

**Boiler Fuel Conversion from RFO to Biomass Based Briquettes at Fresenius  
Kabi India Private Limited, Ranjangaon (M.S.), India**

**MONITORING REPORT**

**Boiler Fuel Conversion from RFO to Biomass  
Based Briquettes at Fresenius Kabi India  
Private Limited, Ranjangaon (M.S.), India**

**(UNFCCC Reference Number – 1497)**

**Submitted By**

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From 01<sup>st</sup> May 2009 – 30<sup>th</sup> April 2010 (Inclusive of both days)

**CER Claimed: 6821 T-CO<sub>2</sub>-e**

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**1. INTRODUCTION**

Fresenius Kabi India Private Limited (FKIPL) has registered a small-scale project activity of boiler fuel conversion as a Clean Development Mechanism (CDM) project with CDM Executive Board of United Nations Framework Convention on Climate Change (UNFCCC). Subsequent to the registration of the project and issuance of CERs for the first monitoring period 01 May 08 to 30 Apr 09 (Inclusive of both days), the project participant proposes to verify the emission reductions generated by the project activity for the monitoring period 01 May 09 to 30 Apr 10 (Inclusive of both days) and request for issuance of Certified Emission Reductions (CERs). This monitoring report is prepared for verification of the emission reductions generated by the project activity for the second monitoring period.

Sectoral Scope: 1 Energy industries (renewable - / non-renewable sources)

Verification Period: 1<sup>st</sup> May 2009 – 30<sup>th</sup> April 2010 (Inclusive of both days)

**2. PROJECT REFERENCE:**

<b>Sr. No.</b>	<b>Particulars</b>	<b>Reference</b>
1	Baseline Methodology Used	AMS I.C. (Version 09: 23 Dec 2006 Thermal energy for the user)
2	Registered PDD Version	Version 06 Dated: 12 <sup>th</sup> Oct 2007
3	Validation Report	<b>Validated By:</b> DNV (Report No. 2007 – 1029 Revision No. 03 Date of First Issue: 05-06-07, Project No.: 46071029 <b>Approved by:</b> Michael Lehmann (Technical Director) <b>Organizational unit:</b> DNV Certification, International Climate Change Services
4	Monitoring Methodology	As per Para 11 AMS I.C. (Version 09: 23 December 2006 Thermal energy for the user)
5	Project Registration Date	1 <sup>st</sup> May 2008
6	UNFCCC Reference No.	1497

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8	Crediting Period	10 yr fixed crediting period
9	Monitoring Period	1 <sup>st</sup> May 2009 – 30 <sup>th</sup> April 2010
10	Version of Monitoring report	1
11	Involved Host Party	India
12	Annex 1 Party	Switzerland <sup>1</sup>

**3. BRIEF PROJECT DESCRIPTION:**

Earlier plant had two Residual Furnace Oil (RFO) fired Boilers. Out of two boilers one was 10 TPH (smoke tube boiler) & another was of 8 TPH (water tube boiler). Initially 8 TPH boiler was acting as standby to the 10 TPH RFO fired boiler. In this project, fuel conversion (from RFO to biomass based briquettes) was carried out in the 8 TPH water tube boiler for steam generation. The project got commissioned on 13<sup>th</sup> June 2006. The boiler produces saturated steam at a pressure of 10 Kg/cm<sup>2</sup> with saturation temperature of 183.3 Deg C. While 10 TPH RFO fired boiler keeps acting as standby arrangement to project activity boiler. Now 10 TPH RFO fired boiler is also retrofitted to briquette firing mode in September 08 and kept as a standby. Its operation and briquette consumption, steam generation and monitoring is done separately.

In the first monitoring period, Verification of emissions reductions were carried out and total 6507 CERs were requested. After deducting 2% CERs for adaptation funds, total 6377 CERs were issued by UNFCCC. In the second monitoring period there were no additions done by PP in project activity for further improvement. Also project activity boiler was operated successfully for 349 days in a year. As per registered PDD of project (Ref. No. 1497), briquette consumption for the year is considered as 6600 Tonne per year. While in actual practice briquette was consumed equivalent to 6627 Tonne per year. Accordingly estimated baseline emissions are equivalent to 8131 tonnes per year of CO<sub>2</sub> equivalent by emitting CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O. Where as the baseline emissions as per PDD are 7856 Tonnes of CO<sub>2</sub>. Therefore we can say that project activity is performing as envisaged in the PDD.

As per monitoring plan direct boiler efficiency is evaluated annually and it is equivalent to 72.02% which is lower than 75.31% taken in PDD. This is again as per standard operating practices observed in industry. All monthly briquette samples are sent for NCV test. This value is used for calculating NCV ratio of FO and briquette on monthly basis thereby equivalent RFO consumption is evaluated. Also project emissions are calculated by considering N<sub>2</sub>O and CH<sub>4</sub> emissions due to combustion of briquettes in boiler as per IPCC values whenever required. In addition to emissions due to electricity consumption at briquette manufacturing plant GHG emissions due

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<sup>1</sup> <http://cdm.unfccc.int/Projects/DB/DNV-CUK1199787528.27/view>

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to transportation of biomass and briquettes are calculated. These are equivalent to 1310 tonnes of CO<sub>2</sub> which is more than 1298 tonnes of CO<sub>2</sub> estimated in PDD. The deviations in project emissions are arising as loading per truck and the number of trips has varied compared to that of estimated in the PDD. In line with the conservative estimation as per para 4.6 “Estimate of GHG Emission” of final validation report, the maximum distance for transportation of briquette from briquette manufacturing location to FKIPL was compared with distances from certificates given by supplier. Finally maximum distance of 800 Km has been considered. Furthermore maximum distance for the biomass collection for briquette manufacturing has been considered as 50 Km which is also confirming to the para 4.6 “Estimate of GHG Emission” of final validation report and distance certificates supplied by briquette supplier. Project has abided with all legal compliances and has all certificates from boiler inspector and pollution control board.

The RFO fired boilers were contributing to GHG emissions. This CDM project activity primarily aims at reducing these GHG emissions by fuel conversion in the boilers for steam generation (i.e. firing briquettes in place of Residual Fuel Oil). These boilers fully comply the existing pollution norms and also operating efficiently, however FKIPL has opted to have environmentally sustainable solution for steam generation and therefore it has taken-up this project activity.

