PROJECT CONCEPT NOTE

CARBON OFFSET UNIT (CoU) PROJECT

Title: MMMOCL (Line-2A and Line-7)

Version 1.0
Date 02/05/2025
First CoU Issuance Period: 10 years, 0 months
Date: 01/01/2023 to 31/12/2032

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

BASIC INFORMATION	
Title of the project activity	MMMOCL (Line-2A and Line-7)
Scale of the project activity	Large Scale
Completion date of the PCN	02/05/2025
Project participants	Maha Mumbai Metro Operation Corporation Limited (MMMOCL)
Host Party	India
Applied methodologies and standardized baselines	ACM0016 ver. 4 - Mass Rapid Transit Projects
Sectoral scopes	Sectoral Scope 7: Transport
Estimated amount of total GHG emission reductions	19,67,416 CoUs (19,67,416 tCO_2eq)

SECTION A. Description of project activity

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

The project "MMMOCL (Line-2A and Line-7)" is located in Mumbai, Maharashtra, India.

The details of the registered project are as follows:

Purpose of the project activity:

The objective of the large-scale project activity is to register 2 operational lines viz. Line-2A and Line-7 of Maha Mumbai Metro Operation Corporation Limited (MMMOCL) operational in Mumbai as UCR project activity. The existing lines would provide new corridors which will be covering new geographical areas within the city.

The total length of both the lines as part of project activity is 35.1 km.

The trains on these lines runs on Standard Gauge (1435 mm).

As the metro transportation system is more efficient compared to the traditional means of transport in the baseline, the project activity achieves emission reductions through improved efficiency in the transportation achieved and calculated per passenger-kilometre. On average, metro system has lower GHG emissions per passenger-kilometre than those used in the absence of the project activity, hence, results in GHG emission reductions.

General Description of the project activity:

The project – "MMMOCL (Line-2A and Line-7)" is located in Mumbai.

The details of the MMMOCL Line-2A and Line-7 are as follows:

1. Line 2A: Dahisar (East) to Andheri (West)
   Network Length: 18.6 km
   No. of Stations: 17

2. Line 7: Ovaripada to Gundavali
   Network Length: 16.5 km
   No. of Stations: 13

Line	Corridor Name	Network Length (in km)	No. of Stations	Commissioning Date
Line - 2A	Dahisar (East) - Dahanukarwadi	9.8 km	9	02/04/2022
	Dahanukarwadi – Andheri West	8.8 km	8	20/01/2023
Line - 7	Ovaripada - Aarey	10.7 km	9	02/04/2022
	Aarey - Gundavali	5.8 km	4	20/01/2023

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:**
  1. The safe and efficient mode of transportation features of MMMOCL ensures the social wellbeing of the region.
  2. MMMOCL reduces the travel time of the passengers significantly and, indirectly helps in eliminating traffic congestion on the roads as a result of mode shift by passengers.
  3. MMMOCL 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.
  4. MMMOCL also reduces the number of accidents per passengers transported.

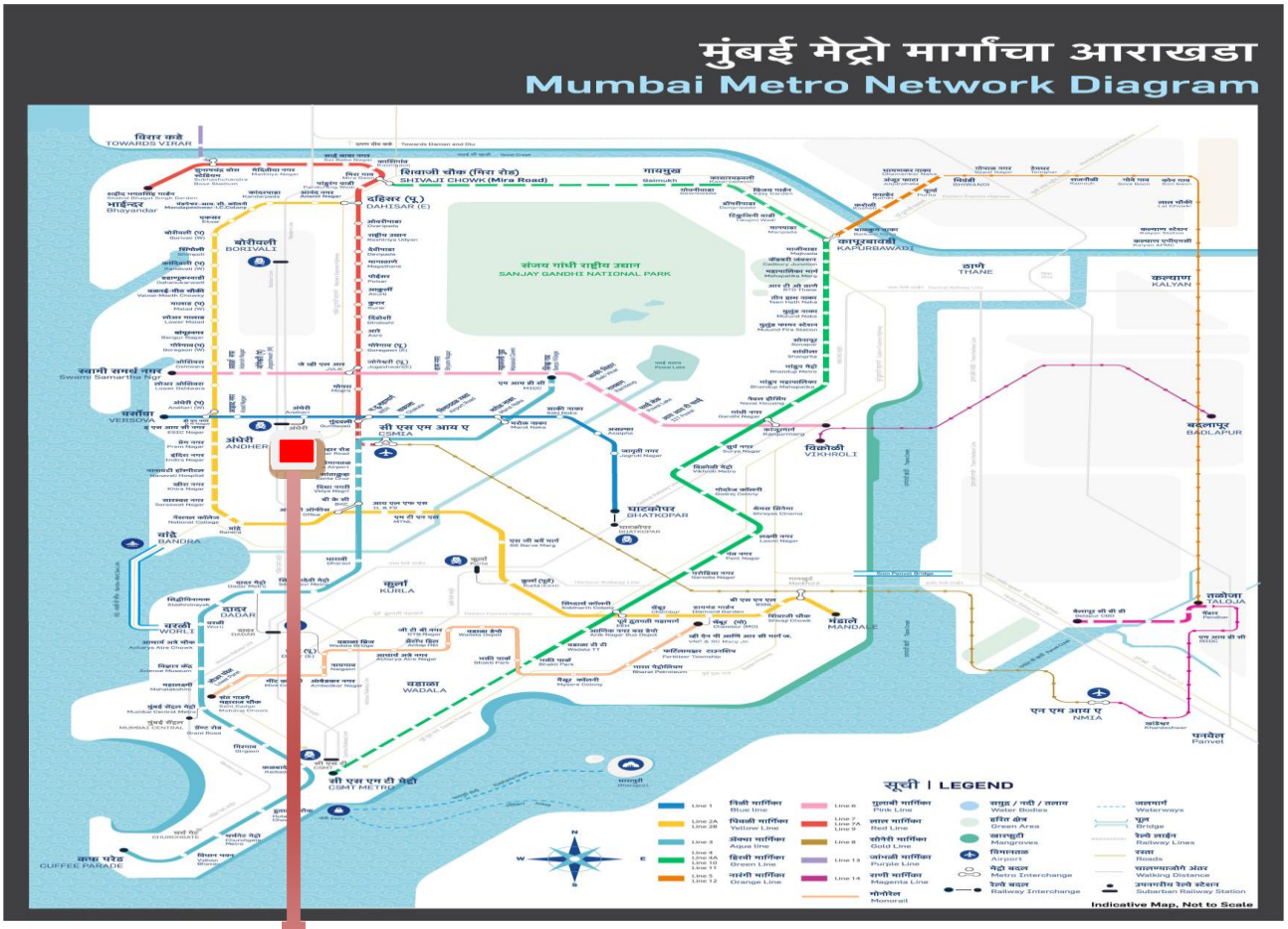
- **Environmental benefits:**
  1. The project replaces the partial grid electricity therefore the equivalent emissions which could have generated are avoided.
  2. The project undoubtedly contributes to environmental improvement, as it reduces the pollution levels in the city by using electricity instead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

- **Economic benefits:**
  1. 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.
  2. 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
State: Mumbai

S. No.	Line	Corridor Name	Terminal Station	Latitude	Longitude
1.	2A	Dahisar (East) – Andheri West	Dahisar (East)	19°15'4.26"N	72°52'1.40"E
			Andheri West	19°7'44.86"N	72°49'53.26"E
2.	7	Ovaripada – Gundavali	Ovaripada	19°14'35.94"N	72°51'51.46"E
			Gundavali	19°6'52.38"N	72°51'18.75"E


मुंबई मेट्रो मार्गाचा आराखडा
Mumbai Metro Network Diagram
सूची | LEGEND
Indicative Map, Not to Scale


शहीद भगतसिंह गार्डन
Shahid Bhagat Singh Garden
भाईन्दर
Bhayandar
मंडपेश्वर-आय. सी. कॉलनी
Mandapeshwar-I.C.Colony
कांदरपाडा
Kandarpada
आनंद नगर
Anand Nagar
दहिसर (पू)
DAHISAR (E)
एकसर
Eksar
ओवरीपाडा
Ovaripada
बोरीवली (प)
Borivali (W)
बोरीवली
BORIVALI
राष्ट्रीय उद्यान
Rashtriya Udyan
शिंपोली
Shimpoli
देवीपाडा
Devipada
कांदिवली (प)
Kandivali (W)
मागाठाणे
Magathane
डहाणूकरवाडी
Dahanukarwadi
पोईसर
Poisar
वळनई-मीठ चौकी
Valnai-Meeth Chowky
आकुर्ली
Akurli
मालाड (प)
Malad (W)
कुरार
Kurar
लोअर मालाड
Lower Malad
दिंडोशी
Dindoshi
बांगूरनगर
Bangur Nagar
आरे
Aare
गोरेगाव(प)
Goregaon (W)
गोरेगाव (पू)
Goregaon (E)
ओशिवरा
Oshiwara
आदर्श नगर
Adarsh Nagar
जोगेश्वरी (प)
Jogeshwari (W)
जे व्ही एल आर
JVLR
जोगेश्वरी (पू)
Jogeshwari(E)
स्वामी समर्थ नगर
Swami Samartha Ngr
लोअर ओशिवरा
Lower Oshiwara
मोगरा
Mogra
अंधेरी (प)
Andheri (W)
आझाद नगर
Azad Nagar
अंधेरी
Andheri
एच/पू महामार्ग
WEH
चकाला
Chakala
वर्सोवा
VERSOVA
डी एन नगर
D N Nagar
गुंदवली
Gundavali
Western Line
Harbour Line
Western Express Highway

A.4. Technologies/measures >>

The MMMOCL Lines viz. Line-2A: Dahisar (East) to Andheri (West) and Line-7: Ovaripada to Gundavali comprises of a total of 35.1 km of transit system. Both the lines are purely elevated. Each train will have between 6 cars and will run frequencies between 6 and 10 minutes depending on lines, time of the day and passenger demand.

Trains will be approximately 3.2 m wide modern rolling stock with stainless steel body. The capacity of a 6 car standard gauge train is approx. 1,756 passengers. The trains will run at an average speed of 35 kmph and maximum speed of 80 kmph.

Long lasting track structure requiring minimum or no maintenance and ensuring high stability, safety, reliability and comfort is proposed for the MRTS system. The track structure proposed is of two types:

- Ballast less tracks on Viaducts
- Normal ballasted tracks in depots

Based on the passenger forecasting study in the detailed project report (DPR) for the lines covered in this project activity, the daily ridership is mentioned in the table below:

Year	Daily Ridership
2023	10,04,722
2032	13,11,648

Traction system is 25kV AC 50 Hz single phase. The power supply will be sourced from grid sub stations. The auxiliary power will be provided from 110kV power supply distribution system. The 33 kV power will be distributed along the alignment through 33 kV Ring main cable network for feeding traction and auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct.

Scenario existing prior to the project activity:
In absence of the project activity, continuation of baseline mode of transport would have been prevalent.

A.5. Parties and project participants >>

Party (Host)	Participants
India (host)	Public entity: Maha Mumbai Metro Operation Corporation Limited (MMMOCL)

A.6. Baseline Emissions>>

The baseline scenario is defined as the most likely scenario in the absence of the proposed project activity. As per approved methodology, ACM0016, Version 04, “If the project activity is deemed to be additional, then the baseline scenario is assumed to be the continuation of the use of current modes of transport provided that the project participants can provide an explanation showing that the existing transport system would be sufficient to meet the transportation demand that will be met by the project system.

