology:

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In case, the regulations of the country/region/industrial sector require the project activity to take place, the guidance need to be followed as per "Consolidated Additionality Tools" referred above in section D.3, to demonstrate additionality of project.

D.5. Project boundary (gases and sources included, physical delineation):

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From the Annex A of the Kyoto Protocol carbon di-oxide (CO_2) is the chosen GHG to which this methodology is applicable and the same is included in the project boundary. The reduction in fuel consumption and change in net electricity consumption due to CDM project activity affects only CO_2 emission and not the other gases covered under Kyoto Protocol.

Project Boundaries

As per definition of project boundary as given in CDM glossary of terms, "it will encompass all anthropogenic emissions by sources of Green House Gases (GHGs) under the control of project participants that are significant and reasonably attributable to the CDM project activity."

Based on the definition, the project boundary would cover the following:

- Heat conversion and heat transfer equipment
- Hot streams going to the equipment
- Cold streams going to the equipment
- Useful output[3] streams from the equipment
- Source of electricity for additional electrical loads or change in electricity consumption (if any) due to project activity for transporting the fluid.

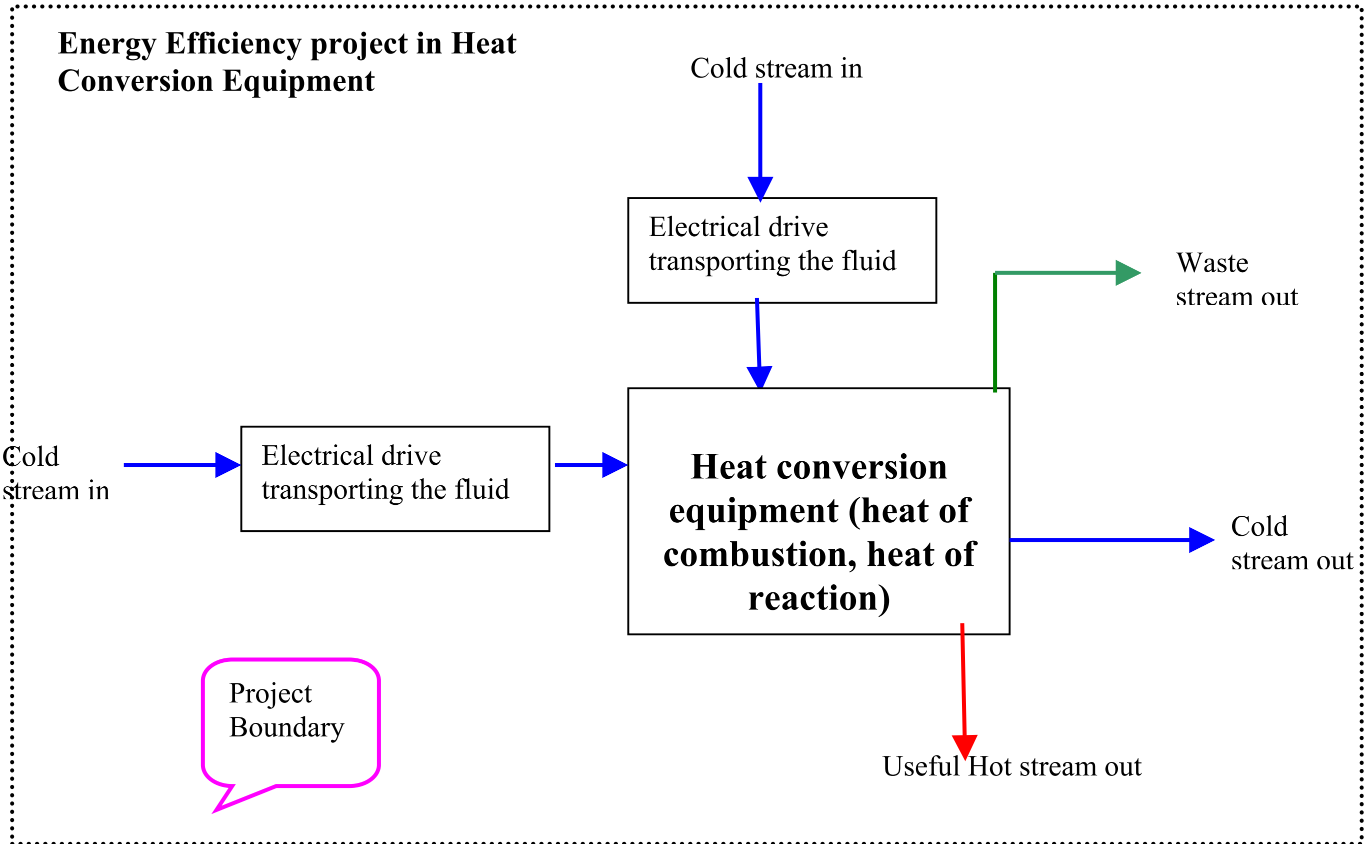
The figure shows the project boundary considered under methodology.