**4. APPLICATION OF MONITORING METHODOLOGY & DESCRIPTION OF THE MONITORING PLAN**

**4.1 Data and parameters monitored:**

<b>Data / Parameter:</b>	BRQ
Data unit:	MT/Day
Description:	Quantity of briquettes consumed per day
Source of data to be used:	Boiler log sheets maintained at the FKIPL, Ranjangaon
Value of data	18.98 (Average Value of daily briquette Consumption)
Description of measurement methods and procedures to be applied:	Electronic weighing balance is used to measure the briquette quantity in truckload. Daily briquette consumption is measured by number of tipper loads. Record of receipt of briquette quantity in truckloads through external weighing balance & also daily record of number of tipper loads carrying briquettes to the furnace is maintained at the plant.
QA/QC procedures to be applied:	Quantity of briquette consumed is monitored by using calibrated weighing scale.
Any comment:	The data monitored will be archived in Logbook (Paper) for 3 years and Spread sheet (Electronic) for 12 years.

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<b>Data / Parameter:</b>	BRQ (NCV)
Data unit:	Kcal/Kg
Description:	NCV of briquettes
Source of data to be used:	Test records maintained at Fresenius Kabi
Value of data	See excel calculation sheet, under “CER calculation” worksheet, row no. 9
Description of measurement methods and procedures to be applied:	Values obtained from test records from accredited laboratory & verified from briquette purchase invoices
QA/QC procedures to be applied:	Sample of briquettes should be sent once in a month to accredited laboratory for measurement of NCV of briquettes & Verification should be done from briquette purchase invoices
Any comment:	The data monitored will be archived in Logbook (Paper) for 3 years and Spread sheet (Electronic) for 12 years.

<b>Data / Parameter:</b>	Efficiency of briquette fired boiler
Data unit:	%
Description:	Ratio of heat output to the heat input
Source of data to be used:	Boiler log sheet maintained at Fresenius Kabi
Value of data	72.02
Description of measurement methods and procedures to be applied:	Direct Efficiency of the boiler will be evaluated by BEE Certified Energy Auditor once in a year.
QA/QC procedures to be applied:	The Boiler efficiency is checked by BEE Certified Energy Auditor and proper reports are maintained
Any comment:	The data monitored will be archived in Logbook (Paper) for 3 years and Spread sheet (Electronic) for 12 years.

<b>Data / Parameter:</b>	SG
Data unit:	T/day
Description:	Quantity of steam generation per day
Source of data to be used:	Boiler log sheet maintained at Fresenius Kabi
Value of data	77.79 (Average Value of daily steam generation)
Description of measurement	By Qualified and Trained Operator

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methods and procedures to be applied:	
QA/QC procedures to be applied:	Quantity of steam generation is metered on continual basis and monitored daily with the help of online cumulative meter which is already installed
Any comment:	The data monitored will be archived in Logbook (Paper) for 3 years and Spread sheet (Electronic) for 12 years.

<b>Data / Parameter:</b>	Distance of the briquette supplier from the FKIPL
Data unit:	KM
Description:	Average distance traveled by the vehicle from briquette supplier to FKIPL
Source of data to be used:	From Briquette supplier
Value of data	See excel calculation sheet, under “Briquette, Steam, Distance data” worksheet, from D24 to D34.
Description of measurement methods and procedures to be applied:	Start to end point the distance traveled is known and available.
QA/QC procedures to be applied:	
Any comment:	The data monitored will be archived in Logbook (Paper) for 3 years and Spread sheet (Electronic) for 12 years.

<b>Data / Parameter:</b>	$E_{Br}$
Data unit:	KWh/tonne
Description:	Electricity consumption at briquetting plant in KWh per metric tonne of briquette produced.
Source of data to be used:	Monitored data of monthly electricity bill
Value of data	See excel calculation sheet, under “Project Emissions” worksheet, row no. 45
Description of measurement methods and procedures to be applied:	From consultation with Briquetting plant and verifying the data from the electricity bill received at the Briquetting plant
QA/QC procedures to be applied:	Electricity consumption at briquetting plant will be verified annually once from the Briquette Manufacturer.
Any comment:	The data monitored will be archived in Logbook (Paper)

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	for 3 years and Spread sheet (Electronic) for 12 years.
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<b>Data / Parameter:</b>	Distance of the biomass supplier from briquetting plant
Data unit:	KM
Description:	Average distance traveled by the vehicle from biomass supplier to briquetting plant
Source of data to be used:	Based on details provided by the Briquette Manufacturer
Value of data	See excel calculation sheet, under “Briquette, Steam, Distance data” worksheet, from E24 to E34.
Description of measurement methods and procedures to be applied:	From consultation with briquette manufacturing plant
QA/QC procedures to be applied:	Average distance traveled by the vehicle for biomass supply will be checked if the source of biomass supply changes
Any comment:	The data monitored will be archived in Logbook (Paper) for 3 years and Spread sheet (Electronic) for 12 years.

<b>Data / Parameter:</b>	$T_s$
Data unit:	$^{\circ}\text{C}$
Description:	Temperature of the steam generated
Source of data to be used:	Boiler log sheet maintained at Fresenius Kabi
Value of data	185
Description of measurement methods and procedures to be applied:	Temperature of the steam generated will be daily monitored with the help of temperature gauge
QA/QC procedures to be applied:	Temperature measuring instrument will be calibrated once in a year to check its degree of accuracy
Any comment:	The data monitored will be archived in Logbook (Paper) for 3 years and Spread sheet (Electronic) for 12 years.

<b>Data / Parameter:</b>	$P_s$
Data unit:	$\text{Kg}/\text{cm}^2$
Description:	Pressure of the steam generated
Source of data to be used:	Boiler log sheet maintained at Fresenius Kabi

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Value of data	10
Description of measurement methods and procedures to be applied:	Pressure of the steam generated will be daily monitored with the help of Pressure gauge
QA/QC procedures to be applied:	Pressure measuring instrument will be calibrated once in a year to check its degree of accuracy
Any comment:	The data monitored will be archived in Logbook (Paper) for 3 years and Spread sheet (Electronic) for 12 years.

<b>Data / Parameter:</b>	MT steam (yr)
Data unit:	MT/Year
Description:	Quantity of Steam Generation in a Year
Source of data to be used:	Boiler log sheet maintained at the plant
Value of data	27150
Description of measurement methods and procedures to be applied:	Steam meter has been provided which is duly calibrated. Daily steam generated is recorded.
QA/QC procedures to be applied:	The flow meter is calibrated every year.
Any comment:	The data monitored will be archived in Logbook (Paper) for 3 years and Spread sheet (Electronic) for 12 years.

