Monitoring report form for CDM project activity
(Version 07.0)

Complete this form in accordance with the instructions attached at the end of this form.

MONITORING REPORT		
Title of the project activity	Efficiency Improvement by Boiler Rehabilitation in fossil fuel-fired (Natural Gas) Steam Boiler System	
UNFCCC reference number of the project activity	10006	
Version number of the PDD applicable to this monitoring report	10.1	
Version number of this monitoring report	1.1	
Completion date of this monitoring report	08/12/2019	
Monitoring period number	3	
Duration of this monitoring period	01/10/2017 to 30/09/2019	
Monitoring report number for this monitoring period	NA	
Project participants	Al Jubail Fertilizer Company (Al Bayroni) Saudi Basic Industries Corporation (SABIC)	
Host Party	Kingdom of Saudi Arabia	
Applied methodologies and standardized baselines	AM0056 - Efficiency improvement by boiler replacement or rehabilitation and optional fuel switch in fossil fuel-fired steam boiler systems Version 1.0	
Sectoral scopes	1: Energy industries (renewable - / non-renewable sources)	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	0 tCO2e	102,084 tCO2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	69,674 tCO2e for two years	

SECTION A. Description of project activity

A.1. General description of project activity

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Al Jubail Fertilizer Company (Al Bayroni), is a petrochemical complex in the business of manufacturing ammonia, urea, 2 Ethyl Hexanol and DOP. Al Bayroni is an affiliate of Saudi Basic Industries Corporation (SABIC) and a joint venture with Taiwan Fertilizer Company (TFC). Saudi Basic Industries Corporation (SABIC) is another project participant.

Al Bayroni currently operates three packaged boilers supplied by Mitsubishi Heavy Industries (MHI). Steam from the boilers is utilized exclusively within Al Bayroni at the process plants. The purpose of this project is to enhance energy efficiency and reduce fuel consumption of these boilers whilst maintaining present steam quality and production rates.

The potential for energy savings and in turn reduction of GHG emissions have been evaluated through an independent study in 2007-2008 by M/S Mitsubishi, Japan and subsequently confirmed through a study by KBR during the same period. As a result, the following modifications and installations have been done to realize energy and GHG savings from the packaged boilers:

- New Economizer
- New modified super-heater
- Associated modifications in convection ducts

The new economizer unit improves energy efficiency by heat recovery from the exhaust gases. Economizers are essentially (heat exchange) mechanical devices, which utilize exhaust gases to preheat boiler feed water thereby reducing overall heat demand and consequentially fuel consumption for steam production.

Super heater units proposed in the project will also improve energy efficiency by utilizing heat from flue gas to convert wet steam to dry steam. The super heater is placed in the path of flue gases from the combustion chamber allowing steam to be heated above its saturation temperature removing moisture at constant pressure.

The emission reductions achieved for the current monitoring period: 69,674 tCO2e

A.2. Location of project activity

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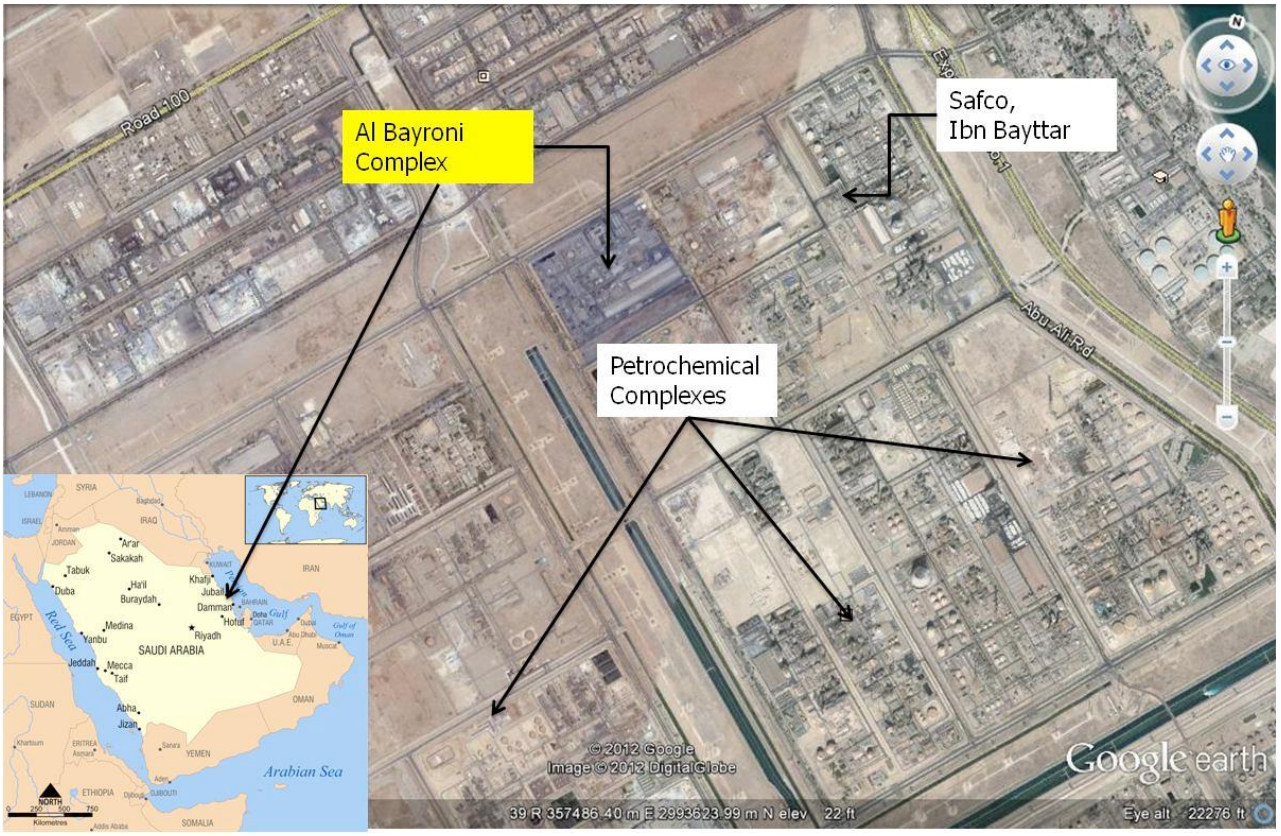
The project is located inside Al Bayroni, in Jubail Industrial City, Eastern Province, Kingdom of Saudi Arabia (49° 33′ 27.98″ E and 27° 3′ 54.64″ N)

Figure A-1: Project Location and Surrounding Land Use



A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Kingdom of Saudi Arabia (host)	Private: Al Jubail Fertilizer Company (Al Bayroni) a subsidiary of Saudi Basic Industries Corporation	No
Kingdom of Saudi Arabia	Private: Saudi Basic Industries Corporation (SABIC)	No

A.4. References to applied methodologies and standardized baselines

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The Baseline and Monitoring method has been established for the proposed project following the approved methodology AM0056 (version 1.0) “Efficiency improvement by boiler replacement or rehabilitation and optional fuel switch in fossil fuel-fired steam boiler systems”. No standardized baseline has been used for the project activity.

