PROJECT CONCEPT NOTE

CARBON OFFSET UNIT (CoU) PROJECT

Title: Delhi Metro, India
Version 1.0
Date 29/09/2023
First CoU Issuance Period: 10 years, 0 months
Date: 01/01/2013 to 31/12/2022

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

BASIC INFORMATION	
Title of the project activity	Delhi Metro, India
Scale of the project activity	Large Scale
Completion date of the PCN	29/09/2023
Project participants	Delhi Metro Rail Corporation Limited (DMRC)
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	11,750,443 CoUs (11,750,443 tCO_2eq)

SECTION A. Description of project activity

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

Purpose of the project activity:

The objective of the large-scale project activity is to register 3 existing lines to a Delhi Metro system operational in NCT of Delhi under phase 1 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 Ph-I lines as part of project activity is 65.1 km.

The trains on these lines runs on broad gauge (1676 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 Delhi Metro, India Phase 1 MRTS project is located in Delhi.

The details of the Delhi Metro Phase-I are as follows:

1. Line 1: Shahdara – Rithala
   Network Length: 22 km

2. Line 2: Vishwavidyalaya - Central Secretariat
   Network Length: 11 km

3. Line 3: Dwarka Sector 9 – Indraprastha
   Network Length: 32.1 km

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

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

Social benefits:

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

Environmental benefits:

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

Economic benefits:

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

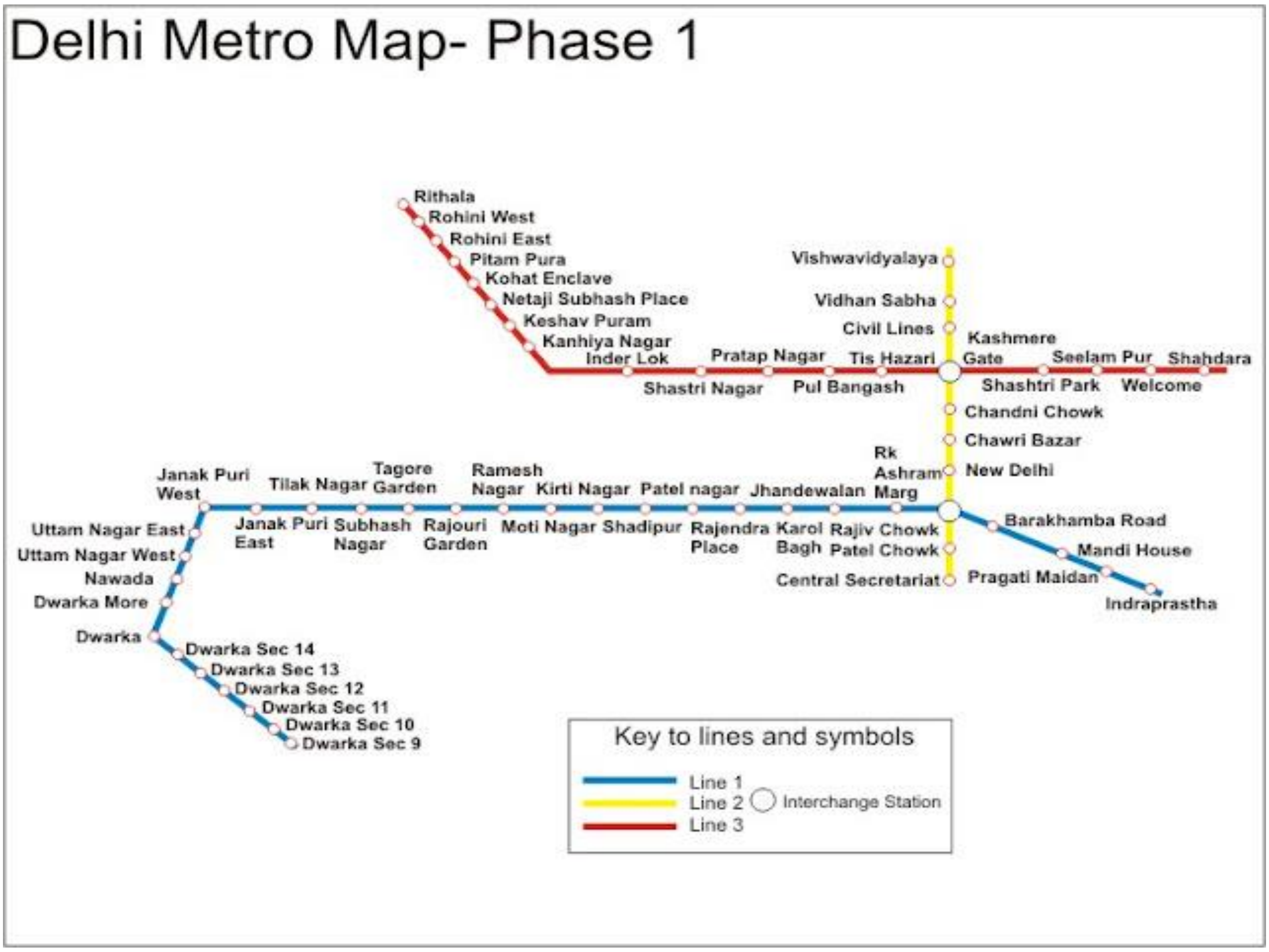
- The project will contribute to further economic development, as all the metro facilitate opportunity for the businesses by construction of shopping complexes to serve the passengers and nearby locality. Hence, the project ensures the economic wellbeing of the country.