<b>Data / Parameter:</b>	KWh-B in KWh/MT of Steam-Briquette
Data unit:	KWh/MT
Description:	Electricity consumption in briquette fired boiler per MT of Steam
Source of data to be used:	Data recorded and maintained in Boiler Records of the plant
Value of data	See excel calculation sheet, under “Briquette, Steam, Distance data” worksheet, from H5 to H16.
Description of measurement methods and procedures to be applied:	Electricity consumption will be measured by KWh meter and steam flow will be measured by steam flow meter.
QA/QC procedures to be applied:	Electricity Meter and Flow Meter are calibrated every year.
Any comment:	The data monitored will be archived in Logbook (Paper)

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	for 3 years and Spread sheet (Electronic) for 12 years.
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<b>Data / Parameter:</b>	Evaluation for surplus biomass availability for briquette manufacturing
Data unit:	MT/year
Description:	Annual evaluation of whether there is a surplus of biomass in the region will be carried out by BEE accredited Energy Audit agency. Accordingly any leakage that may need to be estimated and deducted from the emission reductions in accordance with the Board's "General guidance on leakage in biomass project activities (Ver.2) will be accounted for.
Source of data to be used:	Data available from reliable sources backed by physical survey for biomass availability in the area
Value of data	1358065
Description of measurement methods and procedures to be applied:	As described above
QA/QC procedures to be applied:	Feedback from briquette manufacturer will also be undertaken
Any comment:	The data monitored will be archived in Logbook (Paper) for 3 years and Spreadsheet (Electronic) for 12 years.  As per EB 47, Annex 28, biomass study needs to be done Ex-ante. i.e. once before starting of crediting period. Therefore now it is not required to carry out biomass study

**4.2 Description of the monitoring plan:**

In this project activity, as per paragraph 11 of "Type AMS. I.C. Thermal energy for the user (Version 09: 23 December 2006)", energy generated due to firing of briquette (a renewable energy source) is quantified. To verify reduction in GHG emission, the monitoring has to ensure that the quantity of steam generation is consistent with baseline steam generation.

The data monitoring will involve measurement of:

1. Quantity of briquettes consumed per day on daily basis
2. NCV of briquette once in a month
3. Efficiency of Briquette Fired Boiler to be evaluated once in a year by Certified Energy Auditor

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4. Quantity of steam generation is measured on continues basis by qualified and trained operators
5. Average distance traveled by the vehicle for briquette supply to the plant will be checked if the source of briquette supply changes
6. Electricity consumption for briquette manufacturing in KWh per MT of briquette produced; this will be verified annually once from briquette manufacturer.
7. Average distance traveled by the vehicle for biomass supply will be checked if the average sources of biomass supply changes.
8. Temperature & Pressure of the steam generated is recorded in the boiler log sheet on regular basis.
9. Electricity consumption in the boiler house will be monitored with KWh meter on daily basis.
10. Annual evaluation for surplus biomass availability for briquette manufacturing will be checked.

For measurement of all the parameters and maintenance of records due care has been taken and to prepare elaborated formats for data collection, methodology has been described for measurement and collection of each of the parameter. Proper training is being provided to concerned personnel. Other instruments such as steam flow meter, KWh meter, electronic weigh bridge, pressure and temperature gauge are calibrated.

**Quality Control & Quality Assurance Procedures identified for data monitoring are explained in detail:**

**Procedures identified for maintenance of steam generation system (boiler + furnace):**

FKIPL has already contracted an agency for maintenance of the steam generation system (boiler + furnace). When the boiler is shut down for maintenance purposes, steam requirement will be fulfilled by standby smoke tube boiler.

**Procedures identified for monitoring, measurements & reporting:**

Quantity of briquette received is measured by monitoring the receipt briquette quantity in truckloads through external electronic weighing balance. Daily briquette consumption is measured by number of tipper loads. The report will be archived to make it available for the external audit & verification purposes.

**Procedures identified for dealing with possible monitoring data adjustments and uncertainties:**

The important parameter in calculating baseline and project emission is briquette consumption quantity. Briquette consumption is measured by weighing each tipper load of briquette consumed in boiler with the help of calibrated electronic weighing

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balance. In actual practice, it may happen that the external electronic weighing balance may not work. In such cases, corresponding values from briquette purchasing invoices will be applied.

**Procedures identified for internal audits of GHG project compliance with operational requirements as applicable:**

In order to check the project's compliance with operational requirements, internal audit can be carried out. For this purpose, a team will be formed under the supervision of the Project Manager.

**Procedures identified for day-to-day record handling (including what records to keep, storage area of records and how to process performance documentation):**

Procedures identified for day-to-day record handling are as follows:

1. Daily record of quantity of the briquette consumed should be maintained properly in the format provided.
2. Records of the parameters that are monitored monthly should be maintained properly in the format provided.
3. All these records should be placed properly at the place provided.
4. Performance parameters are to be monitored by the outside accredited agencies. Monitored data should be collected from the agencies and stored properly for further reference.

**5. EMISSION REDUCTIONS FROM THE SMALL SCALE PROJECT ACTIVITY:**

**5.1 Baseline Emissions:**

As described in the item B.4 of registered PDD (Ref. No. 1497), the proposed baseline is the GHG emissions that would have occurred due to use of RFO in the boiler in absence of this project activity. After switching from RFO to briquettes, the boiler's efficiency will reduce so it will consume more fuel (in terms of input energy) than with RFO. Baseline emissions are calculated based on the equivalent RFO consumption in the boiler in the absence of the project activity. Equivalent RFO consumption in the boiler in the absence of the project activity is calculated based on the quantity of briquette consumed in the project activity.

