MONITORING REPORT FORM (CDM-MR) *
Version 01 - in effect as of: 28/09/2010

CONTENTS

* as contained within the document entitled "Guidelines for completing the monitoring report form (CDM-MR)" (EB 54 meeting report, annex 34).

MONITORING REPORT
Version: 06 and date 15/03/2013

Construction of additional cooling tower cells at AES Lal Pir (Pvt) Limited. Muzaffar Garh, Pakistan.
Reference No. 2401
Monitoring period - 1.0 dates (first and last days included (01/05/2009 - 30/04/2011))

SECTION A. General description of the project activity

A.1. Brief description of the project activity: >>

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AES Lal Pir (Pvt.) Limited, Pakistan owns and operates Lal Pir & Pak Gen power plants (two units) located near Muzaffar Garh, Pakistan. Each unit consists of a 365 MW steam turbine and cooling tower with seven cells. The purpose of this project is to utilize the latest technology to improve the heat rate of the power plants which is construction of an additional cooling tower cell for each unit's cooling tower. A better heat rate will lower CO_2 emissions via a reduction in the quantity of fuel required to generate electricity. So, the intention in this project activity is to reduce the CO2 emission by replacing the existing technology with the latest technology.

Project Background: Heavy fuel oil is combusted to produce steam which rotates the rotor of the turbine in order to generate electricity. The steam is then routed through a water-cooled condenser which condenses the steam by removing the heat of vaporization. A vacuum is then produced in the steam space of the condenser through the rapid and considerable change in volume as each pound of steam condenses into water. By maintaining a vacuum in the steam condenser, the efficiency of the power plant can be increased due to the fact the greater the vacuum in the system, the greater the enthalpy drop of the steam. This allows more work to be available per kilogram of steam condensing. The vacuum reduces the back pressure upon the turbine by a considerable degree, and the work done per kg of steam during expansion is increased. This results in greater electricity production per unit of fuel input.

Cooling towers have a direct impact on the heat rate of the power plant. The heat rate is a measurement that describes how well the heat from combustion of fuel is being converted into electricity. A high heat rate indicates an inefficient use of fuel which creates higher CO_2 emissions. The cooling water used to condense the steam comes from the cooling towers. The cooler the water is coming from these towers, the more heat of vaporization removed during the condensing process. The result is a stronger vacuum and more work being done per unit of fuel input. Installing an additional cooling tower cell that employs the most advanced technology will result in cooling water with a lower temperature than is produced by the current cooling tower configuration. Cooler water will lower the heat rate of the system, improving the efficiency of the power plant and resulting in fewer CO_2 emissions.

The project was registered in May 2009. Credits are being claimed from 01/05/2009 to 30/04/2011. Total emission reductions achieved during the period were 41,080 tCO_2e. In this report 'LP' will represent Lal Pir & 'PG' will represent Pak Gen.

A.2. Project Participants

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Name of Party involved ((host) indicates a host Party)	**Private and/or public entity(ies) project participants (as applicable)**	**Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)**
Pakistan (host)	AES Lal Pir (Pvt) Limited.	No

A.3. Location of the project activity:

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Project location: The Project is located in southern Punjab region of Punjab Province, Pakistan near District Muzaffar Garh which is approximately 70 km from Multan.

Project longitude: 70º 59' 51" E, latitude: 30º 10' 27" N and altitude: 113 Meters

A.4. Technical description of the project

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Project equipment:

The project equipment was installed as described in the PDD. There are no deviations. The project activity used the newest available technology for cooling tower components such as the gear boxes, nozzles, fills, and fans. In specific, the nozzles installed whereof a new design which improves the distribution system of the water and helps to reduce the temperature.

Technology:

The project technology was installed as described in the PDD and became operational in December 2008. The efficiency improvement program under the project activity consists of the following:

- ✓ Construction of additional cooling tower cells
- ✓ Installation of advanced technology
- ✓ Mechanical works including piping, connections, etc.
- ✓ Electric connection with the existing system
- ✓ Logics from DCS for new cooling tower cells
- ✓ Constant monitoring of the operation

New technologies being introduced in this project activity, of which the new cooling tower cell is a major part, bode well for technological development. These advances have come about through continuous research and development on new technology to increase energy efficiency.

The technology includes the following components:

1. The distribution system inside the cooling tower cell will use ecojet spray nozzles. This innovative nozzle is Spig patented and has been designed in order to reach the followings main goals:
   - Large square water distribution area (approximately 1 m^2) in order to avoid overlap of water distribution area
   - Uniform specific water load in order to prevent air by-pass when the feed water is low
   - Self cleaning surface by means of rotating impeller
   - Anti clogging

2. The self-spacing film packing that will act as filling is constructed with slightly sloped waves and corrugated surfaces. This serves to mix the external and internal layers of water thereby considerably improving the heat and mass exchange coefficients.
3. The drift eliminators are a wave type which utilizes a series of sinusoidal shaped rows that allow for very low pressure drop losses.
4. The electric motor driving the fans is designed for rigorous cooling tower service. Motor supports are designed to transfer dynamic loads to the cooling tower structure, minimizing vibrations and allowing easy maintenance and alignment.