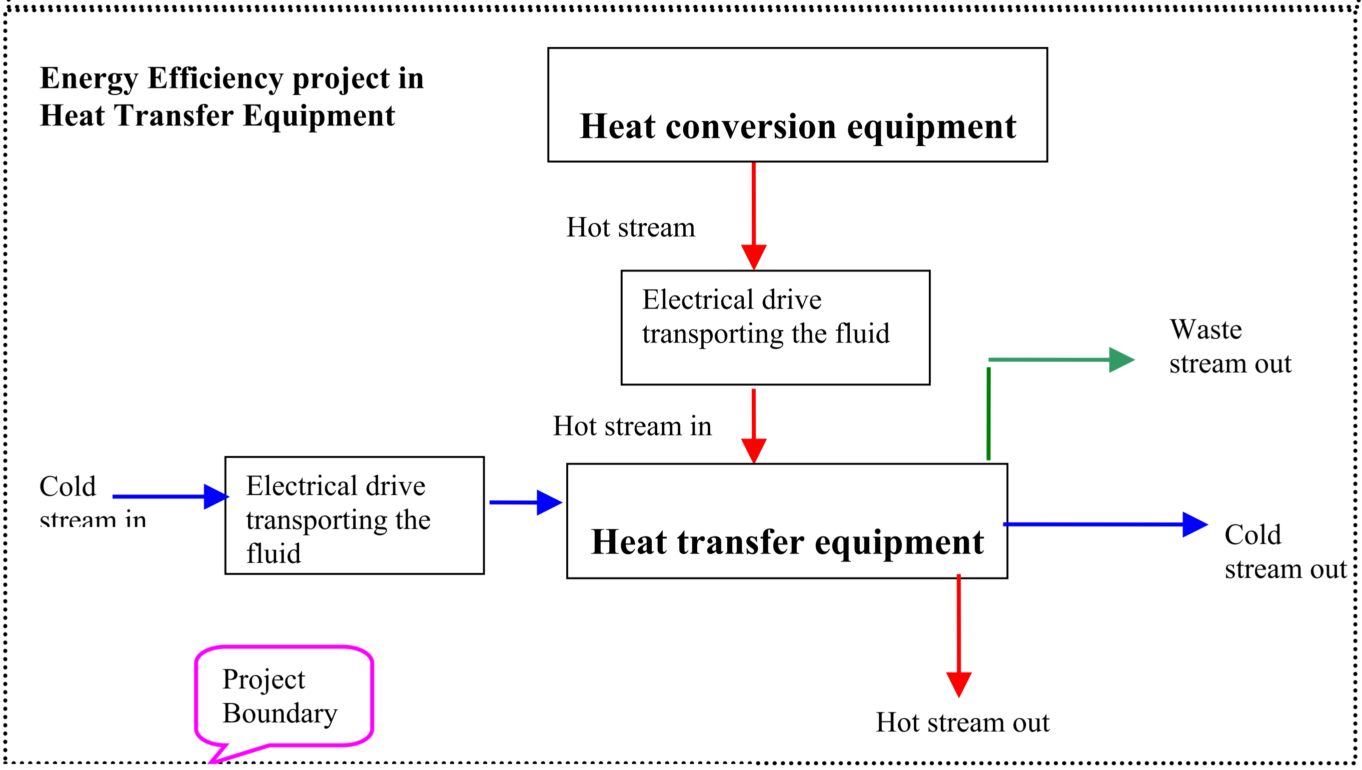
[3] Useful output is defined as the output of heat transfer /conversion equipment for which the equipment is in use. Following are examples of useful output stream

1. Hot air stream of air preheater.

2. The milk stream in case of chilled water heat exchanger, chilling milk in a dairy,

CDM Project Boundary





Note: Useful output stream may change from application to application.