A.3. Location of project activity >>

Country: India
State: New Delhi
Longitude[1]: 28° 38' 41.2800" N
Latitude: 77° 13' 0.1956" E

[1] https://www.latlong.net/place/new-delhi-delhi-india-2441.html


INDIA
State and Union Territories


Delhi Metro Map- Phase 1
Rithala
Rohini West
Rohini East
Pitam Pura
Kohat Enclave
Netaji Subhash Place
Keshav Puram
Kanhiya Nagar
Inder Lok
Shastri Nagar
Pratap Nagar
Pul Bangash
Tis Hazari
Vishwavidyalaya
Vidhan Sabha
Civil Lines
Kashmere Gate
Seelam Pur
Shahdara
Shashtri Park
Welcome
Chandni Chowk
Chawri Bazar
New Delhi
Rk Ashram Marg
Janak Puri West
Tilak Nagar
Tagore Garden
Ramesh Nagar
Kirti Nagar
Patel nagar
Jhandewalan
Janak Puri East
Subhash Nagar
Rajouri Garden
Moti Nagar
Shadipur
Rajendra Place
Karol Bagh
Rajiv Chowk
Patel Chowk
Central Secretariat
Barakhamba Road
Mandi House
Pragati Maidan
Indraprastha
Uttam Nagar East
Uttam Nagar West
Nawada
Dwarka More
Dwarka
Dwarka Sec 14
Dwarka Sec 13
Dwarka Sec 12
Dwarka Sec 11
Dwarka Sec 10
Dwarka Sec 9
Key to lines and symbols
Line 1
Line 2
Line 3
Interchange Station

A.4. Technologies/measures >>

The Delhi Metro Ph-I MRTS is a 65.1 km of transit system. The metro will run partially underground, partially at grade and partially elevated. Each train will have between 6 and 8 cars and will run frequencies between 3 and 12 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 and 8 car broad gauge train is approx. 2,240 and 3,000 passengers respectively. 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 and inside tunnels
- Normal ballasted tracks in depots

Based on the passenger forecasting study in the detailed project report (DPR), the project activity expects a ridership of 41,61,484 in the year 2013 to 53,52,903 in year 2022 for the lines covered in this project activity. 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 form 33kV power supply distribution system. Cables in tunnel will be of LSOH type while those in grade and elevated will be of HR PVC seat head type.

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: Delhi Metro Rail Corporation Limited (DMRC)

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. According to a report by Ministry of Road Transport & Highways, about 87 per cent passenger traffic is carried by road. According to the same report, easy availability, adaptability[2] Outcome Budget 2012-13; Ministry of Road Transport & Highways, Government of India to individual needs and the cost savings are some of the factors which go in favour of road transport. The number of vehicles has been growing at an average pace of around 10 per cent per annum. The share of road traffic in total traffic has grown from 15.4 per cent of passenger traffic in 1950-51 to an estimated 90.2 per cent of passenger traffic by the end of 2009-10. The rapid expansion and strengthening of the road network, therefore, is imperative, to provide for both present and future traffic and for improved accessibility to the hinterland. Thus, from the above description it is evident that the existing transport system is the most plausible baseline scenario for the proposed project activity.

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.

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.	

[2] Outcome Budget 2012-13; Ministry of Road Transport & Highways, Government of India

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
(Version 4 has been applied as the baseline has been sourced from the CDM PoA 9863 and the baseline is alike in the proposed UCR project. Therefore, to make consistent terminologies/equations/baseline the version 4 of methodology preferred.

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 project DPR of phase 1 of DMRC 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 condition apply:	**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 for different modes of transportation used by the passengers, Such as, gasoline for passenger cars and motorcycles, CNG for taxis, auto rickshaws and buses and diesel

S. No.	Applicability Condition under ACM0016, version 04	UCR Project meets the applicability conditions since
		for passenger cars. 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 Delhi. The purpose of metro line is to connect the various parts of Delhi NCR. 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 (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

