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

CONTENTS

SECTION A. Identification of methodology

A.1. Title of the proposed methodology:

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Grasim monitoring 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 and where the energy is saved in heat conversion equipment as a result of energy efficiency project taken up in heat transfer and/or hear 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.

i. Boilers and hot water generators
ii. Thermic fluid (hot oil) heaters
iii. Hot air / water generators,
iv. Heat exchangers like shell and tube, plate type heat exchangers

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

v. Fuel /electricity fired ovens, dryers, evaporators, furnaces, kilns
vi. Distillation columns, where heating takes place by steam used through direct injection or in reboilers.
vii. Reaction vessels, steam jacketed vessels or vessels with limpet coils.
viii. 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.

A.3. Conditions under which the methodology is applicable to CDM project activities:

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. 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.
3. 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.
4. 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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There is no approved methodology available on UNFCCC web site for demand side energy efficiency project capacity of more than 15 GWh and therefore, the methodology demonstrates the potential demand side energy efficiency CDM project.

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

Other, strength of this methodology is its use of measured and analysed data for estimation of emission reductions, generated by using reliable metering and monitoring system. The number of assumptions is very less, and those considered in the methodology, are conservative.

The weakness of the methodology is that there is good deal of understanding (of engineering concepts) required in monitoring normal range of output data, heat balance calculations and estimation of equipment efficiency.

SECTION B. Proposed new monitoring methodology

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B.1. Brief description of the new methodology:

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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 the 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. This monitoring methodology is applicable to the energy efficiency projects.
The methodology suggests the monitoring of equipment efficiency before and after CDM project activity i.e. in baseline and project scenario. The interval for monitoring the methodology is each shift or each batch.

Parameters to be monitored are as follows. These are the basic parameters and may change (reduce/ increase) based on typical applications of heat conversion/heat transfer equipment, where CDM project activity has been taken up.

1. Flow rates of input and output streams
2. Temperature of input and output streams
3. Heat of reaction
4. Latent heat of phase change stream
5. Quantity of electricity consumed
6. Flow rate of fuel (in case of energy conversion equipment)
7. Calorific value of fuel.
8. Emission factor of fuel (if estimated based on ultimate analysis of fuel in inhouse laboratory).
9. Retrofits affecting energy efficiency of equipment, to be monitored. (Refer retrofit monitoring test)

10. Efficiency of heat conversion equipment

B.2. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario:

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B.2.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:

ID number (Please use numbers to ease cross-referencing to table B.7)	*Data variable*	*Source of data*	*Data unit*	*Measured (m), calculated (c) or estimated (e)*	*Recording frequency*	*Proportion of data to be monitored*	*How will the data be archived? (electronic/ paper)*	*Comment*
B.2.1	Useful Output of equipment	Instrument	kg/hr or m^3/hr	M	Each shift or each batch and daily	100%	Electronic	Depends upon phase of useful output stream (solid, liquid, gas). Measured by automatic or manual weighing balance or by volume in the plant premises to the best accuracy and will be monitored at the end of shift/batch (either manually or through DCS).
B.2.2	Flow rate of Input streams	Instrument	Kg/hr or m^3/ hr	M & C	In each shift or each batch	2.5%	Electronic	Since the methodology is based on constant output, it is expected that data to be monitored will be constant. The 2.5% time in a shift (12 minutes) can represent the value of flow rate across the shift.
B.2.3	Specific heat of the streams	Data book	Kcal/kg°C or kcal/m^3°C	C	In each shift or each batch	100%	Electronic	Specific heat of gases and liquid depends upon temperature.
B.2.4	Inlet temperature	Instrument	°C	M	In each shift or each batch	2.5%	Electronic	One reading at the end of shift (three readings/day) takes into

