PROJECT CONCEPT NOTE

CARBON OFFSET UNIT (CoU) PROJECT

Title: Installation of Low Green House Gases (GHG) emitting rolling stock cars in metro system

Version 1.0

Date: 20/09/2023

First CoU Issuance Period: Y years, Y months

Date: 01/01/2013 to 31/12/2022

Project Concept Note (PCN)
CARBON OFFSET UNIT (CoU) PROJECT

BASIC INFORMATION	
Title of the project activity	Installation of Low Green House Gases (GHG) emitting rolling stock cars in metro system
Scale of the project activity	Small Scale
Completion date of the PCN	20/09/2023
Project participants	Delhi Metro Rail Corporation (DMRC)
Host Party	India
Applied methodologies and standardized baselines	AMS III.C. "Emission reductions by low greenhouse gas emitting vehicles" Version: 10
Sectoral scopes	07 Transport
Estimated amount of total GHG emission reductions	328,634 CoUs (328,634 tCO_2eq) per annum

SECTION A. Description of project activity

A.1. Purpose and general description of Carbon offset Unit (CoU) project activity >> :

Purpose of the project activity:

The project activity operates low GHG emitting rolling stocks having regenerative braking system in Delhi Metro Rail Corporation (DMRC). The project activity replaces the conventional electrodynamic rheostatic braking technology, with regenerative braking technology fitted rolling stocks. The regenerated electrical energy reduces the consumption of equivalent grid electrical energy required by the powering trains, thereby conserving electrical energy and subsequently leading to GHG emission reduction.

Delhi Metro Rail Corporation (DMRC) has electrical driven Mass Rapid Transport System which uses 4 car / 6 car / 8 car rolling stocks on different service lines. A typical rolling stock used by DMRC consists of two units, each comprising of four / six / eight cars, having a combination of Driving Trailer car (DT), Trailer Car (T) and a Motor Car (M). The Delhi Metro System is designed for rolling stock where coaches are equipped with 3 phase AC traction motors with regenerative braking system. The regenerative braking technology employed in DMRC is different from the prevalent system adopted by metro system in the country which uses conventional electro-dynamic rheostatic braking system. The electro-dynamic rheostatic braking system converts the kinetic energy of decelerating Rolling stock into the thermal energy of rheostats which is dissipated as heat without regenerating electrical energy while decelerating. Hence, the choice made by DMRC for using regenerative braking technology displays the environmental consciousness of the management. The technology for regenerative braking system in the rolling stock is provided by Mitsubishi Electric Corporation, Japan without any technology transfer. The regenerative braking system works on the principle of converting kinetic energy of the rolling stock while decelerating, into electrical energy using 3 phase Induction motor and Variable Voltage Variable Frequency Control (VVVF) Technology. In the regenerative mode, the traction motors work as generators and the Converter- Inverter (CI) converts the electrical energy regenerated to Direct Current (DC). The DC is subsequently converted to single-phase line frequency AC voltage, which is stepped up by transformer to the level of 25 kV. The single-phase line frequency AC voltage is then fed back to the Over Head Equipment (OHE). The regenerated electrical energy supplied back to the OHE is used by other accelerating Rolling stock in the same service line. The regenerated electrical energy reduces the consumption of equivalent amount of grid electrical energy which would otherwise have been consumed by the accelerating trains, thereby conserving electrical energy and reducing GHG emissions.

DMRC intends to include all its Rolling Stocks (except 70 Rolling Stocks as verification and issuance of CERs of 70 Rolling Stocks under UNFCCC/GS has been already completed – PC 1351 & GS 4597) for the period 01st January, 2013 – 28th December, 2017 and all 328 Rolling Stocks (including 70 Rolling Stocks mentioned above) for the remaining period of the crediting period.

Technical data of the project activity

Sr. No	Year wise Details of Trains	Car Configuration			Total No. of Cars	No. of Cars[1] (Cumulative)	Total No. of Trains	No. of Trains[2] (Cumulative)	Cumulative CARs Considered for UCR
		4	6	8					
1.	2013	0	82	70	152	1,198	0	208	918[3]
2.	2014	0	32	4	36	1,234	0	208	954
3.	2015	0	76	0	76	1,310	7	215	1,030
4.	2016	20	66	8	94	1,404	12	227	1,124
5.	2017	0	84	172	256	1,660	22	249	1,380
6.	2018	0	396	78	474	2,134	75	324	2,134[4]
7.	2019	0	24	0	24	2,158	4	328	2,158
8.	2020	0	0	20	20	2,178	0	328	2,178
9.	2021	0	0	20	20	2,198	0	328	2,198
10.	2022	0	0	8	8	2,206	0	328	2,206

[1] As on 31/12/2012, the total no. of cars is 1,046.
[2] As on 31/12/2012, the total no. of trains is 208.
[3] The 70 Rolling Stocks having 4 cars each i.e., a total of 280 Cars considered for the CDM/GS Project activity and verified for the period 01/01/2013 to 28/12/2017 are excluded.
[4] The 70 Rolling Stocks having 4 cars each i.e., a total of 280 Cars considered for the CDM/GS Project activity and verified for the period 01/01/2013 to 28/12/2017 are included in the project as the remaining lifetime of the rolling stocks is available for the rest of crediting period.