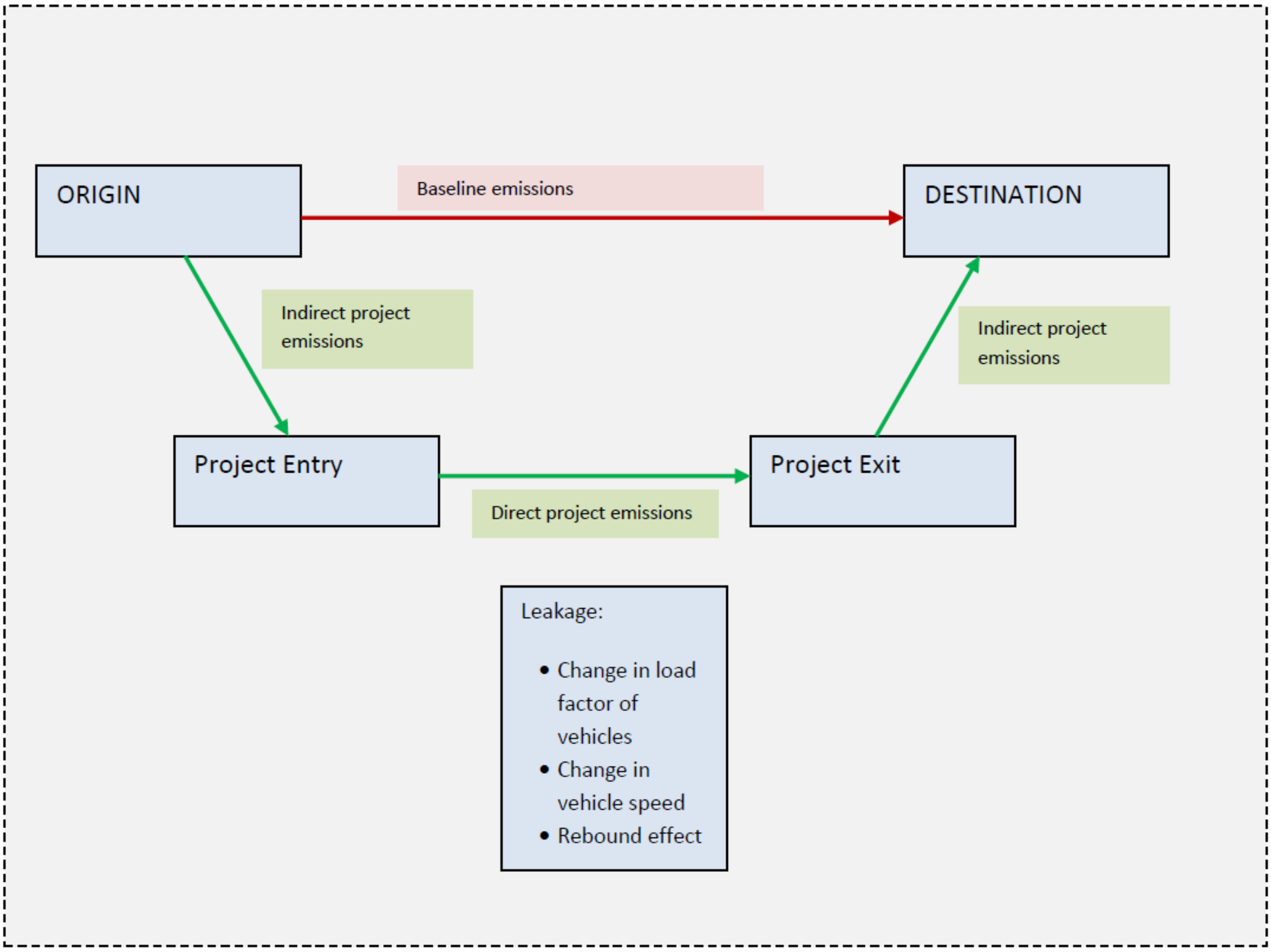
S. No.	Applicability Condition under ACM0016, version 04	UCR Project meets the applicability conditions since
		to 0.1kWh/pkm. This is demonstrated in ER spreadsheet. Notwithstanding that additionality demonstration is not a criteria under UCR scheme.
9.	**Applicability conditions under "Tool to calculate 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 phase 1 of the metro is part of UCR project activity and it is not part of any other GHG scheme. Therefore, the project does not come under double counting. The phase wise demarcation of DMRC project is well documented.

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

The project boundary includes the physical, geographical site(s) of the DMRC phase 1:



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 in Delhi Metro, 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:

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

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:

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

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, non-motorised transport and induced traffic have 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. BRT
3. Urban rail
4. Metro (non-project existing metro)
5. Taxi
6. Passenger cars;
7. Two-wheelers and Motorcycles;
8. Auto rickshaws (motorized)
9. Bicycle or per foot
10. 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 year x (km)
x	=	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:

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

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.

<u>Occupancy rate of taxis/motorcycles or passenger cars:</u>

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

The field data for taxi/motorcycles or passenger cars were also collected at all locations whereby simultaneously vehicular count was being carried out by separate data collectors. It was found that in all the locations (survey points), coverage of occupancy points has been higher than 95% of the vehicular count at those survey points.

Location: ITO	Vehicular count	Occupancy counts	Coverage percentage
Car	16108	15441	96%
Taxi	2390	2330	97%
Auto	13150	12662	98%
Two wheeler	21181	20637	97%

Location: Kalindi	Vehicular count	Occupancy counts	Coverage percentage
Car	30387	28945	95%
Taxi	15283	14738	96%
Auto	6153	6082	99%
Two wheeler	41482	39254	95%

Location: Kalka	Vehicular count	Occupancy counts	Coverage percentage
Car	66010	63245	96%
Taxi	6742	6488	96%
Auto	11456	11134	97%
Two wheeler	44088	42976	98%

Location: Dabri	Vehicular count	Occupancy counts	Coverage percentage
Car	38499	37449	97%
Taxi	4765	4567	96%
Auto	5848	5581	95%
Two wheeler	34885	34038	98%

Location: South-ex	Vehicular count	Occupancy counts	Coverage percentage
Car	53790	51110	95%
Taxi	7634	7335	96%
Auto	12729	12271	96%
Two wheeler	40411	38626	96%

