Monitoring report form for CDM project activity

(Version 08.0)

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

MONITORING REPORT			
Title of the project activity	Sapphire 49.5 MW Wind Farm Project		
UNFCCC reference number of the project activity	8163		
Version number of the PDD applicable to this monitoring report	1.5		
Version number of this monitoring report	1		
Completion date of this monitoring report	26/08/2021		
Monitoring period number	1		
Duration of this monitoring period	22/11/2015-31/12/2017		
Monitoring report number for this monitoring period	NA		
Project participants	Sapphire Wind Power Co. Ltd. UPM Umwelt-Projekt-Management GmbH		
Host Party	Islamic Republic of Pakistan		
Applied methodologies and standardized baselines	ACM0002 - Consolidated baseline methodology for grid-connected electricity generation from renewable sources (Version 12.3.0) Standardized baselines are not applicable.		
Sectoral scopes	Sectoral Scope: 1 Energy Industries (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 until 31 December 2020	Amount achieved from 1 January 2021
	0 tCO_2e	193,376 tCO_2e	0 tCO_2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	165,175 tCO_2e		

SECTION A. Description of project activity

A.1. General description of project activity

>>

The purpose of Sapphire 49.5MW Wind Farm Project (hereinafter the "project activity" or the "project" or the "wind farm") is to utilize wind resources for electricity generation through the construction of a wind farm with a total capacity of 52.8 MW and to deliver the electricity generated from the project to the *Water and Power Development Authority* (WAPDA) grid. By replacing the electricity supplied by the WAPDA grid, which is heavily dominated by fossil fuel fired power plants, with electricity generated from wind power the proposed project activity will achieve obvious greenhouse gas (GHG) emission reductions by avoiding CO_2 emissions.

The project owner is Sapphire Wind Power Co. Ltd. The project activity involves the installation and operation of 33 wind turbines with unit capacity of 1,600kW, which will supply an average annual generation of 137,500 MWh to the WAPDA grid. The total installed capacity is 52.8 MW.

The start date of the project is 27/08/2011. The project was in full commercial operation on 22/11/2015. Since then, the operation of the project has been continued in accordance with the project design as well as the description in the registered PDD. The CDM registration date was 14/11/2012. The start date of crediting period has been changed to be 22/11/2015 (formerly 01/01/2014)[1]. Therefore, the crediting period is 22/11/2015 – 21/11/2025 (Fixed). See following key events of the project as below Table.

Date	Key event	Document
14/11/2012	CDM Registered at UNFCCC CDM EB	UNFCCC CDM EB Webpage[2]
28/08/2014	Construction started	Letter of Notice to proceed
29/09/2014	Implementation of the changes was decided	Turbine provider Letter of Capacity Enhancement to the project owner
24/04/2015	Issuance of Generation License by NEPRA for the capacity increase from 49.5MW (33*1.5MW) to 52.8MW (33*1.6MW)	Revised Generation License
22/11/2015	Commercial Operation Date	Certificate of Commissioning of Complex of Sapphire wind project
10/04/2017	Post-Registration change (PRC) Approval by CDM EB regarding the PRC on power capacity increase and change on the start date of crediting period.	UNFCCC CDM EB Webpage[3]

The total emission reductions achieved in this monitoring period are 193,376 tCO_2e.

A.2. Location of project activity

>>

The project is located in Pakistan, Sindh Province, northeast of Jhimpir City, within a narrow corridor, spanned by the following coordinates:

	Longitude	Latitude
1.	67º51'48.33" E	25º07'18.40" N
2.	67º51'48.03" E	25º07'10.59" N

[1] https://cdm.unfccc.int/PRCContainer/DB/prcp771647029/view

[2] http://cdm.unfccc.int/Projects/DB/BVQI1352703902.61/view

[3] https://cdm.unfccc.int/PRCContainer/DB/prcp771647029/view

3.	67º54'40.46" E	25º06'20.95" N
4.	67º56'01.05" E	25º05'35.46" N
5.	67º57'53.13" E	25º05'03.55" N
6.	67º58'08.95" E	25º05'28.90" N

The maps below illustrate the project location.

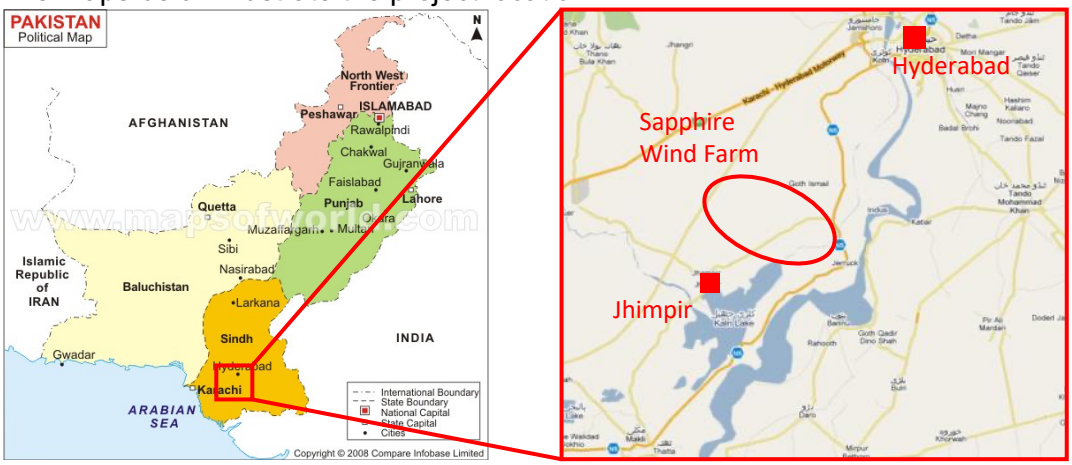


Figure 1: Map of the project location

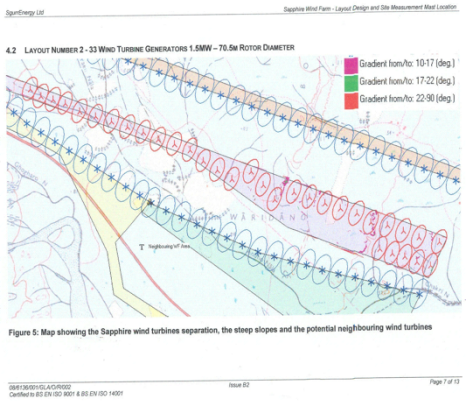


Figure 2: Map of the project location

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Islamic Republic of Pakistan (host)	Sapphire Wind Power Co. Ltd	No
Germany	UPM Umwelt-Projekt-Management GmbH	No

A.4. References to applied methodologies and standardized baselines

>>

Title of the baseline methodology:

ACM0002 - Consolidated baseline methodology for grid-connected electricity generation from renewable sources (Version 12.3.0)

Furthermore, the following tools have been applied:

Tool for the demonstration and assessment of additionality, Version 6.0.0 (EB 65 Annex 21)

Tool to calculate the emission factor for an electricity system Version 2.2.1, (EB 63 Annex 19)

The above could be found at the link:

https://cdm.unfccc.int/methodologies/DB/VJI9AX539D9MLOPXN2AY9UR1N4IYGD

A.5. Crediting period type and duration

>>
22/11/2015 – 21/11/2025 (Fixed)

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

>>

During the project implementation, 33 units of GE 1.6xle 50Hz wind turbine generators (WTG) are installed. The project has a total installed capacity of 52.8 MW and generates an annual estimated amount of electricity of 137,500 MWh at a plant load factor of 29.7%.

The GE 1.6xle 50 Hz WTG uses a power converter system that consists of a converter on the rotor side, a DC intermediate circuit, and a power inverter on the grid side. Altogether this complete system functions as a pulse-width-modulated converter in 4-quadrant operation. The converter consists of an insulated gate bipolar transistor (IGBT) power module and the associated electrical equipment. Variable output frequency of the converter allows a rotational speed-module operation of the generator within the range of 1000 rpm to 2000 rpm.

The WTGs are 3-bladed, upwind, horizontal-axis WTGs and are equipped with a SCADA (Supervisory Control and Data Acquisition) system for monitoring.