Weblink: http://cdm.unfccc.int/EB/041/eb41_repan11.pdf
Tool to calculate project or leakage CO2 emissions from fossil fuel combustion (Version 2, EB 41, Annex 11)

A.5. Crediting period type and duration

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01/10/2014 – 30/09/2024 (Fixed, 10 years)

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

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This project involves the following modifications and installations to realize energy and GHG savings from the packaged boilers:

- New Economizer
- New modified super-heater
- Associated modifications in convection ducts

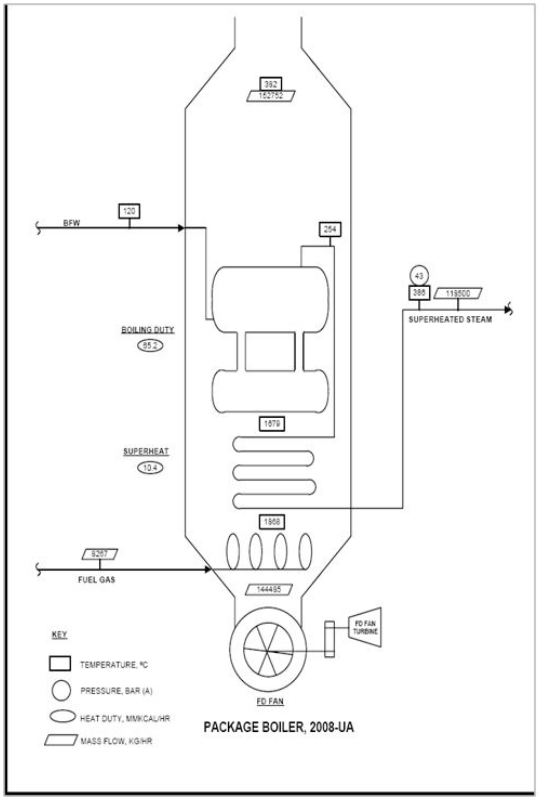
The new economizer unit improves energy efficiency by heat recovery from the exhaust gases. Economizers are essentially (heat exchange) mechanical devices, which utilize exhaust gases to preheat boiler feed water thereby reducing overall heat demand and consequentially fuel consumption for steam production. Super heater units in the project also improve energy efficiency by utilizing heat from flue gas to convert wet steam to dry steam. The super heater is placed in the path of flue gases from the combustion chamber allowing steam to be heated above its saturation temperature removing moisture at constant pressure.

Project Timeline, Status and Monitoring
16/05/2013: Modification of the two boilers (2008 U and 2008 UA) has been completed.

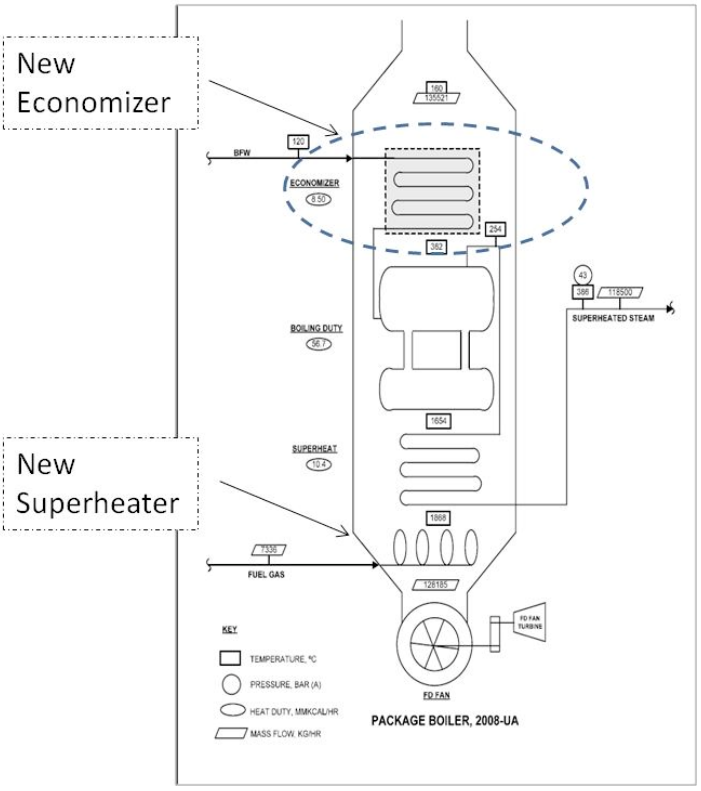
Please see appendix 5 for shutdown periods:

Pre Modification and Post Modification Case:

Pre-Project Boiler Configuration



Post-Project Boiler Configuration



B.2. Post-registration changes

B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies, standardized baselines or other methodological regulatory documents

>>
There are no temporary deviations from the registered monitoring plan, applied methodology or applied standardized baseline.

B.2.2. Corrections

>>
There are the following corrections which all were assessed and accepted as part of UNFCCC approved PRC (ref number PRC-10006-001 of 05/07/2016):

Change #1: Change in the Data Unit from "tons per hour and tons per year" to "Tonnes per year". The proposed change in Data Unit is in accordance with the applied methodology.

Change #2: The GWP of the CH4 was erroneously considered as 21 in the registered PDD. The revised PDD includes GWPCH4 as ex ante parameter and corrected the value under B.6.3 for ex ante estimates of leakage emissions. The said change has been proposed as per para 1 of Appendix 1 of CDM PS Version 9.

Change #3: Minor formatting changes in the revised PDD either as a consequence of using the latest PDD template or representing the correct information at various places in the revised PDD due to other proposed changes.

The following correction were assessed and accepted as part of UNFCCC approved PRC (ref number PRC-10006-002 of 09/03/2017):
1. The line diagram given in PDD did not reflect the position of pressure transmitters for both the boilers. Thus, they were revised to give relevant information.

B.2.3. Changes to the start date of the crediting period

>>
There is no change to the start date of the crediting period

B.2.4. Inclusion of monitoring plan

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No inclusion to the monitoring plan which was not part of the registered PDD.

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other methodological regulatory documents

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There are the following changes which all were assessed and accepted as part of UNFCCC approved PRC (ref number PRC-10006-001 of 05/07/2016):

Change #1: Change of monitoring frequency for parameters PP,J,k,y (System) and TEMPPJ in the registered monitoring plan from 'Hourly' to 'Every 15 minutes' in the revised PDD. The change is necessitated in order to ensure compliance with the prescribed monitoring frequency in the applied methodology.

Change #2: Inclusion of additional monitoring parameters viz., NCVi,y, FCi,j,y and EFCO2 i,y under section B.7.1 of the revised PDD. The inclusion is necessitated to properly determine the project

emissions as prescribed in the registered PDD (page 29, 30) and "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" Version 2 /10/.

Change #3: Additional details for measurement methods has been included with regard to some parameters that are required to be monitored as per ASME PTC 4 Standard under Note 1 in the revised PDD. The changes made has been proposed as part of para 5(f) of Appendix 1 of CDM PS Version 9.

B.2.6. Changes to project design

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The project design has been changed. The original project design includes modifications to three boilers: the first two (identified as 2008-U and 2008-UA) are designed to use only natural gas as a fuel. The third one (identified as 2052-U) was designed to use primarily natural gas. It can also use waste liquid fuels. At the time of writing PDD, it was envisaged that boiler 2052-U would use waste liquid fuel in the quantities not exceeding 1% of all the fuel used in this project, which is in accordance with methodology requirement.

Due to operational necessity during the monitoring period, the boiler 2052-U has exceeded the use of waste liquid fuel by more than 1%. In order to comply with methodology requirements the Project Proponent has excluded the boiler 2052-U from project boundary and have proposed a changes to the registered PDD which have been approved by the UNFCCC (PRC ref number PRC-10006-001 of 05/07/2016).