Location: Akshar-dham	Vehicular count	Occupancy counts	Coverage percentage
Car	56624	53829	95%
Taxi	8069	7634	95%
Auto	8393	7134	95%
Two wheeler	38969	37530	96%

Location: Daryaganj	Vehicular count	Occupancy counts	Coverage percentage
Car	19266	18502	96%
Taxi	2287	2188	95%
Auto	13594	13288	98%
Two wheeler	25461	24654	98%

Location: GTK Depot	Vehicular count	Occupancy counts	Coverage percentage
Car	11959	11601	97%
Taxi	2344	2265	97%
Auto	4214	4214	97%
Two wheeler	20060	20060	98%

Location: Dhaula Kuan	Vehicular count	Occupancy counts	Coverage percentage
Car	40056	38906	97%
Taxi	12072	11550	96%
Auto	9488	9308	98%
Two-wheeler	26154	24804	95%

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:

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

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.

Determining baseline emissions based on the shares of passengers shifted from baseline vehicle categories i to the project urban public system(s) and an average trip distance on each relevant vehicle category. Baseline emissions are estimated as follows:

$$BE_y = \left(\sum_i (IR_i)^{t+y-1} \times EF_{PKM,i,x} \times D_i \times S_i \right) \times P_y \times 10^{-6} \qquad (6)$$

Where:

BE_y	=	Baseline emissions in year y (t CO_2eq)
IR_i	=	Technology improvement factor[5] for vehicle category i per year (ratio)
T	=	Time difference (in years) between the year for which data is available for vehicle category i and the year of establishing standardized baseline or start date of project in case the tool is used to determine baseline emissions of project
$EF_{PKM,i,x}$	=	Emission factor per passenger-kilometer for electricity-based or road-based vehicle category i in year x (g CO_2eq/PKM)
D_i	=	Average trip distance travelled by passengers who shifted from electricity-based or road-based vehicle category i (km)
P_y	=	Number of passengers travelled by the project system in year y
S_i	=	Share of passengers who shifted from electricity-based or road- based vehicle category i (%)
I	=	Vehicle categories (such as passenger car (C), bus (B), motorcycle (M) or rail based urban transit (R)
Y	=	Crediting year when emissions reductions are estimated

The share of passengers Si (%) out of total number of passengers using the project system who have shifted from electricity-based or road-based vehicle categories i to the urban public system(s) established as CDM project activities as well as an average trip distance on each relevant vehicle category Di,y are determined from a survey of the project system by the project developers.(Note: in case of the development of a standardized baseline this parameter remains project specific and, therefore, project proponents, not DNAs, should collect these data).

Surveys conducted in year 1 and year 4 of the first crediting period shall be used to determine: (i) the entry and exit stations for each surveyed passenger to determine the average trip distance on each relevant vehicle category Di,y (ii) the vehicle category from which each surveyed passenger had shifted to determine the share of passengers Si (%) out of total number of passengers using the project system who have shifted from each relevant vehicle category. The data from the survey in year 1 shall be used for the first three years of the first crediting period while the data from the survey in year 4 shall be used until the end of the crediting periods of the project activity.

The total number of passengers shall be monitored annually, which when multiplied by the shares of passengers Si (%) who have shifted from electricity-based or road-based vehicle categories, respective trip distances on these vehicle categories Di,y and emission factors per passenger-kilometre $EF_{PKM,i,x}$ are used in equation (4) to calculate baseline emissions.

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

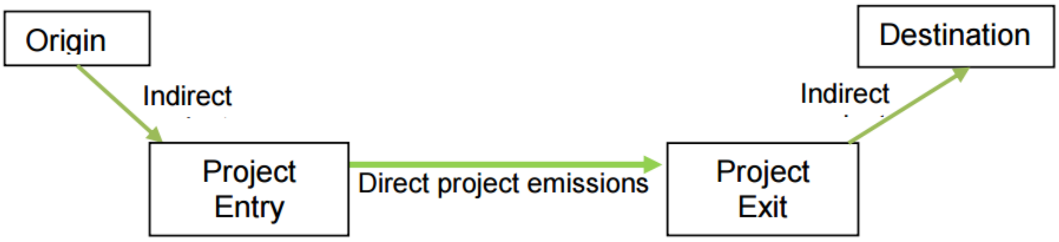
Baseline emission estimated as per the above formulas, would determine the total emissions that would have occurred in the absence of the project activity, as a result of baseline trips made by the project passengers. Baseline trips emissions are calculated based on the distance travelled by the passengers 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.

The origin and destination of the trip is assumed to be equal for the baseline as for the project case with exception of induced traffic included only as project but not as baseline trips. The trip distance and the modes used between O and D are however different in the baseline than in the project case. The trip distance may vary as some passengers using the project MRTS may be willing e.g. to make detours due to the higher speed of the MRTS versus conventional bus transport. To fully capture all potential changes the methodology thus 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.