ID number (Please use numbers to ease cross-referencing to table B.7)	*Data variable*	*Source of data*	*Data unit*	*Measured (m), calculated (c) or estimated (e)*	*Recording frequency*	*Proportion of data to be monitored*	*How will the data be archived? (electronic/ paper)*	*Comment*
	of streams							account the variation in ambient conditions throughout the day. The 2.5% time in a shift (12 minutes in 8-hour shift) can represent the value of flow rate across the shift.
B.2.5	Heat of reaction of streams which have exothermic /endothermic reaction.	Data book /plant	$kCal/m^3$ or kCal/kg	M & C	In each shift or each batch	100%	Electronic	
B.2.6	Latent heat of streams which will change phase during heat exchange.	Data book	Kcal/kg or $Kcal/m^3$	M	In each shift or each batch	100%	Electronic	
B.2.7	Calorific value of fuel fired (flow rate from input streams)	Instrument	Kcal/kg or $Kcal/m^3$	M	In each shift or each batch	1%	Electronic	Once in a day, or the change in consignment of fuel
B.2.8	Electricity used in fluid transportation (separately for each inlet stream)	Instrument	KkWh/hr	M & C	In each shift or each batch	2.5%	Electronic	One reading at the end of shift (three readings/day) takes into account the variation in ambient conditions throughout the day. The 2.5% time in a shift (12 minutes) can represent the value of average electricity consumption across

ID number (Please use numbers to ease cross-referencing to table B.7)	*Data variable*	*Source of data*	*Data unit*	*Measured (m), calculated (c) or estimated (e)*	*Recording frequency*	*Proportion of data to be monitored*	*How will the data be archived? (electronic/ paper)*	*Comment*
								the shift.
B.2.9	Flow rate of output streams	Instrument	Kg/hr or m3/hr	M	In each shift or each batch	2.5%	Electronic	Since the methodology is based on constant output, it is expected that data to be monitored will be constant. The 2.5% time in a shift (12 minutes) can represent the value of flow rate across the shift.
B.2.10	Specific heat of the streams	Data book	Kcal/kg°C or kcal/m^3°C	C	In each shift or each batch	100%	Electronic	Depends on temperature
B.2.11	Outlet temperature of stream	Instrument	°C	M	In each shift or each batch	2.5%	Electronic	One reading at the end of shift (three readings/day) takes into account the variation in ambient conditions throughout the day. The 2.5% time in a shift (12 minutes) can represent the value of flow rate across the shift.
B.2.12	Electricity consumption (for electrically heated conversion equipment)	Instrument	KWh/hr	M	In each shift or each batch	2.5%	Electronic	Once, at the end of shift.
B.2.13	Retrofit (Event)	Plant log books	-	M	As and when occurs.	100%	Paper	Follow Retrofit Monitoring Test as given in this methodology

B.2.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

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Nomenclature for the terms used in formulae is following:

S. No.	Representation	Description
1	H	This letter is used for heat transfer (or heat generation)
2	T	This letter is used for temperature.
3	M	This letter is used for mass flow rate
4	Cp	This notation is used for specific Heat
5	$_h$	This suffix (subscript) is used for hot stream
6	$_c$	This suffix (subscript) is used for cold stream
7	$_{hl}$	This notation (subscript) is used for latent heat
8	p	This small letter is used Phase change reaction.
9	e	This small letter is used for Electrical energy
10	h	This small letter is used for heat content (e.g. heat of reaction)
11	c	This small letter is used for combustion reaction
12	$_{input}$	This suffix (subscript) is used for input streams (e.g. heat of input streams)
13	$_{output}$	This suffix (subscript) is used for output streams (e.g. heat of output streams)
14	i	This small letter is used for incoming streams. (e.g. incoming hot stream)
15	o	This small letter is used for outgoing streams. (e.g. outgoing hot stream)
16	r	This small letter is used as indication of chemical reaction
17	k	Small letter k is used for no. streams (e.g. no. of hot incoming streams k=0,1,2…..n)
18	n	This small letter is used for total no of streams
19	$_p$	This suffix (subscript) is the indication of the values after project activity (e.g. η_p)
20	b	This small letter is the indication of the values before project activity (Baseline)
21	*A, B, C……m*	This letters are the indications for shifts in a day. (e.g A shift)
22	m	Small letter m represents total no of shifts in a day
23	η	This symbol represents the efficiency of the system.
24	NCV	This notation is used for net calorific value
25	s	This small letter indicates no. of fuel used.
26	E	This capital letter is used for emissions from fuel
27	EF	This notation used for the emission factor
28	$_{total}$	The suffix (subscript) is used for total value. (e.g. H_{total} total heat saved)

29	$_{avg,heat}$	The suffix (subscript) is used for average value based on calorific value (e.g. $E_{avg-heat}$ is emissions $kgCO_2/kCal$)
30	$_{saving}$	The suffix (subscript) is used for Saving. (e.g H_{saving}= Heat saving)
31	$_{actual}$	The suffix (subscript) is used for actual savings. (e.g H_{actual}= actual heat saving)
32	Nm^3	N is used for normal.