A.2 Do no harm or Impact test of the project activity>>

There are social, environmental, economic and technological benefits which contribute to sustainable development.

Social benefits:

- The safe and efficient mode of transportation features of Delhi Metro ensures the social wellbeing of the region.
- Delhi Metro reduces the travel time of the passengers significantly and also, indirectly helps in eliminating traffic congestion on the roads as a result of mode shift by passengers.
- Delhi Metro reduces the exposure of commuters to various gaseous and particulate matter pollutants by road transportation, other than directly reducing the pollution level in the city through efficient utilization of energy (electricity of fossil fuel) as means of power source, instead of burning fossil fuels in the city.
- Delhi Metro also reduces the number of accidents per passengers transported.

Environmental benefits:

- The project replaces the partial grid electricity therefore the equivalent emissions which could have generated are avoided.
- The project undoubtedly contributes to environmental improvement, as it reduces the pollution levels in the city by using electricity instead of fossil fuels in case of Metro.
- The efficient mode of transport means the reduction in consumption of energy resources and hence, conserving the precious natural resources.

Economic benefits:

- Implementation of metro as whole improves the economic development of the city by facilitating modern and efficient mode of transportation to the city, which reduces the loss of travel time in the current modes of transportation and reducing traffic congestion on the roads. The subsequent impacts of the above benefits lead to the overall economic development of the city and enhancing the positive image of the city with modern infrastructure in place.

- The project will contribute to further economic development, as all the metro facilitate opportunity for the businesses by construction of shopping complexes to serve the passengers and nearby locality. Hence, the project ensures the economic wellbeing of the country.

A.3. Location of project activity >>

Country: India
Region: Delhi-NCR covering areas of Delhi, Uttar Pradesh (Noida and Ghaziabad) & Haryana (Gurugram, Faridabad and Bahadurgarh).
Longitude[5]: 77°06′32″E
Latitude: 28°39′38″N

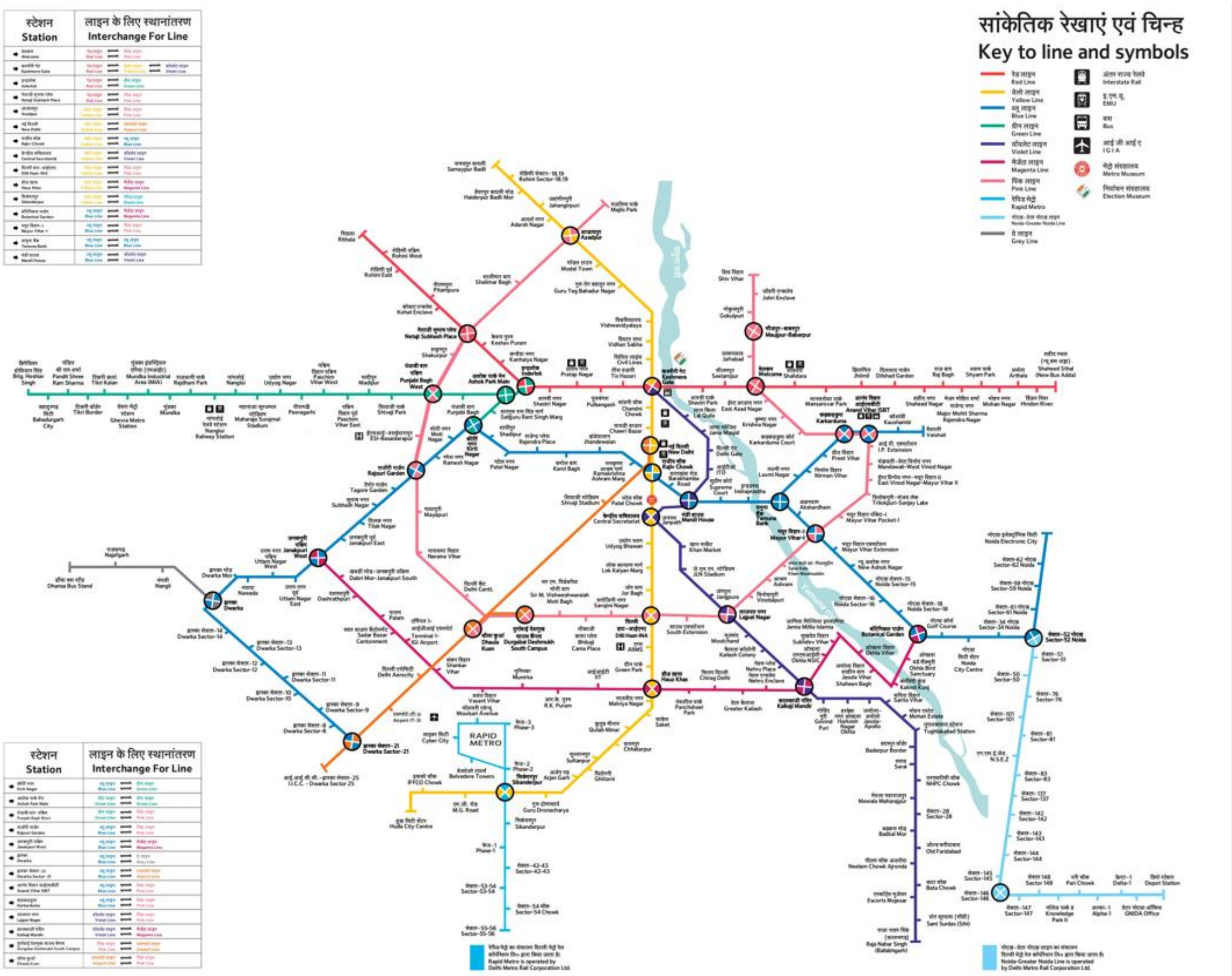
The project activity has been implemented in Delhi-NCR on the following nine metro lines