Year	Annual Passenger Flow	PSPER	Expanded baseline emission (gCO2e)	Baseline Emission (tCO_2e)
2013	1,51,89,41,660	49,43,784	5,49,74,66,650	16,89,057
2014	1,56,72,59,995	49,43,784	5,49,74,66,650	17,42,786
2015	1,61,55,78,330	49,43,784	5,49,74,66,650	17,96,516
2016	1,66,84,55,286	49,43,784	5,49,74,66,650	18,55,315
2017	1,71,22,15,000	49,43,784	5,44,24,91,983	18,84,936
2018	1,76,05,33,335	49,43,784	5,38,80,67,063	19,18,747
2019	1,80,88,51,670	49,43,784	5,33,41,86,393	19,51,694
2020	1,86,22,58,142	49,43,784	5,28,08,44,529	19,89,224
2021	1,90,54,89,887	49,43,784	5,22,80,36,084	20,15,050
2022	1,95,38,09,768	49,43,784	5,17,57,55,723	20,45,486

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:

$$PE_y = DPE_y + IPE_y \quad \text{(7)}$$

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.

$$PE_{EC,y} = \sum_j EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y}) \quad \text{(8)}$$

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 has been fixed ex ante as follows:

Grid	Unit	Value
Indian	tCO_2/MWh	0.900

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:

$$TE_{CPA,y} = TE_{Total-RSS,y} * \frac{Car-km_{CPA-MRTS,y}}{Car-km_{RSS-Total,y}}$$

Where,

$TE_{CPA,y}$ = Traction energy consumed by project MRTS line in year *y*

$TE_{Total\text{-}RSS,y}$ = Total traction energy supplied by RSS in year *y*

$Car\text{-}km_{CPA\text{-}MRTS,y}$ = Total car-km of project MRTS line in year *y*

$Car\text{-}km_{RSS\text{-}Total,y}$ = Total car-km supplied traction energy by the RSS in year *y*

Year	Traction Energy	Emission factor in tCO2/Mwh (As per UCR Standard)	TDL	DPEy (Calculated)
2013	4,81,861	0.900	0.0693	4,63,729
2014	4,95,265	0.900	0.0693	4,76,628
2015	5,08,671	0.900	0.0693	4,89,530
2016	5,24,271	0.900	0.0693	5,04,543
2017	5,39,871	0.900	0.0693	5,19,556
2018	5,55,471	0.900	0.0693	5,34,569
2019	5,71,071	0.900	0.0693	5,49,582
2020	5,86,671	0.900	0.0693	5,64,595
2021	6,02,276	0.900	0.0693	5,79,612
2022	6,17,881	0.900	0.0693	5,94,630

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. 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. The distances between origin and entry and between exit and destination are calculated based, e.g. on public transit routes, electronic maps and GPS, etc. 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.

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

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.

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

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

Year	Annual Passenger Flow	PSPER	Expanded Project emission (gCO_2e)	Indirect project emission (tCO_2e)
2013	1,51,89,41,660	49,43,784	54,09,63,117	1,66,207
2014	1,56,72,59,995	49,43,784	54,09,63,117	1,71,494
2015	1,61,55,78,330	49,43,784	54,09,63,117	1,76,781
2016	1,66,84,55,286	49,43,784	54,09,63,117	1,82,567
2017	1,71,22,15,000	49,43,784	53,58,97,846	1,85,601
2018	1,76,05,33,335	49,43,784	53,08,83,227	1,89,053
2019	1,80,88,51,670	49,43,784	52,59,18,754	1,92,425
2020	1,86,22,58,142	49,43,784	52,10,03,926	1,96,255
2021	1,90,54,89,887	49,43,784	51,61,38,246	1,98,936
2022	1,95,38,09,768	49,43,784	51,13,21,224	2,02,077

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. The same has been demonstrated in above 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:

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

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 components $LE_{LFB,y}$, $LE_{LFT,y}$, $LE_{CON,y}$, $LE_{UP,y}$ 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 fixed 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:

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

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:

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

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 IEE for T (taxis).

Determination of emissions due to a change in load factor of motorized autorickshaws ($LE_{LFMR,y}$)

Similar to above, the determination of $LE_{LFMR,y}$ will also be determined in consideration of the same as a public mode of transport. The equation 13 will be used substituting 'T' (taxis) for 'MR' (motorised auto-rickshaws).

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:

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

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.

The project activity is applicable to rail-based MRTS, the implementation of which has no effect on the road capacity of the urban zone. Apart from that as a result of implementation of the MRTS, few number of bus units are to be retired in the route of the MRTS. Thus, $BSCR_y$ is positive, hence ARS_y is positive. Thus $LE_{CON,y}$ is assumed to be zero.

Emission Reductions:

Year	**Baseline emissions ($t\ CO_{2e}$)**	**Project emissions ($t\ CO_{2e}$)**	**Leakage ($t\ CO_{2e}$)**	**Emission reductions ($t\ CO_{2e}$)**
2013	16,89,057	6,29,936	0	10,59,121
2014	17,42,786	6,48,122	0	10,94,664
2015	17,96,516	6,66,311	0	11,30,205
2016	18,55,315	6,87,110	0	11,68,205
2017	18,84,936	7,05,157	0	11,79,779
2018	19,18,747	7,23,622	0	11,95,125
2019	19,51,694	7,42,007	0	12,09,687
2020	19,89,224	7,60,850	0	12,28,375
2021	20,15,050	7,78,548	0	12,36,502
2022	20,45,486	7,96,707	0	12,48,780
Total number of crediting years	10			
Total	**18,88,881**	**7,13,837**	**0**	**11,75,044**

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 the CDM PoA 9863 and the baseline is alike in the proposed UCR project. Therefore, to make consistent terminologies/equations/baseline the version 4 of methodology preferred.