Baseline is determined as: Continuation of current public and individual transport system

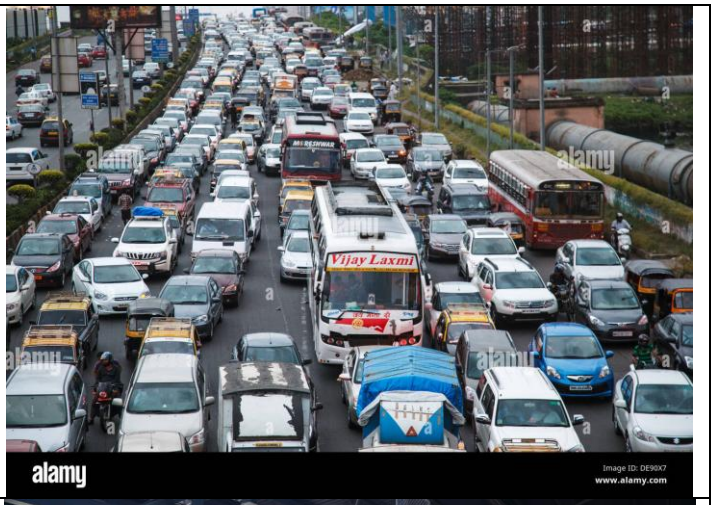
has various advantages, as not being involved in considerable risks in technical and financial aspects and does not attract large scale investments at within a short span, like metro project.

The total population of Greater Mumbai in 2011 was 124.42 Lakhs, more than double of population of 59.7 Lakhs in 1971. The rise in population was about 38.02% during 1971 – 81 but was about 20.54% during 1981–91 and 19.94% during 1991-2001. Between 2001 to 2011 the growth in population is only 4.5%.

In Mumbai, there has been phenomenal increase in road vehicles in Greater Mumbai leading to road traffic, which is a major source of air pollution. Air Pollution due to road traffic has increased by almost 400% during the last two decades. Number of private vehicles per 1000 population was 18.11 in 1971 has increased to 150.32 in 2011. The rate of growth of vehicles has increased further during the last few years.

So, as the population of the city grows, the share of public transport, road or rail-based, should increase. For a city with population of 1.0 million, the share of public transport should be about 40 - 45%. The percentage share of public transport should progressively increase with further growth in the population of the city, reaching a value of about 75% when the population of the city touches 5 million mark.

The continuation of current baseline transportation system indicates inefficient and emissions intensive nature of the modes and hence, implementation of the current metro project activity reduces the emissions from the baseline to the extent of passengers transported by project system. Public Transport System viz. MRTS is an efficient user of space and energy, with reduced level of air and noise pollution.

BASELINE SCENARIO Use of fossil fuel by using the multiple public transports/personal vehicles by the commuters.	
PROJECT SCENARIO Passengers are using newly developed metro system the replaces the baseline.	

A.7. Debundling>>

This proposed UCR project is not a part of any other large-scale project, therefore the debundling is not applicable.

SECTION B. Application of methodologies and standardized baselines

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

SECTORAL SCOPE – 07 Transport
Type II - Operation of new rail-based mass rapid transit systems (MRTS)

CATEGORY - ACM0016 - "Mass Rapid Transit Projects", Version 04.0.0, EB 85
(Methodology Deviation Request for use of Version 4 of ACM0016 has been approved by UCR on 22/03/2025 and the link to the official confirmation of the same is provided in the footnote below[1]).

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

S. No.	Applicability Condition under ACM0016, version 04	UCR Project meets the applicability conditions since
1.	The project constructs a new rail-based infrastructure or segregated bus lanes. • For rail systems, the project needs to involve the construction of a new infrastructure (new rail lines); • For BRTs the project can be based on existing road infrastructure, but which separates physically bus lanes from mixed traffic.	**Applicable and Fulfilled** The project activity is construction of a new rail-based infrastructure (Metro), which can be evidenced from the Detailed Project Report (DPR). The PoA does not include BRT, hence this point is not applicable. Criteria met.
2.	The methodology is applicable for the segregated BRT bus lanes or the rail based MRTS replaces existing bus routes (e.g. through scrapping units or through closing or re-scheduling existing bus routes) operating under mixed traffic conditions	**Applicable and Fulfilled** The metro rail projects under the project replaces passenger trips by the existing bus operations and result in the reduction in number of buses.
3.	The methodology is not applicable for operational improvements (e.g. new or larger buses) of an already existing and operating bus lane or rail-based MRTS;	**Applicable and Fulfilled** The project is a new rail-based system and not an operational improvement to the existing infrastructure. The DPR of Line-2A and Line-7 of MMMOCL clearly evidence the same.
4.	Fuels including (liquefied) gaseous fuels or biofuel blends, as well as electricity can be used in the baseline or project case. The following	**Applicable and Fulfilled** The project activity uses only electricity for its operations. Where as in the baseline case, the usage of three fuels has been identified

[1] https://medium.com/@UniversalCarbonRegistry/deviation-request-approval-acm0016-large-scale-consolidated-methodology-for-mass-rapid-transit-af6f740df1f8

S. No.	Applicability Condition under ACM0016, version 04	UCR Project meets the applicability conditions since
	condition apply:	for different modes of transportation used by the passengers, such as, gasoline for passenger cars and motorcycles, CNG for taxis, passenger cars, auto rickshaws and buses and diesel for passenger cars, buses and taxis. The project activity uses only electricity for its operations, whereas, the baseline modes of transport uses different types of fuels, including gaseous fossil fuels (gasoline and diesel) and CNG. However, as there is no other fuel consumption, except the traction energy (electricity by the project activity, as evident from the DPR, there is no possibility of more consumption of gaseous fossil fuels by project activity. Hence, the condition, usage of more gaseous fossil fuel in the project case is not applicable.
i)	In the case of gaseous fossil fuels, the methodology is applicable if equal or more gaseous fossil fuels are used in the baseline scenario than in the project activity. The methodology is not applicable in its current form if more gaseous fossil fuel is used in the project activity compared to the baseline scenario.	The baseline modes of transport uses different types of fuels, including gaseous fossil fuels (gasoline and diesel) and CNG. The project activity only uses electricity. However, as there is no other fuel consumption, except the traction energy (electricity by the project activity), as evident from the DPR, there is no possibility of more consumption of gaseous fossil fuels by project activity. Hence, the condition, usage of more gaseous fossil fuel in the project case is not applicable.
5.	The methodology is applicable for urban or suburban trips. It is not applicable for inter-urban transport.	**Applicable and Fulfilled** The project activity is meant for urban transport in Mumbai. The purpose of metro line is to connect the various parts of Mumbai. Metro line map clearly indicates the project operations are restricted for urban trips only.
6.	The methodology is applicable if the most plausible baseline scenario is the continuation of the use of current modes of transport.	**Applicable and Fulfilled** The identified baseline scenario of the project is continuation of current public transport system, as described and justified in 'Establishment and description of baseline scenario under baseline section of PCN.
7.	The implementation of Air-and Water- based transport system	**Not Applicable** As evident from the project documents

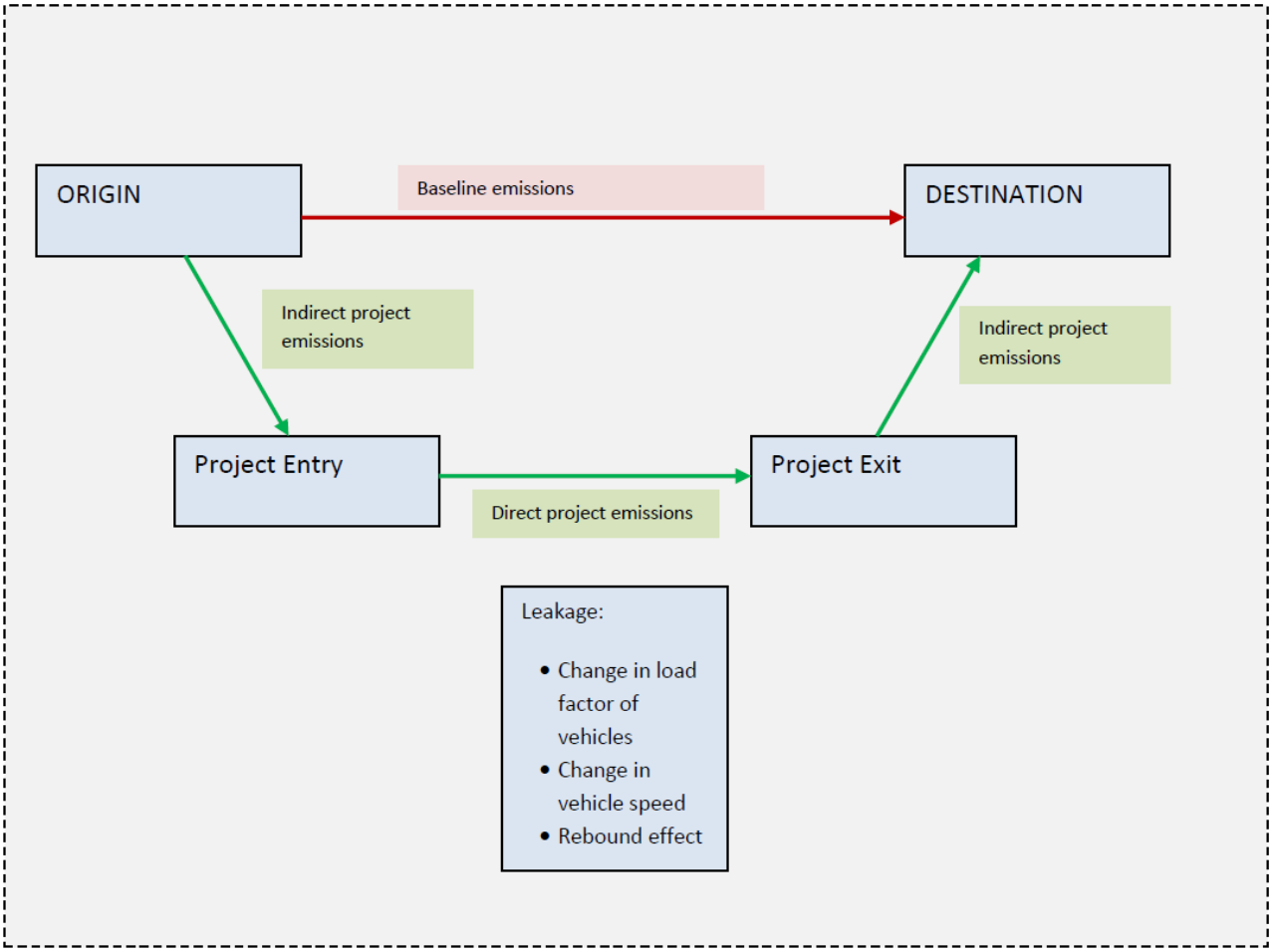
S. No.	Applicability Condition under ACM0016, version 04	UCR Project meets the applicability conditions since
		(DPR), there is no air and/or water-based transport involved in the project activity.
8.	**Applicability conditions of "Tool for the demonstration and assessment of additionality", Version 07.0.0**	**Not Applicable** The project uses performance analysis i.e. proves for rail based MRTS projects - Electricity consumption is less than or equal to 0.1 kWh/pkm. This is demonstrated in ER spreadsheet. Notwithstanding that additionality demonstration is not a criteria under UCR scheme.
9.	**Applicability conditions under "Tool to calculate baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation", version 03**	**Applicable and fulfilled as demonstrated below**
i.	This tool provides procedures to estimate the baseline, project and/or leakage emissions associated with the consumption of electricity and procedures to monitor the amount of electricity generated by the project power plant.	**Applicable and Fulfilled** The project activity will consume electricity to maintain traction energy for propulsion of metro. This is evident from the DPR. Thus, the tool is used to calculate direct project emissions from consumption of electricity.
ii.	The tool is only applicable if one out of the following three scenarios applies to the sources of electricity consumption: Scenario A: Electricity consumption from the grid. Scenario B: Electricity consumption from (an) off-grid fossil fuel fired captive power plant(s). Scenario C: Electricity consumption from the grid and (a) fossil fuel fired captive power plant(s).	The project activity applies to Scenario A, where electricity will be consumed from the grid to maintain traction energy for the metro line. This is evident from the DPR. Hence scenario A is applicable.
10.	**"Baseline measures for modal shift measures in urban passenger transport" version 01.0**	**Applicable** The tool is applicable to project activities in urban passenger transport that implement a measure, or a group of measures aimed at a modal shift to urban public transit such as metro, bus rapid transit, light rail and trams. The project activity is a metro system aimed at modal shift thus the tool is applicable.