D.6. Elaborate and justify formulae/algorithms used to determine the baseline scenario. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):

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Step-1: Benchmarking the baseline data for output

The historical data on shift-wise or batch-wise (in case of batch process) output[4] of the process equipment is to be analysed and representative output value (P_{rep}) is to be calculated. The extreme values are to be segregated from the available values of output rate (shift or batch output). This is because the energy efficiency of equipment increases with increased output rates (improved utilisation or load factor). The methodology suggests fixing baseline efficiency for normal output (nameplate capacity in terms of heat output). A normal output value is the function of load factor-efficiency relationship. Based on general experience (also in case of project proponent), the load factor-efficiency relationship is not significantly sensitive up to +/-5% of normal rated output[5]. Therefore +/- 5% range can be taken as 'normal output range' for this purpose. If output fluctuates (from shift to shift or batch to batch) beyond normal range, the deviated values should not be considered for efficiency calculations in step-3.

Step-2: Heat balance across the equipment

The heat balance is the first step to determine energy efficiency. The flow and temperature of input and output streams is required for estimation of efficiency. Since the continual measurement of flow and temperatures of all the streams not possible, the methodology recommends to measure these parameters once in a shift.. The shift-wise measurement also ensures that for the representative ambient temperature and humidity conditions (which may vary from shift-to-shift and may play significant role in energy efficiency of equipment) have been taken into account while estimating efficiency of equipment.

Following heat calculations need to be conducted for heat balance of heat conversion and/or heat transfer equipment.

[4] Output means the output of useful stream e.g. in the pasteurising process in milk dairy, the output of milk from steam heated heat exchanger, need to be measured.

[5] Please refer UNFCCC approved methodology AM-0018 for benchmarking the baseline data of output.

Step 2a) Heat transfer equipment

Step 2a)1. Heat transfer equipment with not more than two fluid streams (e.g. parallel or counter flow shell & tube or plate heat exchangers)

Following heat calculations can be performed in such heat transfer equipment.

1. Sensible heat (shell & tube heat exchanger) and /or latent heat (steam jacketed vessel) transfer equipment

$$Maximum\ heat\ transfer\ possible\ (in\ case\ of\ sensible\ heat\ transfer\ only) = t_h \times m_h \times C_{ph} - t_c \times m_c \times C_{pc}$$

$$Maximum\ heat\ transfer\ possible\ (in\ case\ of\ latent\ heat\ plus\ sensible\ heat\ transfer) = E_{hl} \times m_h + t_h \times m_h \times C_{ph} - t_c \times m_c \times C_{pc}$$

$$Useful\ Heat = Heat\ gained\ by\ useful\ stream\ (output\ stream)$$

Where:

t_h = Temperature of incoming hot steam
m_h= flow rate of incoming hot stream
C_{ph} = Specific heat of incoming hot stream
t_c = Temperature of outgoing cold steam
m_c= flow rate of outgoing cold stream
C_{pc} = Specific heat of outgoing cold stream
E_{hl} = Latent heat of hot incoming stream

Note: Useful heat to be calculated by multiplication of flow rates, specific heat and difference between temperature of incoming heat gaining useful stream and outgoing heat gaining/loosing useful stream.

2. Heat input through phase transformation (Latent heat)

$$Heat\ Input = Mass\ of\ material \times Enthalpy\ of\ phase\ transformation$$

3. Heat input through electricity

The heat input through electricity needs to be calculated in cases where the various streams to equipment are transported by electrical drive like pumps or fans. The electrical energy of these drives gets converted into heat energy and adds to heat content of individual stream. The electrical energy consumption value of drive should be appropriately multiplied by efficiency of motor to estimate the heat energy added in stream.

$$Heat\ Input = Thermal\ equivalent\ of\ Electricity\ used$$

Step 2a)2. Heat transfer equipment with more than two streams exchanging heat (e.g. in a reaction vessel where reaction takes place with external heat addition, it is bubbled through compressed air and which has waste heat stream and inlet and outlet material stream).

In such an application various types of heat can be generated/exchanged e.g. sensible heat, latent heat (heat of phase transformation) and/or heat of reaction (exothermic or indothermic) Following heat calculations can be performed in such heat transfer equipment.

1. Heat input through exothermic reaction

$$Heat\ Input = Mass\ of\ reactants \times Heat\ of\ reaction\ \ kCal / unit\ mass$$

2. Sensible heat input through hot/cold stream

$$Heat\ input = Mass\ of\ stream \times Specific\ heat\ capacity\ of\ stream \times Temperature\ difference$$

Note: The temperature difference above denotes the heat content of the input stream, based on the datum of 0 deg C.