B.9. Monitoring period number and duration>>

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

B.8. Monitoring plan>>

Ex ante calculation of emission reductions

Data / Parameter	**OC_B**
Unit	Passengers
Description	Average occupation rate of buses
Source of data	Survey report dated July 2012
Value(s) applied	37.1
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	To estimate baseline emissions
Additional comment	

Data / Parameter	**OC_C**
Unit	Passengers
Description	Average occupation rate of passenger cars
Source of data	Third Party Survey Report dated July 2012
Value(s) applied	1.91
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	To calculate baseline emissions
Additional comment	N/A

Data / Parameter	OC_T
Unit	Passengers
Description	Average occupation rate of taxis
Source of data	Survey Report dated July 2012
Value(s) applied	2.31
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 2012
Value(s) applied	1.37
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 2012
Value(s) applied	1.65
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 2012
Value(s) applied	For baseline emission estimation: 0.076 For project emission estimation: 0.075
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. The minimum sample size is 623 and the sample size achieved at the survey was 3568. Upper boundary value has been considered for baseline estimations and lower 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 2012
Value(s) applied	For baseline emission estimation:0.0543 For project emission estimation:0.0536
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. The minimum sample size is 230 and the sample size achieved at the survey was 601. Upper boundary value has been considered for baseline estimations and lower 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 2012
Value(s) applied	For baseline emission estimation: 0.0645 For project emission estimation: 0.0635

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. The minimum sample size is 377 and the sample size achieved at the survey was 694. Upper boundary value has been considered for baseline estimations and lower boundary used for estimating indirect project emissions.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	$\mathbf{SFC}_{T,\ CNG}$
Unit	kg/ km
Description	Specific fuel consumption of taxis using CNG
Source of data	Survey report dated July 2012
Value(s) applied	For baseline emission estimation: 0.0629 For project emission estimation: 0.0627
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. The minimum sample size is 14 and the sample size achieved at the survey was 742. Upper boundary value has been considered for baseline estimations and lower boundary used for estimating indirect project emissions.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	The taxis in Delhi used fuel, CNG and gasoline. Gasoline is generally used as an alternative/emergency fuel for the taxis, considering the price difference between the fuel and economy.

Data / Parameter:	**AD_B**
Data Unit:	Kms/bus
Description:	Average annual distance driven by baseline buses
Source of data:	Delhi Statistical Handbook (2010-11)
Value(s) applied:	47,077.69 Km (2010-2011)
Choice of data or Measurement methods and procedures :	Based on publicly available information Vintage maximum 3 years
Purpose of data:	To calculate leakage emissions
Additional comment:	

Data / Parameter:	**AD_T**
Data Unit:	Kms/taxi
Description:	Average annual distance driven by baseline taxi
Source of data:	Survey report July 2012
Value(s) applied:	91,250 km
Choice of data or Measurement methods and procedures :	Survey carried out
Purpose of data:	To calculate leakage emissions
Additional comment:	