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

The Line-2A and Line-7 of MMMOCL is part of the UCR project activity and it is not part of any other GHG scheme. Therefore, the project does not come under double counting. The line-wise demarcation of the MMMOCL project is well documented.

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

The project boundary includes the physical, geographical site(s) of MMMOCL Line 2A and Line 7:



Emission sources included in or excluded from the project boundary

	Source	Gas	Included	Justification/Explanation
Baseline	Mobile source emissions of different modes of transport due to the trips made by the passengers using the MRTS	CO_2	Yes	Major emission source
		CH_4	No	Included only if gaseous fuels are used. Vehicle tailpipe CH_4 emissions are excluded for liquid fuels. Combined CH_4 and N_2O emissions make less than 2% of total CO_2eq emissions in diesel/gasoline vehicles. Its omittance in baseline as well as project emissions is conservative as fuel consumption and thus also CH_4 emissions are reduced through the project.
		N_2O	No	Combined CH_4 and N2O emissions make less than 2% of total CO_2eq emissions in diesel/gasoline vehicles. Its omittance in baseline as well as project emissions is

				conservative as fuel consumption and thus also CH_4 emissions are reduced through the project.
Project Activity	Mobile source emissions of the project transport system (MRTS) due to the trips made by the passengers using it	CO_2	Yes	Major emission source
		CH_4	No	Included only if gaseous fuels are used. Vehicle tailpipe CH_4 emissions are excluded for liquid fuels. Combined CH_4 and N_2O emissions make less than 2% of total CO_2eq emissions in diesel/gasoline vehicles. Its omittance in baseline as well as project emissions is conservative as fuel consumption and thus also CH_4 emissions are reduced through the project.
		N_2O	No	Combined CH_4 and N2O emissions make less than 2% of total CO_2eq emissions in diesel/gasoline vehicles. Its omittance in baseline as well as project emissions is conservative as fuel consumption and thus also CH_4 emissions are reduced through the project.
	Mobile source emissions of different modes of transport due to the trips made by the passengers using the MRTS, from their trip origin to the MRTS and from the MRTS to their trip destination	CO_2	Yes	Major emission source
		CH_4	No	Included only if gaseous fuels are used. Vehicle tailpipe CH_4 emissions are excluded for liquid fuels. Combined CH_4 and N_2O emissions make less than 2% of total CO_2eq emissions in diesel/gasoline vehicles. Its omittance in baseline as well as project emissions is conservative as fuel consumption and thus also CH_4 emissions are reduced through the project.

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

Baseline emissions include the emissions that would have happened due to the transportation of the passengers who use the project activity, had the project activity not been implemented. This is differentiated according to the modes of transport (relevant vehicle categories) that the passengers would have used in the absence of the project.

Baseline emissions are calculated per passenger surveyed. For each passenger surveyed, the individual baseline emissions are calculated and multiplied with the individual expansion factor thus getting the baseline emissions of all passengers of the specific week surveyed. These are then multiplied with the total of the passengers of the period to arrive at baseline emissions.

The following steps would be realised:

Step 1: Conduct a survey, following the procedures presented in Appendix 4 of methodology, in which for each surveyed passenger, the trip distance per transport mode that would have taken place in the baseline is determined.

Step 2: Calculate the individual baseline emissions for each surveyed passenger.

Step 3: Apply an individual expansion factor to each surveyed passenger in accordance with the

survey sample design, and summarize these to get the total baseline emissions of the period (week) surveyed. To get the annual (or monitoring period) baseline emissions the baseline emissions of the surveyed period (week) are calculated per passenger of the period (week) and multiplied with the total passengers transported per year (or monitoring period).

Step 4: Take the lower limit of the 95% confidence interval as total baseline emissions.

Baseline emissions are calculated as follows:

$$BE_y = \frac{P_y}{P_{SPER}} \sum_p \left(BE_{p,y} \times FEX_{p,y} \right) \quad (1)$$

Where:

BE_y = Baseline emissions in the year y (gCO_2)
$BE_{p,y}$ = Baseline emissions per surveyed passenger p in the year y (gCO_2)
$FEX_{p,y}$ = Expansion factor for each surveyed passenger p surveyed in the year y (each surveyed passenger has a different expansion factor)
P = Total number of passengers in the year y
P_{SPER} = Number of passengers in the time period of the survey (1 week)
P = Surveyed passenger (each individual)
y = Year of the crediting period

The baseline emission per surveyed passenger p is calculated based on the mode used, the trip distance per mode and the emission factor per mode:

$$BE_{p,y} = \sum_i BTD_{p,i,y} \times EF_{pkm,i,y} \times 10^{-6} \quad (2)$$

Where:
$BE_{p,y}$ = Baseline emissions per surveyed passenger p in the year y (gCO_2)
$EF_{PKM,i,y}$ = Emission factor per passenger-kilometre of mode iin the year y (gCO_2/PKM)
$BTD_{p,i,y}$ = Baseline trip distance per surveyed passenger p using mode iin the year y (PKM)
p = Surveyed passenger (each individual)
i = Relevant vehicle category
y = Year of the crediting period

(1) Criteria for identifying the vehicle categories are as follows:

(a) At a minimum, public transport has to be included;

(b) Conditions to include categories with reliable data on fuel consumption and load factors;

(c) Only include categories that are relevant for the MRTS project. If the project will only generate credits from public transport without modal shift, then passenger cars, taxis and motorcycles need not be included;

(d) Differentiate relevant fuel types for each category. Diesel, gasoline and gas (CNG or LPG) are listed separately if a minimum of 10 per cent of vehicles of the respective category use such a fuel, while the threshold for zero-GHG-emission7 fuels is minimum 1 per cent. The 10 per cent threshold is justified, as greenhouse gas (GHG) emission differentials between diesel, gasoline and gaseous fuels are less than 20 per cent;

(e) In case of a system extension, the currently operating system is not included as a vehicle category.

Identification of the relevant vehicle categories (modes of transport)

Following vehicle categories have been identified as the applicable modes of transport in the absence of the project MRTS:

1. Buses
2. Urban rail
3. Metro (non-project existing metro)
4. Taxi
5. Passenger cars;
6. Two-wheelers and Motorcycles;
7. Auto rickshaws (motorized)
8. Bicycle or per foot
9. Others

If some vehicle categories are not explicitly identified or do not fit into one of the categories above; they should be entered in the survey as "others".

Baseline emissions of this category are counted as 0. The index i is used to identify each relevant vehicle category (mode of transport) included in the analysis. In indirect project emissions, the highest emission factor of all categories is taken if the survey respondent chooses the item "others".

(2) Determination of the emission factor per passenger-kilometer ($EF_{PKM,i,y}$)

Passenger-kilometer (PKM) is defined as the average passenger trip distance multiplied by the number of passengers. The emission factors per PKM are determined ex ante for each vehicle category. Any change in the occupancy rate of taxis and buses influencing the corresponding emission factors is monitored as leakage. The emission factor per PKM is calculated as follows:

(2.1) Emission factor per PKM for electricity-based transport systems (Existing metro rail):

$$EF_{PKM,i,x} = \frac{TE_{EL,i,x}}{P_{EL,i,x} \cdot D_{EL,i,x}} \times 10^6 \qquad (3)$$

Where:

$EF_{PKM,i,x}$	=	Emission factor per passenger-kilometre for electricity-based vehicle category i in year x (gCO_2/PKM)
$TE_{EL,i,x}$	=	Total emissions from the electricity-based vehicle category i in year x (tCO_2)
$P_{EL,i,x}$	=	Total passengers transported per year by the electricity-based vehicle category i in year x (passengers)
$D_{ELI,xi}$	=	Average trip distance travelled by passengers using the electricity-based vehicle category i in
x	=	year x (km) Most recent calendar year for which data is available. Data not older than three years

The total emissions from the existing metro rail category i, $TE_{EL,i,y}$, is calculated, using the 'Tool to calculate baseline, project and/or leakage emissions from electricity consumption'. When applying the tool, the parameter $EC_{BL,k,y}$ is taken as the amount of electricity used by the electricity-based vehicle category i for year y, consistent with the transportation of $PE_{L,i,y}$ passengers along the average distance $TD_{EL,i.}$

(2.2) For fuel-based vehicle categories identified above (bus/taxi/passenger car/Auto rickshaw/motorcycle), the emission factor per PKM is calculated as follows:

$$EF_{PKM,i,x} = \frac{EF_{KM,i,x}}{OC_{i,x}} \quad \text{(4)}$$

Where:

$EF_{PKM,i,x}$	=	Emission factor per passenger-kilometre of vehicle category i in year x (gCO_2/PKM)
$EF_{KM,i,x}$	=	Emission factor per kilometre of vehicle category i in year x (gCO_2/km)
$OC_{i,x}$	=	Average occupancy rate of vehicle category i in year x (passengers)
i	=	Road based vehicle categories (such as passenger car (C) bus (B), Motorcycle (M)
X	=	Most recent calendar year for which data is available. Data not older than three years

(2.2.1) Determination of the average occupancy rate (OC_i)

The average occupancy rate (OCi) of vehicle category i is determined based on visual occupancy studies for all vehicle categories i. For buses, besides the visual occupancy studies, the occupancy rate can also be based on boarding-alighting studies or electronic smart tickets, with expansion factors for routes served to determine the average occupancy rate along the entire route. For taxis, the driver should not be included.

Occupancy rate of taxis/motorcycles or passenger cars:

Load factor studies for taxis/motorcycles or passenger cars is carried out through visual occupancy as per Appendix 3 of ACM0016. The actual number of passengers excluding the driver of taxis is counted in a given point within a given time period.

The procedures to establish visual occupancy:

a. Locations, days and times for field study were defined, avoiding days immediately after or before a holiday.

b. Field data is collected. Coverage of the occupancy counts should be higher than 95% of the number of taxis that cross the checkpoint. One hundred per cent coverage is desired. To control this outcome, a separate vehicle count is advised. Data can be adjusted with the actual count

c. Occupancy is the number of passengers using the vehicle. The driver is not counted for taxis. Taxis without passengers were counted as no (zero) occupancy;

d. The total number of vehicles and the total number of passengers was reported. The average occupancy rate of vehicles is the total number of passengers divided by the total number of vehicles in which counts were performed;

e. The study is realized in different locations of the larger urban zone of the city

In the case of taxis and auto rickshaws, the driver is not included in the study. The occupancy studies would be conducted as per the guidance provided under Appendices 1, 2 and 3 of the methodology.

Baseline emission estimated as per the above formulas, would determine the total emissions that would have occurred in the absence of the project activity, as a result of baseline trips made by the project passengers. Baseline emissions cover the entire emissions which would have been caused by the project passenger in absence of the project from his trip origin to his trip destination:

(a) The origin and destination of the trip are assumed to be equal for the baseline as for the project case with an exception of induced traffic included only as project but not as baseline trips;

(b) The trip distance and the modes used between O (origin) and D (destination) are however different in the baseline than in the project case;

(c) The trip distance may vary as some passengers using the project MRTS may be willing to make detours due to the higher speed of the MRTS versus conventional bus transport.