Following change were assessed and accepted as part of UNFCCC approved PRC (ref number PRC-10006-002 of 09/03/2017),

The estimated fuel savings from 9.7% to 20.18% based on data derived from real life operations was changed at the time of first verification.

B.2.7. Changes specific to afforestation or reforestation project activity

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Not Applicable

SECTION C. Description of monitoring system

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Al Bayroni's monitoring programme is integral to the company's third party certified (i.e. by British Standards Institute-BSI) ISO 9001:2008 compliant Quality Management System (QMS). All monitoring programmes including associated calibration is within the scope of the QMS and subjected to several audits and reviews including Internal Audits, SABIC Corporate Audits and Third Party (BSI) audits.

Further, Al Bayroni subscribes to SABIC corporate's Safety, Environment, Health & Security Management Systems (SHEMS) applicable to all Rotating equipment, Pressure Relief Devices, Instrument Devises, Tanks & Pressure vessels, Piping, Car seals and Blinds, Hoses, Critical Instruments & Devices by pass, and Cathodic protection program. As a result, any modifications/ changes, replacements and emergency response is governed by the SHEMS programme. Al Bayroni is also certified to the American Chemistry Council Technical Specification Responsible Care® RC 14001.

All the modified facilities have passed through safety review during the design stage (namely HAZOP review) to identify all potential hazards and appropriate mitigation were incorporated during design phase of the project." In addition, there are Standard Operating Procedures (SOPs) available with operating personnel to start, operate and shutdown the boiler safely that includes the emergency scenarios of failure also. These SOPs are facilitated by the online instrumentation, Distributed Control System and Emergency Shutdown System.

Through the management systems, monitoring and measurements program, testing and calibration is achieved. Testing and calibration are scheduled through the SAP system and notified by the workflow system to the Instrument division through the SAP maintenance planner.

The Equipment / tag for the boilers is marked in block diagrams Figure C.1 – C2 below). The flow and temperature is continually monitoring through DCS log sheet (Table C.1). The monitoring testing and its frequency with the management system procedure reference is also provided in Table C.2.

Figure C.1: Packaged Boiler Block Diagram (Boiler 2008-UA)

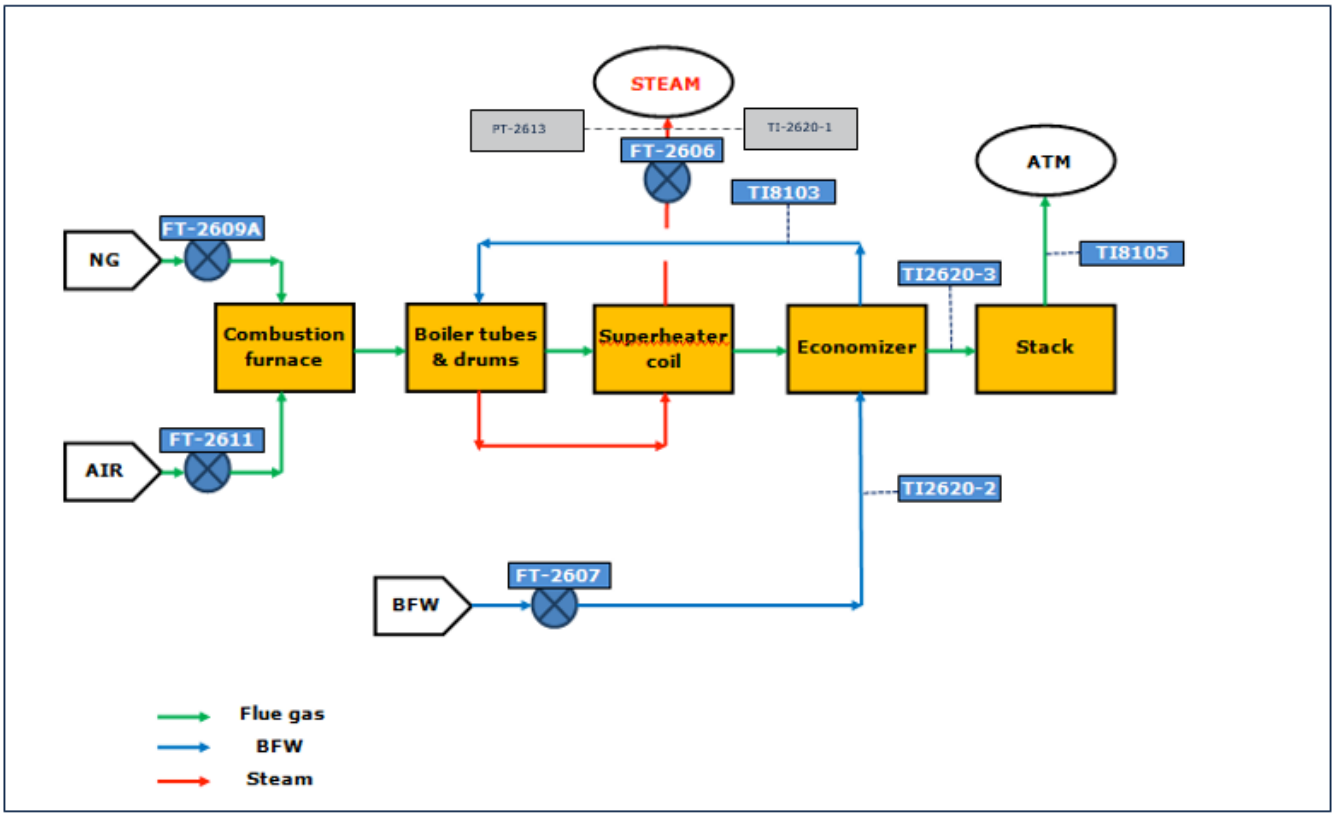

Figure C.2: Packaged Boiler Block Diagram (2008-U)