Data / Parameter:	**AD_{MR}**
Data Unit:	Kms/motorised autorickshaw
Description:	Average annual distance driven by baseline autorickshaw
Source of data:	Report of expert committee on the matter of autorickshaw fare revision
Value(s) applied:	43,800 km
Choice of data or Measurement methods and procedures :	Publicly available information
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:	Statistical Handbook of Delhi 2010-11
Value(s) applied	6,204
Measurement methods and procedures:	The data will be considered from the official/public sources of information.
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	Supreme court order - Supreme Court of India mandated that all commercial passenger vehicles including taxis be CNG powered - 'The Impact of Delhi's CNG Program on Air Quality' 2007.
Value(s) applied	6,204 (100%)
Choice of data or Measurement methods and procedures	Mandatory regulation/order by apex authority.
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:	Statistical Handbook of Delhi 2010-11
Value(s) applied	57,958
Measurement methods and procedures:	The data will be considered from the official/public sources of information.
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	Supreme court order - Supreme Court of India mandated that all commercial passenger vehicles including taxis be CNG powered
Value(s) applied	57,958 (100%)
Choice of data or Measurement methods and procedures	Mandatory regulation/order by apex authority.
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:	Statistical Handbook of Delhi 2010-11
Value(s) applied	88,181
Measurement methods and procedures:	The data will be considered from the official/public sources of information.
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	Supreme court order - Supreme Court of India mandated that all commercial passenger vehicles including taxis be CNG powered - ‘The Impact of Delhi’s CNG Program on Air Quality’ 2007.
Value(s) applied	88,181 (100%)
Choice of data or Measurement methods and procedures	Mandatory regulation/order by apex authority.
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:	Statistical Handbook of Delhi 2010-11
Value(s) applied	43,42,403
Measurement methods and procedures:	The data will be considered from the official/public sources of information.
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	Air Quality Monitoring Project-Indian Clean Air Programme (ICAP), Emission Factor development for Indian Vehicles, ARAI, Pune
Value(s) applied	43,42,403 (100%)
Choice of data or Measurement methods and procedures	The source of data is authenticated and publicly available. Hence, considered appropriate.
Purpose of data	To calculate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter:	N_C
Data unit:	Number
Description:	Number of cars circulating in the city
Source of data:	Delhi Transport Department
Value(s) applied	15,43,326
Choice of Data Or Measurement methods and procedures:	The data will be considered from the official/public sources of information.
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	$N_{C, gasoline}$
Unit	Number
Description	Number of cars using gasoline
Source of data	Delhi Transport Department
Value(s) applied	10,23,106 (66%)
Choice of data or Measurement methods and procedures	The data will be considered from the official/public sources of information.
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	Delhi Transport Department
Value(s) applied	3,16,897 (21%)
Choice of data or Measurement methods and procedures	The data will be considered from the official/public sources of information.
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	Delhi Transport Department
Value(s) applied	2,03,323 (13%)
Choice of data or Measurement methods and procedures	The data will be considered from the official/public sources of information.
Purpose of data	To calculate 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	DTC manages the urban bus fleet of Delhi. The fuel consumed by the buses is only CNG.
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
Source of data	Survey Report dated July 2012
Value(s) applied	For baseline emission estimation: 0.0303 For project emission estimation: 0.0301
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. Upper boundary value has been considered for baseline estimations and lower boundary used for estimating indirect project emissions The minimum sample size is 18 and the sample size achieved at the survey was 234.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	$SFC_{M, Gasoline}$
Unit	kg/ km
Description	Specific fuel consumed by motorized two wheelers
Source of data	Survey Report dated July 2012
Value(s) applied	For baseline emission estimation:0.0177 For project emission estimation:0.0175
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 is 218 and the sample size achieved at the survey was 1240. Upper boundary value has been considered for baseline estimations and lower boundary used for estimating indirect project emissions. Survey realized using upper 95% confidence interval.
Purpose of data	To estimate baseline emissions and indirect project emissions
Additional comment	

Data / Parameter	$TD_{EL,i}$
Unit	Km
Description	Average trip distance travelled by passengers using electricity-based vehicle category *i* (like metro or sub-urban rail) prior to project start
Source of data	DMRC and Indian railways data for suburban rail
Value(s) applied	Metro: 17 km Sub-urban rail: 18 km
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>N_i</td></tr>
<tr><td>Data Unit</td><td>Vehicles</td></tr>
<tr><td>Description</td><td>Number of vehicles of category i prior to the project start</td></tr>
<tr><td>Source of data</td><td>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>Value(s) applied</td><td>
<table>
<tr><th>S. No.</th><th>Type of Vehicle</th><th>Total No. of vehicles</th></tr>
<tr><td>1</td><td>2 wheeler</td><td>43,42,043</td></tr>
<tr><td>2</td><td>Auto</td><td>88,181</td></tr>
<tr><td>3</td><td>Taxi</td><td>57,958</td></tr>
<tr><td>4</td><td>Car</td><td>15,43,326</td></tr>
<tr><td>5</td><td>Bus</td><td>6,204</td></tr>
<tr><td colspan="2">Total</td><td>60,37,712</td></tr>
</table>
</td></tr>
<tr><td>Choice of data
or
Measurement methods and procedures</td><td>Used for all vehicle categories included in the project.</td></tr>
<tr><td>Purpose of data</td><td>To calculate baseline and indirect project emission</td></tr>
<tr><td>Additional comment</td><td></td></tr>
</table>

<table>
<tr><td>Data / Parameter</td><td>$N_{x,i}$</td></tr>
<tr><td>Data Unit</td><td>Dimensionless</td></tr>
<tr><td>Description</td><td>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.</td></tr>
<tr><td>Source of data</td><td>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>Value(s) applied</td><td>
<table>
<tr><th>Type of Vehicle</th><th>Fuel type</th><th>Total no. of vehicles</th></tr>
<tr><td>2-wheeler</td><td>Petrol</td><td>43,42,043</td></tr>
<tr><td>Auto</td><td>CNG</td><td>88,181</td></tr>
<tr><td>Taxi</td><td>CNG</td><td>57,958</td></tr>
<tr><td rowspan="3">Car</td><td>Petrol</td><td>10,23,106</td></tr>
<tr><td>Diesel</td><td>3,16,897</td></tr>
<tr><td>CNG</td><td>2,03,323</td></tr>
<tr><td>Bus</td><td>CNG</td><td>6,204</td></tr>
</table>
</td></tr>
<tr><td>Choice of data
or
Measurement methods and procedures</td><td>Mandatory regulation/order by apex authority.</td></tr>
<tr><td>Purpose of data</td><td>To calculate baseline and indirect project emissions</td></tr>
<tr><td>Additional comment</td><td></td></tr>
</table>

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, company data (for buses) or surveys
Value(s) applied	(see table below)
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

Vehicle Type	Petrol	Diesel	CNG	Total
4W Car	66	21	13	100
4W Taxi	-	-	100	100
2 W	100	-	-	100
3W	-	-	100	100
Bus	-	-	100	100

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 / Parameter	**$EF_{Grid,CM}$**
Unit	tCO_2/MWh
Description	Combined emission factor of the regional grid
Source of data	AS per UCR Standard
Value(s) applied	Indian Grid: 0.90
Choice of data or Measurement methods and procedures	The value has been fixed ex-ante at project level and as per the UCR standard.
Purpose of data	To calculate baseline and project emissions
Additional comment	Combine margin emission factor considered and fixed ex-ante.