To fully capture all the potential changes, the methodology compares emissions per O-D trip of the baseline with emissions per O-D trip of the project. The data to determine O-D mode(s) and distances per mode are derived from a representative survey of project passengers realized annually. Total baseline emissions are calculated thereafter annually based on these parameters, the emissions per pkm and the amount of passengers transported by the project.

(2.2.2) Determination of the emission factors per kilometre ($EF_{KM,i,x}$)

Differentiate relevant fuel types for each of the relevant road-based vehicle categories identified in Step 1. Vehicles in a vehicle category using diesel, gasoline, biofuel, biofuel blend, electricity or gas (compressed natural gas (CNG) or liquefied petroleum gas (LPG)) should be listed separately.

Estimating emission factor per kilometre based on the fraction of vehicles using a specific fuel type, the consumption of each fuel type and CO_2eq emissions per unit of fuel consumed:

$$EF_{KM,i,x} = \frac{\sum_{n}\left(SFC_{i,n,x} \cdot NCV_{i,n} \cdot EF_{CO2,n} + SECi,x.EFCO2,X\right)}{} .Ni,nx/Ni,x \quad \text{(5)}$$

Where,

$EF_{KM,i,x}$	=	Emission factor per kilometre of vehicle category i in year x (g CO_2/km)
$SFC_{i,n,x}$	=	Specific fuel consumption of vehicle category i using fuel type n in year x (mass or volume units of fuel/km)
$NCV_{x,n}$	=	Net calorific value of fuel n used in vehicle category i (J/mass or volume units of fuel)
$EF_{CO2,n}$	=	Emission factor for fuel type n(g CO_2/MJ)

$SEC_{i,x}$	=	Specific electricity consumption of vehicle category I using electricity in year x (Kwh/ Km)
$EF_{CO2,x}$	=	Emission factor for electricity in year x (g CO_2/KWh)
$N_{i,x}$		Number of vehicles – Kilometres of category i driven in year x (VKM) or number of vehicles of category i in year x (units)
$N_{i,n,x}$	=	Number of vehicle – kilometres vehicle category i using fuel type n driven in year x (VKM) or number of vehicles in vehicle category i using fuel type n in year x (units)
N	=	Fuel types used in vehicle category i in year x
I	=	Road- based vehicle categories (passenger car (C), bus (B), motorcycle (M) etc.
x	=	Most recent calendar year for which data is available, Data not older than three years.

The technology improvement factors provided in the tool is listed in the following table are applied:

Vehicle Category	Technology improvement factor (IR)
Buses	0.99
Passenger cars	0.99
Taxis	0.99
Motorcycles (inc. Tricycles)	0.99

Baseline emission estimated as per the above formulas, would determine the total emissions that would have occurred in the absence of the project activity, as a result of baseline trips made by the project passengers. Baseline trips emissions are calculated based on the distance travelled by the passengers from their trip origin to trip destination and the mode of transport used to make the respective trip. The survey carried out for the purpose of determining the baseline trip distance and modes used, also covers the passenger those would not have made the trip in the absence of the project activity.

Total baseline emissions are calculated thereafter annually based on these parameters, the emissions per PKM and the amount of passengers transported by the project.

Line-2A

Year	Annual Passenger Flow	PSPER*	Expanded baseline emission* (gCO2e)	Baseline Emission (tCO_2e)
2023	16,36,03,950	49,43,784	5,12,39,98,166	1,69,568
2024	17,14,46,112	49,43,784	5,07,27,58,184	1,75,919
2025	17,83,51,410	49,43,784	5,02,20,30,602	1,81,174
2026	18,57,25,140	49,43,784	4,97,18,10,296	1,86,778
2027	19,30,98,870	49,43,784	4,92,20,92,193	1,92,252
2028	20,10,21,840	49,43,784	4,87,28,71,271	1,98,138
2029	20,78,46,330	49,43,784	4,82,41,42,558	2,02,816

2030	21,52,20,060	49,43,784	4,77,59,01,133	2,07,912
2031	22,25,94,155	49,43,784	4,72,81,42,121	2,12,885
2032	23,05,97,971	49,43,784	4,68,08,60,700	2,18,334

Line-7

Year	Annual Passenger Flow	PSPER*	Expanded baseline emission* (gCO2e)	Baseline Emission (tCO_2e)
2023	20,31,19,580	49,43,784	5,12,39,98,166	2,10,524
2024	20,87,63,838	49,43,784	5,07,27,58,184	2,14,210
2025	21,32,67,310	49,43,784	5,02,20,30,602	2,16,643
2026	21,83,41,175	49,43,784	4,97,18,10,296	2,19,579
2027	22,34,15,040	49,43,784	4,92,20,92,193	2,22,435
2028	22,91,14,902	49,43,784	4,87,28,71,271	2,25,829
2029	23,35,62,770	49,43,784	4,82,41,42,558	2,27,910
2030	23,86,36,635	49,43,784	4,77,59,01,133	2,30,533
2031	24,37,09,770	49,43,784	4,72,81,42,121	2,33,079
2032	24,94,65,161	49,43,784	4,68,08,60,700	2,36,198

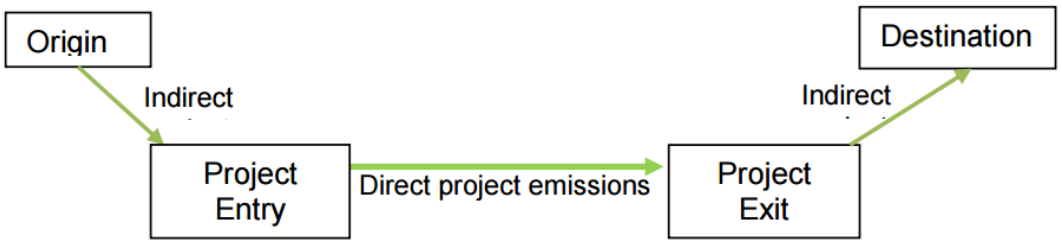
Total of Line-2A and Line-7

Year	Annual Passenger Flow	PSPER*	Expanded baseline emission* (gCO2e)	Baseline Emission (tCO_2e)
2023	36,67,23,530	49,43,784	5,12,39,98,166	3,80,092
2024	38,02,09,950	49,43,784	5,07,27,58,184	3,90,129
2025	39,16,18,720	49,43,784	5,02,20,30,602	3,97,817
2026	40,40,66,315	49,43,784	4,97,18,10,296	4,06,357
2027	41,65,13,910	49,43,784	4,92,20,92,193	4,14,686
2028	43,01,36,742	49,43,784	4,87,28,71,271	4,23,967
2029	44,14,09,100	49,43,784	4,82,41,42,558	4,30,727
2030	45,38,56,695	49,43,784	4,77,59,01,133	4,38,444
2031	46,63,03,925	49,43,784	4,72,81,42,121	4,45,964
2032	48,00,63,131	49,43,784	4,68,08,60,700	4,54,532

*Values of PSPER and Expanded Baseline Emission are taken from PoA-DD of DMRC's CDM PoA Project No. 9863.

Project emissions:

Project emissions are based on the fuel and/or electricity consumed by the MRTS (direct project emissions) plus emissions caused by project passengers from their trip origin to the entry station of the project and from the exit station of the project to their final destination (indirect project emissions), as illustrated in Figure below.



Project emissions are calculated as follows:

$$PE_y = DPE_y + IPE_y \quad (6)$$

Where:

$PE_{,y,}$ = Project emissions in the year y (tCO_2)
DPE_y = Direct project emissions in the year y (tCO_2)
IPE_y = Indirect project emissions in the year y (tCO_2)
y = Year of the crediting period

Determination of direct project emissions (DPEy)

Case 1: Use of fossil fuels in the project activity transport system (Not Applicable since Fuel consumption is not involved in the project activity).

Case 2: Use of electricity in the project activity transport system (Applicable).

If the project activity involves electricity-based transport systems (e.g. electrical railway systems), the emissions from electricity consumption will be based on the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". The parameter $PE_{EC,y}$ in the tool corresponds to the direct project emissions from the project transport system in year y (DPEy). Only electricity consumed for train propulsion should be included in rail-based MRTS.

For calculation of direct project emissions which in this case is from the use of electricity in the project activity transport system, "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" is to be used. The parameter $PE_{EC,y}$ in the tool corresponds to the direct project emissions from the project transport system in year y (DPEy). Only electricity consumed for train propulsion should be included in rail-based MRTS.

$$PE_{EC,y} = \sum_j EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y}) \quad (7)$$

Where,

$PE_{EC,y}$ = Project emissions from electricity consumption in year y (tCO_2/yr)
$EC_{PJ,j,y}$ = Quantity of electricity consumed by the project electricity consumption source j in year y (MWh/yr)

$EF_{EL,j,y}$ = Emission factor for electricity generation for source j in year y (tCO_2/MWh)
$TDL_{j,y}$ = Average technical transmission and distribution losses for providing electricity to source j in year y
j = Sources of electricity consumption in the project

Since electricity for train propulsion will be imported from grid, hence the baseline emission factor has been chosen in accordance with UCR guideline.

The combined emission factor for electricity consumption is as follows:

Grid	Unit	Value
Indian	tCO_2/MWh	0.919

Traction Energy	Emission factor	TDL_y	DPEy
x	y	z	x*y*(1+z)

The traction energy will vary and depend on the estimated value from DPR or project feasibility report. Energy at high voltage will be received at Receiving Substation (RSS), internal transmission and distribution loss from RSS to Rolling stock would be recorded and measured.

In MRTS system, the Receiving Substation (RSS) supplies electricity to various lines of the MRTS system (both project and non-project lines). In the event, the RSS supplies dedicatedly to the project line, then the total reading of the meter for traction energy will be monitored and used for the calculation of direct project emissions.

In case the RSS supplies electricity to other lines of the MRTS system along with the project line, then the following formula will be used to calculate traction energy used by project line during the monitoring period:

$$TE_{CPA,y} = TE_{Total-RSS,y} * \frac{Car-km_{CPA-MRTS,y}}{Car-km_{RSS-Total,y}} \quad \text{_____(8)}$$

Where,

$TE_{CPA,y}$ = Traction energy consumed by project MRTS line in year *y*
$TE_{Total-RSS,y}$ = Total traction energy supplied by RSS in year *y*
$Car\text{-}km_{CPA-MRTS,y}$ = Total car-km of project MRTS line in year *y*
$Car\text{-}km_{RSS-Total,y}$ = Total car-km supplied traction energy by the RSS in year *y*

Line-2A

Year	Traction Energy	Emission factor in tCO_2/Mwh	TDL	DPEy (Calculated)
2023	1,01,835	0.919	3.27%	96,647
2024	1,04,676	0.919	3.30%	99,372
2025	1,06,945	0.919	3.30%	1,01,526
2026	1,09,500	0.919	3.30%	1,03,951

2027	1,12,055	0.919	3.30%	1,06,377
2028	1,14,924	0.919	3.30%	1,09,100
2029	1,17,165	0.919	3.30%	1,11,228
2030	1,19,720	0.919	3.30%	1,13,653
2031	1,22,403	0.919	3.30%	1,16,200
2032	1,25,318	0.919	3.30%	1,18,968

Line-7

Year	Traction Energy	Emission factor in tCO_2/Mwh	TDL	DPEy (Calculated)
2023	75,425	0.919	3.27%	71,582
2024	75,792	0.919	3.30%	71,951
2025	75,744	0.919	3.30%	71,906
2026	75,904	0.919	3.30%	72,057
2027	76,063	0.919	3.30%	72,209
2028	76,431	0.919	3.30%	72,558
2029	76,382	0.919	3.30%	72,512
2030	76,542	0.919	3.30%	72,663
2031	76,701	0.919	3.30%	72,814
2032	77,071	0.919	3.30%	73,166

Total of Line-2A and Line-7

Year	Traction Energy	Emission factor in tCO_2/Mwh	TDL	DPEy (Calculated)
2023	1,77,260	0.919	3.27%	1,68,229
2024	1,80,468	0.919	3.30%	1,71,323
2025	1,82,689	0.919	3.30%	1,73,432
2026	1,85,404	0.919	3.30%	1,76,009
2027	1,88,118	0.919	3.30%	1,78,586
2028	1,91,355	0.919	3.30%	1,81,659
2029	1,93,547	0.919	3.30%	1,83,739
2030	1,96,262	0.919	3.30%	1,86,316
2031	1,99,104	0.919	3.30%	1,89,015
2032	2,02,389	0.919	3.30%	1,92,134

Determination of indirect project emissions (IPE_y)

Indirect project emissions are those caused by passengers from their trip origin up to the project activity entry station, and from the project activity exit station up to the trip final destination:

a) The survey realized identifies the origin, the project entry station, the project exit station and the final destination of the passenger and the modes used between the different points, e.g. bicycle from origin to project entry station and taxi from project exit station to final destination.

b) The distances between origin and entry and between exit and destination are calculated based, e.g. on public transit routes, electronic maps and GPS (identical to baseline trip determination);
c) The emission factors per passenger-kilometre used for indirect project emissions are identical to the baseline passenger-kilometre factors ($EF_{PKM,i,y}$).