The fan is a multi-blade type and has the primary function of ensuring the cooling tower air volume necessary for cooling. The fan is placed on the highest section of the cell (fan deck) and is directly coupled with the gear box. The cooling tower is completed with the following items which have been designed in accordance with the most up to date safety regulations: fan deck handrails, inspection hatch, and stair and ladder.

This kind of innovative and effective energy saving measure serves to demonstrate to other companies the operational efficacy of such improvements and encourage others to adopt similar measures which will lead to further conservation of energy, fuel and environment.

By adopting this technology, energy improvement within power plants will provide local distributed generation and site-specific reliability, transmission and distribution benefits indicated below:

- Improved power quality
- Reduced fuel consumption
- Power control
- Mitigation of natural resource losses.

It is also proposed by a third party that by installing new cells with new technology the performance of the existing tower cells will be improved. As a result of this performance improvement, emissions will be further reduced

Monitoring and metering equipment:

Monitoring and metering equipment was installed as described in the PDD. The devises installed and their location is as follows:

- Net electricity Generation Metering system: It is installed on the outgoing power transmission lines in the switch yard area. An online reading is also available in the control room via the computerized system.
- Fuel Properties: Density of fuel is monitored in the lab through density meter.
- Fossil Fuel Consumption: Fossil Fuel consumption will be recorded, which is located on the fuel supply line of boiler at ground floor. Its online consumption will be monitored in the control room through DCS.

A.5. Title, reference and version of the baseline and monitoring methodology applied to the project activity:

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Project Title:	**Construction of additional cooling tower cells at AES Lal Pir (Pvt) Limited. Muzaffar Garh, Pakistan.**
UNFCCC Registration Number:	2401
Methodology/Version:	AMS-II.B. Supply side energy efficiency improvements / Version 9
Report Number/Version/Date:	MR01-V6.0 / 15/03/2013

A.6. Registration date of the project activity:

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Project activity registered in UNFCCC as on 01/05/2009.

A.7. Crediting period of the project activity and related information (start date and choice of crediting period):

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Crediting period taken for this project activity is 01/05/2009 to 30/04/2016 (Renewable). Project cycle of 07 years opted which includes start date of 01/05/2009 for this project.

A.8. Name of responsible person(s)/entity(ies):

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- Mr. Farhan Javed
  Climate Change Manager
  Lal Pir Thermal Power plant, Muzaffar Garh. Pakistan. Ph: +92 66 2300030
  Farhan.javed@lalpir.com

- Mr. Muhammad Farhan
  Performance Engineer
  Lal Pir Thermal Power plant, Muzaffar Garh. Pakistan. Ph: +92 66 2300030
  Muhammad.farhan@lalpir.com

SECTION B. Implementation of the project activity

B.1. Implementation status of the project activity

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The project is in operation since December 2008. Project activity was implemented as per plan and all monitoring done in accordance with the plan as prescribed in PDD.

Following is the detail of electricity export and Fuel Consumption from 01/05/2009 to 30/04/2011.

Generation & Fuel Consumption Data (May 2009 to April 2010)						
	Lal Pir		Pak Gen		Total	
Month	Net Gen	Fuel Cons	Net Gen	Fuel Cons	Net Gen	Fuel Cons
	MWh	Ton	MWh	Ton	MWh	Ton
May-09	232,484	56,153	233,270	55,817	465,754	111,970
Jun-09	220,425	54,449	223,735	53,577	444,160	108,026
Jul-09	218,728	53,828	180,302	43,893	399,030	97,721
Aug-09	4,061	2,060	166,324	40,696	170,385	42,756
Sep-09	164,044	40,598	120,568	29,660	284,612	70,258
Oct-09	191,076	45,473	66,164	15,913	257,240	61,386
Nov-09	135,022	33,100	193,789	46,296	328,811	79,396
Dec-09	180,109	43,357	198,338	47,530	378,447	90,887
Jan-10	170,125	41,860	197,860	47,503	367,985	89,363
Feb-10	204,250	49,028	175,455	42,074	379,705	91,102
Mar-10	250,389	59,586	147,283	35,258	397,672	94,844
Apr-10	237,579	56,736	210,610	50,122	448,189	106,858
Total					**4,321,989**	**1,044,567**

Generation & Fuel Consumption Data (May 2010 to April 2011)						
	Lal Pir		Pak Gen		Total	
Month	Net Gen	Fuel Cons	Net Gen	Fuel Cons	Net Gen	Fuel Cons
	MWh	Ton	MWh	Ton	MWh	Ton
May-10	207,885	50,083	196,256	47,021	404,141	97,104
Jun-10	190,087	47,053	166,006	40,460	356,093	87,513
Jul-10	109,268	27,443	202,609	49,990	311,877	77,432
Aug-10	16,188	4,062	26,854	6,659	43,042	10,721
Sep-10	Force Majeure Period due to flood.					
Oct-10						
Nov-10	-	-	88,752	22,477	88,752	22,477
Dec-10	53,665	12,496	158,823	38,286	212,488	50,782
Jan-11	207,752	49,019	172,588	41,216	380,340	90,235
Feb-11	155,631	37,443	87,551	21,244	243,182	58,687
Mar-11	83,426	19,768	184,882	44,693	268,308	64,461
Apr-11	187,150	44,392	43,168	10,581	230,318	54,973
Total					**2,538,541**	**614,386**

Data for the period 06/08/2010 to 05/11/2010 for Pak Gen and 06/08/2010 to 23/12/2010 for Lal Pir could not be collected as Plant was under shutdown/force majeure due to flood in this area. That's why data of this period excluded from the calculations of monitoring period.