The baseline methodology is applied in the context of the project activity as follows:

GHG (yr) = GHG emissions due to RFO burning in boiler, in tons of CO<sub>2</sub>-e per year

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$$\text{GHG (yr)} = \{(\text{Energy generated from Equivalent RFO consumption in TJ/year} \times \text{Carbon oxidation factor for RFO} \times \text{IPCC default value for CO}_2 \text{ emission coefficient for RFO in T/TJ}) + (\text{Energy generated from Equivalent RFO consumption in TJ/year} \times \text{IPCC default value for CH}_4 \text{ emission coefficient for RFO in T/TJ} \times \text{GWP for CH}_4) + (\text{Energy generated from Equivalent RFO consumption in TJ/year} \times \text{IPCC default value for N}_2\text{O emission coefficient for RFO in T/TJ} \times \text{GWP for N}_2\text{O}) + (\text{Electricity required per MT of Steam Generation in FO fired Boiler GHG emission} \times \text{Steam Generation per Year} \times \text{MT of CO}_2\text{e generated per KWh})\}$$

$$\begin{aligned} \text{GHG (yr)} = & \{(\text{FOH-e (yr) in TJ/year} \times 1 \times 77.4 \text{ TCO}_2/\text{TJ}) \\ & + (\text{FOH-e (yr) in TJ/year} \times 0.003 \text{ TCH}_4/\text{TJ} \times 21 \text{ TCO}_2/\text{TCH}_4) \\ & + (\text{FOH-e (yr) in TJ/year} \times 0.0006 \text{ TN}_2\text{O}/\text{TJ} \times 310 \text{ TCO}_2/\text{TN}_2\text{O}) \\ & + (\text{KWh-B in KWh/MT of Steam FO} \times \text{MT steam (yr)} \times \text{TCO}_2/\text{KWh}) \\ & \} \dots\dots\dots \text{(Eq. 1)} \end{aligned}$$

$$\begin{aligned} \text{FO-e (yr)} &= \text{Equivalent RFO consumption in KT/year} \\ &= (\text{Briquette Consumption in KT per year}/2.55) \times (\eta_{\text{B-Br}} / \eta_{\text{B-RFO}}) \end{aligned}$$

(Oil to Briquette conversion factor is 2.55 which is because of Net Calorific Value difference; NCV of RFO = 9,665 Kcal/kg and NCV of Briquette = 3,787Kcal/kg. Ratio of these two NCVs is 2.55. While in CER calculations similar ratio is calculated for each month from laboratory tested net calorific value of briquette and IPCC NCV value of FO)

Where,

- $\eta_{\text{B-RFO}}$  = Efficiency of RFO fired boiler
- $\eta_{\text{B-Br}}$  = Efficiency of briquette fired boiler

$$\begin{aligned} \text{FOH-e (yr.)} &= \text{Net Heat generated by Equivalent RFO Consumption in TJ/year} \\ &= \text{FO-e (yr)} \times 40.4 \\ &\text{(Where 40.4 = NCV of RFO in TJ/KT)} \end{aligned}$$

**5.2 Project Emissions:**

Evaluation of project emissions of the project activity is based upon the quantity of briquette (renewable energy source) burnt in the boiler. GHG emissions due to burning of briquettes are evaluated based on the energy generated from burning of briquette & considering the factors for CH<sub>4</sub> & N<sub>2</sub>O per TJ of energy generated from

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burning of briquette. It also involves the emissions related to briquette, which consists of the emissions due to transportation of biomass, manufacturing of briquette & also due to the transportation of briquette. Detailed calculations are as follows:

GHG-P (yr) = GHG emission due to burning of briquettes in boiler, in tCO<sub>2</sub>e per year

$$\text{GHG-P (yr)} = \{(\text{Energy generated from burning of briquettes in TJ/year} \times \text{IPCC default value for CH}_4 \text{ emission coefficient for Biomass in T/TJ} \times \text{GWP for CH}_4) + (\text{Energy generated from burning of briquettes in TJ/year} \times \text{IPCC default value for N}_2\text{O emission coefficient for Biomass in T/TJ} \times \text{GWP for N}_2\text{O}) + \text{KWh-B in KWh/MT of Steam-Briquette} \times \text{MT of steam generated per year} \times \text{TCO}_2/\text{KWh}\}$$

$$\text{GHG-P (yr)} = \{(\text{BRH in TJ/year} \times 0.03 \text{ TCH}_4/\text{TJ} \times 21 \text{ TCO}_2/\text{TCH}_4) + (\text{BRH in TJ/year} \times 0.004 \text{ TN}_2\text{O}/\text{TJ} \times 310 \text{ TCO}_2/\text{TN}_2\text{O}) + (\text{KWh-B in KWh/MT of Steam-Briquette} \times \text{MT steam (yr)} \times \text{TCO}_2/\text{KWh})\} \dots \dots \dots \text{(Eq. 2)}$$

$$\begin{aligned} \text{BRH (TJ/year)} &= \text{Net heat generated by briquette consumption in TJ/year} \\ &= \text{BRQ (KT/year)} \times \text{NCV}_{\text{Br}} \text{ (TJ/KT)} \end{aligned}$$

Where,

$$\text{BRQ (KT/year)} = \text{Briquette consumption in KT/year}$$

$$\text{NCV}_{\text{Br}} \text{ (TJ/KT)} = \text{Net calorific value of briquette in TJ/KT}$$

**GHG emissions due to Briquettes:**

**GHG-L (yr)** is sum of (a), (b) and (c)

(a) GHG emissions due to road transportation of biomass to the briquetting plant: **GHG-LR (yr)**

$$\text{GHG-LR (yr)} = \text{HSD-RM-e (yr) in TJ/year} \times \text{Carbon oxidation factor for HSD} \times \text{CO}_2 \text{ emission factor for HSD (TCO}_2/\text{TJ)}$$

$$\text{GHG-LR (yr)} = \text{HSD-RM-e (yr) in TJ/year} \times 1 \times 74.1 \text{ TCO}_2/\text{TJ} \dots \text{(Eq. 3)}$$

$$\begin{aligned} \text{HSD-RM-e (yr)} &= \text{Net Heat value of total HSD consumption in raw material transport from field to the briquette manufacturing plant} \\ &= \text{HSD1 consumption in KT/Year} \times 43.3 \text{ TJ/KT} \\ &\text{(Where 43.3 is NCV for HSD in TJ/KT)} \end{aligned}$$

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HSD1 consumption in KT/year = ((Total KM travelled per year/Vehicle average fuel consumption in KM/lit) x (Density of HSD in Kg/lit) x 10<sup>-6</sup>))

Total KM travelled per year = ((Total quantity of agro waste required in MT per year/Average quantity of agro waste per vehicle in MT) x (Average distance travelled per trip))

Total quantity of Agro waste required per year = (Dry biomass required in MT per year /0.65)

(65% yield and 35 % considering maximum Moisture in the Biomass received at the Briquetting plant)

Dry biomass required per year = ((Total quantity of briquette required in MT per year x 0.02) + (Total quantity of briquette required in MT per year))

(To produce briquette, dry biomass required is 2 % more than the actual quantity of briquette produced)

(b) GHG emissions due to electricity usage in briquette manufacturing: **GHG-LM (yr)**

**GHG-LM (yr) = BRQ in Tonnes/year x E<sub>Br</sub> (KWh/MT) x 0.89 (TCO<sub>2</sub>/MWh) x 0.001... (Eq. 4)**

BRQ (MT/year) = Quantity of briquette consumed in tonnes per year  
E<sub>Br</sub> (KWh/Tonne) = Electricity consumption at briquetting plant in KWh per metric tonne of briquette produced.