The following steps would be followed to determine the indirect project emissions:

Step 1: A survey conducted, as per Appendix 4 of the Methodology ACM0016, to determine the trip distance per transport mode used to/from the project metro stations.

Step 2: Indirect project emissions for each surveyed passenger are calculated as per equation 10.

Step 3: Apply to each surveyed passenger an individual expansion factor in accordance with the survey sample design (as defined in Appendix 4 of the Methodology ACM0016) and summarize these to get the total indirect project emissions for the survey period (week). To get the annual (or monitoring period) indirect project emissions the indirect project emissions of the surveyed period (week) are calculated per passenger of the survey period (week) and multiplied with the total passengers transported per year (or period), as per equation 9 below.

Step 4: Apply the upper 95% confidence interval to the total indirect project emissions.

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$$IPE_y = \frac{P_y}{P_{SPER}} \sum_P (IPE_{p,y} \times FEX_{p,y}) \times 10^{-6} \quad \text{(9)}$$

Where,

IPE_y = Indirect project emissions in the year y (g CO_2)
$IPE_{p,y}$ = Indirect project emissions per surveyed passenger p in the year y (g CO_2)
$FEX_{p,y}$ = Expansion factor for each surveyed passenger p surveyed in the year y (each surveyed passenger has a different expansion factor)
P_y = Total number of passengers in the year y
P_{SPER} = Number of passengers in the time period of the survey (1 week)
p = Surveyed passenger
y = Year of the crediting period

The indirect project emissions per surveyed passenger are calculated based on the transport mode used, the trip distance per mode and the emission factor per mode.

$$IPE_{p,y} = \sum_i IPTD_{p,i,y} \times EF_{pkm,i,y} \quad \text{(10)}$$

Where:

$IPE_{p,y}$ = Indirect project emissions per surveyed passenger p in the year y (g CO_2)
$IPTD_{,p,i,y}$ = Indirect project trip distance p per surveyed passenger using mode i in the year y (PKM)
$EF_{PKM,i,y}$ = Emission factor per passenger-kilometre of mode i in the year y (gCO_2/PKM)
i = Relevant vehicle category
p = Surveyed passenger

y = Year of the crediting period

Line-2A

Year	Annual Passenger Flow	PSPER^	Expanded Project emission^ (gCO_2e)	Indirect project emission (tCO_2e)
2023	16,36,03,950	49,43,784	50,65,52,371	16,763
2024	17,14,46,112	49,43,784	50,18,31,207	17,403
2025	17,83,51,410	49,43,784	49,71,57,254	17,935
2026	18,57,25,140	49,43,784	49,25,30,041	18,503
2027	19,30,98,870	49,43,784	48,79,49,100	19,059
2028	20,10,21,840	49,43,784	48,34,13,969	19,656
2029	20,78,46,330	49,43,784	47,89,24,189	20,135
2030	21,52,20,060	49,43,784	47,44,79,307	20,656
2031	22,25,94,155	49,43,784	47,00,78,873	21,165
2032	23,05,97,971	49,43,784	46,57,22,444	21,723

Line-7

Year	Annual Passenger Flow	PSPER^	Expanded Project emission^ (gCO_2e)	Indirect project emission (tCO_2e)
2023	20,31,19,580	49,43,784	50,65,52,371	20,812
2024	20,87,63,838	49,43,784	50,18,31,207	21,191
2025	21,32,67,310	49,43,784	49,71,57,254	21,447
2026	21,83,41,175	49,43,784	49,25,30,041	21,752
2027	22,34,15,040	49,43,784	48,79,49,100	22,051
2028	22,91,14,902	49,43,784	48,34,13,969	22,403
2029	23,35,62,770	49,43,784	47,89,24,189	22,626
2030	23,86,36,635	49,43,784	47,44,79,307	22,903
2031	24,37,09,770	49,43,784	47,00,78,873	23,173
2032	24,94,65,161	49,43,784	46,57,22,444	23,501

Total of Line-2A and Line-7

Year	Annual Passenger Flow	PSPER^	Expanded Project emission^ (gCO_2e)	Indirect project emission (tCO_2e)
2023	36,67,23,530	49,43,784	50,65,52,371	37,575
2024	38,02,09,950	49,43,784	50,18,31,207	38,594
2025	39,16,18,720	49,43,784	49,71,57,254	39,382
2026	40,40,66,315	49,43,784	49,25,30,041	40,256
2027	41,65,13,910	49,43,784	48,79,49,100	41,110
2028	43,01,36,742	49,43,784	48,34,13,969	42,060
2029	44,14,09,100	49,43,784	47,89,24,189	42,761
2030	45,38,56,695	49,43,784	47,44,79,307	43,559
2031	46,63,03,925	49,43,784	47,00,78,873	44,338

2032	48,00,63,131	49,43,784	46,57,22,444	45,224

^Values of PSPER and Expanded Project Emission are taken from PoA-DD of DMRC's CDM PoA Project No. 9863.

Based on the surveyed passenger and the survey design the corresponding expansion factors are applied to calculate total indirect project emissions. Total indirect project emissions are determined based on the upper limit of the 95% confidence interval as results are based on a sample/survey.

Leakage emissions: The same include the following sources:

- Emissions due to changes of the load factor of taxis and buses of the baseline transport system due to the project; ($LE_{LFB,y}$ and $LE_{LFT,y}$)
- Emissions due to reduced congestion on affected roads, provoking higher average vehicle speed, plus a rebound effect; ($LE_{CON,y}$).
- Upstream emissions of gaseous fuels ($LE_{UP,y)}$.

The impact on traffic (additional trips) induced by the new transport system is included as project emissions and thus is not part of leakage. This is addressed by including, as project emissions, the emissions from the trips of passengers who would not have travelled in the absence of the project.
Leakage emissions are calculated as follows:

$$LE_y = LE_{LFB,y} + LE_{LFT,y} + LE_{Con,y} + LE_{UP,y} \quad \text{(11)}$$

Where,

LE_y = Leakage emissions in the year y (tCO_2)
$LE_{LFB,y}$ = Leakage emissions due to change of load factor of buses in the year y (tCO_2)
$LE_{LFT,y}$ = Leakage emissions due to change of load factor of taxis in the year y (tCO_2)
$LE_{CON,y}$ = Leakage emissions due to change in congestion in the year y (tCO_2)
LE_{UP},y = Leakage emissions due to upstream emissions of gaseous fuels in year y (tCO_2)

As a conservative approach, it is assumed that for each component viz. $LE_{LFB,y}$, $LE_{LFT,y}$, $LE_{CON,y}$, $LE_{UP,y}$ and LE_{UP},y only the positive value (leading to net emissions) is considered.

For ex ante calculation leakage is considered to be zero.

Determination of emissions due to change of load factor of buses ($LE_{LFB,y}$)

The project could have a negative impact on the load factor of the conventional bus fleet. Load factor changes are monitored for the entire city as the potential impact is not necessarily in the proximity of the project MRTS (buses can be used in other parts of the city). The load factor of buses is monitored in the years 1, 4, 7 and 10 of the crediting period, if te
crediting period is chosen. Leakage from load factor change of buses is only included if the load factor of buses has decreased by more than 10 percentage points comparing the monitored value with the baseline value, and are calculated as:

$$LE_{LFB,y} = max\left\{\frac{1}{10^6} \times N_{B,y} \times AD_B \times EF_{km,B,y} \times \left(1 - \frac{OC_{B,y}}{OC_B}\right); 0\right\} \quad \text{(12)}$$

Where,

$LE_{LFB,y}$ = Leakage emissions due to change of load factor of buses in the year y (tCO_2)
$N_{B,y}$ = Number of baseline buses in the year y (buses)
AD_B = Average annual distance driven by baseline buses (km/bus)
$EF_{KM,B,y}$ = Emission factor per kilometre of baseline buses in the year y (gCO_2/km)
$OC_{B,y}$ = Average occupancy rate of baseline buses in the year y (passengers)
OC_B = Average occupancy rate of baseline buses prior project start (passengers)

For the purpose of determining the occupancy rate of buses, the study method of visual occupancy is chosen. The monitoring method will be used for the entire project monitoring period.

Determination of emissions due to change of load factor of taxis ($LE_{LFT,y}$)

The project could have a negative impact on the load factor of taxis. Taxis include cars as well as motorized rickshaws realizing taxi services. For both types of services, the load factor change is monitored separately. Load factor changes are monitored for the entire city as taxis operate all over the city and are not confined to deliver their services in certain areas. The load factor of taxis is monitored in the years 1, 4, 7 and 10 of the crediting period, as the fixed crediting period is chosen. This leakage is calculated as:

$$LE_{LFT,y} = max\left\{N_{T,y} \times AD_T \times EF_{km,T,y} \times \left(1 - \frac{OC_{T,y}}{OC_T}\right) \times \frac{1}{10^6}; 0\right\} \quad \text{(13)}$$

Where,

$LE_{LFT,y}$ = Leakage emissions due to change of load factor of taxis in the year y (tCO_2)
$N_{T,y}$ = Number of baseline taxis in the year y (taxis)
AD_T = Average annual distance driven per taxi (km/taxi)
$EF_{KM,T,y}$ = Emission factor per kilometre of taxis in the year y (g CO_2/km)
$OC_{T,y}$ = Average occupancy rate of taxis in the year y (passengers)
OC_T = Average baseline occupancy rate of taxis prior project start (passengers)
y = Year of the crediting period

The maximum load factor change attributed to taxis is the emission reductions due to passengers switching from taxis to the project (calculated by the emission factor per passenger-kilometre for taxis, the trip distance and the number of passengers transported by the project, which would have used taxis in absence of the project). This maximum condition is established as load factors might worsen citywide also due to factors external to the project and leakage from a load factor change taxis due to the project can at maximum be according to the number of passengers transported by the project who in absence of latter would have taken a taxi.

For the purpose of determining the occupancy rate of taxis, the study method of visual occupancy would be chosen. The monitoring method will be used for the entire project monitoring period.

The parameter emission factor per kilometre of baseline taxis in the year y ($EF_{KM,T,y}$) is calculated using the equation for $EF_{KM,i,y}$ presented in the tool "Baseline emissions for modal shift measures in urban passenger transport" section, substituting i for T (taxis).

