Project design document form
(Version 11.0)

BASIC INFORMATION	
Title of the project activity	Metro Delhi, India
Scale of the project activity	☒ Large-scale ☐ Small-scale
Version number of the PDD	5.0
Completion date of the PDD	03/09/2019
Project participants	Delhi Metro Rail Corporation Ltd. (private entity) Grütter Consulting AG (private entity)
Host Party	India
Applied methodologies and standardized baselines	ACM0016: Baseline Methodology for Mass Rapid Transit Projects; Version 04
Sectoral scopes	Transport (sectoral scope 7)
Estimated amount of annual average GHG emission reductions	516,307 tCO_{2e}

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

The Mass Rapid Transit System (MRTS) is a partially elevated, partially underground and partially at-grade heavy duty metro.

The CDM project includes all corridors of Phase II except New Delhi – Airport and Airport – Dwarka Sector 21 of Metro Delhi managed by DMRC (Delhi Metro Rail Corporation Ltd.). Phase I is not included as CDM project.

Core aspects of Metro Delhi are:

- A new infrastructure consisting of 102 kilometres of state-of-the art metro with new trains, and pre-board ticketing using rechargeable electronic cards.
- Equipment and turnstiles at the entrance to each station will deduct the corresponding fare.
- Centralized coordinated train control providing monitoring and communications to schedule services and real-time response to contingencies.

For implementation and subsequent operation of Metro Delhi MRTS, a company under the name Delhi Metro Rail Corporation Ltd. (DMRC) was registered on 03/05/1995 under the Companies Act, 1956. DMRC has equal equity participation from GOI (Government of India) and GNCTD (Government of National Capital Territory of Delhi).

The baseline situation is a continuation of traditional modes of transport including buses, taxis, private cars, rickshaws, motorcycles and bikes. In absence of the project the passengers move from their trip origination to their trip destination by buses, by taxis, by motorized rickshaws, by the existing 3 lines of the metro and by NMT (Non-Motorized Transport). To a very limited degree some urban trips are also made by the existing railway lines although latter are used basically for inter-urban travel. In the baseline situation, these modes of transport would continue to operate and transport passengers from their trip origin to their trip destination.

In the project situation, the metro complements other modes of transport and replaces partially trips made by conventional or traditional means of transit by metro. The CDM project replaces trips made by conventional transport modes with metro, being a more efficient, faster, safer and more reliable transport means. The baseline scenario is comparable to the situation prior to the project. The baseline scenario however incorporates technological advancements in terms of emissions per distance driven of various modes of transport as well as eventual fuel changes of baseline modes of transport during the project activity.

Emission reductions are achieved through reducing GHG emissions per passenger-kilometre, comparing conventional modes of transport with metro. The metro has as main environmental aspect that the resource efficiency of transporting passengers in Delhi is improved i.e. emissions per passenger kilometre are reduced compared to the situation without project.

The project was registered as a CDM project as of 30/06/2011. All lines as described in the registered PDD are fully operational. The last section started full operations 30/10/2010[1].

A.2. Location of project activity

Host country: India
Region/State/Province: New Delhi
City/Town/Community: Delhi

The spatial extent of the project is, according to the methodology, the metropolitan area of Delhi. The spatial area includes the trip origins and destinations of passengers using Metro Delhi. Inter-urban traffic is not included in the spatial project boundary. The geographical coordinates of Delhi are 28˚24' to 28˚53' North and 76˚50' to 77˚20' East.[2]