1. Line 1: Red Line – Rithala to Shaheed Sthal (New Bus Adda)
2. Line-2: Yellow Line – Samaypur Badli to Huda City Centre
3. Line-3: Blue Line – Dwarka Sec 21 to Noida Electronic City

[5] https://en.wikipedia.org/wiki/National_Capital_Region_(India)

4. Line-4: Blue Line – Yamuna Bank to Vaishali
5. Line-5: Green Line – Kirti Nagar / Inderlok to Brig. Hoshiar Singh (Bahadurgarh)
6. Line-6: Violet Line – Kashmere Gate to Raja Nahar Singh (Ballabhgarh)
7. Line-7: Pink Line – Majlis Park to Shiv Vihar
8. Line-8: Magenta Line – Janakpuri West to Botanical Garden
9. Line-9: Grey Line – Dwarka to Dhansa Bus Stand

The map of these metro lines is as follows:



A.4. Technologies/measures >>

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The technology for regenerative braking system in the rolling stock is provided by Mitsubishi Electric Corporation, Japan without any technology transfer. The regenerative braking system works on the principle of converting kinetic energy of the rolling stock while decelerating, into electrical energy using 3 phase Induction motor and Variable Voltage Variable Frequency Control (VVVF) Technology. In the regenerative mode, the traction motors work as generators and the Converter- Inverter (CI) converts the electrical energy regenerated to Direct Current (DC). The DC is subsequently converted to single-phase line frequency AC voltage, which is stepped up by transformer to the level of 25 kV. The single-phase line frequency AC voltage is then fed back to the Over Head Equipment (OHE). The regenerated electrical energy supplied back to the OHE is used by other accelerating Rolling stock in the same service line. The regenerated electrical energy reduces the consumption of equivalent amount of grid electrical energy which would otherwise have been consumed by the accelerating trains, thereby conserving electrical energy and reducing GHG emissions.

A.5. Parties and project participants >>

Party (Host)	Participants
India	Delhi Metro Rail Corporation (DMRC)

A.6. Baseline Emissions>>

The baseline scenario identified at the PCN stage of the project activity is:

The baseline is the energy use per unit of service for the vehicle that would otherwise have been used times the average annual units of service per vehicle times the number of vehicles affected times the emission coefficient for the fuel used by vehicle that would otherwise have been used. If electricity is used by the vehicles, the associated emissions shall be estimated in accordance with paragraphs of category I.D".

In the absence of the regenerative braking system the equivalent electricity produced by the rolling stocks would have been imported from the grid. Therefore, the grid electricity emissions are considered as baseline.