The technical parameters of WTGs are shown in the following Table:

Parameter	Value
Rated power	1.6MW
Diameter of Rotor	82.5m
Number of blades	3
Swept area	5,346m^2
Rotor speed range	9 to 18 rpm
Rotational direction	Clockwise looking downwind
Maximum tip speed	77.2m/s
Orientation	Upwind
Speed regulation	Pitch control
Manufacturer	GE
Lifetime	20 years

The start date of the project started on 27/08/2011. The project was in full commercial operation on 22/11/2015. Since then, the operation of the project has been continued in accordance with the project design as well as the description in the registered PDD.

The normal implementation of the project has been maintained and no events or situations which may impact the applicability of the methodology has been observed during this monitoring period.

The technical and monitoring diagram is as follows:

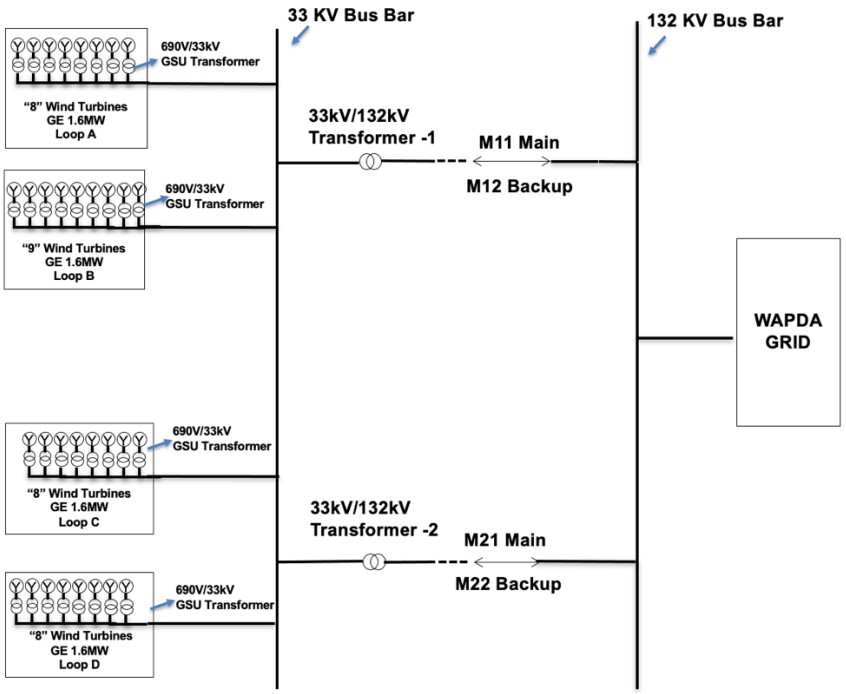


Figure 3: technical and monitoring diagram of the project

B.2. Post-registration changes

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

>>
No temporary deviations from registered monitoring plan or applied methodology have been applied during this monitoring period.

B.2.2. Corrections

>>
No corrections to project information or parameters fixed at validation have been approved during this monitoring period or submitted with this monitoring report.

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

>>
The start date of crediting period has been changed to be 22/11/2015 (formerly 01/01/2014), see the link: https://cdm.unfccc.int/PRCContainer/DB/prcp771647029/view

Such post-registration change (PRC-8163-001) has been approved by CDM EB on 10/04/2017.

B.2.4. Inclusion of monitoring plan

>>
N/A

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

>>
N/A

B.2.6. Changes to project design

>>

The install power capacity has been increased from 49.5MW (33*1.5MW) to 52.8MW (33*1.6MW), Such post-registration change (PRC-8163-001) has been approved by CDM EB on 10/04/2017, see the link: https://cdm.unfccc.int/PRCContainer/DB/prcp771647029/view

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

>>

N/A. The project is not an afforestation or reforestation project.

SECTION C. Description of monitoring system

>>

The monitoring system is designed in accordance with the requirements of methodology ACM0002, Consolidated baseline methodology for grid-connected electricity generation from renewable sources (Version 12.3.0).

1. Monitoring objects

The main monitoring objects are the net electricity supplied to the grid $EG_{facility,y}$ (i.e. electricity delivered to the grid $EG_{export,y}$ and the electricity imported from the grid $EG_{import,y}$) and the grid emission factor. To calculate the grid emission factor, the following parameters are monitored:

- Amount of fossil fuel type i consumed in the project electricity system in year y ($FC_{i,y}$);
- Net calorific value (energy content) of fossil fuel type i in year y ($NCV_{i,y}$);
- CO2 emission factor of fossil fuel type i used in power unit m in year y ($EF_{CO2,i,y}$);
- Net electricity generated by the project electricity system in year y (EG_y);
- Average net energy conversion efficiency of power unit m in year y ($\eta_{m,y}$)

2. Management structure

A CDM departm.ent set up by the project owner has appointed personnel to carry out the monitoring plan. The personnel structure is as follows:

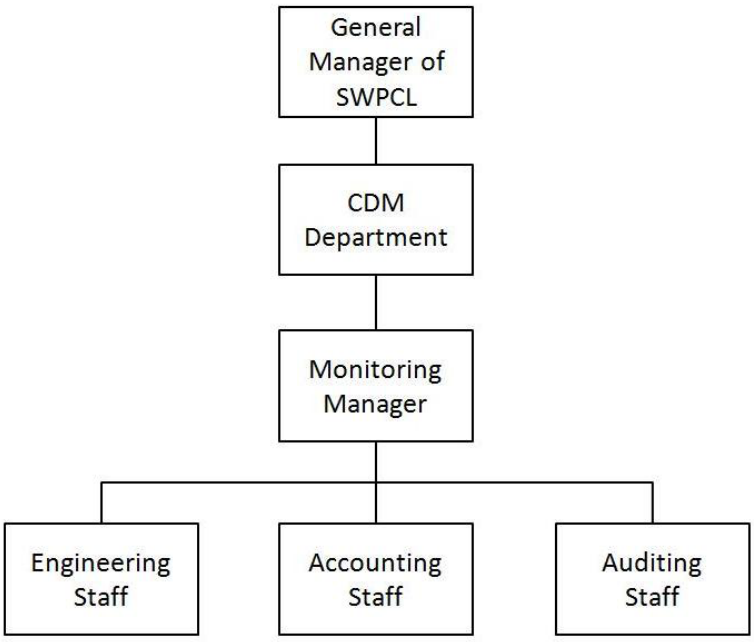


Figure 4: Monitoring organigram

A monitoring manager will be appointed to supervise the implementation of the monitoring plan, while further staff, including engineering staff, accounting staff and (internal) auditing staff, will be appointed to carry out the monitoring plan.

- The engineering staff is responsible for data collection (such as meter readings), daily maintenance of equipment (if required) and the emission reduction calculation.
- The accounting staff is responsible for the process of power transactions with the power grid company and power sale receipts keeping.
- The auditing staff is responsible for reviewing the data and receipt collected, ensuring the veracity and transparency of them.