B.2. Revision of the monitoring plan

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There has been no revision in the monitoring plan.

B.3. Request for deviation applied to this monitoring period

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There has been no request for deviation applied to the monitoring period.

B.4. Notification or request of approval of changes

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There has been no notification or request of approval of changes from the project activity as described in the registered CDM-PDD.

SECTION C. Description of the monitoring system

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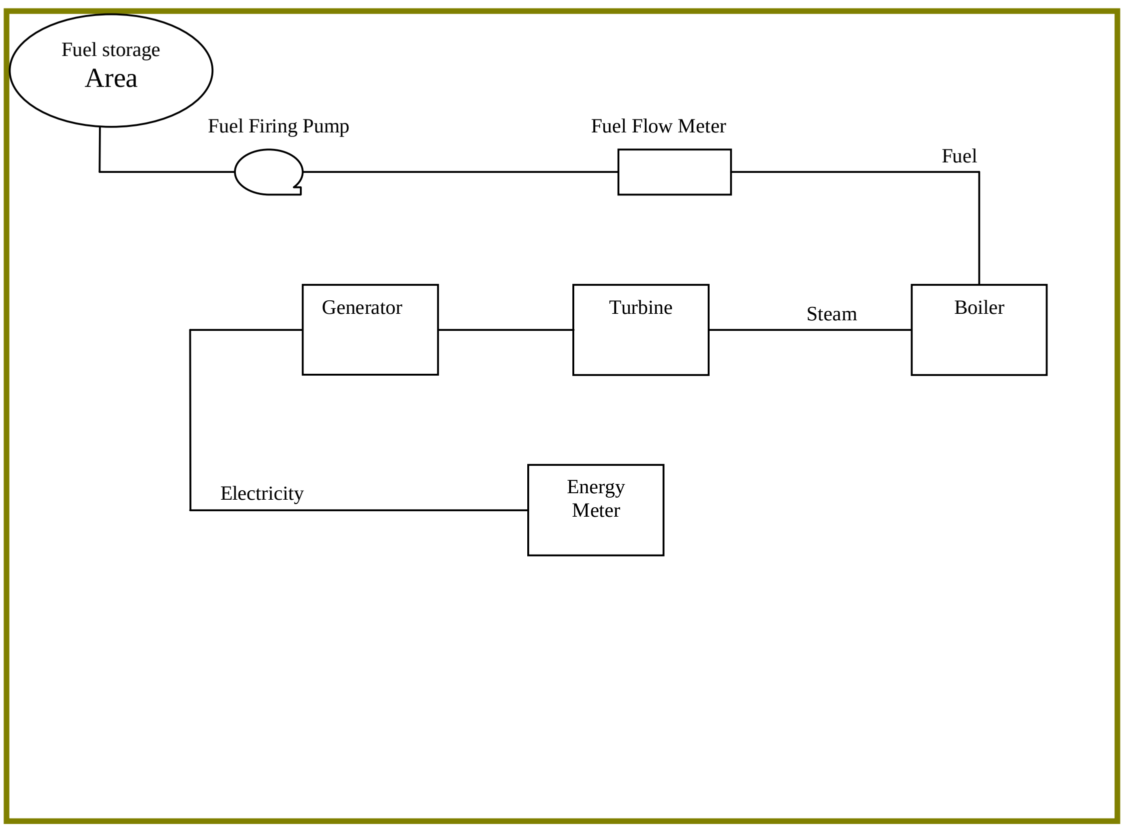
The Commercial group of Lal Pir is responsible for the collection and management of data. The group has also documented the data and sources, carried out the analysis of the data collected, and filed all the information (monitored and calculated) needed for the crediting of the emission reductions to be claimed by the project activity. The Project Developer has a team of professional engineers on site that are responsible for monitoring emissions reductions of the project activity, as well.

Monitoring procedures:

Details of monitoring procedures provided below;

- The monitoring equipment allowed automated and continuous recording and reporting of data. These readings were checked for any anomalies before being filed for future reference.
- The data were monitored and recorded by control room engineers and commercial Engineers according to the monitoring plan. Electricity records were cross verified with the Water & Power Authority of the country – WAPDA on monthly basis.
- The data were electronically archived.
- Proper management process and routine procedures are in placed to ensure the quality of reports required by verification audits.
- The maintenance team calibrated and maintained the monitoring equipment on defined intervals in accordance with the high standards of the organization.