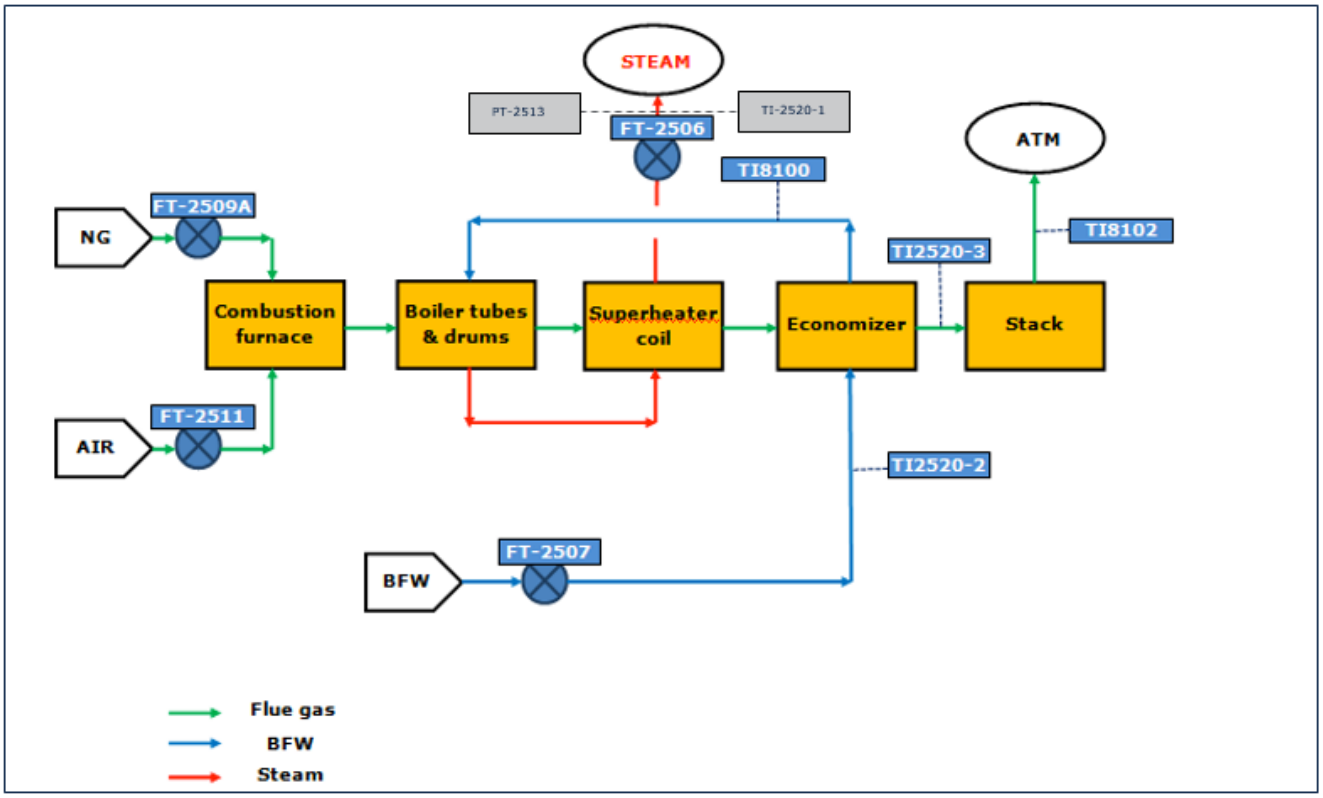

Table C.1 Sample DCS Log Sheet

Log Items	STEAM SUPPLY			STEAM DRUM		BFW			CBD		FUEL GAS (NG)			
	Temp.	SH Stm Press.	Flow	Level (N)	Level (S)	Flow	Temp.	Econ. Out T.	Cond.	PH	Header Press.	Flow	Burner Press.	Flow Meter
	TI-2520-1	PI-2513	FIC-2506	LIC-2508	LI-2516	FIC-2507	TI-2520-2	TI-8100	CI-2517	AI-2518	PIC-2219	FIC-2509	PIC-2510	FI-2509A
	°C	BAR	T/H	MM	MM	M^3/H	°C	°C	µS/cm	pH	BAR	NM^3/H	BAR	NM^3
C. R.	360-410	37-43	<129	-25 ~+100	-25 ~+100	<135	105-125	160-190	<500	9.0-11	2.5-3.5	<12000	0.1-0.9	-
00/MV														
02:00														
04:00														
06:00														
08/MV														
10:00														
12:00														
14:00														
16/MV														
18:00														
20:00														
22:00														

Log Items	(a)	COMBUSTION AIR							FLUE GAS					LOAD
	Fuel/Air Ratio	Flow	F.D.Fan Speed	2008-UJM	F.D.Fan Suc. T.	F.D.Fan Out Pres.	Windbox Pressure	Furnace Pressure	Furnace Draft Pr.	Econ. out Press	Outlet Temp.	Econ. out Temp	Excess O_2	MV Open
	HC-2511-1	FIC-2511	-	Selector mode	TI-2520-4	PI-2515-1	PI-2515-2	PI-2515-3	PI-2515-4	PI-8102	TI-2520-3	TI-8102	AI-2519	XMV 2505
	%	KNM^3/H	RPM	A .O .M	°C	mmH_2O	mmH_2O	mmH_2O	mmH_2O	mBar	°C	°C	%	%
C. R.	70-99	100-170	1600-1850	CP LP	4-55	230-330	220-330	80-150	-10 ~+10	-10 ~+10	320-400	144-205	1.0-3.5	<80
00/MV														
02:00														
04:00														
06:00														
08/MV														
10:00														
12:00														
14:00														
16/MV														
18:00														
20:00														
22:00														

REMARKS:

SIGNATURE BY:	1ST SHIFT	2ND SHIFT	3RD SHIFT
DCS BRD. OPERATOR:			
SHIFT SUPERVISOR:			

BQMS-UTL-LOG-12/06 V12 MAY 1, 2013

Table C.2

Boiler 2008 U				Boiler 2008 U A			
	Tag #	Calibration / Testing Frequency	Procedure#		Tag #	Calibration / Testing Frequency	Procedure#
1	Natural Gas			**1**	Natural Gas		
	FT 2509 A	3 Yearly	IMP-017		FT 2609 A	3 Yearly	IMP-017
2	Steam			**2**	Steam		
	FT 2506	3 Yearly	IMP-017		FT 2606	3 Yearly	IMP-017
3	Steam Temperature			**3**	Steam Temperature		
	TI 2520-1	Yearly	IMP-103		TI 2620-1	Yearly	IMP-103
4	Pressure of steam			4	Pressure of steam		
	PT - 2513	Yearly	IMP-019		PT-2613	Yearly	IMP-019

Note: Instrument, Maint. Procedure -SHEM 03.02

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/parameter:	CAP
Unit	Tons/Hour (steam)
Description	Maximum long-term load (capacity) of the boiler or steam system (tonnes of steam output per hour at full load)
Source of data	Hourly Measurement Data
Value(s) applied)	100-120Tons/Hour for each of the two boilers
Choice of data or measurement methods and procedures	Boiler load classes have been selected based on review of third independent assessments of boiler performance, name plate capacity and historical data. All measurements shall comply with ASME PTC 4-1998
Purpose of data	Baseline emissions
Additional comments	All Measurements are in compliance to ASME PTC 4-1998

Data/parameter:	Boiler load class, i and j
Unit	Range Tons/Hour
Description	Boiler load classes in case of multi-boiler installations. For each boiler 'j' load classes 'i' are introduced.
Source of data	Hourly Measurement Data
Value(s) applied	See Appendix 1
Choice of data or measurement methods and procedures	The proposed methodology requires the project developer to choose at least two boiler load classes per boiler freely.

Purpose of data	Baseline emissions
Additional comments	NA

Data/parameter:	System Load Class “K”
Unit	(Tons/Hour) Tons/Annum
Description	System Load Classes
Source of data	Hourly Measurement Data
Value(s) applied)	See Appendix 2
Choice of data or measurement methods and procedures	Facility operates 24 hours continuously over the calendar year. Hence hourly measurements and annual totals are available
Purpose of data	Baseline emissions
Additional comments	NA

Data/parameter:	FC_{BLi}
Unit	M3/h
Description	Fuel Consumption in each load class (Data available hourly/annually)
Source of data	Hourly Measurement Data
Value(s) applied)	See Appendix 3
Choice of data or measurement methods and procedures	Information from steam system operator based on measurements following strictly international or national acknowledged norms and guidelines.
Purpose of data	Calculation of baseline emissions
Additional comments	NA

Data/parameter:	PB_{Li}
Unit	Tons/Hour (Tons/Annum)
Description	Average Hourly Steam Production in each load class
Source of data	Hourly Measurement Data
Value(s) applied)	See Appendix 3
Choice of data or measurement methods and procedures	Information from steam system operator based on measurements following strictly international or national acknowledged norms and guidelines
Purpose of data	Calculation of baseline emissions
Additional comments	NA