3. Heat input through phase transformation (Latent heat)

$$Heat\ Input = Mass\ of\ material \times Enthalpy\ of\ phase\ transformation$$

4. Heat input through electricity

$$Heat\ Input = Thermal\ equivalent\ of\ Electricity\ used$$

7. Heat output through hot/cold stream (Base Temperature 0 °C)[6]

$$Heat\ output = Mass\ of\ stream \times Specific\ heat\ capacity\ of\ stream \times Temperature\ difference$$

8. Heat output through phase transformation (e. g. evaporation)

$$Heat\ output = Mass\ of\ material \times Enthalpy\ of\ phase\ transformation$$

9. Heat output through endothermic reaction

$$Heat\ Output = Mass\ of\ reactants \times Heat\ of\ Reaction\ \ kCal / unit\ mass$$

Step 2 b) for heat conversion equipment

The formula used for estimation of the heat is as follows:

1. Heat input due to combustion of fuel

$$Heat\ input = Mass\ of\ fuel\ used \times Calorific\ value\ of\ fuel$$

2. Heat input through exothermic reaction

$$Heat\ Input = Mass\ of\ reactants \times Heat\ of\ Reaction$$

3. Heat input through hot/cold stream (Base temperature 0 deg C)

$$Heat\ input = Mass\ of\ stream \times Specific\ heat\ capacity\ of\ stream \times Temperature\ difference$$

4. Heat input through phase transformation

$$Heat\ Input = Mass\ of\ material \times Enthalpy\ of\ phase\ transformation$$

5. Heat input through electricity

$$Heat\ Input = Thermal\ equivalent\ of\ Electricity\ used$$

6. Heat output through hot/cold stream

$$Heat\ output = Mass\ of\ stream \times Specific\ heat\ capacity\ of\ stream \times Temperature\ difference$$

7. Heat output through phase transformation (e. g. evaporation)

$$Heat\ output = Mass\ of\ material \times Enthalpy\ of\ phase\ transformation$$

8. Heat output through endothermic reaction

[6] The base temperature 0°C denotes that the heat content of incoming/outgoing hot or cold stream has to be estimated based on the difference of its temperature from 0°C. For example temperature difference to be taken in calculation to estimate the heat content of a stream at 100°C is to be taken as (100-0).

$$Heat\ output = Mass\ of\ reac\tan ts \times Heat\ of\ \mathrm{Re}action\ kCal / unit\ mass$$

Note :
Above formulae can be used in various type of;

- heat transfer equipment
- heat conversion
- combination of heat transfer and heat conversion equipment.

These formulae are to be used to estimate accurate energy balance across these equipment. This will enable the calculation of efficiency (or 'effectiveness' as termed for heat exchangers) in next step.

Step-3: Estimation of energy efficiency of the equipment

The baseline efficiency of the equipment can be obtained by either of the formulae mentioned below:

1. Efficiency $\eta_b = [\frac{Useful\ energy\ Output}{Energy\ input}] \times 100$
2. Efficiency[7] $\eta_b = [{Useful\ heat\ transfer} / {Maximum\ heat\ transfer\ possile}] \times 100$

Step-4 : Bench marking of efficiency

$$\eta_b = \frac{[\eta_{bA} + \eta_{bB} ..... + \eta_{bm}]}{m}$$

Where:

$\eta_{bA} .... \eta_{bm}$ = Efficiencies in various shifts/batches (considering total 'm' no. of shifts/batches per day).

Note: In case no. of batches per day is not an integral value (say 2.7 batches/day) or batch time is more than 24 hours, the efficiency should be estimated batch-wise and daily average should not be worked out.

The daily average efficiency of the system will be worked out for minimum one-month data and the average of all values will be fixed as baseline efficiency. This value will be used for the calculation of emission reduction in project scenario.

D.7. Elaborate and justify formulae/algorithms used to determine the emissions from the project activity. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):

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Step-1: Monitoring the output data

The useful output data need to be monitored shift-basis or batch basis. This may be either by maintaining shift-wise/batch-wise log-book or with the help of control system. The energy efficiency of equipment should not be calculated (in step-3) for the shift in which output data is beyond 'normal range'.

The change in output beyond normal range, as a result of retrofit measure, will change the baseline of equipment and should be monitored though 'retrofit monitoring test' given below. In such cases the nameplate capacity needs to be reverified and normal range of operation should be redefined, and the

[7] Efficiency for two stream heat exchanger. Step 2a.

impact of new output on equipment energy efficiency is taken into account for emission reduction calculations.

Step-2: Heat balance across the equipment

Following heat calculations need to be performed to estimate efficiency of heat conversion and/or heat transfer equipment in project scenario.