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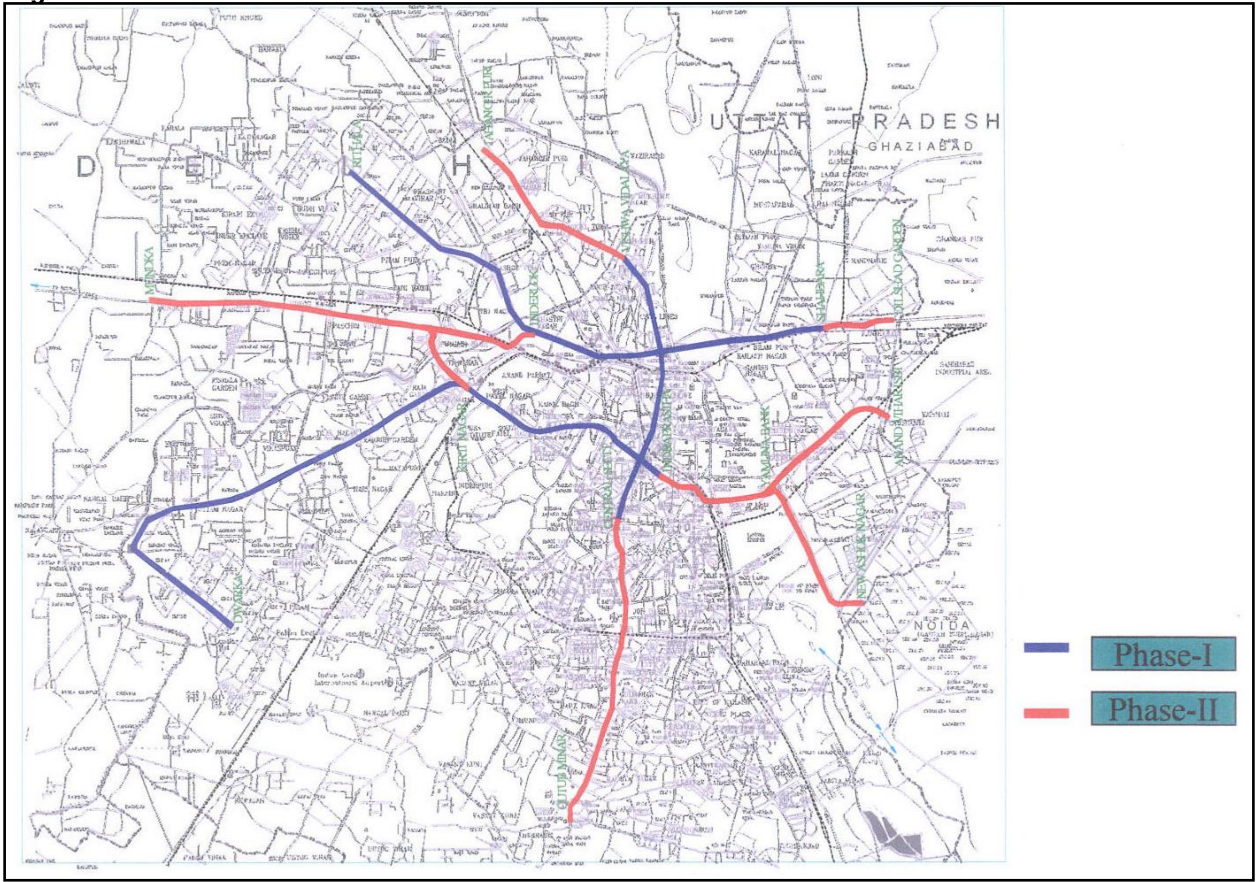
[1] See Table 1 approved monitoring report 4th monitoring period from 01/07/2016 to 29/06/2018

[2] Delhi Statistical Hand Book 2007, p. 1

The metro lines included in the project are listed in Table 1. Figure 1 shows the lines Phase I and Phase II of DMRC. Only Phase II lines form part of the project.

Figure 1: Metro Delhi Phase I and II



The total length of metro tracks included in the project is 102.23 km. The following table lists all metro corridors part of the CDM project.

Table 1: Corridors of CDM Project Metro Delhi, India

Corridor	Length (km)	Commissioning date
Shahadara-Dilshad Garden	3.1	04/06/2008
Vishwavidyalaya-Jhahangirpuri	6.4	04/02/2009
Indraprastha-New Ashok Nagar	8.1	13/11/2009
New Ashok Nagar-Noida	7.0	13/11/2009
Inderlok – Kirtinagar –Mundka	18.5	02/04/2010
Yamuna Bank –Anand Vihar ISBT	6.2	07/01/2010
Anand Vihar – Vaishali	2.6	14/07/2011
Qutab Minar - Gurgaon	14.5	21/06/2010
Central Secretariat –Qutab Minar	12.5	03/09/2010
Central Secretariat – Badarpur	20.2	14/01/2011
Dwarka Sector 9 – 21	2.8	30/10/2010
Total	**101.67**	