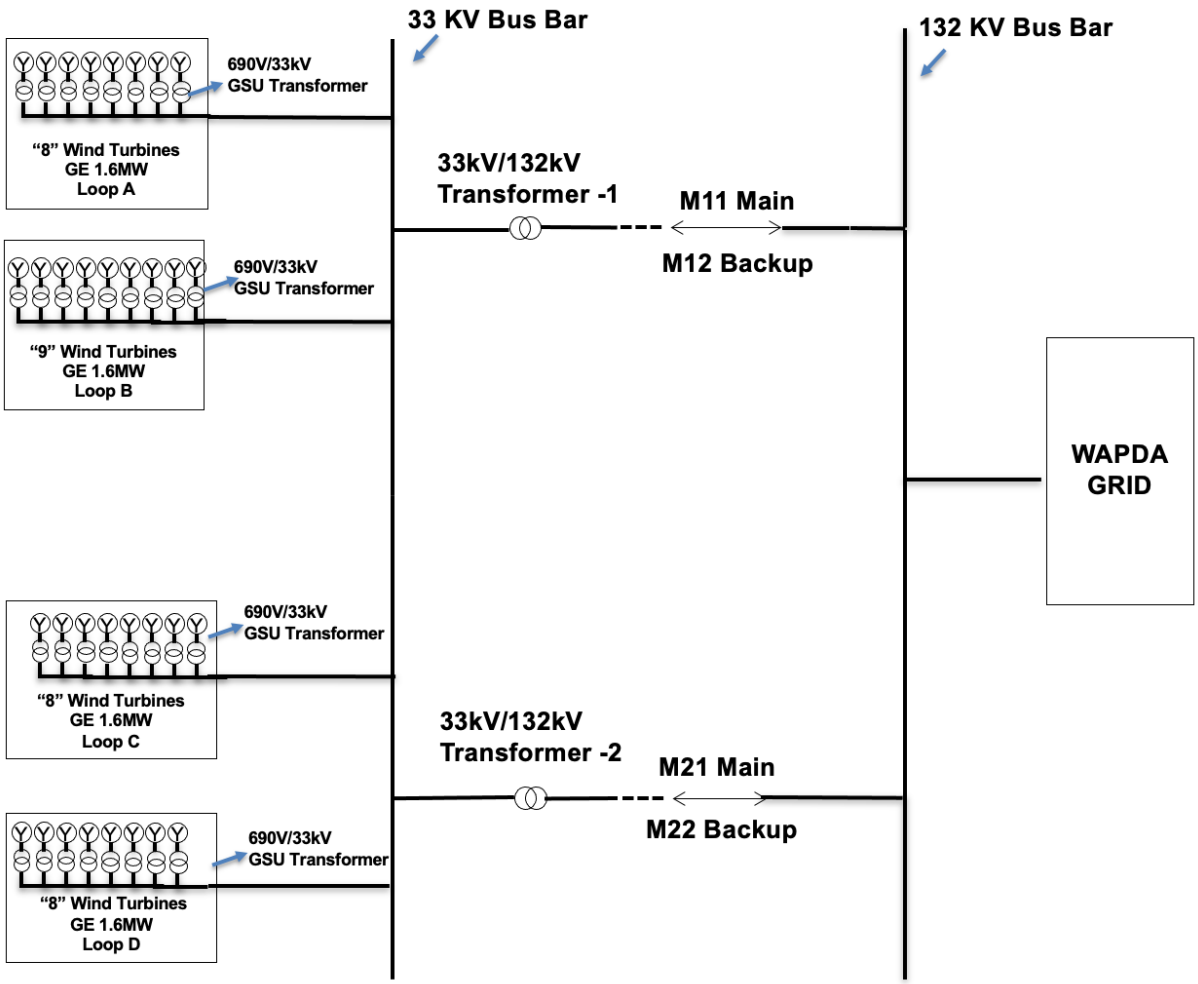
3. Monitoring equipment and installation

Four electricity meters are adopted in the monitoring system of the project. The meters have been installed at the interconnection point to the grid for monitoring the electricity delivered to the grid.

Two bidirectional electricity meters with the accuracy of 0.2s (M11 and M21) are installed as the main meters at the output side of the 132 kV substation to monitor the electricity exported to the grid ($EG_{export,y}$) and imported from the grid ($EG_{import,y}$) by the project activity. Another two bidirectional electricity meters of the same accuracy of 0.2s (M12 as backup meter for M11; M22 as backup meter for M21) are also installed as the backup meters of the main meters of M11 and M21 at the 132 kV substation.

The emission reductions are calculated based on records of the main meters, and can be cross-checked with electricity sales & purchase receipts.

The monitoring system is illustrated as follows:



Net electricity generation supplied by the project to the grid during the year y ($EG_{facility,y}$) equals to the difference between electricity exported to the grid ($EG_{export,y}$) and electricity imported from the grid ($EG_{import,y}$) by the project in year y.

Testing and calibration of all the energy meters M11, M12, M21 and M22 have been carried out by the grid as per the specification the energy purchase agreement (EPA), which is signed between the grid company and SWPCL. The meters have been sealed after calibration. Neither the project owner nor the power grid company could unseal or change the meters without the presence of the other party.

Relevant monitoring parameters with the grid emission factor calculation are sourced from latest Pakistan Energy Yearbooks, Ministry of Petroleum & Natural Resources and the grid emission factor is calculated based on "Tool to calculate the emission factor for an electricity system" Version 2.2.1.

4. Data recording, collection and reporting

The monitoring staffs are responsible for the measurement of electricity by reading the meters on-site according to the Energy Purchase Agreement (EPA). Every month, the monitored data has been archived electronically, at the same time the paper document has been archived. The project owner keeps the receipts of power sales/purchase. The monitoring plan has been carried out mainly by the CDM department and conducted by the appointed personnel. All key documents have been kept collectively.

The grid emission factor is calculated annually based on "Tool to calculate the emission factor for an electricity system" Version 2.2.1 and latest data from Pakistan Energy Yearbooks and Ministry of Petroleum & Natural Resources.

The monitored data will be kept during the whole crediting period and 2 years after the end of the crediting period or until the last issuance of CERs, whichever occurs later.

5. Emergency procedures for monitoring system

Electricity measured by the main meter alone should suffice for the purpose of billing and emissions reduction verification as long as the error in the main meter is within the permissible limits. However, should either the project owner or the grid company find the function of the main meter abnormal or broken-down, the other party and the authorized meter inspection institution need to be informed immediately to address the issues and make the meter function normally again as soon as possible. In addition, should any previous monthly readings of the main meter be inaccurate by more than the allowable error, or be functioned improperly, the electricity generated by the project shall be determined by:

a) First, by reading the backup main meter, unless a test by either party reveals it is inaccurate;
b) If the backup also meter fails to function normally, the project owner and the grid company shall jointly estimate the correct reading in a conservative manner;
c) If the project owner and the grid company fail to mutually estimate of the correct reading, the readings will be taken as zero, it is conservative.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Not applicable.

D.2. Data and parameters monitored

Data/Parameter	$EG_{facility,y}$
Unit	MWh

Description	Quantity of net electricity generation supplied by the project plant/unit to the grid in year y
Measured/calculated/ default	Measured and Calculated
Source of data	Continuous measurement, directly measured by the main meter or the backup meter installed at the output side of the 132 kV substation The following parameters are measured: (i) The quantity of electricity supplied by the project plant/unit to the grid ($EG_{export,y}$); and (ii) The quantity of electricity delivered to the project plant/unit from the grid ($EG_{import,y}$) Difference between $EG_{export,y}$ and $EG_{import,y}$ is taken as $EG_{facility,y}$

Value(s) of monitored parameter

Month	Value (MWh)
22/11/2015-30/11/2015	5,515.47
01/12/2015-31/12/2015	8,025.43
01/01/2016-31/01/2016	6,606.33
01/02/2016-28/02/2016	8,132.64
01/03/2016-31/03/2016	10,131.88
01/04/2016-30/04/2016	12,158.58
01/05/2016-31/05/2016	23,715.53
01/06/2016-30/06/2016	21,219.23
01/07/2016-31/07/2016	25,352.38
01/08/2016-31/08/2016	15,413.45
01/09/2016-30/09/2016	18,300.36
01/10/2016-31/10/2016	5,508.90
01/11/2016-30/11/2016	4,626.36
01/12/2016-31/12/2016	5,032.72
01/01/2017-31/01/2017	10,579.42
01/02/2017-28/02/2017	7,239.98
01/03/2017-31/03/2017	7,622.42
01/04/2017-30/04/2017	13,920.73
01/05/2017-31/05/2017	16,334.51
01/06/2017-30/06/2017	18,684.70
01/07/2017-31/07/2017	15,409.29
01/08/2017-31/08/2017	12,910.51
01/09/2017-30/09/2017	8,817.45
01/10/2017-31/10/2017	4,505.54
01/11/2017-30/11/2017	5,428.08
01/12/2017-31/12/2017	15,289.65
Total	306,481

Where,
- The values of EGexport,y is as follows:

Meters	M11 (back up M12)	M21 (back up M22)	Total Wind Turbines
22/11/2015-30/11/2015	2,818.32	2,703.03	5,521.35
01/12/2015-31/12/2015	3,775.74	4,330.74	8,106.48
01/01/2016-31/01/2016	3,379.05	3,293.80	6,672.85
01/02/2016-28/02/2016	169.62	8,025.84	8,195.46
01/03/2016-31/03/2016	0	10,171.13	10,171.13
01/04/2016-30/04/2016	4,829.56	7,349.10	12,178.66
01/05/2016-31/05/2016	12,097.51	11,623.10	23,720.61
01/06/2016-30/06/2016	10,924.24	10,319.25	21,243.49
01/07/2016-31/07/2016	12,986.39	12,366.38	25,352.77
01/08/2016-31/08/2016	7,834.28	7,607.64	15,441.92
01/09/2016-30/09/2016	9,313.37	8,988.69	18,302.06
01/10/2016-31/10/2016	2,984.75	2,561.04	5,545.79
01/11/2016-30/11/2016	2,469.12	2,246.53	4,715.65
01/12/2016-31/12/2016	2,661.70	2,490.08	5,151.78
01/01/2017-31/01/2017	5,337.99	5,306.31	10,644.30
01/02/2017-28/02/2017	3,768.30	3,524.44	7,292.74
01/03/2017-31/03/2017	3,996.03	3,684.69	7,680.72
01/04/2017-30/04/2017	7,173.57	6,765.89	13,939.46
01/05/2017-31/05/2017	8,342.01	7,998.65	16,340.66
01/06/2017-30/06/2017	9,581.98	9,110.92	18,692.90

	01/07/2017-31/07/2017	8,199.64	7,233.35	15,432.99
	01/08/2017-31/08/2017	6,598.19	6,324.49	12,922.68
	01/09/2017-30/09/2017	4,416.12	4,424.25	8,840.37
	01/10/2017-31/10/2017	2,350.50	2,226.24	4,576.74
	01/11/2017-30/11/2017	2,813.54	2,674.79	5,488.33
	01/12/2017-31/12/2017	7,888.13	7,433.44	15,321.57
	Total	146,709.65	160,783.81	307,493.46

Value(s) of monitored parameter

- The values of $EG_{import,y}$ is as follows:

Meters	M11 (back up M12)	M21 (back up M22)	Total Wind Turbines
22/11/2015-30/11/2015	3.20	2.68	5.88
01/12/2015-31/12/2015	43.62	37.43	81.05
01/01/2016-31/01/2016	36.95	29.57	66.52
01/02/2016-28/02/2016	8.97	53.85	62.82
01/03/2016-31/03/2016	0	39.25	39.25
01/04/2016-30/04/2016	9.76	10.32	20.08
01/05/2016-31/05/2016	2.95	2.13	5.08
01/06/2016-30/06/2016	14.06	10.20	24.26
01/07/2016-31/07/2016	0.26	0.13	0.39
01/08/2016-31/08/2016	16.49	11.98	28.47
01/09/2016-30/09/2016	1.00	0.70	1.70
01/10/2016-31/10/2016	17.89	19.00	36.89
01/11/2016-30/11/2016	50.07	39.22	89.29
01/12/2016-31/12/2016	65.75	53.31	119.06
01/01/2017-31/01/2017	35.86	29.02	64.88
01/02/2017-28/02/2017	29.70	23.06	52.76
01/03/2017-31/03/2017	33.41	24.89	58.30
01/04/2017-30/04/2017	11.72	7.01	18.73
01/05/2017-31/05/2017	3.68	2.47	6.15
01/06/2017-30/06/2017	5.15	3.05	8.20
01/07/2017-31/07/2017	14.47	9.23	23.70
01/08/2017-31/08/2017	7.41	4.76	12.17
01/09/2017-30/09/2017	14.12	8.80	22.92
01/10/2017-31/10/2017	42.04	29.16	71.20
01/11/2017-30/11/2017	32.69	27.56	60.25
01/12/2017-31/12/2017	15.61	16.31	31.92
Total	516.83	495.09	1,011.92

Monitoring equipment	Equipment: Meter M11 (Main meter) Type: ISKRA MT-860 Accuracy class: 0.2S Serial number: 41601054 Dates of last calibrations: 23/09/2015, 20/09/2017 Calibration frequency: 2 years Calibration Validity: 23/09/2015 – 22/09/2017, 20/09/2017-19/09/2019 Equipment: Meter M12 (Back up meter for M11) Type: ISKRA MT-860 Accuracy class: 0.2S Serial number: 41601051 Dates of last calibrations: 23/09/2015, 20/09/2017 Calibration frequency: 2 years Calibration Validity: 23/09/2015 – 22/09/2017, 20/09/2017-19/09/2019 Equipment: Meter M21 (Main meter) Type: ISKRA MT-860 Accuracy class: 0.2S Serial number: 41601050 Dates of last calibrations: 23/09/2015, 20/09/2017 Calibration frequency: 2 years Calibration Validity: 23/09/2015 – 22/09/2017, 20/09/2017-19/09/2019 Equipment: Meter M22 (Back up meter for M21) Type: ISKRA MT-860 Accuracy class: 0.2S Serial number: 41601049 Dates of last calibrations: 23/09/2015, 20/09/2017 Calibration frequency: 2 years Calibration Validity: 23/09/2015 – 22/09/2017, 20/09/2017-19/09/2019
Measuring/reading/recording frequency	Measured continuously and recorded monthly
Calculation method (if applicable)	$EG_{facility,y} = EG_{export,y} - EG_{import,y}$
QA/QC procedures	Monitoring equipments are tested and maintained in accordance with the relevant technical codes. The net on-grid electricity generation can be cross-checked by electricity sales & purchase receipts.
Purpose of data/parameter	Baseline emission calculation
Additional comments	None

Data / Parameter:	$EF_{grid,y}$
Unit:	tCO_2e/MWh
Description:	Grid Emission factor of WAPDA grid
Measured/ Calculated / Default:	Calculated

Source of data:	Calculated as per "Tool to calculate the emission factor for an electricity system" Version 2.2.1 and the latest data available from the Pakistan Energy Yearbook 2014, 2015 and 2016, Ministry of Petroleum & Natural Resources. As the monitoring period covers year 2015, 2016 and 2017, the grid emission factor is calculated separately.
Value(s) of monitored parameter:	Grid Emission Factor for year 2015: 0.6217; Grid Emission Factor for year 2016: 0.6445; Grid Emission Factor for year 2017: 0.6164;
Monitoring equipment:	NA
Measuring/ Reading/ Recording frequency:	Calculated annually as per "Tool to calculate the emission factor for an electricity system" Version 2.2.1 and the latest data available from the Pakistan Energy Yearbook 2014, 2015 and 2016, Ministry of Petroleum & Natural Resources
Calculation method (if applicable):	Calculated annually as per "Tool to calculate the emission factor for an electricity system" Version 2.2.1 and the latest data available from the Pakistan Energy Yearbook 2014, 2015 and 2016, Ministry of Petroleum & Natural Resources
QA/QC procedures:	Appropriateness of the data is reviewed and changes are applied annually by the Sapphire. It will be recalculated annually.
Purpose of data:	Baseline emission calculation
Additional comment:	The latest data available from the Pakistan Energy Yearbook 2015, 2016 and 2017 are used at the time of MR writing, the calculated $EF_{grid,CM,y}$ is the emission factor of the WPADA grid in year 2015, 2016 and 2017

Data / Parameter:	$FC_{i,y}$
Unit:	Mass unit
Description:	Amount of fossil fuel type *i* consumed in the project electricity system in year **y**
Measured/ Calculated / Default:	Default
Source of data:	Pakistan Energy Yearbook 2014, 2015 and 2016, Ministry of Petroleum & Natural Resources
Value(s) of monitored parameter:	Refer to ER sheet
Monitoring equipment:	NA
Measuring/ Reading/ Recording frequency:	NA
Calculation method (if applicable):	NA
QA/QC procedures:	NA
Purpose of data:	Baseline emission calculation
Additional comment:	None

Data / Parameter:	$NCV_{i,y}$
Unit:	GJ/Mass unit
Description:	Net calorific value (energy content) of fossil fuel type i in year y
Measured/ Calculated / Default:	Default