Data/parameter:	$NCV_{FF,BL}$
Unit	GJ/m3
Description	Net Calorific Value of Fossil Fuel Used (Natural Gas)
Source of data	Hourly Measurement Data
Value(s) applied)	See Appendix 3
Choice of data or measurement methods and procedures	Information from steam system operator based on measurements following strictly international or national acknowledged norms and guidelines.
Purpose of data	Calculation of baseline emissions
Additional comments	NA

Data/parameter:	$EF_{C,FF,BL}$

Unit	tC/GJ
Description	Carbon Emission Factor for fuel used in the boiler system
Source of data	IPCC default value; table 1.4 of Chapter 1 of Vol 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value(s) applied)	0.056tCO2e/GJ
Choice of data or measurement methods and procedures	Regional/local emission factors are not available; hence IPCC factors have been used.
Purpose of data	Calculation of baseline emissions
Additional comments	NA

Data/parameter:	OXIDFF,BL
Unit	Fraction
Description	Oxidation factor for the fossil fuel used in the baseline boiler
Source of data	IPCC/ Industry Practice
Value(s) applied)	1
Choice of data or measurement methods and	Regional/local emission factors are not available
Purpose of data	Calculation of baseline emissions
Additional comments	NA

Data/parameter:	$PRESS_{BL,MIN}$
Unit	Bar
Description	Lowest measured pressure of the generated steam during determination of the specific energy consumption
Source of data	Measurement. Use test result for calculations
Value(s) applied)	3.1
Choice of data or measurement methods and	Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998.
Purpose of data	Calculation of baseline emissions
Additional comments	NA

Data/parameter:	$PRESS_{BL,MAX}$
Unit	Bar
Description	Highest measured pressure of the generated steam during determination of the specific energy consumption.
Source of data	Measurement. Use test result for calculations
Value(s) applied)	38.3
Choice of data or measurement methods and	Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998 .
Purpose of data	Calculation of baseline emissions
Additional comments	NA

Data/parameter:	$TEMP_{BLMIN}$
Unit	K
Description	Lowest measured temperature of the generated steam during determination of the specific energy consumption
Source of data	Measurement. Use test result for calculations.

Value(s) applied)	571.1
Choice of data or measurement methods and	Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998
Purpose of data	Calculation of baseline emissions
Additional comments	NA

Data/parameter:	$TEMP_{BLMAX}$
Unit	K
Description	Highest measured temperature of the generated steam during determination of the specific energy consumption
Source of data	Measurement. Use test result for calculations
Value(s) applied)	671.9
Choice of data or measurement methods and	Measurement strictly following international acknowledged norms and guidelines such as ASME PTC 4-1998.
Purpose of data	Calculation of baseline emissions
Additional comments	Highest measured temperature of generated steam

Data/parameter:	GWP_{CH4}
Unit	-
Description	Global Warming Potential of Methane (CH4)
Source of data	IPCC
Value(s) applied)	25
Choice of data or measurement methods and	Default Value
Purpose of data	Calculation of leakage emissions
Additional comments	Valid from 1 Jan 2013 onwards

D.2. Data and parameters monitored

All key details of monitoring equipment (tag number, make, type, model, accuracy, initial test date, methodology, calibration date, next calibration date, accuracy of meters etc.) are specified for individual boilers in Appendix 4 Monitoring Equipment.

Data/parameter:	$P_{PJ,i,y}$ (Individual Boilers)
Unit	(Tons/Hour) Tons/Annum
Description	Generated steam in the monitoring period subdivided into load classes in the case of single boiler installations
Measured/calculated/default	There is no single boiler installation therefore not applicable.
Source of data	There is no single boiler installation therefore not applicable.
Value(s) of monitored parameter	There is no single boiler installation therefore not applicable.
Monitoring equipment	There is no single boiler installation therefore not applicable.
Measuring/reading/recording frequency:	There is no single boiler installation therefore not applicable.
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Not applicable

Purpose of data:	Not applicable
Additional comments:	Not applicable

Data/parameter:	$P_{PJ,k,y}$ (System)
Unit	t/yr
Description	Generated steam in the monitoring period (01/10/2017 to 30/09/2019) subdivided into load classes in the case of Multi boiler
Measured/calculated/default	Measured
Source of data	Monitoring Data measured and archived at the facility. Measurement of the mass flow rate of generated steam following international acknowledged norms and guidelines (ASME PTC 4-1998).
Value(s) of monitored parameter	Refer to ER sheet for multiple reading inline to monitoring frequency.
Monitoring equipment	D/P Transmitter (see appendix 4)
Measuring/reading/recording frequency:	Every 15 minutes, allocated and aggregated into load classes. Online PIMS Server Data Stamping (Sec/Min/Hours).
Calculation method (if applicable):	NA
QA/QC procedures:	Please see Note 1 below.
Purpose of data:	Calculation of project emissions
Additional comments:	NA

Data/parameter:	$EF_{PJ,upstream,CH4}$
Unit	t CH4/GJ Fuel
Description	Emission factor for upstream fugitive methane emissions of fossil fuel used in the project activity from production, transportation, distribution, and, in the case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or distribution system, in t CH4 per GJ fuel supplied to final consumers.
Measured/calculated/default	not applicable as this parameter is not included into the project activity
Source of data	not applicable as this parameter is not included into the project activity
Value(s) of monitored parameter	not applicable as this parameter is not included into the project activity
Monitoring equipment	not applicable as this parameter is not included into the project activity
Measuring/reading/recording frequency:	not applicable as this parameter is not included into the project activity
Calculation method (if applicable):	not applicable as this parameter is not included into the project activity
QA/QC procedures:	not applicable as this parameter is not included into the project activity
Purpose of data:	not applicable as this parameter is not included into the project activity
Additional comments:	not applicable as this parameter is not included into the project activity

Data/parameter:	$EF_{BL,upstream,CH4}$
Unit	t CH4/GJ Fuel
Description	Emission factor for upstream fugitive methane emissions of fossil fuel used in the project activity from production, transportation, distribution, and, in the case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or distribution system, in t CH4 per GJ fuel supplied to final consumers.
Measured/calculated/default	not applicable as this parameter is not included into the project activity

Source of data	not applicable as this parameter is not included into the project activity
Value(s) of monitored parameter	not applicable as this parameter is not included into the project activity
Monitoring equipment	not applicable as this parameter is not included into the project activity
Measuring/reading/recording frequency:	not applicable as this parameter is not included into the project activity
Calculation method (if applicable):	not applicable as this parameter is not included into the project activity
QA/QC procedures:	not applicable as this parameter is not included into the project activity
Purpose of data:	not applicable as this parameter is not included into the project activity
Additional comments:	not applicable as this parameter is not included into the project activity

Data/parameter:	EFCO2,upstream,CH4
Unit	t CH4/GJ Fuel
Description	Emission factor for upstream fugitive methane emissions of fossil fuel used in the project activity from production, transportation, distribution, and, in the case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or distribution system, in t CH4 per GJ fuel supplied to final consumers.
Measured/calculated/default	not applicable as this parameter is not included into the project activity
Source of data	not applicable as this parameter is not included into the project activity
Value(s) of monitored parameter	not applicable as this parameter is not included into the project activity
Monitoring equipment	not applicable as this parameter is not included into the project activity
Measuring/reading/recording frequency:	not applicable as this parameter is not included into the project activity
Calculation method (if applicable):	not applicable as this parameter is not included into the project activity
QA/QC procedures:	not applicable as this parameter is not included into the project activity
Purpose of data:	not applicable as this parameter is not included into the project activity
Additional comments:	not applicable as this parameter is not included into the project activity