QA/QC roles and responsibilities:
Below are summary of QA/QC responsibilities and documentation applied for the monitored parameters:

Parameter	Documentation	Performed by	QA/QC check performed by
Yearly consumption of fossil fuel "$\mathbf{FC_{fuel\ oil,\ y}}$"	Daily Monitoring Report (Electronic)	OP	QA, CG
Net Electricity generation by the facility "$\mathbf{EG_y}$"	Daily Monitoring Report (Electronic)	OP	QA, CG
Measurement of calorific value of the fuel oil consumed "$\mathbf{CV_{fuel\ oil}}$"	Batch wise Monitoring Report (Paper) from Lab. record	OP	QA,CG
Measurement of density of the fuel oil consumed "$\boldsymbol{\rho_{fuel\ oil}}$"	Batch wise Monitoring Report (Paper) from Lab. record	OP	QA, CG
Month End Net electricity generated invoice to WAPDA which also includes the fuel consumption of the month	Month End Invoice	CG	CG

CG- Commercial Group; QA - quality assurance; OP - operations

Training of operations and monitoring personnel:
Following training program was conducted for the concerned persons to look after all responsibilities of project activity which are;

- Off site training from Singapore by the supplier to handle the project activity.
- Installation of the latest technology program for contractors & supervisors
- Operation of the project activity instructions/training

Training topics included in the training program were:

- CDM project overview
- System overview like engineering of gear boxes with fan
- Protections applicable on gear box operation
- Mechanism of nozzles for water distribution
- How surface area has been increased by applying latest technology measures
- Data collection & monitoring, malfunction diagnostics, fault reporting and escalation measures
- QA & QC Procedures

Technology:

This project activity includes utilizing the newest available technology for cooling tower components such as the gear boxes, nozzles, fills, and fans. In specific, the nozzles are of a new design which improved the distribution system of the water and helps to reduce the temperature.

The feasibility report for the addition of a new cell in each cooling tower was prepared by Spig S.p.A. The technology includes the following components:

1. The distribution system inside the cooling tower cell is using Ecojet spray nozzles. This innovative nozzle is Spig patented and has been designed in order to reach the followings main goals:

- Large square water distribution area (approximately 1 m2) in order to avoid overlap of water distribution area
- Uniform specific water load in order to prevent air by-pass when the feed water is low
- Self cleaning surface by means of rotating impeller
- Anti clogging

2. The self-spacing film packing that act as filling is constructed with slightly sloped waves and corrugated surfaces. This serves to mix the external and internal layers of water thereby considerably improving the heat and mass exchange coefficients.
3. The drift eliminators are a wave type which utilizes a series of sinusoidal shaped rows that allow for very low pressure drop losses.
4. The electric motor driving the fans is designed for rigorous cooling tower service. Motor supports are designed to transfer dynamic loads to the cooling tower structure, minimizing vibrations and allowing easy maintenance and alignment.
5. The fan is a multi-blade type and has the primary function of ensuring the cooling tower air volume necessary for cooling. The fan is placed on the highest section of the cell (fan deck) and is directly coupled with the gear box. The cooling tower is completed with the following items which have been designed in accordance with the most up to date safety regulations: fan deck handrails, inspection hatch, and stair and ladder.

By the implementation of this project, generation capacity has not increased. It has only improved the heat rate by reducing the fuel consumption. The electricity export is dependent on customer's demand. Total monthly export in March 2008 (with 7 cooling tower cells) was 465,442 MW while the maximum monthly export during the monitoring period was 465,754 MW in May 2009. This shows that this project did not increase the capacity of the plant.

SECTION D. Data and parameters

The amount of CO_2 that would be emitted to the atmosphere due to the project activity and within the project boundaries can be estimated based on the technical losses multiplied by the IPCC emission coefficient for fuel oil. Project activity technical losses are calculated based on an estimated percentage increase in heat rate which will affect the efficiency of the generating unit thereby requiring less fuel input to produce the same amount of electricity production. Below is a detail of parameters used in the whole project activity calculations;

D.1. Data and parameters determined at registration and not monitored during the monitoring period, including default values and factors

Data / Parameter:	Emission Coefficient
Data unit:	tonnes CO2/TJ NCV
Description:	Emission Coefficient of CO2 per TJ of NCV
Source of data used:	Table 2.3, page 2.17 in Chapter 2 Stationary Combustion IPCC 2006
Value(s) :	77.4 tonnes CO2/TJ NCV
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	The data is used to calculate Baseline emission.
Additional comment:	The value is fixed for the entire crediting period.

Data / Parameter:	$\mathbf{CV_{fuel\ oil}}$
Data unit:	TJ/tonne
Description:	Net calorific value of Fuel
Source of data used:	Table 1.2, page 1.19 in Chapter 1 IPCC 2006

Value(s) :	0.0404 TJ/tonne
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	The data is used to calculate Baseline emission.
Additional comment:	The value is fixed for the entire crediting period.

D.2. Data and parameters monitored	
Data / Parameter:	$FC_{fuel\ oil,\ y}$
Data unit:	TJ
Description:	Yearly consumption of fossil fuel
Measured /Calculated /Default:	Measured
Source of data:	Data collected during monitoring period by Flow meter.
Value(s) of monitored parameter:	As measured and mentioned in the spread sheet. (1,658,953 Tons during the monitoring period)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	The data is used to measure the project emission.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	The parameters fuel consumption is measured using the Continuous Flow meter installed in the power plant. No specific calibration requirement are mentioned in PDD and also according to the OEM, calibration is not required. Accuracy Class: ±0.05% (ELITE)
Measuring/ Reading/ Recording frequency:	The parameters are measured and recorded on hourly basis.
Calculation method (if applicable):	Data will be archived electronically and kept for the duration of the project + 2 years.
QA/QC procedures applied:	Lal Pir employs an internal QA audit process that ensures monitoring activities are conducted in accordance with the monitoring plan and verifies the accuracy of data reported.