Source of data:	IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC
Value(s) of monitored parameter:	Refer to ER sheet
Monitoring equipment:	NA
Measuring/ Reading/ Recording frequency:	NA
Calculation method (if applicable):	NA
QA/QC procedures:	NA
Purpose of data:	Baseline emission calculation
Additional comment:	None

Data / Parameter:	$EF_{CO2,y}$
Unit:	tCO_2/GJ
Description:	CO_2 emission factor of fossil fuel type i used in power unit m in year y
Measured/ Calculated / Default:	Default
Source of data:	IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC
Value(s) of monitored parameter:	Refer to ER sheet
Monitoring equipment:	NA
Measuring/ Reading/ Recording frequency:	NA
Calculation method (if applicable):	NA
QA/QC procedures:	NA
Purpose of data:	Baseline emission calculation
Additional comment:	None

Data / Parameter:	EG_y
Unit:	MWh
Description:	Net electricity generated by the power unit of electricity system in year y
Measured/ Calculated / Default:	Default
Source of data:	Pakistan Energy Yearbook 2014, 2015 and 2016, Ministry of Petroleum & Natural Resources
Value(s) of monitored parameter:	Refer to ER sheet
Monitoring equipment:	NA

Measuring/ Reading/ Recording frequency:	NA
Calculation method (if applicable):	NA
QA/QC procedures:	NA
Purpose of data:	Baseline emission calculation
Additional comment:	None

Data / Parameter:	$\eta_{m,y}$
Unit:	-
Description:	Average net energy conversion efficiency of power unit m in year y
Measured/ Calculated / Default:	Default
Source of data:	The default values provided in the table in Annex 1 of the Tool to calculate the emission factor of an electricity system
Value(s) of monitored parameter:	Refer to ER sheet
Monitoring equipment:	NA
Measuring/ Reading/ Recording frequency:	NA
Calculation method (if applicable):	NA
QA/QC procedures:	NA
Purpose of data:	Baseline emission calculation
Additional comment:	None

D.3. Implementation of sampling plan

>>
N/A

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

>>

Baseline emissions (BE_y) are calculated as follows:

$$BE_y = EG_{facility,y} \times EF_{grid,y}$$
$$= EG_{facility,y} \times EF_{grid,CM,y}$$

Where:

BE_y	Baseline emission in year y (tCO_2e)
$EG_{facility,y}$	Quantity of net electricity generation supplied by the project plant/unit to the grid in year y (MWh)
$EF_{grid,CM,y}$	Combined margin CO_2 emission factor of the WAPDA grid in year y (tCO_2/MWh)
$EF_{grid,y}$	Grid Emission factor of WAPDA grid in year y (tCO_2/MWh), equals to $EF_{grid,CM,y}$

$EF_{grid,CM,y}$ = 0.6217 tCO_2/MWh for vintage 2015, 0.6445 tCO_2/MWh for vintage 2016 and 0.6164 tCO_2/MWh for vintage 2017. The calculation is as follows:

Calculation of the grid emission factor

To calculate the second factor of equation to calculate the baseline emissions, the *Tool to calculate the emission factor for an electricity system* has to be used. Following the tool, this factor is calculated as a combined margin (CM), consisting of the simple average of the operating margin emission factor (OM) and the build margin (BM) emission factor:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

With the input values:

$EF_{grid,CM,y}$	Combined margin grid emission factor in year *y* (tCO_2/MWh)
$EF_{grid,OM,y}$	Operation margin grid emission factor in year *y* (tCO_2/MWh)
$EF_{grid,BM,y}$	Build margin grid emission factor in year *y* (tCO_2/MWh)
w_{OM}	Weighting of operation margin factor (%)
w_{BM}	Weighting of build margin factor (%)

For the calculation of these input values, the *Tool to calculate the emission factor for an electricity system* describes six steps:

STEP 1. Identify the relevant electricity systems.
STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional).
STEP 3. Select a method to determine the operating margin (OM).
STEP 4. Calculate the operating margin emission factor according to the selected method.
STEP 5. Calculate the build margin (BM) emission factor.
STEP 6. Calculate the combined margin (CM) emissions factor.

Step 1: Identify the relevant electricity systems
The Pakistani DNA has not published any delineation of the project electricity system and a connected electricity system. Moreover, the criteria provided in the "Tool to calculate the emission factor for an electricity system" under Step 1 do not result in a clear grid boundary as

1) there is no official data for market prices for electricity over periods of time in Pakistan
2) there is no official data available with regard to the operation of the transmission line between different electricity systems.

In such cases, the "Tool to calculate the emission factor for an electricity system" suggests "to use a regional grid definition in the case of large countries with layered dispatch systems (e.g. provincial/regional/national)" to distinguish a connected electricity system. As a provincial grid definition may be too narrow, the national grid definition should be used by default, as per the tool.

Pakistan comprised two electricity grids, the Karachi Electricity Supply Company (KESC) grid, which supplies Karachi city and adjoining areas of Sindh and Balochistan, and the national electricity grid, managed by the *Water and Power Development Authority (WAPDA).* The national grid covers the whole of Pakistan, except the city of Karachi, which is supplied by the KESC grid.

The Pakistan Energy Yearbook, which is annually published by the Government of Pakistan, Ministry of Petroleum and Natural Resources, provides the official data for energy generation in Pakistan for

KESC and WAPDA. Further does it mention the IPPs (Independent Power Producers), which deliver their generated power either to WAPDA or KESC[4].

The project is connected to the national electricity grid (WAPDA). According to the *Tool to calculate the emission factor for an electricity system,* the project electricity system can be identified as the national grid by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity (e.g. the renewable power plant location or the consumers where electricity is being saved) and that can be dispatched without significant transmission constraints.

Although the two grids are interconnected for occasional supply from the national grid to the smaller KESC grid, electricity imports and exports are not foreseen during standard operation. According to the definitions in the above-mentioned tool, the KESC grid can be identified as connected electricity system.
Since none of the two grids is physically connected to foreign grids, electricity imports to the national grid can therefore be excluded.

Electricity exports are not subtracted from the electricity generation data, as advised in the *Tool to calculate the emission factor for an electricity system.*

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional)
According to Option I of step 2, off-grid power plants are not included in the calculation.

Step 3: Select a method to determine the operating margin (OM)
Four alternatives for the calculation of OM are given in the tool:

a) Simple OM; or
b) Simple adjusted OM; or
c) Dispatch data analysis OM; or
d) Average OM.

The simple OM method (option a) can only be used if low-cost/must-run resources[5] constitute less than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production.

As calculated with the data available from the Pakistan Energy Yearbooks published by the Government of Pakistan, Ministry of Petroleum & Natural Resources, the share of low-cost/must-run resources has constituted less than 50% of total grid generation in average of the five most recent years:

2009	35.76%
2010	35.98%
2011	41.46%

[4] On the website of the Private Power & Infrastructure Board, Government of Pakistan, Ministry of Water & Power (http://www.ppib.gov.pk/N_commissioned_ipps.htm) it is mentioned which IPPs deliver their generated power to which electricity system (WAPDA or KESC). Currently only two IPPs (Gul Ahmed, Karachi, and Tapal Energy, Karachi) deliver to KESC, while the other IPPs deliver to WAPDA. In 1998, as part of the government's privatization policy, the National Transmission & Despatch Company (NTDC) "was organized to take over all the properties, rights and assets obligations and liabilities of 220 KV and 500KV Grid Stations and Transmission Lines/Network Transmission Lines/Network owned by Pakistan Water and Power Development Authority (WAPDA) (See http://www.ntdc.com.pk). IPPs commissioned under the 2002 power policy are therefore mentioned as delivering their generated power to NTDC.

[5] Low-cost/must-run resources are defined as power plants with low marginal generation costs or power plants that are dispatched independently of the daily or seasonal load of the grid. They typically include hydro, geothermal, wind, low-cost biomass, nuclear and solar generation. If coal is obviously used as must-run, it should also be included in this list, i.e. excluded from the set of plants.