Step 2a) Heat transfer equipment

Step 2a)1. Heat transfer equipment with not more than two fluid streams (e.g. parallel or counter flow shell & tube or plate heat exchangers)

Following heat calculations can be performed in such heat transfer equipment.

1. Sensible heat (shell & tube heat exchanger) and /or latent heat (steam jacketed vessel) transfer equipment

$$Maximum\ \ heat\ transfer\ \ possible\ \ (in\ case\ \ of\ \ sensible\ \ heat\ transfer\ \ only) = t_h \times m_h \times C_{ph} - t_c \times m_c \times C_{pc}$$

$$Maximum\ \ heat\ transfer\ \ possible\ \ (in\ case\ \ of\ latent\ \ heat\ \ plus\ sensible\ \ transfer\ \ only) = E_{hl} \times m_h - t_c \times m_c \times C_{pc}$$

$$Useful\ \ Heat = Heat\ \ gained\ \ by\ useful\ \ stream\ \ (output\ \ stream)$$

Where :

t_h = Temperature of incoming hot steam

m_h= flow rate of incoming hot stream

C_{ph} = Specific heat of incoming hot stream

t_c = Temperature of outgoing cold steam

m_c= flow rate of outgoing cold stream

C_{pc} = Specific heat of outgoing cold stream

E_{hl} = Latent heat of hot incoming stream

Note: Useful heat to be calculated by multiplication of flow rates, specific heat and difference between temperature of incoming heat gaining useful stream and outgoing heat gaining/loosing useful stream. Useful stream here means the one for which energy efficiency CDM project is installed e.g. in case of steam heated heat exchanger in pasteurisation process on milk in a dairy, the milk stream mass flow to be multiplied by specific heat of milk and temperature difference.

2. Heat input through phase transformation (Latent heat)

$$Heat\ Input = Mass\ of\ \ material \times Enthalpy\ of\ \ phase\ transformation$$

3. Heat input through electricity

The heat input through electricity needs to be calculated in cases where the various streams to equipment are transported by electrical drive like pumps and fans. The electrical energy of these drives gets converted into heat energy and adds to heat content of individual stream. The electrical energy consumption value of drive should be appropriately multiplied by efficiency of motor to estimate the heat energy added in stream.

$$Heat\ Input = Thermal\ equivalent\ of\ \ Electricity\ used$$

Step 2a)2. Heat transfer equipment with more than two streams exchanging heat (e.g. in a reaction vessel where reaction takes place with external heat addition, it is bubbled through compressed air and which has waste heat stream and inlet and outlet material stream).

In such an application various types of heat can be generated/exchanged e.g. sensible heat, latent heat (heat of phase transformation) and/or heat of reaction (exothermic or indothermic) Following heat calculations can be performed in such heat transfer equipment.

1. Heat input through exothermic reaction

$$Heat\ Input = Mass\ of\ reac\tan ts \times Heat\ of\ \mathrm{Re}action\ \ kCal / unit\ mass$$

2. Sensible heat input through hot/cold stream

$$Heat\ input = Mass\ of\ stream \times Specific\ heat\ capacity\ of\ stream \times Temperature\ difference$$

Note: The temperature difference above denotes the heat content of the input stream, based on the datum of 0 deg C.

3. Heat input through phase transformation (Latent heat)

$$Heat\ Input = Mass\ of\ material \times Enthalpy\ of\ phase\ transformation$$

4. Heat input through electricity

$$Heat\ Input = Thermal\ equivalent\ of\ Electricity\ used$$

7. Heat output through hot/cold stream

$$Heat\ output = Mass\ of\ stream \times Specific\ heat\ capacity\ of\ stream \times Temperature\ difference$$

8. Heat output through phase transformation (e. g. evaporation)

$$Heat\ output = Mass\ of\ material \times Enthalpy\ of\ phase\ transformation$$

9. Heat output through endothermic reaction

$$Heat\ Output = Mass\ of\ reac\tan ts \times Heat\ of\ reaction\ \ kCal / unit\ mass$$

Step 2 b) for heat conversion equipment

The formula used for estimation of the heat is as follows:

1. Heat input due to combustion of fuel

$$Heat\ input = Mass\ of\ fuel\ used \times Calorific\ value\ of\ fuel$$

2. Heat input through exothermic reaction

$$Heat\ Input = Mass\ of\ reac\tan ts \times Heat\ of\ \mathrm{Re}action$$

3. Heat input through hot/cold stream (Base temperature 0 deg C)

$$Heat\ input = Mass\ of\ stream \times Specific\ heat\ capacity\ of\ stream \times Temperature\ difference$$