Data / Parameter:	EGy
Data unit:	MWh
Description:	Net Electricity exported by plant
Measured /Calculated /Default:	Measured
Source of data:	Electricity meter installed at main 220 KV line outlet.
Value(s) of monitored parameter:	As measured and mentioned in the spread sheet. (6,860,530 MWH during the monitoring period)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	The data is used to measure the baseline value/project emission.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	The parameters are measured using the Electricity meters no: 10042001-04 & 10046001-04 installed in the power plant. The calibration can be done as and when required by customer. Accuracy class is CL2 according to IEC standard. Meters before flood: 97280005-06,95490011-12,97330001,96490008,97280007,95490003 These meters were of same make and quality.
Measuring/ Reading/ Recording frequency:	The parameters are measured and recorded on half hourly basis.

Calculation method (if applicable):	Data will be archived electronically and kept for the duration of the project + 2 years.
QA/QC procedures applied:	Lal Pir employs an internal QA audit process that ensures monitoring activities are conducted in accordance with the monitoring plan and verifies the accuracy of data reported.

Data / Parameter:	CV fuel oil
Data unit:	GJ/t
Description:	Measurement of calorific value of the fuel oil consumed during the project activity.
Source of data:	Laboratory Result
Value(s) of monitored parameter:	Variable (0.0403 average value for Monitoring period) **
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	The data is used for quality assurance of oil.
Description of measurement and procedures to applied	Measuring by using Bomb Calorimeter (ASTM-D240)
QA/QC procedures applied:	Lal Pir employs an internal QA audit process that ensures monitoring activities are conducted in accordance with the monitoring plan and verifies the accuracy of data reported.

Data / Parameter:	$\rho_{fuel\ oil}$
Data unit:	t/m^3
Description:	Measurement of density of the fuel oil consumed during the project activity.
Source of data:	Laboratory Result
Value(s) of monitored parameter:	Variable (0.9406 average value for MP)
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	The data is used for quality assurance of oil.
Description of measurement and procedures to applied	Measured by using the glass density meter
QA/QC procedures applied:	Lal Pir employs an internal QA audit process that ensures monitoring activities are conducted in accordance with the monitoring plan and verifies the accuracy of data reported.

**The default value as per IPCC, the value of CV of fuel oil ‘0.0404 GJ/ton’ will be used through out the crediting period of the project activity for the calculation of CO2 emission as per applied methodology “AMS II.B, Version 9 § 7” in the registered PDD. The CV of Fuel Oil is measured by Power Plant only for quality assurance of oil, which is supplied by fuel supplier to plant.

Previously used value in monitoring report of CV 0.0405 GJ/ton (variable) was of fuel which is being stored in fuel tanks not for fuel which is being consumed online and taken of few months in crediting period. The fuel stored in tanks are supplied by fuel supplier and on the basis of requirement of power plant, fuel supplier allows us to take fuel from that tanks and used accordingly. This creates difference in fuel CV as in tank moisture remains higher whereas while its consumption it becomes low and subsequently fuel CV gets better and improves fuel quality. To monitor this quality check, power plant is recording fuel CV at all stages before its consumption. However, the actual fuel CV which we record during online system and being used in boiler is true value for power plant efficiency. That’s why actual value is taken of whole crediting period of fuel CV which is being logged in centred control room and laboratory on daily basis (i.e. detailed sheet is provided and witnessed to DOE). This data reflects the average value of fuel CV 0.0403 GJ/ton of whole crediting period mentioned in monitoring report from 01/05/2009 - 30/04/2011. However IT’S clear that project proponent will use the monitoring value just for quality assurance and default value of fuel CV will be used throughout crediting period as per project methodoly.

Other Data and Parameters:

Below is history of equipments used in this project activity;

Equipment	Date of Removal	Date of Replacement	Comments
Fuel Meters on both units	15/10/2010	16/10/2010	Damaged due to Flood
Energy Meters on LP	10/12/2010	10/12/2010	Damaged Due to Flood
Energy Meters on PG	10/05/2011	10/05/2011	Damaged Due to Flood

SECTION E. Emission reductions calculation

E.1. Baseline emissions calculation

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<u>Baseline Emissions</u>

The amount of CO_2 that would be emitted in the absence of the project activity can be estimated by referring to the UNFCCC-approved methodology AMS II.B, version 9, *Supply side energy efficiency improvements – generation* which states that the emissions baseline is the energy baseline multiplied by an emission coefficient for the fuel used by the generating unit. The energy baseline is the technical losses of energy within the project boundary. This is demonstrated by the formulas below. Also, the EF value is an IPCC default value.
The energy baseline data was calculated on the basis of actual fuel consumption and electricity export of year 2007 (That was the last full year of operation with 7 Cooling Tower Cells). The baseline will remain fix for the whole crediting period.