Step 1:

Monitor output quantity and check whether it is within the normal output range or not.
If output is with in the range then calculate the efficiency as per following calculations.

Step 2:

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)

MH	=	T_h	×	M_h	×	C_{ph}	-	T_c	x	M_c	x	C_{pc}

Maximum heat transfer possible (in case of sensible heat transfer plus latent heat transfer)

MH	=	E_{h1}	×	M_h	-	T_c	x	M_c	x	C_{pc}		

MH = Maximum heat transfer possible (kCal/hr) T_h = Temperature of incoming hot steam (°C) M_h= Flow rate of incoming hot stream (kg/hr or m^3/hr) C_{ph} = Specific heat of incoming hot stream (kCal/kg °C or kCal/m^3°C) T_c = Temperature of outgoing cold steam (°C) M_c= Flow rate of outgoing cold stream (kg/hr or m^3/hr) C_{pc} = Specific heat of outgoing cold stream (kCal/kg °C or kCal/m^3°C) E_{hl} = Latent heat of hot incoming stream (kCal/kg or kcal/m^3)

Heat input by phase change						
Hp_{input}	=	Mp	×	hp		
Hp_{input} = Heat input by phase change (kcal/hr) Mp = Flow rate of phase change stream (kg/hr or m^3/hr) **Hp = Enthalpy of phase change material (kCal/kg or kCal/m^3)**						
Heat input through electricity						
He_{input}	=	**EE**	×	3600	/	4.1816
He_{input} = Heat input through electricity (kcal/hr) **EE= Electrical Energy used (kWh/hr)**						

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) and heat conversion equipment.

<table>
<tr><td colspan="7">Heat balance</td></tr>
<tr><td colspan="7">Heat input through heat of combustion</td></tr>
<tr><td>Hc_{input}</td><td>=</td><td>Mc</td><td>×</td><td colspan="3">Hc</td></tr>
<tr><td colspan="7">Hc_{input} = Heat input by heat of combustion (kCal/hr)
Mc = Flow rate of combustible fuel used (kg/hr or m^3/hr)
Hc = Heat of combustion (calorific value) (kCal/kg or kcal/m^3)</td></tr>
<tr><td colspan="7">Heat input by any incoming stream (Base temperature 0°C)</td></tr>
<tr><td>Hi_{input}</td><td>=</td><td>Mi</td><td>×</td><td>Cpi</td><td>×</td><td>Ti</td></tr>
<tr><td colspan="7">Hi_{input} = Heat input by hot/cold stream (kCal/hr)
Mi = Flow rate of incoming stream (kg/hr or m^3/hr)
Cpi = Specific heat of the stream (kcal/kg °C or kcal/m^3 °C)
Ti = Inlet temperature of the stream (°C)</td></tr>
<tr><td colspan="7">Heat input by the heat of reaction</td></tr>
<tr><td>Hr_{input}</td><td>=</td><td>Mr</td><td>×</td><td colspan="3">hr</td></tr>
<tr><td colspan="7">Hr_{input} = Heat input through heat of reaction (kCal/hr)
Mr = Flow rate of reactants (kg/hr or m^3/hr)
Hr = Heat of reaction (kcal/kg or kCal/m^3)</td></tr>
<tr><td colspan="7">Heat input by phase change</td></tr>
<tr><td>Hp_{input}</td><td>=</td><td>Mp</td><td>×</td><td colspan="3">hp</td></tr>
</table>