0.89 (TCO<sub>2</sub>/MWh) = CO<sub>2</sub> emission factor for combined margin for Western Grid Region in TCO<sub>2</sub>/MWh---- (As per PDD)

0.001 = Conversion from KWh to MWh

(c) GHG emission due to road transportation of briquettes to FK IPL, Ranjangaon: **GHG-LT (yr)**

GHG-LT (yr) = HSD-BRQ-e (yr) in TJ/year x Carbon oxidation factor for HSD x CO<sub>2</sub> emission factor for HSD (TCO<sub>2</sub>/TJ)

**GHG-LT (yr) = HSD-BRQ-e (yr) in TJ/year x 1 x 74.1 TCO<sub>2</sub>/TJ... (Eq. 5)**

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$$\begin{aligned} \text{HSD-BRQ-e (yr)} &= \text{Net Heat value of total HSD consumption in Briquettes} \\ &\quad \text{from briquette manufacturing plant to FK IPL,} \\ &\quad \text{Ranjangaon} \\ &= \text{HSD2 consumption in KT/Year} \times 43.3 \text{ TJ/KT} \end{aligned}$$

$$\text{HSD2 consumption in KT/year} = ((\text{Total KM travelled per year/Vehicle} \\ \text{average fuel consumption in KM/lit}) \times \\ \text{(Density of HSD in Kg/lit)} \times 10^{-6})$$

$$\text{Total KM travelled per year} = ((\text{Total quantity of briquettes required in MT} \\ \text{per year/Average quantity of briquettes per} \\ \text{vehicle in MT}) \times (\text{Average distance traveled} \\ \text{per trip}))$$

$$\begin{aligned} \text{GHG-L (yr)} &= \text{GHG emissions due to Briquettes in Tonnes per year} \\ &= \text{GHG-LR (yr)} + \text{GHG-LM (yr)} + \text{GHG-LT (yr)} \dots \text{(Eq. 6)} \end{aligned}$$

Total GHG emissions that will occur due to the project activity are calculated from summation of GHG emissions obtained from Eq.2 and Eq.6.

$$\text{Total project activity emissions} = \text{GHG-P (yr)} + \text{GHG-L (yr)} \dots \text{(Eq.7)}$$

**6. LEAKAGES:**

Paragraph 10 of “AMS I.C. Thermal Energy for The User (Version 09: 23 December 2006)” states that

“10. If the generating equipment is transferred from another activity or if the existing equipment is transferred to another activity, leakage is to be considered.”

In the project activity, there is no transfer of energy generating equipment from another activity and no transfer of the existing equipment to another activity hence no leakage is considered.

Further, referring to “General guidance on leakage in Biomass Project Activities” with reference to the attachment C to appendix B of Indicative simplified baseline and monitoring methodologies of SSC, the project has to identify potentially significant source of leakage from renewable biomass. In this regard, following 3 aspects as per Table-1 of “General guidance on leakage in Biomass Project Activities” are evaluated:

1. Shift of previous project activity
2. Emission from Biomass Generation/Cultivation

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3. Surplus biomass availability has been evaluated in the region of the project activity

1. Shift of previous project activity:

Here it is to be noted that the project activity has no bearing on the crop pattern, both of them are totally independence of each other. In absence of the project activity also crop cultivation would have occurred in as usual manner. Therefore any emission due to this reason has not been considered.

2. Emission from Biomass Generation/Cultivation:

As mentioned above there is no increase or decrease in biomass generation/cultivation or in other terms there is no impact on the agricultural practices due to this proposed CDM project activity. Therefore any emission due to this reason has not been considered.

3. Surplus biomass availability has been evaluated in the region of the project activity:

The biomass resource availability assessment for briquette manufacturing was conducted to study the biomass availability. This assessment was carried out in 20 to 200 km radius by third party. The basic objective of the study was to assess the biomass resource availability, their consumption and therefore, the surplus biomass availability. At FKIPL total briquette quantity consumption for first crediting period is 6382 MT. As per calculation details given in section B.6.3 of PDD, for manufacturing this much briquette, total raw biomass required will be equivalent to 10,015 MT. From biomass assessment report it is evident that total biomass availability or biomass generation in the region is 4447628 MT per year. Therefore FKIPL is using 0.22 % of available biomass quantity in the region.

Again it was found that out of total production of biomass residues only 69.46% residues are used for fuel purpose in all forms of activities and 30.54% of biomass residues are remaining as a surplus. Hence there is surplus biomass available in the region, which is not utilized and the available quantity of the surplus biomass is larger (more than 25%) than the quantity of biomass that is utilized including the project activity. Therefore implementation of the project activity has not diverted the biomass from other user to the project plant and therefore no net emission from the fossil fuel combustion due to such diversion are accounted and are considered negligible. Therefore this leakage has been neglected.

**7. EMISSION REDUCTIONS:**

Emission reduction due to the project activity is the difference between baseline emissions & project activity emissions.

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**Emission reductions**

**Due to the project activity = Baseline emissions – Project activity emissions  
= ((GHG emission through Eq.1) - (GHG emission  
through Eq.7))..... (Eq. 8)**

**SAMPLE CALCULATION:**

**Emission Reduction calculation for the month of May 2009:**

**1. Baseline Emissions:**

Referring to Eq. 1, Baseline emissions are calculated as:

$$\begin{aligned} \text{GHG (month)} = & \{(\text{FOH-e (month) in TJ/month} \times 1 \times 77.4 \text{ TCO}_2/\text{TJ}) \\ & + (\text{FOH-e (month) in TJ/month} \times 0.003 \text{ TCH}_4/\text{TJ} \times 21 \\ & \text{TCO}_2/\text{TCH}_4) \\ & + (\text{FOH-e (month) in TJ/month} \times 0.0006 \text{ TN}_2\text{O}/\text{TJ} \times 310 \\ & \text{TCO}_2/\text{TN}_2\text{O}) \\ & + \text{KWh-B in KWh/MT of Steam-FO} \times \text{MT steam (month)} \times \\ & \text{TCO}_2/\text{KWh} \end{aligned}$$