<u>Equation 1: Total baseline emissions</u>

This equation is used to calculate the total baseline CO_2 emission based on actual figures of year 2007

$$BE_y = TL_{BL,y} * EF_{CO2,fuel\ oil}$$

Where:

BE_y	Baseline emissions in the year "y" (tCO_2)
$TL_{BL,y}$	Technical losses in baseline scenario in year "y"
$EF_{CO2,fuel\ oil}$	Emission coefficient for fuel used by the generating unit; IPCC default value

<u>Equation 2: Energy Baseline</u>

This equation is used to calculate the technical losses based on actual figures of year 2007

$$TL_{BL,y} = FC_{fuel\ oil,BL,y} - EG_{BL,y}$$

Where:

$FC_{fuel\ oil,BL,y}$	Energy potential of fossil fuel consumed in baseline in year "y" (TJ)
$EG_{BL,y}$	Energy potential of the electricity produced by the facility in baseline scenario in year "y" (TJ)

Equation 3: Baseline Energy Conversion Efficiency

This equation is used to calculate the baseline efficiency based on actual figures of year 2007

$$\eta_{BL,y} = EG_{BL,y} / FC_{fuel\ oil,BL,y}$$

Baseline data appended below as per PDD;

Baseline Emission:			
			Baseline
Energy Potential of Baseline Energy Produced:	MWh to TJ	TJ	12,211.2
Energy Potential of Baseline Fuel Oil Consumed:	ton to TJ	TJ	33,399.5
Efficiency		%	36.56
Technical losses:		TJ	**21,188.3**
CO2 Emission	t CO2		1,639,971.4

E.2. Project emissions calculation

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This section E.2 was used to calculate the estimated emission reduction after implementation of project for PDD. It is not relevant to calculate the actual emission reduction of project.

The amount of CO_2 that would be emitted to the atmosphere due to the project activity and within the project boundaries can be estimated based on the technical losses multiplied by the IPCC emission coefficient for fuel oil. Project activity technical losses are calculated based on an estimated percentage increase in heat rate which will affect the efficiency of the generating unit thereby requiring less fuel input to produce the same amount of electricity production.

Equation 4: Estimated Emissions after Project Implementation

This equation is used to calculate the total estimated CO_2 emissions after the implementation of project

$$PE_y = TL_{PJ,y} * EF_{CO2,fuel\ oil}$$

Where:

PE_y	Estimated emissions after implementation of project for year “y” (tCO_2)
$TL_{PJ,y}$	Estimated technical losses in project scenario in year “y”
$EF_{CO2,fuel\ oil}$	Emission coefficient for fuel used by the generating unit; IPCC default value

Equation 5: Technical Losses in Project Scenario

This equation is used to calculate the estimated technical losses after the implementation of project

$$TL_{PJ,y} = FC_{fuel\ oil,PJ,y} - EG_{BL,y}$$

Where:

$FC_{fuel\ oil,\ PJ,y}$	Estimated energy potential of fossil fuel consumed in project scenario in year “y”
$EG_{BL,y}$	Energy potential of the electricity produced by the facility in baseline scenario in year “y”

Equation 6: Estimated Fossil Fuel Consumption

This equation is used to calculate the estimated fuel consumption after the implementation of project for the same electricity export based on improved efficiency

$$\mathbf{FC_{fuel\ oil,PJ,y} = EG_{BL,y} / \eta_{PJ,y}}$$

Where:

$\eta_{PJ,y}$	Estimated energy conversion efficiency in project scenario for year "y"

Equation 7: Estimated Project Energy Conversion Efficiency

This equation is used to calculate the estimated efficiency after the implementation of project for the assumed Heat Rate improvement of 40 Btu/kWh

$$\mathbf{\eta_{PJ,y} = \eta_{BL,y} * HR_{increase,y}}$$

Where:

$\eta_{BL,y}$	Energy conversion efficiency in baseline scenario in year "y"
$HR_{increase,y}$	Estimated percentage increase in heat rate as a result of project activity in year "y"

Equation 8: Estimated Percentage Increase in Heat Rate

This equation is used to calculate the improvement in Heat Rate after the implementation of project

$$\mathbf{HR_{increase,y} = HR_{BL,y} / HR_{PJ,y}}$$

Where:

$HR_{BL,y}$	Heat rate of generating unit in baseline scenario for year "y"
$HR_{PJ,y}$	Estimated heat rate of generating unit in project scenario for year "y"

Equation 9: Estimated Project Emission Reductions

This equation is used to calculate the estimated emission reduction after the implementation of project

$$\mathbf{ER_y = BE_y - PE_y}$$

Where:

ER_y	Emission reductions for year "y" (tCO_2)
BE_y	Baseline emission for year "y" (tCO_2)
PE_y	Emissions after implementation of project for year "y" (tCO_2)

Project Emissions appended below;

Project Emission:			
Energy Potential of project Energy Produced:		TJ	12,211.2
Energy Potential of Project Fuel Oil Consumed efficiency increase:		TJ	33,255.0
Efficiency		%	36.72
Technical losses:			**21,043.8**
CO2 Emission	t CO2		1,628,792.5

E.3. Leakage calculation

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In accordance with AMS II.B, Ver. 9, leakage calculations are not required since the technology being employed in this project is not transferred from or to another activity.