Data/parameter:	PRESSPJ
Unit	Bar
Description	Pressure of the generated steam
Measured/calculated/default	Calculated (test results)
Source of data	Test results
Value(s) of monitored parameter	Refer to ER calculator for multiple reading inline to monitoring frequency
Monitoring equipment	D/P Transmitter (See Appendix 4)
Measuring/reading/recording frequency:	Every 15 minutes. Online PIMS Server Data Stamping (Sec/Min/Hours).
Calculation method (if applicable):	Measurement of the mass flow rate of generated steam following international acknowledged norm and guideline ASME PTC 4-1998.
QA/QC procedures:	Please see Note 1 below.
Purpose of data:	Calculation of project emissions
Additional comments:	NA

Data/parameter:	$TEMP_{PJ}$
Unit	K
Description	Temperature of the generated steam
Measured/calculated/default	Measured. Measurements follow international acknowledged norm and guideline ASME PTC 4-1998.
Source of data	Online PIMS Server Data
Value(s) of monitored parameter	Refer to ER calculator for multiple reading inline to monitoring frequency
Monitoring equipment	Thermocouple (See Appendix 4)
Measuring/reading/recording frequency:	Every 15 minutes. Online PIMS Server Data Stamping (Sec/Min/Hours).
Calculation method (if applicable):	NA
QA/QC procedures:	Please see Note 1 below.
Purpose of data:	Calculation of project emissions
Additional comments:	NA

Data/parameter:	$FC_{i,j,y}$
Unit	m3/yr
Description	Quantity of natural gas combusted in two years
Measured/calculated/default	Measured. Measurements follow international acknowledged norm and guideline ASME PTC 4-1998.
Source of data	Onsite measurements at the facility
Value(s) of monitored parameter	111759215.95
Monitoring equipment	Please refer to appendix 4 for details
Measuring/reading/recording frequency:	Continuously on hourly basis
Calculation method (if applicable):	NA
QA/QC procedures:	Please see Note 1 below. Metered fuel consumption is cross checked with supplier invoices. The consistency of metered fuel consumption quantities is cross-checked with monthly energy balance based on purchased quantities
Purpose of data:	Calculation of project emissions
Additional comments:	NA

Data/parameter:	$NCV_{i,y}$
Unit	GJ/m3
Description	Weighted Average Net Calorific Value of Fossil Fuel Used (Natural Gas)
Measured/calculated/default	Measured. Measurements follow international acknowledged norm and guideline ASME PTC 4-1998.
Source of data	Provided by natural gas supplier (ARAMCO – Saudi Arabian Oil Company) in invoices.
Value(s) of monitored parameter	0.039112904
Monitoring equipment	Provided by natural gas supplier (ARAMCO – Saudi Arabian Oil Company) in invoices.
Measuring/reading/recording frequency:	By supplier (ARAMCO – Saudi Arabian Oil Company) in monthly invoices for each monthly delivery based on weighted average values
Calculation method (if applicable):	NA

QA/QC procedures:	As per the requirement of "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" (version 02), the value (50.2 TJ/Gg) is within the uncertainty range of the IPCC default values (lower value 46.5 TJ/Gg and upper value 50.4 TJ/Gg) provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines.
Purpose of data:	Calculation of project emissions and leakage emissions
Additional comments:	NA

Data/parameter:	$EF_{CO2\ i,\ y}$
Unit	tCO2/GJ
Description	Weighted average CO2 emission factor of natural gas in year y
Measured/calculated/default	NA
Source of data	IPCC default value (table 1.4 of Chapter 1 of Vol 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories)
Value(s) of monitored parameter	0.056
Monitoring equipment	NA
Measuring/reading/recording frequency:	Annual monitoring of IPCC Guidelines on National GHG Inventories.
Calculation method (if applicable):	NA
QA/QC procedures:	NA
Purpose of data:	Calculation of project emissions
Additional comments:	NA

NOTE 1: Al Bayroni's monitoring programme is integral to the company's third party certified (i.e. by British Standards Institute-BSI) ISO 9001:2008 compliant Quality Management System (QMS). All monitoring programmes including associated calibration is within the scope of the QMS and subjected to several audits and reviews including Internal Audits, SABIC Corporate Audits and Third Party (BSI) audits. Further, Al Bayroni subscribes to SABIC corporate's Safety, Environment, Health & Security Management Systems (SHEMS) applicable to all Rotating equipment, Pressure Relief Devices, Instrument Devises, Tanks & Pressure vessels, Piping, Car seals and Blinds, Hoses, Critical Instruments & Devices by pass, and Cathodic protection program. As a result, any modifications/ changes, replacements and emergency response is governed by the SHEMS programme. Al Bayroni is also certified to the American Chemistry Council Technical Specification Responsible Care® RC 14001.

Al Bayroni Instrument testing/calibration compliance to ASME PTC 4 is outlined below:

Measurement	Applicable ASME code	Compliance
Pressure	PTC 19.2	1) The tests done by certified Technicians. 2) Test equipment are traceable to Accredited Standards. 3) The accuracy is up to 1% of span. 4) 5 point calibration carried out
Temperature	PTC 19.3	1) The tests done by certified Technicians. 2) Test equipment are traceable to Accredited Standards. 3) The accuracy is up to 1.2 degrees. 4) 5 point calibration carried out
Flow	PTC 19.5	1) The tests done by certified Technicians. 2) Test equipment are traceable to Accredited Standards. 3) The accuracy is up to 1% of span. 4) Temperature and Pressure compensation is done.

D.3. Implementation of sampling plan

>>

No sampling is required as 100% of data is monitored during the project scenario.

SECTION E. Calculation of emission reductions or net anthropogenic removals

E.1. Calculation of baseline emissions or baseline net removals

>>

Detailed calculation methodology for baseline emissions is fully described in Section B.6.3. of the PDD. Baseline emission for the system is calculated using the formula:

$$BE_y = 44/12 \times EF_{C,FF,BL} \times OXID_{FF,BL} \times SEC_{syst}$$

Where

$BE_{,y}$ Baseline emissions resulting from steam generation within the capacity of the baseline equipment in the monitoring period (tCO2/yr)

SEC_{syst} Specific energy consumption (GJ/t) of the multi boiler steam generation system

$EF_{C,FF,BL}$ Carbon emission factor of baseline fossil fuel (tC/GJ)

$OXID_{FF,BL}$ Oxidation factor of baseline fossil fuel

44/12 Ratio of the molecular weight of CO2 to the molecular weight of carbon

Given the steam generation capacity for two boilers has been determined to be 100-120 Tons/hour and considering that boiler operations are predominantly within this load range, the following has been considered in estimating annual baseline emissions.