$$\begin{aligned} \text{FO-e (month)} &= \text{Equivalent RFO consumption in KT/month} \\ &= ((\text{Briquette Consumption in KT per month/ (NCV}_{\text{FO}}/\text{NCV}_{\text{Br}}) \times (\eta_{\text{B-}} \\ & \text{Br}/\eta_{\text{B-RFO}})) \\ &= ((0.609/2.39) \times (72.02/79.73)) \\ &= 0.23 \text{ KT/month} \end{aligned}$$

$$\begin{aligned} \text{FOH-e (month)} &= \text{Net Heat generated by Equivalent RFO Consumption in TJ/month} \\ &= \text{FO-e (month)} \times 40.4 \\ &= 0.23 \times 40.4 \\ &= 9.29 \text{ TJ/month} \end{aligned}$$

$$\begin{aligned} \text{GHG (month)} = & \{(\text{FOH-e (month) in TJ/month} \times 1 \times 77.4 \text{ TCO}_2/\text{TJ}) \\ & + (\text{FOH-e (month) in TJ/month} \times 0.003 \text{ TCH}_4/\text{TJ} \times 21 \text{ TCO}_2/\text{TCH}_4) \\ & + (\text{FOH-e (month) in TJ/month} \times 0.0006 \text{ TN}_2\text{O}/\text{TJ} \times 310 \\ & \text{TCO}_2/\text{TN}_2\text{O}) \\ & + \text{KWh-B in KWh/MT of Steam-FO} \times \text{MT steam (month)} \times \\ & \text{TCO}_2/\text{KWh} \end{aligned}$$

$$\begin{aligned} \text{GHG (month)} &= ((9.29 \times 1 \times 77.4) + (9.29 \times 0.003 \times 21) + (9.13 \times 0.0006 \times 310) + \\ & (7.2 \times 2541 \times 0.00089)) \\ &= 738 \text{ TCO}_2\text{-e/month} \end{aligned}$$

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$$\text{GHG (month)} = 738 \text{ TCO}_2\text{-e/month}$$

**2. Project Emissions:**

**GHG emissions due to burning of briquettes in boiler:**

Referring to Eq.2, GHG emissions due to burning of briquettes in boiler are as follows:

$$\begin{aligned} \text{GHG-P (month)} = & ((\text{BRH in TJ/month} \times 0.03 \text{ TCH}_4/\text{TJ} \times 21 \text{ TCO}_2/\text{TCH}_4) \\ & + (\text{BRH in TJ/month} \times 0.004 \text{ TN}_2\text{O}/\text{TJ} \times 310 \text{ TCO}_2/\text{TN}_2\text{O}) \\ & + (\text{KWh-B in KWh/MT of Steam-Briquette} \times \text{MT steam (yr)} \\ & \times \text{TCO}_2/\text{KWh}) \end{aligned}$$

$$\begin{aligned} \text{BRH (TJ/month)} &= \text{Net heat generated by briquette consumption in TJ/month} \\ &= \text{BRQ (KT/month)} \times \text{NCV}_{\text{Br}} \text{ (TJ/KT)} \end{aligned}$$

$$\begin{aligned} \text{BRQ (KT/month)} &= \text{Briquette consumption in KT/month} \\ \text{NCV}_{\text{Br}} \text{ (TJ/KT)} &= \text{Net calorific value of briquette in TJ/KT} \end{aligned}$$

$$\begin{aligned} \text{NCV}_{\text{Br}} \text{ (TJ/KT)} &= \text{NCV}_{\text{Br}} \text{ (Kcal/kg)} \times 4.18 \times 0.001 \\ &= 4044.28 \times 4.18 \times 0.001 \\ &= 16.91 \end{aligned}$$

$$\begin{aligned} \text{BRH (month)} &= \text{BRQ (KT/month)} \times \text{NCV}_{\text{Br}} \text{ (TJ/KT)} \\ &= 0.609 \times 16.91 \\ &= 10.29 \end{aligned}$$

$$\begin{aligned} \text{GHG-P (month)} &= ((\text{BRH (month) in TJ/month} \times 0.03 \text{ TCH}_4/\text{TJ} \times 21 \text{ TCO}_2/\text{TCH}_4) \\ &+ (\text{BRH (month) in TJ/month} \times 0.004 \text{ TN}_2\text{O}/\text{TJ} \times 310 \\ &\quad \text{TCO}_2/\text{TN}_2\text{O}) \\ &+ \text{KWh-B in KWh/MT of Steam-Briquette} \times \text{MT steam (month)} \times \\ &\quad \text{TCO}_2/\text{KWh} \\ &= ((10.29 \times 0.03 \times 21) + (10.29 \times 0.004 \times 310) + (8.95 \times 2541 \times \\ &\quad 0.00089)) \\ &= 39.49 \text{ TCO}_2\text{-e/ month} \end{aligned}$$

$$\text{GHG-P (month)} = 39.49 \text{ TCO}_2\text{-e/ month}$$

**GHG emissions due to Briquettes:**

**GHG-L (month)** is sum of (a), (b) and (c)

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(a) GHG emission due to road transportation of biomass to the briquetting plant: **GHG-LR (month)**

Referring to Eq.3, GHG emission due to road transportation of biomass to the briquetting plant is as follows:

$$\begin{aligned} \text{GHG-LR (month)} &= \text{HSD-RM-e (month) in TJ/month} \times 1 \times 74.1 \text{ TCO}_2/\text{TJ} \\ &= 31.79 \dots \text{ (Please refer CER sheet for detail calculation)} \end{aligned}$$

$$\text{GHG-LR (month)} = 31.79 \text{ TCO}_2\text{-e/month}$$

(b) GHG emissions due to electricity usage in briquette manufacturing: **GHG-LM (month)**

Referring to Eq. 4, GHG emissions due to electricity usage in briquette manufacturing are as follows:

$$\text{GHG-LM (month)} = \text{BRQ (Tonnes/month)} \times E_{\text{Br}} \text{ (KWh/MT)} \times 0.89 \text{ (TCO}_2\text{/MWh)} \times 0.001$$

0.89 (TCO<sub>2</sub>/MWh) = CO<sub>2</sub> emission factor for combined margin for Western Grid Region in TCO<sub>2</sub>/MWh---- (As per PDD)

$$= 23.48 \dots \text{ (Please refer CER sheet for detail calculation)}$$

$$\text{GHG-LM (yr)} = 23.48 \text{ TCO}_2\text{-e/month}$$

(c) GHG emission due to road transportation of briquettes to FKIPL, Ranjangaon: **GHG-LT (month)**