Thus, in the baseline scenario for the project activity, rolling stocks without regenerative braking system would have been used and total electricity consumption of rolling stocks would have been met from regional/national grid.

A.7. Debundling>>

This project is not a debundled component of a larger project activity.

SECTION B. Application of methodologies and standardized baselines

B.1. References to methodologies and standardized baselines >>

SECTORAL SCOPE – 07 Transport
TYPE – III Other Projects

CATEGORY – AMS III.C. "Emission reduction by low greenhouse gas emitting vehicles" Version: 10

A deviation was sought by the project owner to UCR to apply the version 10 of methodology, this is to be noted that the partial components (rolling stocks) of project activity were part of CDM project Ref. No. 1351, the crediting period is expired and the project along with other components is applying the UCR registration. The deviation was granted therefore the version 10 of methodology has been applied.

B.2. Applicability of methodologies and standardized baselines >>

AMS-III.C. ver. 10 - Emission reductions by low-greenhouse gas emitting vehicles

"Comprises low-greenhouse gas emitting vehicles". The project boundary covers the low-greenhouse gas emitting rolling stock in all the service lines that are part of the project activity.
"Measures are limited to those that result in emission reductions of less than or equal to 60 kt CO_2 equivalent annually". The emission reductions from the project activity are in total greater than 60 kt CO_2 equivalent annually. But the size of each unit of project comply the requirement of micro scale unit as laid down in 'Glossary CDM Terms' in terms of energy saving for the type II project activities (the project activity falls under energy efficiency and shall be categorized in type II) and energy saving in per rolling stock is less than 20 GWh/annum, therefore over all ERs can breach the threshold of 60 kt CO_2 equivalent annually.

B.3. Applicability of double counting emission reductions >>

There is no double accounting of emission reductions in the project activity due to the following reasons:

- Project is uniquely identifiable based on its location coordinates,
- Project has a dedicated connection point,
- Project is associated with rolling stocks which are dedicated to the consumption point for the project developer.

B.4. Project boundary, sources and greenhouse gases (GHGs)>>

The project boundary includes the physical, geographical site(s) of nine operational lines covered by the project activity.

As per the guidelines mentioned in Type III.C of Appendix-B of the simplified modalities and procedures for small-scale CDM project activities, the project boundary includes low-greenhouse gas emitting vehicles that are a part of the project activity.

The rolling stocks in all operational nine lines are taken into consideration of project boundary. The project boundary therefore, consists of all trains running within the nine operational lines of Delhi Metro. Each of the rolling stock has a unique identification number.

	Source	GHG	Included?	Justification/Explanation
Baseline	Emissions from use fossil fuels from baseline electricity from grid	CO_2	Included	Major source of GHG emission
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
Project Activity	Emissions from on-site electricity use	CO_2	Included	Major source of GHG emission
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative

B.5. Establishment and description of baseline scenario (Methodology) >>

Baseline emission calculations:

The baseline is the use of electro dynamic rheostatic braking system with no electrical energy regeneration in the rolling stock. Thus, in the baseline scenario, the total electrical energy consumed by rolling stock is consumed from the grid only. Therefore, the baseline emissions are equal to the total electrical energy which is consumed by rolling stock in all the service lines during the project activity without the regenerative braking.

Step 1: Total Electrical energy consumed by the rolling stocks[6] without regenerative braking:

$$EG_{Wr} = \left[\sum_{i=1}^{N} \left(\frac{EG_{i,Wr}}{S_i} \right) * S_i \right]$$

(for *i* =1to N, *i* is the number of the rolling stock)

Where,

EG_{Wr} = Total electrical energy consumed by rolling stocks without regenerative braking (GWh / year)
$EG_{i,Wr}$ = Total energy consumed by the rolling stock '*i*' without regenerative braking (GWh / year)
S_i = Total distance covered by the rolling stock '*i*' (Km /year)
N = Total number of operational rolling stocks

[6] The Total electrical energy consumed by the rolling stock includes the electrical energy consumed by the rolling stock for motoring and meeting the Auxiliary electricity requirements.

Step 2: Baseline emission calculation:
The baseline emissions (in tCO_2/ year) from rolling stock cars regenerating electrical energy during a year, is calculated as:
$BE_y = EG_{Wr} * EF_y$

Where,

EF_y = EFy i.e. Emission factor of the India grid (t CO_2e / MWh), CEA version 08 has been used in line with the CDM Tool 07 to compute the emission factor. The CEA database version 08 was the latest at the time of baseline and the start of crediting period in UCR.