2012	39.23%
2013	39.82%
2014	39.51%
2015	39.83%
2016	39.43%

As this requirement is met according to the Energy Yearbooks of 2010 - 2017, the simple OM method (option a) is applicable.

For the calculation of $EF_{grid,OM,y}$, *ex post* calculation is chosen in the registered PDD. As per the tool,

> *Ex post option: If the ex post option is chosen, the emission factor is determined for the year in which the project activity displaces grid electricity, requiring the emissions factor to be updated annually during monitoring. If the data required to calculate the emission factor for year y is usually only available later than six months after the end of year y, alternatively the emission factor of the previous year y-1 may be used. If the data is usually only available 18 months after the end of year y, the emission factor of the year proceeding the previous year y-2 may be used. The same data vintage (y, y-1 or y-2) should be used throughout all crediting periods.*

For the project, the *ex post* option is chosen. This means, that each monitoring report would have to include the latest calculation of the operation margin emission factor. The factor for the year proceeding the previous year (*y-1*) will be used for the calculations.

Step 4: Calculate the operating margin emission factor according to the selected method
The simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the system, not including low-cost/must-run power plants/units.

Two ways of calculation are described in the tool[6]:

> *Option A: Based on the net electricity generation and a CO_2 emission factor of each power unit; or*
> *Option B: Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.*

Whereas Option B can only be applied if:

a) The necessary data for Option A is not available; and
b) Only nuclear and renewable power generation are considered as low-cost/must-run power sources and the quantity of electricity supplied to the grid by these sources is known; and
c) Off-grid power plants are not included in the calculation (i.e., if Option I has been chosen in Step 2).

The exact operation and emission factor data is not available for all connected power plants, only nuclear and hydro power have been considered as low-cost/must-run resources in Step 3 and Option I has been chosen in Step 2. Option B can therefore be chosen to calculate the OM emission factor using the total net electricity generation, emission and utilization data for each fuel type. The necessary data can be found in the present Pakistan Energy Yearbooks.

The calculation of the OM emission factor is based on the net electricity supplied to the grid by all power plants serving the system, not including the low-cost/must-run power plants. To carry out the calculation, the tool provides the following formula:

[6] Cited from *Tool to calculate the emission factor for an electricity system*, v.2.2.1

$$EF_{grid,OMsimple,y} = \frac{\sum_i \left(FC_{i,y} \cdot NCV_{i,y} \cdot EF_{CO_2,i,y}\right)}{EG_y}$$

Where:

$EF_{grid,OMsimple,y}$	Simple operating margin CO_2 emission factor in year y (tCO_2/MWh)
$FC_{i,y}$	Amount of fossil fuel type *i* consumed in the project electricity system in year *y* (mass or volume unit)
$NCV_{i,y}$	Net calorific value (energy content of fossil fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO_2,i,y}$	CO_2 emission factor of fossil fuel type i in year *y* (tCO_2/GJ)
EG_y	Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/most-run power plants/units, in year *y* (MWh)
i	All fossil fuel types combusted in power sources in the project electricity system in year y
y	The relevant year as per the data vintage chosen in Step 3.

As a result of this calculation[7], the simple operation margins for the year 2015, year 2016 and year 2017 are:

$$EF_{grid,OMsimple,2015} = 0.7422 \frac{tCO_2e}{MWh}$$

$$EF_{grid,OMsimple,2016} = 0.7262 \frac{tCO_2e}{MWh}$$

$$EF_{grid,OMsimple,2017} = 0.6964 \frac{tCO_2e}{MWh}$$

Step 5: Calculate the build margin (BM) emission factor

For the terms of data vintage, the tool offers two options[8]:

> ***Option 1:*** *For the first crediting period, calculate the build margin emission factor ex ante based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.*
>
> ***Option 2:*** *For the first crediting period, the build margin emission factor shall be updated annually, ex post, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emissions factor shall be calculated ex ante, as described in Option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.*

[7] All relevant input values and calculations have been provided to the DOE(s) during verification.

[8] Cited from *Tool to calculate the emission factor for an electricity system*, v.2.2.1.

For the proposed project, option 2 is chosen and the build margin is updated every year of the first crediting period. Therefore, the latest figures are calculated in each monitoring report.

Capacity additions from retrofits of power plants should not be included in the calculation of the build margin emission factor.

The sample group of power units *m* used to calculate the build margin should be determined as per the following procedure from the *Tool to calculate the emission factor for an electricity system*[9], consistent with the data vintage selected above:

a) Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently ($SET_{5\text{-}units}$) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-}units}$, in MWh);

(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEG_{SET\text{-}\geq 20\%}$, in MWh);

(c) From $SET_{5\text{-}units}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample}); Identify the date when the power units in SET_{sample} started to supply electricity to the grid. If none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} to calculate the build margin. In this case ignore steps (d), (e) and (f).

Otherwise:

(d) Exclude from SET_{sample} the power units which started to supply electricity to the grid more than 10 years ago. Include in that set the power units registered as CDM project activities, starting with power units that started to supply electricity to the grid most recently, until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) to the extent is possible. Determine for the resulting set ($SET_{sample\text{-}CDM}$) the annual electricity generation ($AEG_{SET\text{-}sample\text{-}CDM}$, in MWh);
If the annual electricity generation of that set is comprises at least 20% of the annual electricity generation of the project electricity system (i.e. $AEG_{SET\text{-}sample\text{-}CDM} \geq 0.2 \times AEG_{total}$), then use the sample group $SET_{sample\text{-}CDM}$ to calculate the build margin. Ignore steps (e) and (f).

Otherwise:

(*e) Include in the sample group $SET_{sample\text{-}CDM}$ the power units that started to supply electricity to the grid more than 10 years ago until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation);*

(f) The sample group of power units m used to calculate the build margin is the resulting set ($SETsample\text{-}CDM\text{-}>10yrs$).

Calculation of $EF_{grid,BM,2015}$

Step (a)

[9] Cited from *Tool to calculate the emission factor for an electricity system*, v.2.2.1

The five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and for which official data about their annual electricity generation is available, are:

$SET_{5\text{-units}}$:

No.	Power Unit	Commission Date	Electricity generation 2014 (MWh)[10]
1	UCH-II POWER	Year 2014	547,670.00
2	NEW JABBAN	Year 2014	38,450.00
3	GOMAL ZAM	Year 2014	6,290.00
4	Jinnah	Year 2013	297,090.00
5	AKHP	Year 2013	332,950.00

$AEG_{SET\text{-}5\text{-}units}$ = 1,222,450 MWh

Step (b)

According to Pakistan Energy Yearbook 2014, Ministry of Petroleum & Natural Resources, the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}) has been calculated as:

AEG_{total} = 92,938,220 MWh

The set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} and for which official data about their annual electricity generation is available, are:

$SET_{\geq 20\%}$:

No.	Power Unit	Commission Date	Electricity generation 2014 (MWh)[11]
1	UCH-II POWER	Year 2014	547,670.00
2	NEW JABBAN	Year 2014	38,450.00
3	GOMAL ZAM	Year 2014	6,290.00
4	Jinnah	Year 2013	297,090.00
5	AKHP	Year 2013	332,950.00
6	KKHP	Year 2012	261,340.00
7	Liberty Power Tech	13/01/2011	774,400.00
8	Halmore Power	16/06/2011	504,260.00
9	Foundation Power	16/05/2011	1,358,340.00
10	Hub Power, Narowal	22/04/2011	1,562,000
11	CHASNUPP-II	27/01/2011	2,386,000.00
12	SAPPHIRE ELECTRIC	04/10/2010	761,420.00
13	NISHAT CHUNIAN Power	21/07/2010	1,084,500.00
14	NISHAT POWER LTD	09/06/2010	1,503,490.00
15	ORIENT POWER LTD	24/05/2010	540,510.00
16	SAIF POWER LTD	27/04/2010	723,180.00
17	ENGRO ENERGY LTD	27/03/2010	1,440,930.00

[10] Pakistan Energy Yearbook 2014, Ministry of Petroleum & Natural Resources

[11] Pakistan Energy Yearbook 2014, Ministry of Petroleum & Natural Resources

18	ATLAS POWER LTD	18/12/2009	1,518,930.00
19	ATTOCK GEN	17/03/2009	1,242,940.00
20	GHAZI BAROTHA	01/07/2003	7,016,410.00

$AEG_{SET-\geq 20\%}$, = 23,901,100 MWh

Step (c)
$SET_{\geq 20\%}$ comprises the larger annual electricity generation and is therefore SET_{sample}.
SET_{sample}. Started to supply electricity on 01/07/2003 – more than 10 years ago – therefore it will be proceeded with step (d).