Determination of emissions due to reduced congestion ($LE_{CON,y}$)

The project activity may reduce the number of remaining buses and potentially other vehicles on roads used by mixed traffic and thus also congestion. It is not possible however to determine ex ante if this effect will result in positive leakage emissions (i.e. emissions increase) or negative leakage emissions (i.e. emissions reductions). Two effects resulting from reduced congestion are considered:

- Induced traffic effect (or rebound effect), i.e. more trips of passenger cars on the affected roads.
- Changes in vehicle speed effect, i.e. change of emissions due to reduced or increased speed of cars on affected roads.

In the case that the implementation of the project activity leads to a reduction of road capacity available for individual motorised transport modes, the impact of changes in congestion shall be monitored in the year 1 and 4 of the crediting period. In other cases (e.g. the project provides a new road infrastructure not taken from the existing road space in the city), monitoring of these changes is not required. This change in road capacity available for individual motorised transport modes may result from the reduction of road space due to the implementation of MRTS and/or a potential reduction of traffic flow due to the withdrawal of conventional public transport units as a result of the project activity.

To determine whether road capacity is reduced, the following procedure shall be applied:

Determination of the additional road capacity available to motorised transport modes

The following equation determines the additional road capacity, available to the transport modes remaining in operation, as a result of the implementation of project activity in the year when the project MRTS is intended to reach its planned capacity:

$$ARS_y = \sum_y \frac{BSCR_y}{N_B} \times SRS - \frac{RS_{BL} - RS_{PJ}}{RS_{BL}} \quad (14)$$

Where,

ARS_y	=	Additional road capacity available to individual motorised transport modes in year y when the project MRTS is intended to reach its planned capacity (in percentage)
$BSCR_y$	=	Bus units retired as a result of the project in year y
N_B	=	Number of buses in use in year x
SRS	=	Share of road space used by public transport in the year x (in percentage)
RS_{BL}	=	Total road space available in year x (lane-kilometres)
RS_{PJ}	=	Total available road space in the project (= RSB minus kilometre of lanes that where reduced due to dedicating bus lanes to the project activity) (lane-kilometres)
x	=	Most recent calendar year for which data is available. Data not older than three years.

The following equation shall be used to determine SRS if no recent and good quality study is available which has calculated this parameter:

$$SRS = \frac{TD_B \times 2.5}{TD_B \times 2.5 + TD_T + TD_C} \quad (15)$$

Where:

SRS	=	Share of road space used by public transport in year x (in percentage)
TD_B	=	Total distance driven by public transport buses in year x (kilometres)
TD_T	=	Total distance driven in kilometres by taxis in year x (kilometres)
TD_C	=	Total distance driven in by passenger cars in year x (kilometres)
x	=	Most recent calendar year for which data is available. Data not older than three years.

It is assumed that one bus occupies 2.5 times more road space than a personal car or a taxi. For all distance variables, the same vintage of data, the same spatial scope and the same time-span (e.g., one month or one year) is required.

If ARS_y is negative, leakage emissions due to increased congestion, as a result of the reduced road capacity due to the project activity, shall be quantified as per the calculation of $LE_{CON,Y}$. If ARS_y is positive, $LE_{CON,y}$ is assumed to be zero.

Emission Reductions:

Emissions reductions are calculated as:

$ERy = BEy – Pey + LEy$ (16)

Where:

ERy = Emissions reductions in year y (tCO_2)

BEy = Baseline emissions in year y (tCO_2)

PEy = Project emissions in year y (tCO_2)

LEy = Leakage emissions in year y (tCO_2)

Year	Baseline emissions (t CO_{2e})	Project emissions (t CO_{2e})	Leakage (t CO_{2e})	Emission reductions (t CO_{2e})
2023	3,80,092	2,05,804	0	1,74,287
2024	3,90,129	2,09,917	0	1,80,212
2025	3,97,817	2,12,814	0	1,85,003
2026	4,06,357	2,16,264	0	1,90,093
2027	4,14,686	2,19,695	0	1,94,991
2028	4,23,967	2,23,719	0	2,00,248
2029	4,30,727	2,26,501	0	2,04,226
2030	4,38,444	2,29,875	0	2,08,569
2031	4,45,964	2,33,353	0	2,12,611
2032	4,54,532	2,37,357	0	2,17,175
Total number	10			

of crediting years				
Total	**41,82,715**	**22,15,299**	**0**	**19,67,416**

B.6. Prior History>>

The project activity has not applied to any other GHG program for generation or issuance of carbon offsets or credits for the said crediting period.

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 >>

ACM0016 - "Mass Rapid Transit Projects", Version 04.0.0, EB 85
Version 4 has been applied as the baseline has been sourced from "DMRC's CDM PoA 9863 & its associated CPA003: Inclusion of Mumbai Metro Rail Corporation Limited Colaba-Bandra-Seepz corridor under MRTS POA (9863-P1-0003-CP1)" and the baseline is alike in the proposed UCR project. Therefore, to make consistent terminologies/equations/baseline the version 4 of the methodology is preferred.

B.9. Monitoring period number and duration>>

First Issuance Period: 10 years, 0 months – 01/01/2023 to 31/12/2032

B.8. Monitoring plan>>

Ex ante calculation of emission reductions

Data / Parameter	**OC_B**
Unit	Passengers
Description	Average occupation rate of buses
Source of data	DPR- MMRCL
Value(s) applied	40 (80% of 50 as per Tool 18 of UNFCCC) The global default value that can be applied is 80% as per the methodological tool: Baseline emissions for modal shift measures in urban passenger transport.
Choice of data or Measurement methods and procedures	Data obtained from the MMRCL DPR.
Purpose of data	To estimate baseline emissions
Additional comment	

Data / Parameter	**OC_C**
Unit	Passengers
Description	Average occupation rate of passenger cars
Source of data	Survey Report dated July 2017
Value(s) applied	1.7

Choice of data or Measurement methods and procedures	Data based on baseline survey carried out. The survey was realised through visual occupation studies as per Annex 1 of ACM0016
Purpose of data **Additional comment**	To calculate baseline emissions N/A

Data / Parameter	**OC_T**
Unit	Passengers
Description	Average occupation rate of taxis
Source of data	Survey Report dated July 2017
Value(s) applied	1.9
Choice of data or Measurement methods and procedures	Data based on baseline survey carried out. The survey was realized through visual occupation studies as per Annex 1 of ACM0016
Purpose of data	To calculate baseline emissions
Additional comment	

Data / Parameter	**OC_M**
Unit	Passengers
Description	Average occupation rate of motorcycles/ two wheelers
Source of data	Survey Report dated July 2017
Value(s) applied	1.3
Choice of data or Measurement methods and procedures	Data based on baseline survey carried out. The survey was realized through visual occupation studies as per Annex 1 of ACM0016
Purpose of data	To calculate baseline emissions
Additional comment	

Data / Parameter	**OC_{MR}**
Unit	Passengers
Description	Average occupation rate of motorized auto-rickshaws
Source of data	Survey Report dated July 2017
Value(s) applied	1.4
Choice of data or Measurement methods and procedures	Data based on baseline survey carried out. The survey was realized through visual occupation studies as per Annex 1 of ACM0016
Purpose of data	To calculate baseline emissions

Additional comment	The auto rickshaw driver is not counted in the occupancy survey. The parameter is also monitored for leakage estimations.

Data / Parameter	**$SFC_{C, G}$**
Unit	Litre/ km
Description	Specific fuel consumption of passenger cars using gasoline
Source of data	Survey Report dated July 2017
Value(s) applied	For baseline emission estimation: 0.0693 For project emission estimation: 0.0678 Globally acceptable default values as per methodology is 0.06 L/Km
Choice of data or Measurement methods and procedures	Measurement of fuel consumption data using representative sample. Survey realized using upper 95% confidence interval. The minimum sample size was determined at 1% desired level of error,95% confidence level and 1.96 critical value. Lower boundary value has been considered for baseline estimations and Upper boundary used for estimating indirect project emissions.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	**$SFC_{C,D}$**
Unit	Litre/ km
Description	Specific fuel consumption of passenger cars diesel
Source of data	Survey Report dated July 2017
Value(s) applied	For baseline emission estimation: 0.073 For project emission estimation: 0.057
Choice of data or Measurement methods and procedures	Measurement of fuel consumption data using representative sample. Survey realized using upper 95% confidence interval. The minimum sample size was determined at 1% desired level of error, 95% confidence level and 1.96 critical value. Lower boundary value has been considered for baseline estimations and Upper boundary used for estimating indirect project emissions.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	**$SFC_{C,CNG}$**
Unit	kg/ km
Description	Specific fuel consumption of passenger cars using CNG
Source of data	Survey Report dated July 2017
Value(s) applied	For baseline emission estimation: 0.056 For project emission estimation: 0.054

Choice of data or Measurement methods and procedures	Measurement of fuel consumption data using representative sample. Survey realized using upper 95% confidence interval. The minimum sample size was determined at 1% desired level of error,95% confidence level and 1.96 critical value. Lower boundary value has been considered for baseline estimations and Upper boundary used for estimating indirect project emissions.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	**$SFC_{T,CNG}$**
Unit	kg/ km
Description	Specific fuel consumption of taxis using CNG
Source of data	Survey Report dated July 2017
Value(s) applied	For baseline emission estimation: 0.049 For project emission estimation: 0.048
Choice of data or Measurement methods and procedures	Measurement of fuel consumption data using representative sample. Survey realized using upper 95% confidence interval. The minimum sample size was determined at 1% desired level of error,95% confidence level and 1.96 critical value. Lower boundary value has been considered for baseline estimations and Upper boundary used for estimating indirect project emissions.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	**$SFC_{T,D}$**
Unit	Ltr/km
Description	Specific fuel consumption of taxis using Diesel
Source of data	Globally applicable default values
Value(s) applied	0.05
Choice of data or Measurement methods and procedures	The global default value is applied as per the Methodological Tool: Baseline emissions for modal shift measures in urban passenger transport.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	**$SFC_{B,CNG}$**
Unit	kg/km
Description	Specific fuel consumption of buses
Source of data	Delhi Transport Corporation (DTC), 2012
Value(s) applied	0.382

Choice of data or Measurement methods and procedures	Delhi Transport Corporation (DTC)
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	**$SFC_{B,D}$**
Unit	Litre/km
Description	Specific fuel consumption of buses
Source of data	DPR- MMRCL
Value(s) applied	Fuel Consumption of buses: 0.279
Choice of data or Measurement methods and procedures	Data obtained from MMRCL DPR.
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	**$SFC_{MR.CNG}$**
Unit	kg/km
Description	Specific fuel consumed by motorized auto-rickshaws using CNG
Source of data	Survey Report dated July 2017
Value(s) applied	For baseline emission estimation: 0.0302 For project emission estimation: 0.0299
Choice of data or Measurement methods and procedures	Measurement of fuel consumption data using representative sample. Survey realized using upper 95% confidence interval. The minimum sample size was determined at 1% desired level of error, 95% confidence level and 1.96 critical value. Lower boundary value has been considered for baseline estimations and Upper boundary used for estimating indirect project emissions.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter:	**AD_B**
Data Unit:	Kms/bus
Description:	Average annual distance driven by baseline buses
Source of data:	RTO Data
Value(s) applied:	63,300 km
Choice of data or Measurement methods and procedures:	MMRCL DPR
Purpose of data:	To calculate leakage emissions
Additional comment:	

Data / Parameter:	**AD_T**
Data Unit:	Kms/taxi
Description:	Average annual distance driven by baseline taxis
Source of data:	RTO Data
Value(s) applied:	30,000 km
Choice of data or Measurement methods and procedures :	MMRCL DPR
Purpose of data:	To calculate leakage emissions
Additional comment:	