Hp_{input} = Heat input by phase change (kcal/hr) Mp = Flow rate of phase change stream (kg/hr or m^3/hr) hp = Enthalpy of phase change material (kcal/kg or m^3/kg)							
Heat input through electricity							
He_{input}	=	EE	×	3600	/	4.1816	
He_{input} = Heat input through electricity (kcal/hr) EE= Electrical Energy used (kWh/hr)							
Heat output by useful outgoing streams (Base temperature 0°C)							
Ho_{output}	=	Mo	×	Cpo	×	To	
Ho_{output} = Heat output by stream (kCal/hr) Mo = Flow rate of output stream (kg/hr or m^3/hr) Cpo = Specific heat of the output stream (kcal/kg °C or kcal/m^3 °C) To = Output temperature of the stream (°C)							
Total heat input							
H_{input}	=	$\sum_{k=0}^{k=1,2,3...n}(Hc_{input}),_k + \sum_{k=0}^{k=1,2,3...n}(Hi_{input}),_k + \sum_{k=0}^{k=1,2,3...n}(Hr_{input}),_k + \sum_{k=0}^{k=1,2,3...n}(Hp_{input}),_k + \sum_{k=0}^{k=1,2,3...n}(He_{input}),_k$					

H_{input} = Total heat input (kCal/hr) Hc_{input} = Heat input through heat of combustion (kCal/hr) Hi_{input} = Heat input through hot and cold streams (kCal/hr) Hr_{input} = Heat input through heat of reaction (kCal/hr) Hp_{input} = Heat input through phase change material (kCal/hr) He_{input} = Heat input through electricity (kCal/hr)		
Useful heat output		
H_{output}	=	$\sum_{k=0}^{k=1,2,3...n} (Ho_{output}),_k$
H_{output} = Useful heat output (Kcal/hr)		

Step 3:

Efficiency of equipment in project scenario				
η_{pA}	=	H_{outpur}	/	H_{input}[3]
η_{pA} = Efficiency of equipment in project scenario (Example A-shift)				

Step 4:

[3] H_{input} 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/hr) as calculated in step-2a)1 earlier. H_{input} in the case of heat transfer equipment (with more than two streams of heat exchange) or heat conversion equipment should be taken as heat input through fuel or electricity source (in kCal/hr or kWh/hr).

Average daily efficiency in project scenario		
η_p	=	$\frac{[\eta_{pA} + \eta_{pB} ..... + \eta_{pm}]}{m}$
η_p = Daily average efficiency η_{pA} ,$\eta_{pB....}\eta_{pm}$ = Efficiency in shifts Ath,Bth……mth shift.		

B.2.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of greenhouse gases (GHG) within the

project boundary and how such data will be collected and archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
B.3.1	Useful Output heat of equipment	Instrument	kCal/hr	M and E	each shift or each batch and daily	100%	Electronic	Depends upon phase of useful output stream (solid, liquid, gas). Measured by automatic or manual weighing balance or by volume in the plant premises to the best accuracy and will be monitored at the end of shift/batch (either manually or through DCS).
B.3.2	Flow rate of Input streams	Instrument	Kg/hr or m^3/hr	M & C	In each shift or each batch	2.5%	Electronic	Since the methodology is based on constant output, it is expected that data to be monitored will be constant. The 2.5% time in a shift (12 minutes) can represent the value of flow rate across the shift.
B.3.3	Specific heat of the streams	Data book	Kcal/kg°C or kcal/m^3°C	C	In each shift or each batch	100%	Electronic	Specific heat of gases and liquid depends upon temperature.
B.3.4	Inlet temperature of streams	Instrument	°C	M	In each shift or each batch	2.5%	Electronic	One reading at the end of shift (three readings/day) takes into account the variation in ambient conditions throughout the day. The 2.5% time in a shift (12 minutes in 8-hour shift) can represent the value of flow rate across the shift.

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
B.3.5	Heat of reaction of streams which have exothermic /endothermic reaction.	Data book /plant	kCal/m^3 or kCal/kg	M & C	In each shift or each batch	100%	Electronic	
B.3.6	Latent heat of streams which will change phase during heat exchange.	Data book	Kcal/kg or Kcal/m^3	M	In each shift or each batch	100%	Electronic	
B.3.7	Calorific value of fuel fired (flow rate from input streams)	Instrument	Kcal/kg or Kcal/m^3	M	In each shift or each batch	1%	Electronic	Once in a day, or the change in consignment of fuel
B.3.8	Electricity used in fluid transportation (separately for each inlet stream)	Instrument	Kwh/hr	M & C	In each shift or each batch	2.5%	Electronic	One reading at the end of shift (three readings/day) takes into account the variation in ambient conditions throughout the day. The 2.5% time in a shift (12 minutes) can represent the value of average electricity consumption across the shift.
B.3.9	Flow rate of output streams	Instrument	Kg/hr m^3/hr	M	In each shift or each batch	2.5%	Electronic	Since the methodology is based on constant output, it is expected that data to be monitored will be constant.