Source: Table 1 registered PDD version 04

A.3. Technologies/measures

In absence of the project the passengers move from their trip origination to their trip destination by buses, by taxis, by passenger cars, by motorcycles, by motorized rickshaws, by the existing 3 lines of metro and by NMT (Non-Motorized Transport). To a very limited degree some urban trips are also made by the existing

railway lines although latter are used basically for inter-urban travel[3]. The CDM project replaces partially these trips made by using, at least for part of the trip, a more efficient, faster, safer and more reliable transport means. The baseline scenario is comparable to the situation prior the project. The baseline scenario however incorporates technological advancements in terms of emissions per distance driven of various modes of transport as well as eventual fuel changes of baseline modes of transport during the project activity. Phase I of Metro Delhi are part of the baseline. They use a comparable technology to Phase II corridors.

The total length of metro tracks included in the project is 101.67 km (see table 1). In total the project has 83 stations. Inderlok and Kirtinagar are shared stations Phase I and Phase II lines. Passengers from these stations are account at 50% for the project. Central Secretariat is shared with 2 Phase II lines and 1 Phase I line. Passengers are therefore accounted to 2/3 to Phase II. Dwarka Section 21 is connected to the airport line and therefore passengers are only counted at 50%.

The corridors consist of two broad gauge lines at 4.1 m centre to centre on elevated sections. For underground corridors, track centres are governed by spacing of tunnels and box design. Track structure on the main lines is broad gauge (1,676 mm) and standard gauge (1.435mm) with 60-kg UIC wear resistant rails. On elevated alignment, the track is of ballastless type.

Traction system is 25kV ac 50Hz single phase. The entire power supply is monitored and controlled from a centralized Operation Central Control (OCC). The OCC takes care of the ongoing monitoring of the metro service via various technical systems and keeps in contact by radio and telephone with the train drivers, the mobile personnel and the metro service vehicles. The control centre also monitors the metro service via the CCTV systems that exist along the train line as well as answering and dealing with calls via the emergency call system at the train stations. The OCC controller is also responsible for monitoring the other technical systems relating to the metro service such as the power supply and signal installations, in addition to lighting, as well as ticket vending machines at the metro stations.

The metro runs partially underground, partially at grade and partially elevated. Each train has between 4 and 6 cars and runs frequencies between 3 and 12 minutes depending on lines, time of the day and passenger demand. 90 broad gauge (of which 89 with 6 cars and 1 with 4 cars) and 48 standard gauge (of which 46 with 4 cars and 2 with 6 cars) trains have been acquired (total 734 cars). 694 cars (95%) are indigenous and the rest are from Germany and South Korea. The seating capacity per car is between 42 and 50 persons and the standing capacity between 272 and 330 thus achieving a capacity of around 1,500 passengers per 4-car train and 2,260 for a 6-car train.

Continuous Automatic Train Control (CATC) system with cab signalling is provided for the metro system operation transporting a high volume of passengers at tight headways to ensure strict safety enforcement monitoring. The metro has automatic signalling in the section. Automatic train supervision provides for high safety with trains running at close headway ensuring continuous safe train operations, and eliminates accidents due to drivers passing signals at danger. It includes continuous speed monitoring and automatic application of brake in case of disregard of signal, providing safety and enforcing speed limits on sections having permanent and temporary speed restrictions and improving capacity with safer and smoother operations as the driver will have continuous display of the target speed and the distance to go status in his cab enabling him to optimize the speed potential of the track section.

For efficient ticketing and passenger control an Automatic Farer Collection (AFC) is provided. The base AFC system makes use of contactless smart tokens for single and “Contact-less Smart Card Tickets” for multiple journey as well as working with multiple operators. Entry gates are computer controlled retractable flap type automatic gates at entry and at exit with disabled wide reversible gates for disabled people.

To ensure the highest degree of reliability and all-time power availability for the underground Metro Corridor, 3 MRTS Power receiving stations are inter-connected for transfer of power from one to another through Fire Retardant Low Smoke (FRLS) cable feeders. These receiving stations are remote controlled from Centralized Operation Control Centre through Supervisory Control & Data Acquisition System (SCADA). In the unlikely event of total power failure due to simultaneous collapse of Northern Grid and IP Gas Turbine Power Station, emergency lighting in the tunnel and at the MRTS stations is automatically switched on and fed the stand by Generator Sets. In addition, all the trains also have modern Ni-Cd Batteries to continue to provide lighting and air conditioning even when the train is stopped in event of complete power failure. The

[3] The metro surveys realized indicated no passengers which in absence of the metro would have used rail and no passengers which used rail to or from the metro.

ventilation and air conditioning arrangements in the tunnel and the underground stations are so designed that emergency ventilation arrangements for the stations and tunnel continue to be maintained from the standby Generator Sets in such exigencies.