4. Heat input through phase transformation

$$Heat\ Input = Mass\ of\ material \times Enthalpy\ of\ phase\ transformation$$

5. Heat input through electricity

$$Heat\ Input = Thermal\ equivalent\ of\ Electricity\ used$$

6. Heat output through hot/cold stream

$$Heat\ output = Mass\ of\ stream \times Specific\ heat\ capacity\ of\ stream \times Temperature\ difference$$

7. Heat output through phase transformation (e. g. evaporation)

$$Heat\ output = Mass\ of\ material \times Enthalpy\ of\ phase\ transformation$$

8. Heat output through endothermic reaction

$$Heat\ output = Mass\ of\ reac\tan ts \times Heat\ of\ \mathrm{Re}action\ kCal / unit\ mass$$

Note:

Above formulae can be used in various type of;

- heat transfer equipment
- heat conversion
- combination of heat transfer and heat conversion equipment.

These formulae are to be used to estimate accurate energy balance across equipment. This will enable the calculation of efficiency (or 'effectiveness' as termed for heat exchangers) in next step.

Step-3: Determination of Energy efficiency of the equipment in project scenario

The efficiency of equipment should be calculated only for corresponding output values, which are in normal range.

The efficiency of the equipment in project scenario can be obtained by any of these formulas:

1. Efficiency $\eta_p^{8} = [\frac{Useful\ energy\ output}{Energy\ input}] \times 100$ (by direct method)
2. Efficiency[9] $\eta_p = [Useful\ heat\ transfer / Maximum\ heat\ transfer\ possile] \times 100$

Step-4 : Estimate average efficiency of the day

$$\eta_p = \frac{[\eta_{pA} + \eta_{pB} ..... + \eta_{pm}]}{m}$$

Where :

$\eta_{pA} \ldots \eta_{pm}$ = Efficiencies in various shifts/batches (considering total 'm' no. of shifts/batches per day).

Note: In case no. of batches per day is not an integral value (say 2.7 batches/day) or batch time is more than 24 hours, the efficiency should be estimated batch-wise and daily average should not be worked out.

D.8. Description of how the baseline methodology addresses any potential leakage of the project activity:

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There is no leakage considered under this methodology.

D.9. Elaborate and justify formulae/algorithms used to determine the emissions reductions from the project activity. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):

>>

Step-1: Estimate the difference in Efficiencies of baseline and project scenarios.

$$\eta_{diff} = \eta_p - \eta_b$$

[8] Efficiency of heat conversion equipment or efficiency of heat transfer equipment with more than two streams.

[9] Efficiency for two stream heat exchanger. Step 2a.

Step-2: Estimate net daily reduction in energy Input

$$E_{net} = [\eta_{diff} / \eta_p]\ x\ HI$$

E_{net} = Net reduction in energy consumption per day.

HI = Heat input[10]

Step-3: Estimate actual energy reduction

In case, energy efficiency CDM project is implemented on heat transfer equipment, divide the net daily reduction in energy consumption (E_{net}) by efficiency of heat conversion equipment.

$$E_{acual} = E_{net} / \eta_c$$

In case, the energy efficiency CDM project is implemented for energy conversion equipment,

$$E_{acual} = E_{net}$$

E_{actual} = Actual reduction in energy due to CDM project activity per day

η_c = Efficiency of heat conversion equipment, monitored monthly. The direct efficiency of equipment to be determined as given in step-3 of section D-7[11].

Effect of future retrofitting on baseline and project emissions:[12]

The following test should be applied while monitoring the effect of future retrofitting within the project boundary (change in output level, process change, equipment change *etc.* affecting efficiency of equipment) on baseline and project emissions. The following question should be asked if retrofit measures reduce the energy consumption within the project boundary.

Question: Does retrofitting reduce the energy consumption of the CDM project activity? (I.e. there is a reduction in estimated project emissions, though not caused by the CDM project activity itself.)

Action: The enhanced steam saving due to the impact of retrofit on CO_2 removal system needs to be estimated and deducted from claimed emission reductions.

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[10] HI in the case of heat transfer equipment with two streams of heat exchange (e.g. shell & tube heat exchangers) is to be taken as maximum heat transfer possible (in kCal/day) as calculated in step-2a)1 earlier. HI in the case of heat transfer equipment (with more than two streams of heat exchange) or heat conversion equipment should be taken as actual heat input through fuel or electricity source (in kCal/day or kWh/day).

[11] Please also refer UNFCCC approved methodology AM-0018 for efficiency parameter monitoring and calculations.