Data / Parameter:	**N_B**
Data unit:	Number
Description:	Number of buses circulating in the city
Source of data:	VAHAAN Database
Value(s) applied	180
Measurement methods and procedures:	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Monitoring frequency:	Once during the year 1 and 4 of the crediting period
QA/QC procedures:	The parameter is proposed to be taken from official sources; hence, QA/QC is not under the control of project proponent.
Purpose of data	To calculate baseline emissions
Additional comment:	

Data / Parameter	**$N_{B,CNG}$**
Unit	Number
Description	Number of bus using CNG
Source of data	VAHAAN Database
Value(s) applied	108 (60%)
Choice of data or Measurement methods and procedures	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	**$N_{B,D}$**
Unit	Number
Description	Number of bus using Diesel
Source of data	VAHAAN Database
Value(s) applied	72 (40%)
Choice of data or Measurement methods and procedures	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter:	**N_T**
Data unit:	Number
Description:	Number of taxis circulating in the city
Source of data:	VAHAAN Database
Value(s) applied	2,126

Measurement methods and procedures:	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Monitoring frequency:	Once during the year 1 and 4 of the crediting period
QA/QC procedures:	The parameter is proposed to be taken from official sources; hence, QA/QC is not under the control of project proponent.
Purpose of data	To calculate baseline emissions
Additional comment:	

Data / Parameter	$N_{T,CNG}$
Unit	Number
Description	Number of taxis using CNG
Source of data	VAHAAN Database
Value(s) applied	1,871 (88%)
Choice of data or Measurement methods and procedures	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	$N_{T,D}$
Unit	Number
Description	Number of taxis using Diesel
Source of data	VAHAAN Database
Value(s) applied	255 (12%)
Choice of data or Measurement methods and procedures	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter:	N_{MR}
Data unit:	Number
Description:	Number of motorized rickshaws circulating in the city
Source of data:	VAHAAN Database
Value(s) applied	1,059
Measurement methods and procedures:	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Monitoring frequency:	Once during the year 1 and 4 of the crediting period
QA/QC procedures:	The parameter is proposed to be taken from official sources; hence, QA/QC is not under the control of project proponent.
Purpose of data	To calculate baseline emissions
Additional comment:	

Data / Parameter	$N_{MR,CNG}$
Unit	%
Description	Percentage of motorized auto-rickshaws using CNG
Source of data	VAHAAN Database
Value(s) applied	1,059 (100%)

Choice of data or Measurement methods and procedures	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter:	N_M
Data unit:	Number
Description:	Number of motorcycles/scooters circulating in the city
Source of data:	VAHAAN Database
Value(s) applied	89,444
Measurement methods and procedures:	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Monitoring frequency:	Once during the year 1 and 4 of the crediting period
QA/QC procedures:	The parameter is proposed to be taken from official sources; hence, QA/QC is not under the control of project proponent.
Purpose of data	To calculate baseline emissions
Additional comment:	

Data / Parameter:	N_C
Data unit:	Number
Description:	Number of cars circulating in the city
Source of data:	VAHAAN Database
Value(s) applied	38,295
Choice of Data Or Measurement methods and procedures:	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Monitoring frequency:	Once during the year 1 and 4 of the crediting period
QA/QC procedures:	The parameter is proposed to be taken from official sources; hence, QA/QC is not under the control of project proponent.
Purpose of data	To calculate baseline emissions
Additional comment:	

Data / Parameter	$N_{M, gasoline}$
Unit	Number
Description	Number of motorcycles using gasoline
Source of data	VAHAAN Database
Value(s) applied	89,444 (100%)
Choice of data or Measurement methods and procedures	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	$N_{C, gasoline}$
Unit	Number
Description	Number of cars using gasoline
Source of data	VAHAAN Database
Value(s) applied	25,658 (67%)
Choice of data or Measurement methods and procedures	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	$N_{C, diesel}$
Unit	Number
Description	Number of cars using diesel
Source of data	VAHAAN Database
Value(s) applied	7,276 (19%)
Choice of data or Measurement methods and procedures	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	$N_{C, CNG}$
Unit	Number
Description	Number of cars using CNG
Source of data	VAHAAN Database
Value(s) applied	5,361 (14%)
Choice of data or Measurement methods and procedures	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	$SFC_{M, Gasoline}$
Unit	Ltr/km
Description	Specific fuel consumed by motorized two wheelers using gasoline
Source of data	Survey Report dated July 2017
Value(s) applied	For baseline emission estimation: 0.022 For project emission estimation: 0.021 Globally acceptable default values as per methodology is 0.02 L/Km
Choice of data or Measurement methods and procedures	Survey realized using upper 95% confidence interval. Measurement of fuel consumption data using representative sample. Survey realized using upper 95% confidence interval. Lower boundary value has been considered for baseline estimations and Upper boundary used for estimating indirect project emissions.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	$DE_{EL,i,x}$
Unit	Km
Description	Average trip distance travelled by passengers using electricity-based vehicle category *i* in year x
Source of data	Official statistics or data obtained from the system operator.
Value(s) applied	23.8
Choice of data or Measurement methods and procedures	Based, in general, on electronic ticketing system or on surveys
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	Only rail trip distance, not total trip distance

Data / Parameter	**$SEC_{i,x}$**
Data Unit	kWh/km
Description	Specific electricity consumption of vehicle category i using electricity in year x
Source of data	. In decreasing order of preference: 1. Local measured data (studies, e.g. performed by universities, other institutions or ordered by project proponent); 2. National or international data from studies; 3. IPCC default values for the respective vehicle categories (latest IPCC report) 4. Design data for relevant vehicle categories Globally applicable default values (See table 2 below)
Value(s) applied	Default value- 0.12 kWh/Km
Choice of data or Measurement methods and procedures	The following alternatives are proposed to determine specific electricity consumption (in order of preference). In case one of the alternatives does not provide required value for all categories, the combination of these alternatives can be used and justification for the use of combination should be provided. Alternative 1: Measurement of electricity consumption data using total data (if available e.g. from bus or taxi companies) or a representative sample for the respective category. Sampling per category should include, as core characteristics, vehicle age and technology to ensure that the sample is as close as possible to the actual vehicle composition in the urban area(s) of the region for which the baseline is established. To be conservative, specific electricity consumptions based on samples shall be based on the lower limit of the uncertainty band at a 95 per cent confidence level. Alternative 2: Use of fixed values based on national or international literature. The literature data can either be based on measurements of similar vehicles in comparable surroundings (e.g. from comparable cities of other countries) or may include identifying the vehicle age and technology of average vehicles circulating in the urban area(s) of the region for which the baseline is established and then matching this with the most appropriate IPCC default values. The most important proxy to identify vehicle technologies is the average age of vehicles used in the urban area(s) of the region for which the baseline is established, to determine whether either of US, Japanese or European default factors apply or local vehicle manufacturer information can be used (in the case of having a substantial domestic vehicle motor industry or source of origin of vehicle imports). Alternative 3: latest IPCC default values reported matching the respective vehicle category, age, vehicle origin and technology. Alternative 4. Design data for relevant vehicle categories. Alternative 5. Globally applicable default value of 0.12 kWh/Km
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

<table>
<tr><td>Data / Parameter</td><td colspan="3">N_i</td></tr>
<tr><td>Data Unit</td><td colspan="3">Vehicles</td></tr>
<tr><td>Description</td><td colspan="3">Number of vehicles of category i prior to the project start</td></tr>
<tr><td>Source of data</td><td colspan="3">Municipal transit authorities based on vehicle registration statistics from the respective city or data from vehicle control stations (technical and emission control stations). If no city/municipal data is available, regional data (canton, state) or, as a last option, national data can be used. Vintage maximum 3 years.</td></tr>
<tr><td rowspan="9">Value(s) applied</td><td colspan="3">Registered Vehicles for the year 2021</td></tr>
<tr><td>S. No.</td><td>Type of Vehicle</td><td>Total No. of vehicles</td></tr>
<tr><td>1</td><td>2 wheeler</td><td>89,444</td></tr>
<tr><td>2</td><td>Auto</td><td>1,059</td></tr>
<tr><td>3</td><td>Taxi</td><td>2,126</td></tr>
<tr><td>4</td><td>Car</td><td>38,295</td></tr>
<tr><td>5</td><td>Bus</td><td>180</td></tr>
<tr><td colspan="2">Total</td><td>1,31,104</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Choice of data
or
Measurement methods and procedures</td><td colspan="3">Used for all vehicle categories included in the project for the year 2021.</td></tr>
<tr><td>Purpose of data</td><td colspan="3">To calculate baseline and indirect project emission</td></tr>
<tr><td>Additional comment</td><td colspan="3"></td></tr>
</table>

Data / Parameter	$N_{x,i}$
Data Unit	Dimensionless
Description	Number of vehicles in vehicle category i using fuel type x prior to the project start. In general, B stands for buses, T stands for taxis, MR for motorised auto-rickshaws, etc.
Source of data	Municipal transit authorities based on vehicle registration statistics from the respective city or data from vehicle control stations (technical and emission control stations). If no city/municipal data is available, regional data (canton, state) or, as a last option, national data can be used. Vintage maximum 3 years
Value(s) applied	

Type of Vehicle	Fuel type	Total no. of vehicles
2-wheeler	Petrol	89,444
Auto	CNG	1,059
Taxi	CNG	1,871
	Diesel	255
Car	Petrol	25,658
	Diesel	7,726
	CNG	5,361
Bus	CNG	108
	Diesel	72

Choice of data or Measurement methods and procedures	The data considered from the official/public sources of information for the year 2021 (prior to project in operation).
Purpose of data	To calculate baseline and indirect project emissions
Additional comment	

Data/Parameter	$N_{i,n,x}/N_{i,x}$
Data unit	Percentage or share
Description	Percentage or share of vehicles in vehicle category i using fuel type n in year x
Source of data	National transport statistics based on vehicle registration statistics for the year 2021
Value(s) applied	

Vehicle Type	Petrol	Diesel	CNG	Total
4W Car	67	19	14	100
4W Taxi	-	12	88	100
2 W	100	-	-	100
3W	-	-	100	100
Bus	-	40	60	100

Measurement procedures (if any)	For buses it should be based on urban units as urban buses often use a different fuel type than inter-urban units
Purpose of data	To calculate baseline and indirect project emissions
Additional comment	Used for all relevant vehicle categories

Data / Parameter	IR_i
Data unit	-
Description	Technology improvement factor for vehicle category i per year
Source of data	-
Value(s) applied	0.99
Measurement procedures (if any)	When the tool is used for estimating baseline emissions, the default technology improvement factor is 0.99 for all vehicle categories;
Purpose of data	To calculate baseline and indirect project emissions
Additional comment	-

Data and parameters to be monitored:

Data / Parameter	$EF_{Grid,CM}$
Unit	tCO_2/MWh
Description	Combined emission factor of the regional grid
Source of data	CEA Database Version 20.0
Value(s) applied	Indian Grid: 0.919
Choice of data or Measurement methods and procedures	The value shall be monitored at project level and as per CEA Database
Purpose of data	To calculate project emissions
Additional comment	Combined margin emission factor considered.

Data / Parameter	$TE_{EL,i,y}$
Unit	tCO_2
Description	Total emissions from the electricity-based rail system in year *y*
Source of data	Rail operator for electricity consumption and as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption
Value(s) applied	NA
Measurement methods and procedures	Calculated as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
Monitoring frequency	Annually
QA/QC procedures	Data will be archived for a period of 2 years after the end of crediting period or last issuance whichever is later.
Purpose of data	To calculate project emissions
Additional comment	When applying the tool, the parameter $EC_{BL,k,y}$ in the tool should be taken as the amount of electricity used by the electricity-based rail system.