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
								The 2.5% time in a shift (12 minutes) can represent the value of flow rate across the shift.
B.3.10	Specific heat of the streams	Data book	Kcal/kg°C or kcal/m^3°C	C	In each shift or each batch	100%	Electronic	Depends on temperature
B.3.11	Outlet temperature of stream	Instrument	°C	M	In each shift or each batch	2.5%	Electronic	One reading at the end of shift (three readings/day) takes into account the variation in ambient conditions throughout the day. The 2.5% time in a shift (12 minutes) can represent the value of flow rate across the shift.
B.3.12	Electricity consumption (for electrically heated conversion equipment)	Instrument	kWh/hr	M	In each shift or each batch	2.5%	Electronic	Once, at the end of shift.

B.2.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

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Step 1:
Bench mark the output data. The benchmarking should be based on the useful output level, normal ratings of the equipments and process conditions.
Step 2:

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)

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)

MH	=	T_h	×	M_h	X	C_{ph}	-	T_c	X	M_c	x	C_{pc}

Maximum heat transfer possible (in case of sensible heat transfer plus latent heat transfer)

MH	=	E_{h1}	×	M_h	-	T_c	x	M_c	X	C_{pc}		

MH = Maximum heat transfer possible (kCal/hr)
T_h = Temperature of incoming hot steam (°C)
M_h= Flow rate of incoming hot stream (kg/hr or m^3/hr)
C_{ph} = Specific heat of incoming hot stream (kCal/kg °C or kCal/m^3°C)
T_c = Temperature of outgoing cold steam (°C)
M_c= Flow rate of outgoing cold stream (kg/hr or m^3/hr)
C_{pc} = Specific heat of outgoing cold stream (kCal/kg °C or kCal/m^3°C)
E_{hl} = Latent heat of hot incoming stream (kCal/kg or kcal/m^3)

Heat input by phase change				
Hp_{input}	=	Mp	×	hp
Hp_{input} = Heat input by phase change (kCal/hr) Mp = Flow rate of phase change stream (kg/hr or m^3/hr) hp = Enthalpy of phase change material (kCal/kg or kCal/m^3)				

Heat input through electricity							
He_{input}	=	EE	×	3600	/	4.1816	
He_{input} = Heat input through electricity (kcal/hr) EE= Electrical Energy used (kWh/hr)							

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) and heat conversion equipment.

Heat balance				
Heat input through heat of combustion				
Hc_{input}	=	Mc	×	Hc
Hc_{input} = Heat input by heat of combustion (kCal/hr) **Mc = Flow rate of combustible fuel used (kg/hr or m^3/hr)** **hc = Heat of combustion (calorific value) (kCal/kg or kcal/m^3)**				

Heat input by any incoming stream (Base temperature 0°C)						
Hi_{input}	=	Mi	×	Cpi	×	Ti

Hi_{input} = Heat input by hot/cold stream (kCal/hr) Mi = Flow rate of incoming stream (kg/hr or m^3/hr) **Cpi = Specific heat of the stream (kcal/kg °C or kcal/m^3 °C)** Ti = Inlet temperature of the stream (°C)							
Heat input by the heat of reaction							
Hr_{input}	=	Mr	×	hr			
Hr_{input} = Heat input through heat of reaction (kCal/hr) Mr = Flow rate of reactants (kg/hr or m^3/hr) Hr = Heat of reaction (kcal/kg or kCal/m^3)							
Heat input by phase change							
Hp_{input}	=	Mp	×	hp			
Hp_{input} = Heat input by phase change (kcal/hr) Mp = Flow rate of phase change stream (kg/hr or m^3/hr) Hp = Enthalpy of phase change material (kcal/kg or m^3/kg)							
Heat input through electricity							
He_{input}	=	EE	×	3600	/	4.1816	
He_{input} = Heat input through electricity (kcal/hr) EE= Electrical Energy used (kWh/hr)							
Heat output by useful outgoing streams (Base temperature 0°C)							
Ho_{output}	=	Mo	×	Cpo	×	To	