A.4. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
India (host)	Delhi Metro Rail Corporation Ltd. (private entity)	No
Switzerland	Grütter Consulting AG (private entity)	No

A.5. Public funding of project activity

The Project activity is partially financed by the Government of Japan through JBIC. The funding however is separate from and is not counted towards the financial obligations of the aforesaid party.

A.6. History of project activity

The CDM project activity is neither registered as a CDM project activity nor included as a component project activity (CPA) in a registered CDM programme of activities (PoA);

The CDM project activity is not a CPA that has been excluded from a registered CDM PoA

No registered CDM project activity or a CPA under a registered CDM PoA whose crediting period has or has not expired (hereinafter referred to as former project) exists in the same geographical location as the proposed CDM project activity.

A.7. Debundling

Not applicable.

SECTION B. Application of methodologies and standardized baselines

B.1. References to methodologies and standardized baselines

ACM0016: Baseline Methodology for Mass Rapid Transit Projects; Version 04.0

This methodology also refers to the latest approved version of the following tools:

- “Tool for the demonstration and assessment of additionality”, Version 05.2
- Tool 05 “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion
- Tool Baseline emissions for modal shift measures in urban passenger transport Version 01
- Methodological Tool 03.0.1 “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period’

B.2. Applicability of methodologies and standardized baselines

This methodology applies to project activities that establish and operate a Mass Rapid Transit System.

Table 2 relates the specific baseline methodology applicability conditions with the proposed project.

Table 2: Applicability Conditions

Applicability condition	Project situation
The project constructs a new rail-based infrastructure or segregated bus lanes. In the case of rail systems, the project needs to provide new infrastructure (new rail lines). The segregated bus lanes or the rail-based MRTS replace existing bus routes operating under mixed traffic conditions (applicability conditions 4a and 5 of ACM0016 version 04)	The MRTS is new rail-based mass transit system and replaces partially bus operations operating under mixed traffic conditions. The rail infrastructure is new. Bus routes and schedules are adapted to metro. Evidence of this is the listing of bus routes to be eliminated along Delhi Metro as well as urban planning documents for multi-mode transport schemes coordinating bus and metro services.
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. (applicability condition 10a of ACM 0016 version 04)	The MRTS is a new metro with new infrastructure.
The methodology is not applicable for bus lanes replacing an existing rail-based system. (applicability condition 10b of ACM 0016 version 04)	The MRTS is rail-based.
Any fuels including electricity, (liquefied) natural gas and biofuel blends can be used in the baseline or project case. Project buss shall use the same biofuel blend as comparable urban buses and not a higher biofuel blends than cars and taxis (applicability condition 6 of ACM0016 version 04).	The project is rail-based only and uses electricity. Baseline transport fuels are diesel, gasoline and gaseous fuels. No bio-fuels are used in the baseline or project case. Baseline buses use CNG while the project uses electricity. Thus, more natural gas is used in the baseline than in the project case as passengers switch partially from buses to metro. The project does not operate any buses (no project buses).
The methodology is not applicable for the implementation of air and water-based transport systems. (applicability condition 10c of ACM 0016 version 04)	No air or water-based transport is included. The MRTS is rail based.
The methodology is applicable for urban or suburban trips. It is not applicable for inter-urban transport. (applicability condition 7 of ACM 0016 version 04)	The MRTS is purely urban transport.
The methodology is only applicable if the application of the procedure to identify the baseline scenario results in that a continuation of the current public transport system is the most plausible baseline scenario. (applicability condition 9 of ACM 0016 version 04)	The identified baseline is a continuation of the current urban transit system.

All applicability conditions for using the methodology are thus fulfilled.