Data and parameters to be monitored:

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. All electricity emission factors used should be defined at the validation stage and fixed for the crediting period. Therefore if the grid emission factor is used, the *ex ante* approach should be used. The grid emission factor has been fixed *ex-ante* as discussed in ex-ante parameter.

<table>
<tr><td>Data / Parameter</td><td>$EC_{pj,y}$</td></tr>
<tr><td>Data Unit</td><td>MWh</td></tr>
<tr><td>Description</td><td>Electricity consumed by project activity vehicles</td></tr>
<tr><td>Source of data</td><td>DMRC Operations and maintenance wing, Traction</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>Year</th><th>Traction Energy</th></tr>
<tr><td>2013</td><td>4,81,861</td></tr>
<tr><td>2014</td><td>4,95,265</td></tr>
<tr><td>2015</td><td>5,08,671</td></tr>
<tr><td>2016</td><td>5,24,271</td></tr>
<tr><td>2017</td><td>5,39,871</td></tr>
<tr><td>2018</td><td>5,55,471</td></tr>
<tr><td>2019</td><td>5,71,071</td></tr>
<tr><td>2020</td><td>5,86,671</td></tr>
<tr><td>2021</td><td>6,02,276</td></tr>
<tr><td>2022</td><td>6,17,881</td></tr>
</table>
</td></tr>
<tr><td>Measurement methods and procedures</td><td>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.</td></tr>
<tr><td>Monitoring frequency</td><td>Annually</td></tr>
<tr><td>QA/QC procedures</td><td>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.</td></tr>
<tr><td>Purpose of data</td><td>To calculate $TE_{EL,i,y}$; (Total emissions from the electricity-based rail system in year y) for project emissions</td></tr>
<tr><td>Additional comment</td><td>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.</td></tr>
</table>

Data / Parameter	TDL_y
Unit	%
Description	Average technical transmission and distribution losses for Delhi
Source of data	Delhi Electricity Regulatory Commission
Value(s) applied	6.93 %
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	$TE_{Total-RSS, y}$
Unit	MWh
Description	Total traction energy recorded at RSS level
Source of data	DMRC 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 DMRC 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	Delhi metro Operations control centre 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	Delhi metro 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	Indraprastha Gas Limited, Oct 2010
Value(s) applied	39.2
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	Survey Reports
Value(s) applied	Buses: 37.1 Taxis: 2.31 Motorized auto-rickshaw: 1.65
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 motorised 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	Delhi Metro Rail Corporation
Value(s) applied	2013: 1,51,89,41,660 2014: 1,56,72,59,995 2015: 1,61,55,78,330 2016: 1,66,84,55,286 2017: 1,71,22,15,000 2018: 1,76,05,33,335 2019: 1,80,88,51,670 2020: 1,86,22,58,142 2021: 1,90,54,89,887 2022: 1,95,38,09,768
Measurement methods and procedures	OD matrix report generated by Automatic Fare Collection System. The automatic fare collection system tracks the entry and the exit of each passenger through smart media unique ID and generates an OD Matrix at the end of the day This report contains entry and exit of DMRC 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	Delhi Statistical Handbook
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	**Di**
Data unit	Kilometres
Description	Average trip distance travelled by passengers who shifted from electricity-based or road-based vehicle category i
Source of data	Survey
Value(s) applied	NA
Measurement methods and procedures	Survey of the project passengers in year 1 and 4 of the first crediting period asking about the entry and exit stations in the project system and noting electricity-based or road-based vehicle category i each surveyed passenger used prior to shifting to the project system (Si)
Monitoring frequency	First crediting year, After that every 3rd year
QA/QC procedures	-
Purpose of data	To calculate baseline and project emissions
Additional comment:	-

Data / Parameter	**Si**
Data unit	%
Description	Share of passengers who shifted from electricity- based or road-based vehicle category i
Source of data	Survey
Value(s) applied	NA
Measurement procedures (if any)	Survey of the project passengers in year 1 and 4 of the first crediting period asking about electricity-based or road-based vehicle category i each surveyed passenger used prior to shifting to the project system and noting the entry and exit stations in the project system ($D_{i,y}$). The data from the survey in year 1 shall be used for the first three years of the first crediting period while the data from the survey in year 4 shall be used until the end of the crediting periods of the project activity
Monitoring frequency	First crediting year, After that every 3rd year
QA/QC procedures	-
Purpose of data	To calculate baseline and project emissions
Additional comment	-

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:	Rail operator (DMRC and Indian railways annual statistical statement 2010-11)
Value(s) applied	Delhi metro: 516,982,658 Sub-urban rail: 3,030,000
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 will be 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 will be taken and a second measurement will be 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.

<u>Data storage and archiving</u>

All of 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.

<u>Training and maintenance procedures</u>

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