Ho_{output} = Heat output by stream (kCal/hr) Mo = Flow rate of output stream (kg/hr or m^3/hr) Cpo = Specific heat of the output stream (kcal/kg °C or kcal/m^3 °C) To = Output temperature of the stream (°C)		
Total heat input		
H_{input}	=	$\sum_{k=0}^{k=1,2,3...n}(Hc_{input}),_k + \sum_{k=0}^{k=1,2,3...n}(Hi_{input}),_k + \sum_{k=0}^{k=1,2,3...n}(Hr_{input}),_k + \sum_{k=0}^{k=1,2,3...n}(Hp_{input}),_k + \sum_{k=0}^{k=1,2,3...n}(He_{input}),_k$
H_{input} = Total heat input (kCal/hr) Hc_{input} = Heat input through heat of combustion (kCal/hr) Hi_{input} = Heat input through hot and cold streams (kCal/hr) Hr_{input} = Heat input through heat of reaction (kCal/hr) Hp_{input} = Heat input through phase change material (kCal/hr) He_{input} = Heat input through electricity (kCal/hr) k = No. of streams		
Useful heat output		
H_{output}	=	$\sum_{k=0}^{k=1,2,3...n}(Ho_{output}),_k$
H_{output} = Useful heat output (Kcal/hr)		

Step 3:

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Efficiency of equipment in baseline scenario				
η_{bA}	=	H_{output}	/	H_{input}
η_{bA} = Efficiency of equipment in baseline scenario(Example A-shift)				

Step 4:

Benchmark baseline efficiency		
η_b	=	$\frac{[\eta_{bA} + \eta_{bB} ..... + \eta_{bm}]}{m}$
$\eta_{bA} + \eta_{bB} ..... + \eta_{bm}$ = Efficiency in shifts A^{th},B^{th}……m^{th} shift. m = no of shift-wise values taken for calculation (Minimum one month shift-wise data is required)		

B.3. Option 2: Direct monitoring of emission reductions from the project activity:

>>

B.3.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

B.3.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

>>

B.4. Treatment of leakage in the monitoring plan:

>> Leakages are not considered in methodology.

B.4.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

B.4.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

>> Leakage is not considered in the methodology.

B.5. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

>>

CO_2 Emission								
E_s	=	NCV_s	×	EF_s	×	4.186	/	1000000

E_s = Emission from the s^{th} fuel (kg CO2/ kg) NCV_s = Net Calorific value of s^{th} fuel (kCal/Kg) EF_s = IPCC emission factors (tCo2/TJ of fuel)				
Heat generated by fuel				
Hs	=	NCV_s	×	Q_s
H_s = Heat generated by s^{th} fuel (kCal/hr) Q_s = Quantity of fuel used (kg/hr)				
Total heat Generation				
H_{total}	=	$\sum_{s=0}^{s=1,2,3...n} (H)_{,s}$		
H_{total} = Total heat generation by fuel used in the direct fired or heat supplying equipment s = No. of fuel used				
Percentage of fuel used in the process				
% s^{th} fuel used	=	H_s	/	H_{total}
Average heating value of the fuel used				
NCV_{avg}	=	Σ(% of s^{th} fuel used × NCV_s)	/	100
NCV_{avg} = Average net calorific value of fuels used (kCal/kg)				
Average emission factor for all the fuels used				
E_{avg}	=	Σ(% of s^{th} fuel used × E_s)	/	100
$E_{avg,heat}$	=	E_{avg}	/	NCV_{avg}
$E_{avg,heat}$ = Average emission factor (kg CO_2/kg)				

Increase in energy efficiency

η_{diff}	=	η_p	-	η_b

η_{diff} = Increase in efficiency

η_b = Baseline efficiency

η_p = Project efficiency

Saving in heat input due to increase in efficiency

H_{saving}	=	(η_{diff} / η_p)	×	H_{input}		

H_{saving} = Saving in heat by the equipment (kCal/ hr)

Actual saving in heat

H_{actual}	=	H_{saving}	/	η_c

H_{actual} = Actual heat saving (In case of heat conversion equipments (H_{actual}= H_{saving})

η_c = efficiency of heat conversion equipment (calculated in the same way as η_b or η_p earlier)

Emission Reduction

ER	=	H_{actual}	×	$E_{havg,heat}$

B.6. Assumptions used in elaborating the new methodology:

>>

The following assumptions are used to elaborate new methodology.