E.4. Emission reductions calculation / table

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Following formulae used to calculate the emission reductions and summary in table given of all baseline and actual emission reduction calculations; Year ‘y’ (2007) is used for baseline year and year ‘z’ is used as year after implementation of project.

Equation 10: Emissions after Project Implementation

This equation is used to calculate the actual CO2 emission after the implementation of project in respective monitoring period

$$\mathbf{PE_z = TL_{PJ,z} * EF_{CO2,fuel\ oil}}$$

Where:

PE_z Emissions after implementation of project for year “z” (tCO_2)

$TL_{PJ,z}$ Technical losses in project scenario in year “z”

$EF_{CO2,fuel\ oil}$ Emission coefficient for fuel used by the generating unit; IPCC default value

Equation 11: Technical Losses in Project Scenario

This equation is used to calculate the actual technical losses after the implementation of project in respective monitoring period

$$\mathbf{TL_{PJ,z} = FC_{fuel\ oil,PJ,z} - EG_{PJ,z}}$$

Where:

$FC_{fuel\ oil,PJ,z}$ Energy potential of fossil fuel consumed in project scenario in year “z”

$EG_{PJ,z}$ Energy potential of the electricity produced by the facility in project scenario in year “z”

Equation 12: Energy Conversion Efficiency of Complex after Project Implementation

This equation is used to calculate the actual efficiency of complex after the implementation of project in respective monitoring period

$$\mathbf{\eta_{PJ,z} = EG_{PJ,z} / FC_{fuel\ oil,PJ,z}}$$

Where:

$\eta_{PJ,z}$	Energy conversion efficiency in Project scenario in year "z"

Equation 13: Fossil Fuel Consumption in baseline scenario in year 'z'

This equation is used to calculate the fuel consumption for the electricity export in respective monitoring period based on baseline efficiency

$$\mathbf{FC_{fuel\ oil,BL,z} = EG_{PJ,z} / \eta_{BL,y}}$$

Where:

$\eta_{BL,y}$	Energy conversion efficiency in baseline scenario for year "y"
$FC_{fuel\ oil,\ BL,z}$	Energy potential of fossil fuel consumed in baseline scenario in year "z"

Equation 14: Baseline Emission for Year 'z'

This equation is used to calculate the CO_2 emission for the electricity export in respective monitoring period based on baseline efficiency

$$\mathbf{BE_z = TL_{BL,\ z} * EF_{CO2,fuel\ oil}}$$

Where:

BE_z	Baseline Emissions for year "z" (tCO_2)
$TL_{BL,z}$	Technical losses in baseline scenario in year "z"
$EF_{CO2,fuel\ oil}$	Emission coefficient for fuel used by the generating unit; IPCC default value

Equation 15: Technical Losses in Baseline Scenario in year 'z'

This equation is used to calculate the technical losses for the electricity export in respective monitoring period based on baseline efficiency

$$\mathbf{TL_{BL,\ z} = FC_{fuel\ oil,BL,z} - EG_{PJ,z}}$$

Where:

$FC_{fuel\ oil,\ BL,z}$	Energy potential of fossil fuel consumed in baseline scenario in year "z"
$EG_{PJ,z}$	Energy potential of the electricity produced by the facility in project scenario in year "z"

Equation 16: Emission Reductions

This equation is used to calculate the actual emission reduction for the respective monitoring period

$$\mathbf{ER_Z = BE_Z - PE_Z}$$

Where:

ER_y	Emission reductions for year "z" (tCO_2)
BE_y	Baseline emission for year "z" (tCO_2)
PE_y	Emissions after implementation of project for year "z" (tCO_2)

Table Project Emission Calculations (01/05/2009 to 30/04/2010)				
1- Baseline Emission:				
			Baseline	**Actual for 01/05/2009 to 30/04/2010**
Energy Potential of Baseline Energy Produced:	MWh to TJ	TJ	12,211.2	15,559.2
Energy Potential of Baseline Fuel Oil Consumed:	ton to TJ	TJ	33,399.5	42,556.6
Technical losses:		TJ	**21,188.3**	**26,997.5**
Current efficiency	%		36.56%	36.56%
Emission Coefficient	t CO2/TJ		77.4	77.4
CO2 Emission	t CO2		1,639,971.4	2,089,602.8
2- Project Emission:				
Energy Potential of project Energy Produced:		TJ	12,211.2	15,559.2
Energy Potential of Project Fuel Oil Consumed efficiency increase:		TJ	33,255.0	42,200.5
Technical losses:			**21,043.8**	**26,641.3**
Project efficiency			36.72%	36.87%
CO2 Emission	t CO2		1,628,792.5	2,062,040.0
Emission Reduction:	**tCO2/yr**		**11,178.89**	**27,562.75**
The following part of Heat Rate improvement is just for clarification and not used for actual emissions reduction calculations				
Improvement in project efficiency expected:				
Expected Heat Rate improvement:	BTU/kWh		40	78
Baseline Heat rate due to efficiency:	BTU/kWh		9,334	9,256
Efficiency Increase (after project activity):			**0.43%**	**0.84%**