Step (d)
As no power units registered as CDM project activities could be included, after excluding power units which started to supply electricity to the grid more than 10 years ago, the resulting set $SET_{sample-CDM}$

$SET_{sample-CDM}$:

No.	Power Unit	Commission Date	Electricity generation 2014 (MWh)[12]
1	UCH-II POWER	Year 2014	547,670.00
2	NEW JABBAN	Year 2014	38,450.00
3	GOMAL ZAM	Year 2014	6,290.00
4	Jinnah	Year 2013	297,090.00
5	AKHP	Year 2013	332,950.00
6	KKHP	Year 2012	261,340.00
7	Liberty Power Tech	13/01/2011	774,400.00
8	Halmore Power	2011/6/16	504,260.00
9	Foundation Power	2011/5/16	1,358,340.00
10	Hub Power, Narowal	2011/4/22	1,562,000
11	CHASNUPP-II	2011/1/27	2,386,000.00
12	SAPPHIRE ELECTRIC	2010/10/4	761,420.00
13	NISHAT CHUNIAN Power	2010/7/21	1,084,500.00
14	NISHAT POWER LTD	2010/6/9	1,503,490.00
15	ORIENT POWER LTD	2010/5/24	540,510.00
16	SAIF POWER LTD	2010/4/27	723,180.00
17	ENGRO ENERGY LTD	2010/3/27	1,440,930.00
18	ATLAS POWER LTD	2009/12/18	1,518,930.00
19	ATTOCK GEN	2009/3/17	1,242,940.00

$AEG_{SET-sample-CDM}$ = 16,884,690 MWh

The annual electricity generation of $SET_{sample-CDM}$ does not comprise at least 20% of AEG_{total}. Therefore it will be proceeded with steps (e) and (f).

Step (e) & (f)
Step (e) and (f) result in following set:

$SET_{sample-CDM->10yrs}$:

[12] Pakistan Energy Yearbook 2014, Ministry of Petroleum & Natural Resources

No.	Power Unit	Commission Date	Electricity generation 2014 (MWh)[13]
1	UCH-II POWER	Year 2014	547,670.00
2	NEW JABBAN	Year 2014	38,450.00
3	GOMAL ZAM	Year 2014	6,290.00
4	Jinnah	Year 2013	297,090.00
5	AKHP	Year 2013	332,950.00
6	KKHP	Year 2012	261,340.00
7	Liberty Power Tech	13/01/2011	774,400.00
8	Halmore Power	16/06/2011	504,260.00
9	Foundation Power	16/05/2011	1,358,340.00
10	Hub Power, Narowal	22/04/2011	1,562,000
11	CHASNUPP-II	27/01/2011	2,386,000.00
12	SAPPHIRE ELECTRIC	04/10/2010	761,420.00
13	NISHAT CHUNIAN Power	21/07/2010	1,084,500.00
14	NISHAT POWER LTD	09/06/2010	1,503,490.00
15	ORIENT POWER LTD	24/05/2010	540,510.00
16	SAIF POWER LTD	27/04/2010	723,180.00
17	ENGRO ENERGY LTD	27/03/2010	1,440,930.00
18	ATLAS POWER LTD	18/12/2009	1,518,930.00
19	ATTOCK GEN	17/03/2009	1,242,940.00
20	GHAZI BAROTHA	01/07/2003	7,016,410.00

According to the *Tool to calculate the emission factor for an electricity system,* the build margin emissions factor is the generation-weighted average emission factor of all power units *m* during the most recent year *y*, for which electricity generation data is available. It can be calculated using the following formula:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \cdot EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year y (tCO_2/MWh).
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh).
$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh).
m	Power units included in the build margin.
y	Most recent historical year for which electricity generation data is available.

As a result of this calculation[14], the build margin for 2015 is:

$$EF_{grid,BM,2015} = 0.2604 \ \frac{tCO_2e}{MWh}$$

Calculation of $EF_{grid,BM,2016}$

Step (a)

[13] Pakistan Energy Yearbook 2014, Ministry of Petroleum & Natural Resources

[14] All relevant input values are provided to the DOE(s) during verification.

The five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and for which official data about their annual electricity generation is available, are:

$SET_{5\text{-units}}$:

No.	Power Unit	Commission Date	Electricity generation 2015 (MWh)[15]
1	DKHP	Year 2015	386,830.00
2	UCH-II POWER	Year 2014	2,415,000.00
3	NEW JABBAN	Year 2014	121,370.00
4	GOMAL ZAM	Year 2014	43,860.00
5	Jinnah	Year 2013	190,690.00

$AEG_{SET\text{-}5\text{-}units}$ = 3,157,750 MWh

Step (b)

According to Pakistan Energy Yearbook 2015, Ministry of Petroleum & Natural Resources, the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}) has been calculated as:

AEG_{total} = 94,658,470 MWh

The set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} and for which official data about their annual electricity generation is available, are:

$SET_{\geq 20\%}$:

No.	Power Unit	Commission Date	Electricity generation 2015 (MWh)[16]
1	DKHP	Year 2015	386,830.00
2	UCH-II POWER	Year 2014	2,415,000.00
3	NEW JABBAN	Year 2014	121,370.00
4	GOMAL ZAM	Year 2014	43,860.00
5	Jinnah	Year 2013	190,690.00
6	AKHP	Year 2013	461,780.00
7	KKHP	Year 2012	253,000.00
8	Liberty Power Tech	2011/1/13	1,515,000.00
9	Halmore Power	2011/6/16	723,570.00
10	Foundation Power	2011/5/16	1,322,610.00
11	Hub Power, Narowal	2011/4/22	1,418,160
12	CHASNUPP-II	2011/1/27	2,744,000.00
13	SAPPHIRE ELECTRIC	2010/10/4	966,540.00
14	NISHAT CHUNIAN Power	2010/7/21	1,415,000.00
15	NISHAT POWER LTD	2010/6/9	1,448,670.00
16	ORIENT POWER LTD	2010/5/24	1,037,300.00
17	SAIF POWER LTD	2010/4/27	770,000.00

[15] Pakistan Energy Yearbook 2015, Ministry of Petroleum & Natural Resources

[16] Pakistan Energy Yearbook 2015, Ministry of Petroleum & Natural Resources

18	ENGRO ENERGY LTD	2010/3/27	1,429,020.00
19	ATLAS POWER LTD	2009/12/18	1,461,690.00

$AEG_{SET-\geq 20\%}$, = 20,124,090 MWh

Step (c)

$SET_{\geq 20\%}$ comprises the larger annual electricity generation and is therefore SET_{sample}. And none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} is used to calculate the build margin.

According to the *Tool to calculate the emission factor for an electricity system,* the build margin emissions factor is the generation-weighted average emission factor of all power units *m* during the most recent year *y*, for which electricity generation data is available. It can be calculated using the following formula:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \cdot EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year y (tCO_2/MWh).
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh).
$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh).
m	Power units included in the build margin.
y	Most recent historical year for which electricity generation data is available.

As a result of this calculation[17], the build margin for 2016 is:

$$EF_{grid,BM,2016} = 0.39965 \ \frac{tCO_2e}{MWh}$$

Calculation of $EF_{grid,BM,2017}$

Step (a)

The five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and for which official data about their annual electricity generation is available, are:

$SET_{5\text{-units:}}$

No.	Power Unit	Commission Date	Electricity generation 2016 (MWh)[18]
1	CCPP Nandipur	Year 2016	371,820.00
2	DKHP	Year 2015	643,070.00
3	UCH-II POWER	Year 2014	2,326,570.00
4	NEW JABBAN	Year 2014	135,140.00
5	GOMAL ZAM	Year 2014	11,860.00

[17] All relevant input values are provided to the DOE(s) during verification.