Table E.1: Annual Baseline Emissions Calculation

Steam Generation & Energy Consumptions	
Boiler Load Classes considered for baseline emissions	100-120 (Individual Boilers)
Two Year Steam Generation within selected load class - 2008U	1,350,500.0
Two Year Steam Generation within selected load class - 2008-UA	1,213,331.00
Total Steam Generation within selected load class (2 boilers) (Tons)	2,563,831.00
Average Fuel Consumption (Nm3/Ton)	83.76
Two Year Fuel Consumption within representative load classes (Nm3)	212,997,131.73
Average Energy Consumption (GJ/Ton)	3.22
Baseline Two Year Energy Consumption (GJ) (SECsyst)	8,209,833.012
Carbon Emission Factor (Fossil Fuel) (tCO2e/GJ) (EFC.FF.BL)	0.056
Oxidation Factor (OXIDFF.BL)	1
Baseline Emission (Tons of CO2e)	540,184.30
Rounddown (Tons of CO2e)	540,184

E.2. Calculation of project emissions or actual net removals

>>

To estimate the project emissions, the 'Tool to calculate project or leakage CO2 emissions from fossil fuel combustion' (version 2) was used. The tool requires CO2 emissions to be calculated using equation as stated below:

$$PE_{FC,JY} = \sum FC_{I,J} \times COEF_{I,Y}$$

Where,

$PE_{FC,JY}$ = Are the CO2 emissions from fossil fuel combustion in process j during the year 'y' (tCO2/year)

$\sum FC_{I,J}$ = Is the quantity of fuel type 'i' combusted in process 'j' during the year y (Mass or Volume Unit/year)

$COEF_{I,Y}$ = Is the CO2 emission coefficient of fuel type 'i' in year 'y' (tCO2/mass or volume unit)

i = are the fuel types

Two options have been provided in the tool to calculate the CO2 emission coefficient (COEFi,y). Option 2 (equation below) (i.e. based on net calorific value and CO2 emission factor) has been used in estimating the emission coefficient.

COEFi,y = NCVi,y X EF CO2i,y

Where,
NCVi,y = Is the weighted average net calorific value of the fuel type i, in year y (GJ/Mass or Volume Unit)

EF CO2 i,y = Is the weighted average CO2 emission factor of fuel type i in year y (tCO2/GJ)

Project emissions have been estimated as presented in Table below.

Table E.2: Project Emissions Calculation

Representative System Load Classes considered	100-120 (Individual Boilers)
Baseline Fuel Consumption within representative load classes (Nm3)	241877728.71
Project Fuel Savings (%)	11.94%
Fuel Consumption in project scenario within representative load classes	212997131.73
Average Calorific Value of Fuel (GJ/m3)	0.038557028
Total Energy Consumption in project period (GJ)	8209833.012
Project Emissions (Tons)	244,788.74
Project Emissions (Tons) rounded up value	459902.03

E.3. Calculation of leakage emissions

>>
Emissions due to leakage have been calculated using equation 9 of AM0056 (v 1.0):

$$LE_{CH4,y} = \left(FC_{PJ,y} \cdot NCV_{PJ,y} \cdot EF_{PJ,upstream,CH4} - FC_{BL,y} \cdot EF_{BL,upstream,CH4}\right) \cdot GWP_{CH4}$$

Quantity of fossil fuel combusted in the project plant during the monitoring period (t or m³), monitored as described in the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" (FCpjy)	212997131.73

Average net calorific value of the fossil fuel combusted during the monitoring period (GJ/t or GJ/m³) monitored as described in the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" (NCVpjy)	0.038557028
Emission factor for upstream fugitive methane emissions of fossil fuel used in project activity from production, transportation, distribution, and, in case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or distribution system, (t CH4 per GJ fuel supplied to final consumers) tCH4/GJ, $EF_{PJ, UPSTREAM CH4}$)	0.000296
Fossil fuel that would have been combusted in the absence of the project activity during the monitoring period (GJ) ($FC_{BL,Y}$)	9646148.185
Global warming potential of methane valid for the relevant commitment period.	25
Leakage (Tons of CO2e)	-10,609

Note: There will be no change in the source of fuel supply or mode of delivery as a result of the project. Therefore, emission factor for upstream fugitive methane emissions remains same prior to and post project.

As per page 11, applied methodology, Where net leakage effects are negative ($LE_{CH4,y}$< 0), project participants should assume $LE_{CH4,y}$= 0.

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	540184.30	459902.03	10,609	0	0	69,674

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante for this monitoring period in the PDD (t CO_2e)
69,674	132,196

E.5.1. Explanation of calculation of "amount estimated ex ante for this monitoring period in the PDD"

Not Applicable

E.6. Remarks on increase in achieved emission reductions

Not Applicable

E.7. Remarks on scale of small-scale project activity

Not Applicable

Appendix 1

The Selected Boiler Load Classes

Boiler Load Class (Tons/hr)	2008-U Load Classes	2008-UA Load Classes
0-20	1	1
21-40	2	2
41-60	3	3
61-80	4	4
81-100	5	5
101-120	6	6
>120	7	7

Appendix 2

System Generation Load Class

System Load Class	System Load	2008U	2008UA
1	21-40	ON	OFF
		OFF	ON
		ON	ON
2	41-60	ON	OFF
		ON	ON
		OFF	ON
3	61-80	ON	OFF
		OFF	ON
4	81-100	ON	OFF
		OFF	ON
		ON	ON
5	101-120	ON	OFF
		OFF	ON
		ON	ON
6	121-140	ON	OFF
		OFF	ON
		ON	ON
7	141-160	ON	ON
8	161-180	ON	ON
9	181-200	ON	ON
10	201-220	ON	ON
11	221-240	ON	ON
12	241-260	ON	ON

Appendix 3

SFC Estimation Per Load Class

Boilers	Load Class	Range (MT/H)	PBL,i	FCBL,i	SFCi,j	Calorific Value
			Steam(Tons/hr)	Fuel (Nm3/Hour)	Nm3/Tsteam	GJ/Nm3
2008-U	1	0-20	4.30	393.39	91.45	0.0389657
	2	21-40	34.04	2371.39	69.67	0.0390647
	3	41-60	53.36	3833.64	71.85	0.0393133
	4	61-80	69.40	5350.69	77.10	0.0389221
	5	81-100	96.85	7493.70	77.37	0.0390940
	6	101-120	103.36	8018.05	77.57287	0.0391140
	7	>120	123.67	9702.58	78.45	0.0391629
2008-UA	1	0-20	1.82	81.66	44.98	0.0389365
	2	21-40	29.00	2509.00	86.52	0.0401098
	3	41-60	52.22	4295.98	82.26	0.0394048
	4	61-80	71.84	6001.02	83.54	0.0389862
	5	81-100	95.21	7970.83	83.72	0.0392231
	6	101-120	104.08	8699.17	83.58	0.0388783
	7	>120	123.74	10355.06	83.69	0.0391

Appendix 4

Monitoring Equipment

Boiler 2008-U

	Tag #	Make	Type	Model	Accuracy	Calibration date	Valid till	Calibration Frequency
1	**FC i,j,y -** Quantity of natural gas combusted							
	FT 2509 A	Emerson	Coriolis Mass Flow meter	1700R12AB FEZZZ	±1% of Full Scale	06/04/2015 31/03/2016 28/12/2017	05/04/2016 30/03/2017 27/12/2018	1 Years
2	**PPJ,k,y -** Generated steam in the monitoring period (01/10/2015 to 30/09/2017) subdivided into load classes in the case of multi boiler installations.							
	FT 2506	Rosemount	D/P Transmitter	3051	±1% of Full Scale	02/04/2013 24/02/2016 28/12/2017	01/04/2014, 23/02/2017 27/12/2018	1 Years
3	**$TEMP_{PJ}$ -** Temperature of the generated steam							
	TI 2520-1	Instrumatics Inc.	K-Type Thermocouple	NA	±1.2ºC	01/11/2015 26/10/2017	31/10/2016 26/10/2018	1 Year
4	**$PRESS_{PJ}$** - Pressure of the generated steam							
	PT - 2513	FOXBRO	D/P Transmitter	IG-PID-D22EIF-M21Z1	±1% of Full Scale	01/07/2014 30/06/2015 04/7/2017	30/06/2015 29/06/2016 04/7/2018	1 year