Table. Project Emission Calculations (01/05/2010 to 30/04/2011)				
1- Baseline Emission:				
			Baseline	**Actual for 01/05/2010 to 30/04/2011**
Energy Potential of Baseline Energy Produced:	MWh to TJ	TJ	12,211.2	9,138.7
Energy Potential of Baseline Fuel Oil Consumed:	ton to TJ	TJ	33,399.5	24,995.8
Technical losses:		TJ	**21,188.3**	**15,857.1**
Current efficiency	%		36.56%	36.56%
Emission Coefficient	t CO2/TJ		77.4	77.4
CO2 Emission	t CO2		1,639,971.4	1,227,338.0
2- Project Emission:				
Energy Potential of project Energy Produced:		TJ	12,211.2	9,138.7
Energy Potential of Project Fuel Oil Consumed efficiency increase:		TJ	33,255.0	24,821.2
Technical losses:			**21,043.8**	**15,682.4**
Project efficiency			36.72%	36.82%
CO2 Emission	t CO2		1,628,792.5	1,213,820.3
Emission Reduction:	**tCO2/yr**		**11,178.89**	**13,517.75**
The following part of Heat Rate improvement is just for clarification and not used for actual emissions reduction calculations				
Improvement in project efficiency expected:				
Expected Heat Rate improvement:	BTU/kWh		40	65
Baseline Heat rate due to efficiency :	BTU/kWh		9,334	9,268
Efficiency Increase (after project activity):			**0.43%**	**0.70%**

Total baseline emissions (01/05/2009 to 30/04/2010): 2,089,602.8 tCO2/yr.
Total project emissions (01/05/2009 to 30/04/2010): 2,062,040.0 tCO2/yr.
Total leakage: Nil
Total emission reductions (01/05/2009 to 30/04/2010): 27,562.75 tCO2/yr.

Total baseline emissions (01/05/2010 to 30/04/2011): 1,227,338.0 tCO2/yr.
Total project emissions (01/05/2010 to 30/04/2011): 1,213,820.3 tCO2/yr.
Total leakage: Nil
Total emission reductions (01/05/2010 to 30/04/2011): 13,517.75 tCO2/yr.

Total baseline emissions (01/05/2009 to 30/04/2011): 3,316,940.80 tCO2/yr.
Total project emissions (01/05/2009 to 30/04/2011): 3,275,860.30 tCO2/yr.
Total leakage: Nil
Total emission reductions (01/05/2009 to 30/04/2011): 41,080 tCO2/yr.

E.5.	**Comparison of actual emission reductions with estimates in the CDM-PDD**

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This section includes a comparison of actual values of the emission reductions achieved during the monitoring period with the estimations in the registered CDM-PDD.

Item	Values applied in ex-ante calculation of the registered CDM-PDD	Actual values reached during the monitoring period
Emission reductions (tCO_2e) (01/05/2009 to 30/04/2010)	11,178.89	27,562.75
Emission reductions (tCO_2e) (01/05/2010 to 30/04/2011)	11,178.89	13,517.75
Total Emission reductions (tCO_2e)	**22,357.78**	**41,080**

E.6.	**Remarks on difference from estimated value in the PDD**

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The project was carried out based on the performance test conducted by third party to evaluate the performance of existing cooling tower and proposing new solutions to improve it further. Upon conclusion, third party recommended a solution to add additional cooling tower cell which will result to reduce cooling water temperature by approximately 2 ^{o}C and eventually reduction in emission due to efficiency improvement. Based on this report, project was executed and in the emission calculations it was estimated the approx. 40 Btu/Kwh heat rate will be improved against cooling water temperature reduction of 2 ^{o}C. And, this improvement will result in reduction of emission as 11,178 tCO2. This need to be clear that heat rate reduction against temperature was based on our internal experience. Whereas, when project commissioned and actual date retrieved which showed us that the reduction in heat rate is more than 40 Btu/Kwh.

After this, we concluded that this was under estimation and we got better results than baseline. Later on, another third party was engaged to carryout different project within same plant. That party submitted their report and they mentioned that by applying their strategy on our system cooling water temperature will be reduced. They mentioned that by reducing 1 ^{o}C temperature, we can save approx. Rs. 24,000-27,000 per hour, which is equivalent to approx. 40 Btu/Kwh and if we reduce 2 ^{o}C then it would be 80 Btu/Kwh. This report is clear evidence to prove our actual heat rate improvement of 78 Btu/Kwh after reducing 2 ^{o}C cooling water temperatures. The actual heat rate improvement is better than estimated heat rate improvement because improvement was under estimated during the project validation

Keeping in view all above, it needs to be clear that this improvement in emission reduction of more than estimated emissions is on actual and permanent. Moreover, this will not affect that project additionality and still the project scale will remain small scale.

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History of the document

Version	Date	Nature of revision
01	EB 54, Annex 34 28 May 2010	Initial adoption.
Decision Class: Regulatory **Document Type**: Guideline, Form **Business Function**: Issuance		