The emission factor of the grid for the ex-ante approach is calculated in the following way: In accordance with the “Tool to calculate the emission factor for an electricity system, Version 07.0,” the grid emission factor is calculated using Combined Margin (CM), comprised of an Operating Margin (OM) emission factor and a Build Margin (BM) emission factor. The following procedure was adopted for estimating the grid electricity emission factor:

<u>Baseline Methodology Procedure</u>:

Project participants shall apply the following six steps:

STEP 1: Identify the relevant electricity system.

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 electric power system:

The tool defines the *electric power system* as the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity and that can be dispatched without significant transmission constraints. Keeping this into consideration, the Indian grid system was divided into five independent regional grids, namely Northern, Eastern, Western, Southern, and North-Eastern. Each grid covered several states (see Table 3.1). Since August 2006, however, all regional grids except the Southern Grid have been integrated and are operating in synchronous mode, i.e. at same frequency. Consequently, the Northern, Eastern, Western and North-Eastern grids will be treated as a single grid and is being named as NEWNE grid.

Table 3.1 Geographical Scope of regional grids in India

NEWNE Grid				Southern grid
Northern	**Eastern**	**Western**	**North-Eastern**	Andhra Pradesh
Chandigarh	Bihar	Chhattisgarh	Arunachal Pradesh	Karnataka

Delhi	Jharkhand	Gujarat	Assam	Kerala
Haryana	Orissa	Daman & Diu	Manipur	Tamil Nadu
Himachal Pradesh	West Bengal	Dadar & Nagar Haveli	Meghalaya	Pondicherry
Jammu & Kashmir	Sikkim	Madhya Pradesh	Mizoram	Lakshadweep
Punjab	Andaman-Nicobar	Maharashtra	Nagaland	
Rajasthan		Goa	Tripura	
Uttar Pradesh				
Uttarakhand				

The project activity is supplying power to NEWNE Grid (Source: CO_2 Baseline Database for the Indian Power sector, Version 8.0 January 2013). Thus, the NEWNE grid has been considered for estimating the grid emission factor. These states under the regional grids have their own power generating stations as well as centrally shared power-generating stations.

STEP2: Choose whether to include off-grid power plants in the project electricity system (optional)

Project participants may choose between the following two options to calculate the operating margin and build margin emission factor:

Option I: Only grid power plants are included in the calculation.

Option II: Both grid power plants and off-grid power plants are included in the calculation.

Since there is no data available with host party regarding all off-grid power plants, project proponent has considered Option I i.e., only grid power plants.

STEP 3. Select a method to determine the operating margin (OM):

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods:

(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 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.

The Share of Low Cost / Must-Run (% of Net Generation) in the generation profile of the different grids in India in the last five years is as follows:

	Share of Must-Run (Hydro/Nuclear) (% of Net Generation)				
	2007-08	2008-09	2009-10	2010-11	2011-12
NEWNE	19.0%	17.4%	15.9%	17.6%	19.2%
South	27.1%	22.8%	20.6%	21.0%	21.0%
India	21.0%	18.7%	17.1%	18.4%	19.6%

Source: CO_2 Baseline Database for the Indian Power sector, Version 8.0 January 2013

The above data clearly shows that the percentage of total grid generation by low-cost/must-run plants (on the basis of average of five most recent years) is much lesser than 50% of the total generation. Thus, Simple OM method is used for calculating the emission factor by CEA.

The project proponents choose an ex ante option for calculation of the Simple OM with a 3-year generation-weighted average as per the CDM Tool 7, based on the most recent data available at the time of determination of baseline and start of crediting period, without requirement to monitor and recalculate the emissions factor during the crediting period. The most recent three-year CEA data published on the emission factor of NEWNE grid is considered available at the start of crediting period and determination of baseline.

STEP 4. Calculate the operating margin emission factor according to the selected method:

a) **Simple OM**

In the Simple OM method, the emission factor is calculated as 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-operating cost and must-run power plants. Simple OM can be calculated using any of the two available methods. Option A has been selected where the data on fuel consumption and net electricity generation of each power plant/ unit is available. The CEA baseline is derived using the following formulae to calculate simple OM

$$EF_{grid,OMsimple,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{grid,OMsimple,y}$ = Simple operating 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 = All power units serving the grid in year *y* except low-cost / must-run power units

y = The relevant year as per the data vintage chosen in Step 3

Determination of $EF_{EL,m,y}$:

The emission factor of each power unit *m* is determined applying Option A1.