Referring to Eq.5, GHG emissions due to road transportation of briquettes to FKIPL, Ranjangaon are as follows:

$$\text{GHG-LT (month)} = \text{HSD-BRQ-e (month) in TJ/month} \times 74.1 \text{ TCO}_2/\text{TJ}$$

$$= 25.03 \dots \text{ (Please refer CER sheet for detail calculation)}$$

$$\text{GHG-LT (month)} = 25.03 \text{ TCO}_2\text{-e/month}$$

Referring to Eq.6, total GHG emissions due to briquettes in tonnes per year are as follows:

$$\begin{aligned} \text{GHG-L (month)} &= \text{GHG emissions due to Briquettes in Tonnes per month} \\ &= \text{GHG-LR (month)} + \text{GHG-LM (month)} + \text{GHG-LT (month)} \end{aligned}$$

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$$= 31.79 + 23.48 + 25.03$$

$$\text{GHG-L (yr)} = 80.3 \text{ TCO}_2\text{-e/month}$$

Referring to Eq.7, total project activity emissions is estimated as follows:

$$\begin{aligned} \text{Total project activity emissions} &= \text{GHG-P (month)} + \text{GHG-L (month)} \\ &= 39.49 + 80.03 \end{aligned}$$

$$\text{Total project activity emissions} = 119.79 \text{ TCO}_2\text{-e/month}$$

### **3. Emission Reduction:**

Referring to Eq. 8, Emission reductions due to project activity are estimated as follows:

#### **Emission reductions**

$$\begin{aligned} \text{Due to the project activity} &= \text{Baseline emissions} - \text{Project activity emissions} \\ &= ((\text{GHG emission through Eq.1}) - (\text{GHG emission} \\ &\quad \text{through Eq.7})) \\ &= ((738 - 119.79)) \\ &= 618.19 \text{ TCO}_2\text{-e/month} \end{aligned}$$

**Emission reductions due to  
the project activity for May 2009 = 618.19 TCO<sub>2</sub>-e/month**

### **8. SUMMARY OF THE ESTIMATED EMISSION REDUCTIONS:**

The estimated Emissions Reductions are **6821 tCO<sub>2</sub>e** for the period of 1<sup>st</sup> May 09 to 30<sup>th</sup> April 10 (inclusive of both days). The break-up of CER is given in following table. As per registered PDD total estimated emission reductions are 6558 per annum. As per PDD briquette consumption for the year is considered as 6600 Tonne per year. While in actual practice briquette was consumed equivalent to 6627 Tonne per year. Therefore difference occurs in calculation of project emission and finally quantity of emission reductions achieved. Also operating days are 349 compared to 330 days taken in PDD.

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**Table: Emission Reductions for the Period: May 2009 to April 2010**

<b>Month</b>	<b>Estimation of project activity emissions (tCO<sub>2</sub>e)</b>	<b>Estimation of baseline emissions (tCO<sub>2</sub>e)</b>	<b>Estimation of leakage (tCO<sub>2</sub>e)</b>	<b>Estimation of overall emission reductions (tCO<sub>2</sub>e)</b>
May-09	119.79	737.98	0	618.19
June-09	110.65	783.02	0	672.38
July-09	115.01	781.74	0	666.73
Aug-09	86.57	709.46	0	622.89
Sep-09	112.98	750.43	0	637.45
Oct-09	86.40	560.21	0	473.81
Nov-09	119.83	663.48	0	543.65
Dec-09	101.75	645.61	0	543.86
Jan-10	127.83	595.24	0	467.41
Feb-10	97.55	637.38	0	539.83
Mar-10	110.98	579.27	0	468.29
Apr-10	119.90	687.58	0	567.68
<b>Total (Tonnes of CO<sub>2</sub>e)</b>	<b>1310</b>	<b>8131</b>	<b>0</b>	<b>6821</b>

**9. ENVIRONMENTAL IMPACT**

The project activity does not have any significant negative environmental impact. Therefore the environmental impact assessment undertaken in accordance with the procedure as required by the host party is not necessary for this project. Still as per regular practice observed in industries all environmental rules and regulations are followed. Flue gas analysis is carried out by third party in each three months and reports are available. Suspended particulate matter and SO<sub>2</sub> levels are well within the prescribed norms stated by Maharashtra Pollution Control Board (MPCB).

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**Annex 1**

**CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT  
ACTIVITY**

*Their contact details are as follows:*

Organization:	Fresenius Kabi India Private Limited
Street/P.O. Box:	A-3, MIDC
Building:	
City:	Ranjangaon
State/Region:	Maharashtra
Postfix/ZIP:	412 209
Country:	INDIA
Telephone:	91-2138-232283/84/85
FAX:	91-2138-232282
E-Mail:	<a href="mailto:gajanan.sathe@fresenius-kabi.com">gajanan.sathe@fresenius-kabi.com</a>
URL:	<a href="http://www.fresenius-kabi-india.com">www.fresenius-kabi-india.com</a>
Represented by:	
Title:	Director-Technical & President Standard Solutions
Salutation:	
Last Name:	Sathe
Middle Name:	D.
First Name:	Gajanan
Department:	
Mobile:	91-9823332064
Direct FAX:	91-20-26059258
Direct tel:	91-20-26053602/3/4/5/6/7
Personal E-Mail:	<a href="mailto:gajanan.sathe@fresenius-kabi.com">gajanan.sathe@fresenius-kabi.com</a>

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**Annex 2**

**Quantity of Briquettes consumed (MT) and Steam generation (MT) at Fresenius  
Kabi India Private Limited, Ranjangaon, India**

<b>Sr.No.</b>	<b>Year-2009-10</b>	<b>Briquette Consumption (MT)</b>	<b>Steam Generation (MT)</b>
1	May-09	609	2541
2	June-09	613	2531
3	July-09	630	2572
4	Aug-09	563	2274
5	Sep-09	602	2433
6	Oct-09	447	1823
7	Nov-09	560	2286
8	Dec-09	522	2159
9	Jan-10	486	1991
10	Feb-10	528	2148
11	Mar-10	493	2032
12	Apr-10	573	2360
<b>13</b>	<b>Total</b>	<b>6627</b>	<b>27150</b>

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**Annex-3**

**Description of Facilities and Working Physical Components at FKIPL,  
Ranjangaon**

FKIPL have following Facilities at their manufacturing plant in Ranjangaon:

1. Briquettes Storage Shed: In the FKIPL there is separate Briquettes Storage Shed to prevent briquettes from atmospheric moisture and from rain. For briquette handling man power is required. Manually briquette feeding takes place in the furnace with the help of trolley.
2. Boiler house: There are two Boilers in the boiler house one is standby and another is used for steam generation. One Boiler of 10 TPH is smoke tube boiler and another of 8 TPH water tube boiler
3. Furnace: Furnace is used to fire the briquettes. Briquette firing takes place manually in the furnace. Hot gases are passed to the Boiler for the Steam generation.