Data / Parameter	$EC_{pj, y}$
Data Unit	MWh
Description	Electricity consumed by project activity vehicles
Source of data	MMMOCL Operations and maintenance wing, Traction
Value(s) applied	

Year	Traction Energy
2023	1,77,260
2024	1,80,468
2025	1,82,689
2026	1,85,404
2027	1,88,118
2028	1,91,355
2029	1,93,547
2030	1,96,262
2031	1,99,104
2032	2,02,389

Measurement methods and procedures	The project's traction energy consumption will be recorded through meters and maintained by rail operator. This is read every month by officials under O&M wing, Traction.
Monitoring frequency	Annually
QA/QC procedures	The data will be measured continuously using meters of accuracy of at least 0.2 (0.2%). The data can be cross-checked against the daily/monthly logbook records. Data will be archived for a period of 2 years after the end of crediting period or last issuance whichever is later. In case the meters are changed for calibration or due to maintenance need the change in meter will be properly documented in history card. Calibration of meters will be done once in 2 years.
Purpose of data	To calculate $TE_{EL,i,y}$; (Total emissions from the electricity-based rail system in year y) for project emissions
Additional comment	Used for MRTS with rail-based systems using electricity. The traction energy will be recorded at RSS level. In case one RSS supplies energy to non-project lines then the traction energy will be divided accordingly among the project line and non-project line.

Data / Parameter	TDL_y
Unit	%
Description	Average technical transmission and distribution losses for Maharashtra
Source of data	Maharashtra State Electricity Transmission Co. Ltd.
Value(s) applied	

Year	TDL
2023	3.27%
2024	3.30%
2025	3.30%
2026	3.30%
2027	3.30%
2028	3.30%
2029	3.30%
2030	3.30%

		2031	3.30%	
		2032	3.30%	
Measurement methods and procedures	Publicly available information			
Monitoring frequency	Annually			
QA/QC procedures	Data will be archived for a period of 2 years after the end of crediting period or last issuance whichever is later.			
Purpose of data	To calculate project emissions			
Additional comment				

Data / Parameter	**$TE_{Total\text{-}RSS,\,y}$**
Unit	MWh
Description	Total traction energy recorded at RSS level
Source of data	MMMOCL Operations and maintenance wing, Traction
Value(s) applied	NA
Measurement methods and procedures	The total traction energy is recorded in traction meters installed at RSS. This is read every month by MMMOCL officials under O&M wing, Traction.
Monitoring frequency	Annually
QA/QC procedures	The data will be measured continuously using meters of accuracy of atleast 0.2 (0.2%) The data can be cross-checked against the daily/monthly logbook records. Data will be archived for a period of 2 years after the end of crediting period or last issuance whichever is later. In case the meters are changed for calibration or due to maintenance need the change in meter will be properly documented in history card Calibration of meters will be done once in 2 years.
Purpose of data	To calculate direct project emissions and traction energy consumed by MRTS line, TE_{CPA}.
Additional comment	Used for MRTS with rail-based systems using electricity. The traction energy will be recorded at RSS level. In case one RSS supplies energy to non-project lines then the traction energy will be divided accordingly among the project line and non-project line

Data / Parameter	**Car-km$_{CPA-MRTS,y}$**
Unit	km
Description	Car-km of CPA MRTS line in year *y*
Source of data	MMMOCL Operations control center morning position report
Value(s) applied	NA
Measurement methods and procedures	The distance between stations under project activity is fixed and the time-table is fixed for specific days in general with any minute changes recorded. Based on the time table, total car km run would be recorded annually
Monitoring frequency	Annually
QA/QC procedures	Data will be archived for a period of 2 years after the end of crediting period or last issuance whichever is later.
Purpose of data	To calculate direct project emissions and traction energy consumed by MRTS line, TE_{CPA}.
Additional comment	

Data / Parameter	**Car-km$_{RSS-Total,y}$**
Unit	km
Description	Total car-km supplied traction energy by the RSS
Source of data	MMMOCL Operations control Centre morning position report
Value(s) applied	NA
Measurement methods and procedures	The distance between stations is fixed and the time table is fixed for specific days in general with any minute changes recorded. Based on the time table, total car km run would be recorded daily and aggregated annually
Monitoring frequency	Annually
QA/QC procedures	Data will be archived for a period of 2 years after the end of crediting period or last issuance whichever is later.
Purpose of data	To calculate direct project emissions and traction energy consumed by MRTS line, TE_{CPA}.
Additional comment	

Data / Parameter	$NCV_{g,d,y}$
Unit	MJ/kg
Description	Net calorific value of gasoline and diesel in year y
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 Guidelines on National GHG Inventories
Value(s) applied	Diesel: 43 Gasoline (petrol): 44.3
Measurement methods and procedures	Default values should be used
Monitoring frequency	Any future revision of the IPCC Guidelines should be taken into account
QA/QC procedures	-
Purpose of data	To calculate baseline and project emissions
Additional comment	

Data / Parameter	$NCV_{cng,y}$
Unit	MJ/kg
Description	Net calorific value of CNG in year y
Source of data	PPAC Reports
Value(s) applied	40.2
Measurement methods and procedures	The data will be considered from published sources of local/national sources. If available, the data from CNG suppliers/distributors of the city will be obtained for the purpose.
Monitoring frequency	Annually
QA/QC procedures	The values will be taken from official/published sources for the fuels during the monitoring period. However, if the values are considered based on measurement method, the values will be verified, if the values are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall outside this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements.
Purpose of data	To calculate baseline and project emissions
Additional comment	

Data / Parameter	$EF_{CO2,g,d,cng,y}$
Unit	gCO_2/MJ
Description	CO_2 emission factor for gasoline, diesel and CNG in year y
Source of data	IPCC default values at the lower limit (for baseline) and upper limit (for project) of the uncertainty at a 95% confidence interval as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value(s) applied	For baseline estimations: Gasoline: 67.5 Diesel: 72.6 CNG: 54.3 For project emissions estimations: Gasoline: 73 Diesel: 74.80 CNG: 58.30
Measurement methods and procedures	Default values should be used
Monitoring frequency	Any future revision of the IPCC Guidelines should be taken into account
QA/QC procedures	No QA/QC required since default values would be used
Purpose of data	To calculate baseline and project emissions
Additional comment	

Data / Parameter	$OC_{B,y}/OC_{T,y}/OC_{MR,y}$
Unit	Passengers
Description	Average occupation rate of vehicle category *i* in year *y*. In particular, B stands for buses, and T for taxis
Source of data	MMRCL DPR and Survey Report dated July 2017
Value(s) applied	Buses: 40 (80% of 50 as per Tool 18 of UNFCCC) Taxis: 1.9 Motorized Auto-Rickshaw: 1.4
Measurement methods and procedures	Based on visual occupation studies for all vehicle categories. For buses the occupation rate is based on visual occupation studies with expansion factors for routes served to determine the average occupation rate along the entire route. For taxis and motorized auto-rickshaws, the driver should not be counted.
Monitoring frequency	Studies conducted in years 1 and 4 of the crediting period
QA/QC procedures	-
Purpose of data	To calculate leakage emissions
Additional comment	-

Data / Parameter	P_y
Unit	Passengers
Description	Total passengers transported by the project activity transport system
Source of data	MMMOCL
Value(s) applied	2023: 36,67,23,530 2024: 38,02,09,950 2025: 39,16,18,720 2026: 40,40,66,315 2027: 41,65,13,910 2028: 43,01,36,742 2029: 44,14,09,100 2030: 45,38,56,695 2031: 46,63,03,925 2032: 48,00,63,131
Measurement methods and procedures	OD matrix report generated by Automatic Fare Collection System. The automatic fare collection system tracks the entry of each passenger through smart media unique ID and generates an OD Matrix at the end of the day This report contains entry of MMMOCL stations falling under project boundary. Report is generated at the end of day at Operation control Centre (OCC) and not at the station.
Monitoring frequency	Frequency: Continuously monitored and aggregated annually.
QA/QC procedures	The real data for the entire year can be verified by PDF files generated daily at OCC level. Live data for a vintage of 15 days would be available at OCC level.
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	The passenger flow will be monitored for individual stations. In case of interlocking stations which supply passengers to non-project lines, the number of passengers will be divided accordingly, for example, if there are two lines interlocking in a station, then passengers will be distributed in the proportion 50:50. The annual passenger for the monitoring period shall be the total number of passengers using the project line. This includes all the passengers that enter project line through project stations as well as stations outside project line.

Data / Parameter	$N_{i,y}$/ $N_{B,y}$/$N_{T,y}$/$N_{MR,Y}$
Data Unit	Number of vehicles ((Buses, Taxis, Motorized Rickshaws)
Description	Number of vehicles of vehicle category i circulating in the larger urban zone of the city. In particular B stands for buses, and T for taxis, MR for motorised auto-rickshaw, etc.
Source of Data	RTO/VAHAAN Database
Value(s) applied	NA
Measurement methods and procedures	The data will be considered from the official/public sources of information.
Monitoring frequency	Studies conducted in years 1 and 4 of the crediting period
QA/QC procedures	NA
Purpose of data	To calculate baseline emissions
Additional Comments	

Data / Parameter:	$P_{EL,i,,y}$
Data unit:	Passengers
Description:	Total passengers transported by baseline rail-system per year in the year *y*
Source of data:	Indian railways annual statistical statement 2023-24
Value(s) applied	NA
Measurement methods and procedures:	Based in general on turnpike or electronic ticketing system; Cross check with ticket sales possible in some cases
Monitoring frequency:	Frequency: annually
QA/QC procedures:	The parameter is proposed to be taken from official sources; hence, QA/QC is not under the control of project proponent.
Purpose of data	To calculate baseline emissions
Additional comment:	Only required in case baseline rail systems operates in the urban zone covered by project MRTS

Description of the monitoring plan:

A survey has been conducted once in the years 1 and 4 of the crediting period during an entire week plus one re-test (for MRTS survey) in the year 1 only. To guarantee that there is no seasonality, and if there was, the way in which it would be approached, the following steps will be taken:

a. In the first year and while the system is stabilized, a single measurement has been taken and a second measurement had been carried out in a later period (test-retest method), with a sample size of less than half of the initial survey;
b. With the passenger flows data of the first year, and with the comparison between the first survey and the test-retest, it is defined if there is any seasonality degree in the year. If there is evidence of the same, within each period where there are apparent differences, independent surveys are performed and at the end, the results are compared regarding the emissions difference and the parameters on the use of modes of transport and the average travel distance;
c. If there are no significant differences between the analysis periods, the measurements of later years will be done only once a year, on the contrary, they will be carried out in the periods in which seasonality is identified;
d. Independent from the result, at least one measurement in a whole week will always be performed in the years 4 and 7 of the crediting period, and the application of the test-retest method in the year 1. The two measurements in the year 1 are done in different periods, one in the first semester of the year and the other in the second semester.

In accordance with methodology, the criteria for identifying if there is any seasonality are the following one:

- A test of mean comparison is carried out between the data reported on the flow of passengers between months, and in the same way, within the weeks of each month;
- A further test consists in the application of a times series model SARIMA, where it is estimated if there is any seasonality degree in the passengers flows, either weekly or monthly. Through the functions of auto-correlation and partial auto-correlation, it is identified if there is any pattern in the data.

PP will employ a dedicated GHG department to monitor the progress of the projects and co-ordinate activities related to project.

Data storage and archiving

All the monitoring parameters under the monitoring plan would be kept for 2 years after the end of the crediting period or the last issuance of CoUs for this project activity, whichever is later. A copy of all the data will also be kept at CME head office in safe storage. The monitored data would be presented to the verification agency or DOE to whom verification of emission reductions is assigned. Necessary formats / tables / log sheets etc. would be developed by the project participants for monitoring and recording of the data and would be made part of the registered monitoring protocol.

Training and maintenance procedures

CME has trained the on-site staff on operation and maintenance of the MRTS and adherence to the Monitoring Plan of the project activity.