B.3. Project boundary, sources and greenhouse gases (GHGs)

Source		GHG	Included?	Justification/Explanation
Baseline	Mobile source emissions of different modes of transport for passengers using MRTS	CO_2	Yes	Major emission source
		CH_4	Yes	Included for gaseous fuels used. For liquid fuels vehicle tailpipe CH_4 emissions are excluded. Combined CH_4 and N_2O emissions make in diesel/gasoline vehicles less than 2% of total CO_{2eq} emissions. 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 N_2O emissions make in diesel/gasoline vehicles less than 2% of total CO_{2eq} emissions. Its omittance in baseline as well as project emissions is conservative as fuel consumption and thus also N_2O emissions are reduced through the project
Project activity	Project transport system (MRTS)	CO_2	Yes	Major source
		CH_4	No	Not included as MRTS does not use gaseous fuels.
		N_2O	No	See argument above.
	Mobile source emissions of different modes of transport for passengers using MRTS from trip origin to MRTS and from MRTS to trip destination	CO_2	Yes	Major source
		CH_4	Yes	Included for gaseous fuels used. See argument above.
		N_2O	No	See argument above.

B.4. Establishment and description of baseline scenario

Step 1: Identification of alternative scenarios to the proposed CDM project activity that are consistent with current laws and regulations

All options are identified that meet the same requirement as the proposed project activity. Alternatives assessed are public transport systems which are complemented with other modes of transport such as passenger cars, taxis, motorcycles, motorized rickshaws and non-motorized transport:

- The establishment of a BRT (Bus Rapid Transit);
- The establishment of a LRT (Light Rail Transit);
- The continuation of the current public and individual transport systems, including (future) investments in road-based infrastructure if applicable;
- The proposed project activity being implemented at a later date in the future, without being registered as a CDM project activity;
- The project proposal not implemented as a CDM project activity i.e. the continuous construction of metro after Phase I.

Metro Lines Phase I are not a baseline mode of transport as the lines of Phase I are not substituted by the project lines of Phase II i.e. the passenger cannot, in absence of the project, use metro lines Phase I to make the trip as these do not operate in the area of metro lines Phase II. Passengers will require for this purpose transit modes which actually perform this trip segment such as buses, cars, taxis etc. Metro lines Phase II i.e. the project metro do not replace the metro lines Phase I nor can the passenger use in absence of metro lines Phase II the metro lines Phase I. Therefore, metro lines Phase I are not a baseline mode of transport.

All alternatives are consistent with current laws and regulations.

Step 2: Assessment of Options

The analysis of options identified in Step 1 is based on the "Tool for the demonstration and assessment of additionality" Version 05.2

ALTERNATIVE 1: ESTABLISHMENT OF A BRT

A BRT is being designed and implemented for parts of Delhi and will complement the metro plus other mass transit options in the city. However, for the areas on which the metro is planned a BRT system was considered as non-feasible basically due to the required passenger per hour capacity. BRT or bus lane systems have typical carrying capacities of 15,000-35,000 passengers per hour per direction (phd) while metros have around 60,000 phd[4]. Also the GTZ sourcebook on sustainable transport modes confirms that capacities of more than 35,000 phd are only achieved by metro, with capacities of metros reaching up to 81,000 phd by the metro of Hong Kong[5]. The ultimate capacity of Delhi Metro is 75-80,000 passengers per hour per direction. Metro Delhi will have on various routes of Phase II more than 35,000 phd thus a BRT based system not being feasible technically[6]. Based on the above consideration a BRT is not considered as a technically viable solution due to the passenger demand on the corridors on which the metro is built.

ALTERNATIVE 2: ESTABLISHMENT OF A LRT

Light rail transit (LRT) includes also trams and monorails. LRTs operate as a single rail car or as a short train of cars typically on exclusive right-of-way lanes at surface levels[7]. This alternative has similar if not more severe constraints than a BRT. LRTs typically have a capacity of 10-25,000 phd or far less than the required capacity for the corridors of Delhi Metro[8]. Also, they reach only about half the average speed of metro (this is also true of normal BRT systems) thus not offering the same level of convenience as metro. Based on above consideration a LRT is not considered as a technically viable solution due to the passenger demand on the corridors on which the metro is built.

Table 6 shows differences between BRTs/Bus Lane systems, LRTs and metros and table 7 gives examples of the carrying capacity of various MRTS worldwide. The two tables clearly show that the options of BRT and LRT are not adequate for the expected passenger demand along the metro lines of Delhi and that metro is the only viable alternative option to the current transport system based on mixed traffic conditions along a variety of roads offering users a wide spectrum of transport options and routes. LRTs and BRTs can however play an important role on segments with lower passenger demand and Delhi is assessing these alternatives for other routes, embarking already on a comprehensive BRT program as well as planning Light-Train Systems for other routes.