[18] Pakistan Energy Yearbook 2016, Ministry of Petroleum & Natural Resources

$AEG_{SET\text{-}5\text{-}units}$ = 3,488,460 MWh

Step (b)

According to Pakistan Energy Yearbook 2016, Ministry of Petroleum & Natural Resources, the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}) has been calculated as:

AEG_{total} = 96,696,810 MWh

The set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} and for which official data about their annual electricity generation is available, are:

$SET_{\geq 20\%}$:

No.	Power Unit	Commission Date	Electricity generation 2016 (MWh)[19]
1	CCPP Nandipur	Year 2016	371,820.00
2	DKHP	Year 2015	643,070.00
3	UCH-II POWER	Year 2014	2,326,570.00
4	NEW JABBAN	Year 2014	135,140.00
5	GOMAL ZAM	Year 2014	11,860.00
6	Jinnah	Year 2013	296,320.00
7	AKHP	Year 2013	568,420.00
8	KKHP	Year 2012	37,640.00
9	Liberty Power Tech	2011/1/13	1,277,000.00
10	Halmore Power	2011/6/16	916,000.00
11	Foundation Power	2011/5/16	1,211,690.00
12	Hub Power, Narowal	2011/4/22	1,161,910
13	CHASNUPP-II	2011/1/27	2,560,000.00
14	SAPPHIRE ELECTRIC	2010/10/4	991,000.00
15	NISHAT CHUNIAN Power	2010/7/21	1,214,000.00
16	NISHAT POWER LTD	2010/6/9	1,307,290.00
17	ORIENT POWER LTD	2010/5/24	1,155,620.00
18	SAIF POWER LTD	2010/4/27	1,061,000.00
19	ENGRO ENERGY LTD	2010/3/27	1,222,150.00
20	ATLAS POWER LTD	2009/12/18	1,320,460.00

$AEG_{SET\text{-}\geq 20\%}$, = 19,788,960 MWh

Step (c)

$SET_{\geq 20\%}$ comprises the larger annual electricity generation and is therefore SET_{sample}. And none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} is used to calculate the build margin.

According to the *Tool to calculate the emission factor for an electricity system,* the build margin emissions factor is the generation-weighted average emission factor of all power units *m* during the most recent year *y*, for which electricity generation data is available. It can be calculated using the following formula:

[19] Pakistan Energy Yearbook 2016, Ministry of Petroleum & Natural Resources

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \cdot EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year y (tCO_2/MWh).
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh).
$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh).
m	Power units included in the build margin.
y	Most recent historical year for which electricity generation data is available.

As a result of this calculation[20], the build margin for 2017 is:

$$EF_{grid,BM,2017} = 0.3767 \frac{tCO_2e}{MWh}$$

As described above, the combined margin emission factor for an electricity system is calculated using the following formula:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \cdot w_{OM} + EF_{grid,BM,y} \cdot w_{BM}$$

The weighting factors w_{OM} and w_{BM} are defined by the *Tool to calculate the emission factor for an electricity system*[21]*:*

> *Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods;*
>
> *All other projects: w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period , and w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period, unless otherwise specified in the approved methodology which refers to this tool.*

Therefore, the combined emission factor for the national grid in Pakistan is:

$$EF_{grid,CM,2015} = 0.7422 \frac{tCO_2e}{MWh} \cdot 0.75 + 0.26044 \frac{tCO_2e}{MWh} \cdot 0.25 = 0.6217 \frac{tCO_2e}{MWh}$$

$$EF_{grid,CM,2016} = 0.7262 \frac{tCO_2e}{MWh} \cdot 0.75 + 0.39965 \frac{tCO_2e}{MWh} \cdot 0.25 = 0.6445 \frac{tCO_2e}{MWh}$$

$$EF_{grid,CM,2017} = 0.6964 \frac{tCO_2e}{MWh} \cdot 0.75 + 0.3767 \frac{tCO_2e}{MWh} \cdot 0.25 = 0.6164 \frac{tCO_2e}{MWh}$$

The $EG_{facility,y}$ during this monitoring period is as follows:

[20] All relevant input values are provided to the DOE(s) during verification.

[21] Cited from *Tool to calculate the emission factor for an electricity system*, v.2.2.1

Monitoring period	$EG_{facility,y}$ (MWh)
22/11/2015-30/11/2015	5,515.47
01/12/2015-31/12/2015	8,025.43
01/01/2016-31/01/2016	6,606.33
01/02/2016-28/02/2016	8,132.64
01/03/2016-31/03/2016	10,131.88
01/04/2016-30/04/2016	12,158.58
01/05/2016-31/05/2016	23,715.53
01/06/2016-30/06/2016	21,219.23
01/07/2016-31/07/2016	25,352.38
01/08/2016-31/08/2016	15,413.45
01/09/2016-30/09/2016	18,300.36
01/10/2016-31/10/2016	5,508.90
01/11/2016-30/11/2016	4,626.36
01/12/2016-31/12/2016	5,032.72
01/01/2017-31/01/2017	10,579.42
01/02/2017-28/02/2017	7,239.98
01/03/2017-31/03/2017	7,622.42
01/04/2017-30/04/2017	13,920.73
01/05/2017-31/05/2017	16,334.51
01/06/2017-30/06/2017	18,684.70
01/07/2017-31/07/2017	15,409.29
01/08/2017-31/08/2017	12,910.51
01/09/2017-30/09/2017	8,817.45
01/10/2017-31/10/2017	4,505.54
01/11/2017-30/11/2017	5,428.08
01/12/2017-31/12/2017	15,289.65
Subtotal for Year 2015	**13,540.90**
Subtotal for Year 2016	**156,198.36**
Subtotal for Year 2017	**136,742.28**
Total	306,481.54

During the monitoring period,

$BE_y = EG_{facility,y} \times EF_{grid,CM,y}$

= 13,540.90MWh × 0.6217 tCO_2/MWh + 156,198.36MWh × 0.6445 tCO_2/MWh + 136,742.28MWh × 0.6164 tCO_2/MWh

= 193,376 tCO_2e

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

>>

As per methodology ACM0002 (Version 12.3.0), for a wind power project, $PE_y = 0$.

E.3. Calculation of leakage emissions

>>

As per methodology ACM0002 (version 12.3.0), no leakage emissions are considered for a wind power project. The sources of main emissions potentially giving rise to leakage are neglected.

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 until 31/12/ 2020	From 01/01/ 2021	Total amount
Total	193,376	0	0	0	193,376	0	193,376

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)
193,376	165,175 (= 78,196tCO_2e/yr*771d/365d)

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

>>

The monitoring period is 22/11/2015-31/12/2017 (both days included), the duration is 771 days. The ex ante emission reduction of the project is 78,196tCO_2e/yr, the amount of emission reduction estimate ex ante for this monitoring period in the PDD is calculated as 165,175 tCO_2e (=78,196tCO_2e/yr*771d/365d).

E.6. Remarks on increase in achieved emission reductions

>>

The actual emission reductions achieved during the current monitoring period are 17.07% higher than stated in the registered PDD of the project. The main reason is that:

- The grid emission factor for vintage year 2015, 2016 and 2017, i.e. 0.6217tCO_2e/MWh, 0.6445tCO_2e/MWh and 0.6164tCO_2e/MWh, is 9.32%, 13.33% and 8.39% higher than the ex ante figure (0.5687 tCO_2e/MWh), respectively;
- Due to richer wind resources, the net electricity supplied to the grid during this current monitoring period is 306,481MWh, which is 5.52% higher than the value in the PDD (137,500MWh/yr*771d/365d = 290,445MWh).

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

>>

Not applicable as the project activity is a large scale project.

- - - - -

Document information

Version	*Date*	*Description*
08.0	6 April 2021	Revision to: • Reflect the “Clarification: Regulatory requirements under temporary measures for post-2020 cases” (CDM-EB109-A01-CLAR).
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.

Version	*Date*	*Description*
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).
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.

Decision Class: Regulatory
Document Type: Form
Business Function: Issuance
Keywords: monitoring report