Boiler 2008-U A

	Tag #	Make	Type	Model	Accuracy	Calibration date	Valid till	Calibration/ Testing Frequency
1	**FC i,j,y -** Quantity of natural gas combusted							
	FT 2609 A	Emerson	Coriolis Mass Flow meter	1700R12ABFEZZZ	±1% of Full Scale	06/04/2015 31/03/2016 28/12/2017	05/04/2016 30/03/2017 27/12/2018	1 Years
2	**PPJ,k,y** - Generated steam in the monitoring period (01/10/2015 to 30/09/2017) subdivided into load classes in the case of multi boiler installations.							
	FT 2606	Rosemount	D/P Transmitter	3051	±1% of Full Scale	02/04/2013 25/02/2016 28/12/2017	01/04/2014 24/02/2017 27/12/2018	1 Years
3	**$TEMP_{PJ}$ -** Temperature of the generated steam							
	TI 2620-1	Instrumatics Inc.	K-Type Thermocouple	NA	±1.2ºC	21/10/2015 08/10/2017	20/10/2016 07/10/2018	1 Year
4	**$PRESS_{PJ}$ -** Pressure of the generated steam							
	PT-2613	Rosemont	D/P Transmitter	3501S1TG4A2A11AB4E5D1	±1%	09/07/2014 06/07/2015 13/07/2017	07/07/2015 05/07/2016 12/07/2018	1 year

Appendix 5

Shutdown periods:

Ammonia (2016)					
Type	S/D Start	Production start	Duration (days)	Production Loss (MT)	Reason
Planned	25-01-2016 00:00	01-02-2016 00:00	7	0	Planned TA as per OP1
Planned	01-02-2016 00:00	01-03-2016 00:00	29	0	Continuation of Planned TA.
Planned	01-03-2016 00:00	05-03-2016 00:00	4	0	Continuation of planned TA
Planned	05-03-2016 00:00	10-03-2016 21:00	5.875	6047	Extension of planned TA.
Unplanned	17-03-2016 17:30	08-03-2016 23:20	1.243	1480	Ammonia plant backend shutdown to attend refrigeration compression anti-surge control valve.
Unplanned	15-08-2016 07:34	18-08-2016 00:15	2.695	2687	Severe external power dip happened causing the BFW motor driven pump to trip and lead to ammonia plant emergency shutdown.
Unplanned	08-11-2016 04:20	10-11-2016 05:00	2.028	2323	1101-JB1T FD-Fan trip and lead to trip Reformer

Unplanned	09-12-2016 12:49	11-12-2016 01:30	1.528	1475	External power failure lead to plant shutdown
Urea (2016)					
Type	S/D Start	Production Start	Duration (Days)	Production loss (MT)	Reason
Planned	25-01-2016 00:00	01/02/2016 0:00	7	0	Planned TA as per OP1.
Planned	01-02-2016 00:00	01/03/2016 0:00	29	0	Continuation of planned TA.
Planned	01-03-2016 00:00	02-03-2016 00:00	1	0	Continuation of Planned TA
Planned	02-03-2016 00:00	04-03-2016 14:10	2.59	5059	Extension of Planned TA
Unplanned	15-08-2016 07:34	17-08-2016 06:27	1.953	3745	Urea Plant shutdown due to ammonia plant forced shutdown because of external power dip.
Unplanned	08-11-2016 04:20	09-11-2016 22:10	1.743	3038	Plant Shutdown due to the Non-availability of CO2 from Ammonia Plant
Unplanned	09-12-2016 12:49	10-12-2016 02:40	0.577	925	External power failure lead to plant shutdown
Unplanned	21-12-2016 00:00	21-12-2016 12:52	0.536	891	Shutdown due to cable short with ground for TSH3001 (CO2 Comp 1st stage Discharge)

2-EH					
Type	S/D Start	Production Start	Duration (Days)	Production loss (MT)	Reason
Planned	29-01-2016 00:00	01/02/2016 0:00	3	0	Planned TA as per OP1.
Planned	01-02-2016 00:00	25-02-2016 22:15	24.927	0	Continuation of planned TA.
Unplanned	02-10-2016 00:00	13/10/2016 11:49	1.492	5135	2-EH plant is shut down due to reformer tube outlet header failure.

DOP					
Type	S/D Start	Production Start	Duration (Days)	Production loss (MT)	Reason
Planned	29-01-2016 00:00	01/02/2016 0:00	3	0	Planned TA as per OP1.
Planned	01-02-	28-02-2016	27	0	Continuation of planned TA.

	2016 00:00	00:00			

2017					
AMMONIA					
Type	S/D Start	Production Start	Duration (Days)	Production loss (MT)	Reason
Planned	2-16-17 0:00	2-26-17 20:00	10.833	0	Planned shutdown as per OP1
Unplanned	7-26-17 8:58	7-29-17 3:00	2.751	2,578	Plant shutdown due to a trip of auxiliary boiler and low draft in reformer box.

DOP					
Type	S/D Start	Production Start	Duration (Days)	Production loss (MT)	Reason
Planned	2-16-17 0:00	2-25-17 14:30	9.604	0	Planned shutdown as per OP1

UREA					
Type	S/D Start	Production Start	Duration (Days)	Production loss (MT)	Reason
Planned	2-16-17 0:00	2-26-17 5:05	10.212	0	Planned shutdown as per OP1
Unplanned	04-05-2017 21:18	14-05-2017 14:03	9.70	16,529	Urea production stopped due to carbamate leak in pump discharge line. Two hours later, a small fire in service condenser pump occurred. Plant Proceed in S/D Activities to replace defected control cables and instrumentations.
Unplanned	26-07-2017 08:58	29-07-2017 16:59	3.33	5,784	Plant shutdown due to the non-availability of CO2 from Ammonia plant.
Unplanned	30-09-2017 14:35	01-10-2017 00:00	0.392	619	Urea plant was blocked-in due to power interruption caused by Transformer TR #1 trip due to popping up of its pressure relief device.
Unplanned	01-10-2017 00:00	01-10-2017 19:09	0.798	1,302	Continuation of September SD
Unplanned	14-11-2017 00:00	15-11-2017 15:20	1.639	2,995	Urea plant SD due to 301-L (Ammonia Ejector) malfunction.

2-EH					
Type	S/D Start	Production Start	Duration (Days)	Production loss (MT)	Reason
Planned	2-16-17 0:00	2-26-17 6:25	10.27	0	Planned shutdown as per OP1

Unplanned	07-05-2017 00:51	07-05-2017 18:55	0.75	327.5	2-EH Plant Back end was shutdown due to lack of N2 supply
Unplanned	30-09-2017 14:35	01-10-2017 00:00	0.39	174	2-EH plant Area-2 and Area-3 were shut down due to power interruption caused by Transformer TR #1 trip due to popping up of its pressure relief device.
Unplanned	01-10-2017 00:00	01-10-2017 10:30	0.44	180	Continuation of September SD

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Document information

Version	*Date*	*Description*
07.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Add a section on remarks on the observance of the scale limit of small-scale project activity during the crediting period; • Add "changes specific to afforestation or reforestation project activity" as a possible post-registration changes; • Clarify the reporting of net anthropogenic GHG removals for A/R project activities between two commitment periods; • Make editorial improvements.
06.0	7 June 2017	Revision to: • Ensure consistency with version 01.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Make editorial improvements.
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).

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