[12] Please refer UNFCCC approved methodology AM-0018.

Step-4: Estimate the reduction in CO_2 emissions (C_{er}) of the project activity per day due to increase in energy efficiency of equipment.

$$C_{er} = E_{acual}\,x\;EF_{average}$$

$$EF_{average} = \sum(\%\,Heat\,\mathrm{sup}\,plied\;by\;fuel \times emission\;factor\;of\;fuel)$$

$$\%\;Heat\,\mathrm{sup}\,plied\;by\;fuel = \frac{Calorific\;value\;of\;fuel \times Quantity\;of\;fuel}{\sum Calorific\;value\;of\;fuel \times Quantity\;of\;fuel}$$

Where

$EF_{average}$ = Average carbon emission factor of the fuel used (t CO_2/TJ). Carbon emission factor for fuel (kT/TJ) to be taken based on actual testing of fuel from reliable laboratory (In case, reliable test report unavailable, use IPCC factor or a national factor for fuel from reliable sources.)

C_{er} = Emission reduction in CO_2

Step-5: Estimate the CO_2 emissions due to additional electrical load or electricity consumption in project scenario (if applicable)

If the energy efficiency project requires operation of additional electrical load, following steps can be followed to estimate CO_2 emissions.

Sub-step-1: Monitor the shift-wise/batch-wise data of electrical consumption or if monitoring facility not available, take the maximum rating (Nameplate data) of motor or heater or any other electricity-consuming device as the consumption.

Sub-step-2: Estimate average shift-wise/batch-wise electrical consumption (E_{avg}) (This sub-step is only to be used in case of actual monitoring of data. In case of Nameplate data, the rated value is the average value).

The shift-wise/batch-wise electrical consumption values corresponding to representative shift-wise/batch-wise output values (as given above) are to be selected and averaged out.

Sub-step-3 : Estimate shift-wise input energy (E_{ine}) to electrical energy source (in case of captive generation).

$$E_{ine} = E_{avg} / \eta_g$$

η_g = Minimum efficiency of Electricity Generating System (EGS) based on historical data of EGS operation during 'normal range' of output (assumed constant).

Sub-step-4 : Estimate CO_2 emissions (in case of captive generation).

$$C_{er1} = E_{ine}\,x\,F_c$$

Where, F_c = Carbon emission factor for fuel (IPCC)

Sub-step-5 : Estimate CO_2 emissions (in case of External grid supply).

$$C_{er2} = E_{avg}\ x\ F_{grid}$$

Where, F_{grid} = Carbon emission factor of the selected grid.

The Carbon emission factor of the selected grid is determined by combined margin method which is average of operating and build margin, mentioned in the point no.7 of section I.D of UNFCCC version-4 (22nd Oct. 2004) document "Appendix-B : Indicative simplified baseline and monitoring methodologies for selected small scale CDM project activity categories".

a) The average of the "approximate operating margin" and the "build margin", where:

(i) The "approximate operating margin" is the weighted average emissions (in kg CO2equ/kWh) of all generating sources serving the system, excluding hydro, geothermal, wind, low-cost biomass, nuclear and solar generation;

(ii) The "build margin" is the weighted average emissions (in kg CO2equ/kWh) of recent capacity additions to the system, which capacity additions are defined as the greater (in MWh) of most recent[13] 20%[14] of existing plants or the 5 most recent plants.";

OR

(b) The weighted average emissions (in kg CO2equ/kWh) of the current generation mix.

Step-5 : Estimate the CO_2 net emission reduction due to project

$$C_{ernet} = C_{er} - C_{er1} \quad \textbf{OR} \quad C_{ernet} = C_{er} - C_{er2} \quad \textbf{OR} \quad C_{ernet} = C_{er} - \left(C_{er1} + C_{er2}\right)$$

SECTION E. Data sources and assumptions:

E.1. Describe parameters and or assumptions (including emission factors and activity levels):

>>

Assumption – 1: Emission Factor of the fuel used

The actual emission factor of fuel should be determined by periodic testing from recognized laboratories. In absence of such facility the methodology also suggests use of Emission Factors proposed by IPCC[15] (or national factor for fuel, if available, from reliable sources) to be applied for the respective fuels used in the equipment.

Key parameters: Emission factor (Actual/IPCC/ National) for fuel used.

Data: Records of the fuel use in the actual system and or the fuel used in other system which is supplying the heat to this system and and test report of reliable in-house/external laboratory.

[13] Generation data available for the most recent year.