If for a power unit m data on fuel consumption and electricity generation is available, the emission factor ($EF_{EL,m,y}$) should be determined as follows:

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{EG_{m,y}}$$

Where:

$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)

$FC_{i,m,y}$ = Amount of fossil fuel type *i* consumed by power unit *m* 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)

$EF_{CO2,i,y}$ = CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)

$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)

m = All power units serving the grid in year *y* except low-cost/must-run power units

i = All fossil fuel types combusted in power unit *m* in year *y*

y = The relevant year as per the data vintage chosen in Step 3

The Operating Margin (including imports) 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 using the CEA CO_2 data base for the NEWNE Grid. The calculation is furnished below:

Simple Operating Margin

Year	**NEWNE*** **(tCO_2/ MWh)**	**Net generation (MWh)**
2009-10	0.9777	4,58,043.0846
2010-11	0.9707	4,76,986.7213
2011-12	0.9688	4,58,043.0846
Recent three year weighted average Simple Operating Margin (tCO_2/MWh)	0.9722	

*Including imports

STEP 5. Calculate the build margin emission factor ($EF_{grid, BM,y}$):

The build margin emissions factor is the generation of weighted average emission factor (tCO_2/MWh) of all power units *m* during the most recent year *y* for which power generation data is available, calculated as follows:

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

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 power generation data is available
Build Margin emission factor is determined as below:

Grid	BM (tCO_2/ MWh)
NEWNE grid (Now Indian)	0.9164

Source: **CEA CO_2 Baseline Database for the Indian Power Sector, Version 8.0, January 2013**

STEP 6. Calculate the combined margin (CM) emissions factor ($EF_{grid, CM, y}$):

The CM can be calculated as per the following:

$EF_{grid,CM,y} = EF_{grid,OM,y} * W_{OM} + EF_{grid,BM,y} * W_{BM}$

Where:

Parameter	Detail
$EF_{grid, OM,y}$	Build Margin CO_2 emission factor in the year *y* (tCO_2/MWh)
$EF_{grid, BM,y}$	Operating Margin CO_2 emission factor in the year *y* (tCO_2/MWh)
W_{OM}	Weighting of operating margin emission factor (%)
W_{BM}	Weighting of build margin emission factor (%)

Where:

As per "Tool to calculate the emission factor for an electricity system, Version 04.0, EB 75, Annex 15"

- Wind and solar power generation project activities weightage for operating margin w_{OM} = 0.75 and weightage for build margin w_{BM} = 0.25 (owing to their intermittent and nondispatchable 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.

Grid	OM, Operating Margin (tCO_2/ MWh)	BM, Build Margin (tCO_2/ MWh)	CM, Combined Margin (tCO_2/ MWh)
NEWNE Grid	0.9722	0.9164	**0.9442** (0.50*0.9722+0.50*0.9164)

Reference: Tool to calculate the emission factor for an electricity system Version 07

Source of Data: CO_2 Baseline Database for the Indian Power Sector, Version 8.0[7], January 2013 published by Central Electricity Authority[8].

The baseline emissions are computed by using the CDM verified data approved by the UNFCCC for the project titled, "1351 Installation of Low Green House Gases (GHG) emitting rolling stock cars in metro system".

Period	Baseline Emissions
01 Jan 2013 - 31 Dec 2013	501,675
01 Jan 2014 - 31 Dec 2014	521,348
01 Jan 2015 - 31 Dec 2015	562,882
01 Jan 2016 - 31 Dec 2016	614,251
01 Jan 2017 - 31 Dec 2017	754,152
01 Jan 2018 - 31 Dec 2018	1,166,204
01 Jan 2019 - 31 Dec 2019	1,179,319
01 Jan 2020 - 31 Dec 2020	1,190,249
01 Jan 2021 - 31 Dec 2021	1,201,179
01 Jan 2022 - 31 Dec 2022	1,205,551
Total	**8,896,810**
Average	**889,681**

Project emissions calculation:

In the project activity, while decelerating, the rolling stocks regenerate electrical energy that is fed to supply line which is consumed by other accelerating rolling stock in the same service line. The equivalent electrical energy regenerated by rolling stock in the project activity would have otherwise been consumed from the grid in the baseline scenario with no regeneration by rolling stock. Therefore, the project emissions are the emissions equivalent to actual energy consumed by rolling stock which is the difference between total electrical energy which is consumed and the electrical energy regenerated by rolling stock in all the service lines.