1. Following reliable measurement/ metering facility is available to record quantities and temperatures.
    - Flow meter
    - Temperature indicators
2. The output data of process area is available at the end of shift or batch.
3. In case the facility for recording for additional electricity consumption due to project activity is not available on shift/batch intervals, it is assumed that nameplate data of motor rating would be taken for calculations.

4. The minimum efficiency of electrical generation is constant; based on historical data. Therefore its monitoring is not necessary.
5. The reliable in-house or external laboratory testing facility for fuel to determine its
    - Net Calorific Value
    - Ultimate analysis
    - Carbon emission factor
6. In case reliable fuel testing facility is not available, the IPCC emission factors (or national emission factor) for the fuel can be used.
7. The measuring/ recording instruments used are calibrated at regular intervals.

B.7. Please indicate whether quality control (QC) and quality assurance (QA) procedures are being undertaken for the items monitored:		
Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC* procedures planned for these data, or why such procedures are not necessary.
B.2.1	Low	The QA procedure needs to be planned because the monitoring of accurate output data is important for accurate emission reduction calculations.
B.2.2	Low	The QA procedure needs to be planned because the monitoring of accurate flow rate data is important for accurate emission reduction calculations and the proportion monitored is very less.
B.2.3	Low	The QC/QA not required. Values from data book.
B.2.4	Low	The procedure and place of monitoring should be defined.
B.2.5	Low	The QC/QA not required. Values from data book.
B.2.6	Low	The QC/QA not required. Values from data book.
B.2.7	Low	The in house monitoring procedure should be defined.
B.2.8	Low	The procedure should be defined, if calculated.
B.2.9	Low	The QA procedure needs to be planned because the monitoring of accurate flow rate data is important for accurate emission reduction calculations and the proportion monitored is very less.

B.2.10	Low	The QC/QA not required. Values from data book.
B.2.11	Low	The procedure and place of monitoring should be defined.
B.2.12	Low	No, direct monitoring by electricity meter will takes place.
B.2.13	Low	No, retrofit to be monitored as and when occurs. Follow guideline in baseline methodology to analyse its impact on emission reduction.
B.3.1	Low	The QA procedure needs to be planned because the monitoring of accurate output data is important for accurate emission reduction calculations.
B.3.2	Low	The QA procedure needs to be planned because the monitoring of accurate flow rate data is important for accurate emission reduction calculations and the proportion monitored is very less.
B.3.3	Low	The QC/QA not required. Values from data book.
B.3.4	Low	The procedure and place of monitoring should be defined.
B.3.5	Low	The QC/QA not required. Values from data book.
B.3.6	Low	The QC/QA not required. Values from data book.
B.3.7	Low	The in house monitoring procedure should be defined.
B.3.8	Low	The procedure should be defined, if calculated.
B.3.9	Low	The QA procedure needs to be planned because the monitoring of accurate flow rate data is important for accurate emission reduction calculations and the proportion monitored is very less.
B.3.10	Low	The QC/QA not required. Values from data book.
B.3.11	Low	The procedure and place of monitoring should be defined.
B.3.12	Low	No, direct monitoring by electricity meter will takes place.

* QA/QC procedures should cover scope, responsibility, sampling of data, frequency of measurements, assumptions (if any), calibration frequency of instruments used (and status of calibration), and calculation/estimation/testing methods.

B.8. Has the methodology been applied successfully elsewhere and, if so, in which circumstances?

>> Some portions of this methodology are referred from UNFCCC approved methodology AM-0018. Appropriate references have been given in the text. AM-0018 is applied successfully in ‘steam optimisation project’ at Indogulf Fertilizers Limited, Jagdishpur, India.

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