[14] If 20% falls on part capacity of a plant, that plant is included in the calculation.

[15] IPCC (Intergovernmental Panel on Climate Change) document IPCC-1996 rev

Assumption – 2:* CO_2 *emission due to additional electricity used

The project activity of energy efficiency improvement may call for operation of additional electrical load. The baseline estimation for CO_2 emissions due to net change in electrical consumption in auxiliary / attached equipment needs to be ascertained. There are two possibilities of electricity supply (a) Own generation or (b) Supply from the grid.

The methodology suggests that CO_2 emission to be ascertained based on the fuel used and heat rate of turbo-generator in case of own generation and based on available emission factor for the grid if the supply is from the external grid. For determining the emission factor of grid the guidelines from point no. 29 of Appendix B of simplified modalities and procedures for small-scale CDM project activities can be used. The IPCC emission factors used for fuels are assumed to be constant, for various consignments received in the plant and used in power stations attached to the grid.

Key Parameters: Source of electricity, fuel mix used for electricity generation, emission factor of the grid, heat rate of electricity generating system.

Data Sources: IPCC emission factors for fuel, published grid emission factors, plant electricity generation and performance records.

Assumption-3: The efficiency of Electricity Generating System is constant (if additional electricity consumption in project scenario is catered by captive generation)

The efficiency of turbo-generator or diesel generator or any other captive Electricity Generation System (EGS) is assumed to be constant. As a conservative estimate, minimum value of efficiency of EGS to be selected based on historical data and assumed constant.

E.2. List of data used indicating sources (e.g. official statistics, expert judgement, proprietary data, IPCC, commercial and scientific literature) and precise references and justify the appropriateness of the choice of such data:

>>Reference for standard data is based on the fact that these are one of the most authentic sources available. For example Chemical Engineers's Handbook referred below is widely used by all institutions and professionals in India. The website of Bureau of Energy Efficiency referred below belongs to Government of India and therefore it is authentic. Other references, similarly, are taken from authentic sources.

1. Heat capacities or specific heats (Reference J. H. Perry) year of publication, Handbook for chemical engineers, Version-7, 1997)
2. Latent heats (Reference J. H. Perry, Handbook for chemical engineers, Version-7, 1997)
3. Equipment efficiency calculations/ performance assessment codes as per Bureau of Energy Efficiency, Government of India (website WWW.energymanagertraining.com)
4. Fuel emission factors (IPCC-1996 revision).
5. Grid emission factor calculations (point no.7 of section I.D of UNFCCC version-4 (22nd Oct. 2004) document "Appendix-B: Indicative simplified baseline and monitoring methodologies for selected small scale CDM project activity categories".

E.3. Vintage of data (e.g. relative to starting date of the project activity):

>> The data required is

1. At least one month before the project activity
2. During crediting period
3. Two years after crediting period

E.4. Spatial level of data (local, regional, national):

>>
Emission factors: IPCC/Local/national
Standard technical data (Such as heat capacity): Standard publications (National/International)
All other data: Local

SECTION F. Assessment of uncertainties (sensitivity to key factors and assumptions):

>>
Error in the baseline values may occur due to following

- If the internal data is collected from the instruments are not credible and reliable due to the fact that they have gone out of calibration.

  The internal data gathered should be reliable and authentic. It is ensured by following strict calibration schedule of the instruments. The same should be validated and verified by knowledgeable independent entity (DoE). Methodology suggest use/application of ISO-9001 (or similar) quality management system.

- If the external data collected is not authentic and reliable, it is likely to change the baseline calculations.

  One of the external data used in the baseline are the IPCC/WBCSD emission factors. This data is considered to be authentic across the world and therefore unlikely to generate uncertainties in baseline. Other data related to the grid emission factor etc. on which project proponent has no control must be collected from authentic and verifiable sources.

- The methodology is applicable to constant output conditions. The efficiency of equipment is to be estimated for monitored 'normal output range' i.e. ±5%. The errors in fixation of normal output range may result into false baseline and erroneous computation of emission reduction values. The same should be validated and verified by knowledgeable independent entity (DoE) to check the trend based on historical data.

SECTION G. Explanation of how the baseline methodology allows for the development of baselines in a transparent and conservative manner:

>> The methodology emphasises the use of minimum data properly recorded or published by authentic sources with conservative approach. All the data used are verifiable by Designated Operational Entity. This way the methodology suggested is easy to apply, conservative and transparent. This methodology

also treats the retrofit after project activity and suggest for the baseline change, so that the emission reduction by this methodology will be actual and conservative.

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