7 https://cea.nic.in/cdm-co2-baseline-database/?lang=en

8 https://cea.nic.in/wp-content/uploads/baseline/2020/07/user_guide_ver8.pdf

Step 1: **Total electrical Energy regenerated by rolling stock:**

$$EG_R = \left[\sum_{i=1}^{N} \left(\frac{EG_{i,R}}{S_i} \right) * S_i \right]$$

(for i =1 to N, i is the number of the rolling stock)

Where,

EG_R = Total electrical energy regenerated with regenerative braking (GWh / year)
$EG_{i,R}$ = Total energy regenerated by the rolling stock 'i' with regenerative braking (GWh/ year)

Step 2: Project emission calculation:
The project emissions (in tCO_2/ year) from rolling stock cars regenerating electrical energy during a year is calculated as:

$$PE_y = [\{\sum_{i=1}^{N} \{\left(\frac{EG_{i,Wr}}{S_i} \right) - \left(\frac{EG_{i,R}}{S_i} \right)\} * S_i\}] * EF_y$$

Where,

EF_y =. Emission factor of the India grid (t CO_2e / MWh), CEA version 08 has been used in line with the CDM Tool 07 to compute the emission factor.

Period	Project Emissions
01 Jan 2013 - 31 Dec 2013	316,364
01 Jan 2014 - 31 Dec 2014	328,770
01 Jan 2015 - 31 Dec 2015	354,963
01 Jan 2016 - 31 Dec 2016	387,356
01 Jan 2017 - 31 Dec 2017	475,580
01 Jan 2018 - 31 Dec 2018	735,427
01 Jan 2019 - 31 Dec 2019	743,697
01 Jan 2020 - 31 Dec 2020	750,590
01 Jan 2021 - 31 Dec 2021	757,483
01 Jan 2022 - 31 Dec 2022	760,240
Total	**5,610,470**
Average	**561,047**

Leakage:
According to the methodology, the baseline emissions as mentioned in paragraph 7 are, "No leakage calculation is required".

COUs (ERs) Calculation			
Period	**Baseline Emissions**	**Project Emissions**	**Emission Reduction**
01 Jan 2013 - 31 Dec 2013	501,675	316,364	185,311
01 Jan 2014 - 31 Dec 2014	521,348	328,770	192,578
01 Jan 2015 - 31 Dec 2015	562,882	354,963	207,919

01 Jan 2016 - 31 Dec 2016	614,251	387,356	226,895
01 Jan 2017 - 31 Dec 2017	754,152	475,580	278,572
01 Jan 2018 - 31 Dec 2018	1,166,204	735,427	430,777
01 Jan 2019 - 31 Dec 2019	1,179,319	743,697	435,622
01 Jan 2020 - 31 Dec 2020	1,190,249	750,590	439,659
01 Jan 2021 - 31 Dec 2021	1,201,179	757,483	443,696
01 Jan 2022 - 31 Dec 2022	1,205,551	760,240	445,311
Total	**8,896,810**	**5,610,470**	**3,286,340**
Average	**889,681**	**561,047**	**328,634**

B.6. Prior History>>

The project was registered as CDM project titled, "Installation of Low Green House Gases (GHG) emitting rolling stock cars in metro system" vide UNFCCC Ref. NO. 1351 and GS ID 4597. The current project under UCR is extension of CDM project which has completed the 10-year crediting period. 70 rolling stocks out of 328 were part of CDM project activity. Therefore, in order the avoid double counting the 70 rolling stocks will contribute only from 29/12/2017 to 31/12/2022 in the UCR crediting cycle.

B.7. Changes to start date of crediting period>>

There is no change in the start date of crediting period.

B.8. Permanent changes from PCN monitoring plan, applied methodology or applied standardized baseline >>

There are no permanent changes from registered PCN monitoring plan and applied methodology.

B.9. Monitoring period number and duration>>

First Issuance Period: 10 years, 0 months – 01/01/2013 to 31/12/2022

B.8. Monitoring plan>>

Data and Parameters available at validation (ex-ante values)

Data / Parameter:	$\mathbf{EF_{grid,OM,y}}$
Data unit:	tCO_2/MWh
Description:	Simple Operating Margin of the NEWNE Grid (Now Indian)
Source of data:	Central Electricity Authority (CEA) of CO_2 India Database as given in user guide version 8.0, January 2013
Values applied	0.9722
Measurement methods and procedures	Calculated by PP from the CEA database for all the regional grids in India. Specifically meant for use in CDM project activities.
Purpose of data	For calculation of emission factor
Additional comment:	This database is an official publication of government of India for the purpose of CDM baseline. It is based on most recent at start of crediting period and baseline determination. As the calculation for baseline has been done ex-ante, its value will remain fixed for the entire period