**Details of Physical Equipments:**

<b>Sr. No.</b>	<b>Equipment/ Facility</b>	<b>Make/specification</b>	<b>Identification No.</b>	<b>Remark</b>
1.	Boiler	<u>Make: Nestler</u> <u>Type: Water Tube</u> <u>Boiler No.: B 1018</u> <u>Capacity: 8 TPH</u> <u>Pressure: 10 kg/cm<sup>2</sup></u> <u>Temperature: 183.3 Deg C.</u>	<u>IB Registry No.:</u> MR 13500	

**Details of Monitoring Equipments and Calibration Schedule:**

<b>Sr. No.</b>	<b>Equipment/ Facility</b>	<b>Make/specification</b>	<b>Identification No.</b>	<b>Remark</b>
1.	Steam Flow meter	<u>Make: Forbes Marshall</u> Installed on the steam line of 8 TPH boiler to measure quantity of steam generated	(Commissioned Date:12 April, 2008)  ID.No.:U08FM0 0100 <u>Type: Krohne Vortex Flow Meter VFM</u>	Steam flow meter will be calibrated once in a year.

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			5097 <u>Sr.No.: 070357</u> <u>Temp. Range:</u> 20 to 240 deg.Centigrade.	
2.	Weighing Bridge	<u>Make: Essae – Teraoka Ltd.</u> <u>Capacity: Min: 20 Kg</u> <u>Max:6000kg</u> <u>Accuracy:2kgs</u> <u>Machine No.:4510757223</u> <u>Working Voltage:90 – 270 Volt</u> <u>A/C 50 Hz</u>	Model No.: DS- 451	Calibrated annually
3.	Pressure Gauge	<u>Make: WIKA</u> <u>Range: 0 to 21 Kg/cm<sup>2</sup></u> <u>Location: M. P. Header</u> <u>Accuracy: +/- 1% F.S.D.</u>	ID Code: U08PG01100	Calibrated Annually
4.	Temperature Gauge	<u>Make: WIKA</u> <u>Range: 0 to 300 deg. Cent.</u> <u>Location: M. P. Header</u> <u>Accuracy: +/- 3% F.S.D.</u>	S.N.: 19789 ID Code: U08TG01100 Model No. R5503/4	Calibrated Annually
5.	KWh Meter	<u>Make: ENERCON</u> <u>Rating: 230 Volts, 5 A</u> <u>Configuration: 3 Phase -4 wire</u> <u>Location: Electrical room</u> <u>Accuracy: Class 1</u>	S.N: 67899/12163- 0805 ID No.: U01KW00100 Model No: 5240	Calibrated Annually

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**NOTATIONS**

<b>Notation</b>	<b>Representing</b>	<b>Unit</b>
%	Percentage	
BEE	Bureau of Energy Efficiency	
BRQ (NCV)	NCV of briquettes	Kcal/Kg
Briquette	Briquettes manufactured using biomass	Tonnes
CDM	Clean Development Mechanism	
CEA	Central Electricity Authority	
VER	Verified Emissions Reduction	
KWh-B in KWh/MT of Steam-FO	Electricity consumption in briquette fired boiler per MT of Steam	
CO <sub>2</sub>	Carbon-di-oxide	
CO <sub>2</sub> -e	CO <sub>2</sub> equivalent	TCO <sub>2</sub> -e
EVR	Evaporation ratio	Kg/Kg
FO-e (yr)	Equivalent RFO Consumption per year	KT
FOH-e (yr)	Net Heat generated by Equivalent RFO Consumption	TJ/year
FKIPL	Fresenius Kabi India Private Limited	
GHG	Green House Gas	
GHG Emissions	Green House Gas Emissions	TCO <sub>2</sub> -e/year
GHG-L (yr)	GHG emission due to the Briquettes	TCO <sub>2</sub> -e/year
GHG-LM (yr)	GHG gases emission due to electricity usage in briquette manufacturing	TCO <sub>2</sub> -e/year
GHG-LR (yr)	GHG gases emission due to road transportation of biomass to the briquette manufacturing plant	TCO <sub>2</sub> -e/year
GHG-LT (yr)	GHG gases emission due to road transportation of briquettes to FKIPL	TCO <sub>2</sub> -e/year
IPCC	Intergovernmental Panel on Climate Change	
Kcal/kg	Kilo Calorie Per Kilo Gram	
Kcal/lit	Kilo Calorie Per Litre	
KG	Kilo Gram	
Kg/Kg	Kilogram Per Kilogram	
Kg/litre	Kilogram Per Litre	
Kg/TJ	Kilogram Per Tera Joule	
kg CO <sub>2</sub> equ/kWh	Kilogram of CO <sub>2</sub> equivalent per Kilo Watt Hour	
KT	Kilo Ton	
KT/month	Kilo Ton Per Month	
KT/year	Kilo Ton Per Year	
KWh	Kilo Watt hour	

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<b>Notation</b>	<b>Representing</b>	<b>Unit</b>
KWh/MT	Kilo Watt Per Metric Ton	
M & P	Modalities and Procedures	
MT/Year	Metric Ton per Year	
NCV	Net Calorific Value	
PDD	Project Design Document	
RFO	Residual Fuel Oil	
TCO <sub>2-e</sub>	Tonnes of CO <sub>2</sub> equivalent	
T-CO <sub>2-e</sub> /TJ	Tonnes of CO <sub>2</sub> equivalent Per Tera Joule	
TJ	Tera Joule	
TJ/KT	Tera Joule Per Kilo Ton	
TJ/year	Tera Joule Per Year	
TPH	Tonnes Per Hour	
UNFCCC	United Nations Framework Convention on Climate Change	
yr.	Year	
$\eta_{(Direct)}$	Direct Efficiency of Boiler	%
$\eta_{(Indirect)}$	Indirect Efficiency of Boiler	%
$\eta_{B-FO}$	Efficiency of RFO Fired Boiler	%
$\eta_{B-Br}$	Efficiency of Briquette Fired Boiler	%