Data / Parameter	$EF_{grid,BM,y}$
Unit	tCO_2/MWh
Description	Build Margin of the NEWNE Grid
Source of data	Central Electricity Authority (CEA) of CO_2 India Database as given in user guide version 8.0, January 2013
Value(s) applied	0.9164
Choice of data or Measurement methods and procedures	Calculated by PP from the CEA database for all the regional grids in India. Specifically meant for use in CDM project activities.
Purpose of data	For calculation of emission factor
Additional comment	This database is an official publication of government of India for the purpose of CDM baseline. It is based on most recent data available at start of crediting period and baseline determination. As the calculation for baseline has been done ex-ante, its value will remain fixed for the entire period

Data / Parameter	$EF_{grid,CO2,y}$
Unit	tCO_2/MWh
Description	Combined margin CO2 emission factor for the project electricity system in year y
Source of data	Central Electricity Authority (CEA) of CO_2 India Database as given in user guide version 8.0, January 2013
Value(s) applied	0.9442
Choice of data or Measurement methods and procedures	Calculated as the weighted average of the Operating margin and Build margin with ratio of 0.50 and 0.50 as per Tool to calculate the emission factor for an electricity system Version 04.0. The OM and BM data is publicly available provided by CEA and is conservative and transparent.
Purpose of data	For calculation of emission factor
Additional comment	This database is an official publication of government of India for the purpose of CDM baseline. It is based on most recent data available at start of crediting period and baseline determination. As the calculation for baseline has been done ex-ante, its value will remain fixed for the entire period

Data and Parameters to be monitored:

Data / Parameter	**N**
Data Unit	--
Description	Total number of operational Rolling stocks in all the service lines in each year y.
Source of data	Rolling Stock Department Log Book
Measurement procedures (if any)	Unique Identification number of each Rolling stock is identified and verified at the regular monitoring interval.
Monitoring frequency	Not applicable

QA/QC procedures	The data is monitored by the operation and maintenance department of DMRC ISO 9001 or similar system is in place.
Any comment	The data monitored would be kept for two years after the end of the crediting period or the last issuance of CoUs for the project activity whichever occurs later.

Data / Parameter	$EG_{i,Wr}$
Unit	GWh/year
Description	Electrical energy consumed by the operational rolling stock 'i'
Source of data	Train Integration and Management System (TIMS) reading
Measurement procedures (if any)	Electrical energy consumed by each rolling stock is the sum of the electrical energy consumed by the rolling stock 'i' for motoring (M) and the Auxiliary electricity consumption (SIV), both of which are monitored by TIMS. The energy data for monitoring will be downloaded from TIMS of Rolling Stock using a maintenance terminal. Since TIMS is software based electronic equipment, it has a high degree of accuracy (+ 0.01%) and as per manufacturer specifications requires no calibration from time to time.
Monitoring frequency	The readings are cumulative. These readings are compiled on yearly basis using TIMS.
QA/QC procedures	The TIMS data is recorded by Rolling Stock Department and is forwarded to Environment Department.
Any comment	The data monitored would be kept for two years after the end of the crediting period or the last issuance of CoUs for the project activity whichever occurs later.

Data / Parameter	$EG_{i,R}$
Unit	GWh/year
Description	Electrical energy regenerated by the operational rolling stock 'i'
Source of data	TIMS reading
Measurement procedures (if any)	Electrical energy regenerated by each rolling stock is monitored by TIMS. The energy data for monitoring will be downloaded from TIMS of Rolling Stock using a maintenance terminal. Since TIMS is software based electronic equipment it has a high degree of accuracy (+ 0.01%) and as per manufacturer specifications requires no calibration from time to time.
Monitoring frequency	The readings are cumulative. These readings are compiled on yearly basis using TIMS.
QA/QC procedures	The TIMS data is recorded by team member (From each service line depot) of the Rolling Stock Department and is forwarded to Environment Department,
Any comment	The data monitored would be kept for two years after the end of the crediting period or the last issuance of CoUs for the project activity whichever occurs later.

Data / Parameter	S_i
Unit	Km
Description	Total distance covered by the rolling stock 'i'
Source of data	Train Integration and Management System (TIMS) reading
Measurement methods and procedures	The distance travelled by each rolling stock is monitored by TIMS. The energy data for monitoring will be downloaded from TIMS of Rolling Stock using a maintenance terminal. Since TIMS is software based electronic equipment it has a high degree of accuracy (+ 0.01%) and as per manufacturer specifications requires no calibration from time to time.
Monitoring frequency	The readings are cumulative. These readings are compiled on yearly basis using TIMS.
QA/QC procedures	The data is monitored by the operation and maintenance department of DMRC ISO 9001 or similar system is in place.
Any comment	The data monitored would be kept for two years after the end of the crediting period or the last issuance of CoUs for the project activity whichever occurs later