Table 3: Comparison BRTs, LRTs and Metros

Characteristic	BRT / Bus lane	LRT / Tram /Monorail	Metro
Passenger carrying capacity (phd)[9]	15-35,000	10-25,000	up to 80,000
Average operating speed (km/h)	15-25	15-25	30-40
Space requirement	2-4 lanes taken away from existing road space	2-4 lanes taken away from existing road space	Separate from roadway corridors

Sources: IEA, Bus Systems for the Future, 2002, Table 2.1. and Table 5

Table 4: Passenger Carrying Capacity of Various BRTs, LRTs and Metros (phd)

System/City	phd (passenger per hour per direction) capacity
Metro Hong Kong	81,000

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[4] IEA, Bus Systems for the Future, 2002, Table 2.1.

[5] GTZ/ITDP sustainable transport sourcebook 3A, Mass Transit Options, 2005, table 10

[6] DPR, 2005, Table 0.4

[7] If elevated or underground, the carrying capacities of LRTs can be increased e.g. the proposed monorail for Delhi could have a carrying capacity of up to 25,000 phd however investment costs will also increase strongly. The LRT thereafter resembles basically a metro.

[8] IEA, Bus Systems for the Future, 2002, Table 2.1.

[9] See examples following table

Metro Sao Paulo	60,000
Metro Bangkok	50,000
LRT Kuala Lumpur	30,000
LRT Tunis	12,000
BRT Bogota	33,000
BRT Quito	15,000
BRT Curitiba	15,000

Source**:** GTZ/ITDP sustainable transport sourcebook 3A, Mass Transit Options, 2005, table 10

ALTERNATIVE 3: CONTINUATION OF THE CURRENT SYSTEM INCL. FUTURE INVESTMENTS

A continuation of the current transport system complies with all applicable legal and regulatory requirements. A continuation of the current system has various advantages compared to all other options:

- No large-scale public investment requiring additional income/tax sources.
- Lowest technical and financial risk of all options.

The carrying capacity of the current public transport system is in line with the actual transport demand. Increasing passenger demand can be accommodated through the establishment of new routes using also alternate roads, which might imply potentially longer travel distances complying however with the purpose of transporting passengers from their trip origin to their trip destination. Additional transit demand might also lead to increased trip times due to increased congestion. The existing transport system relies not on single or fixed routes like a BRT, metro or LRT but on a multitude of possible routes and modes of transport using the existing road infrastructure and modes of transit. It is thus highly flexible and can accommodate passenger flows in excess of any single-route based MRTS.

The current mixed transit system as established in Delhi is continuously expanded i.e. new roads, intersections, flyovers or road extensions are built. The mixed road conditions are continuously upgraded to meet with increasing traffic demand as a result of increased population and economic wellbeing resulting in more trips as well as a rapidly increasing number of private vehicles using additional road space. As of end 2008 Delhi had nearly 6 million vehicles including 1.8 million private cars, more than 45,000 buses, 76,000 motorized rickshaws and nearly 4 million motorcycles. During the last two decades Delhi had an exponential growth in the vehicular population. More than 90% of vehicles circulating are personal vehicles. This huge growth is partially due to the increased income but primarily due to a continuation of inefficient, uncomfortable, unreliable and undignified public transport system[10]. To accommodate for this increasing number of vehicles mixed roads are expanded.

In choosing this alternative, public authorities do not embark upon risky structural changes. The continuation of the current situation is thus clearly a realistic and attractive alternative.

ALTERNATIVE 4: THE PROJECT BEING REALIZED IN A LATER DATE WITHOUT CDM

Delhi follows a strategy of multi-modal public transit systems including metro, Light Rail Transit (LRT), monorail, Bus Rapid Transit (BRT), and conventional bus lines for which a new SPV[11] was set up in 2008 called Delhi Integrated Multi-Modal Transit System (DIMTS)[12]. Various technological options are thus possible and no national or local policy mandates the implementation of a metro. The 9th 5-year plan (1997-2002) of the Government of India has no policy mandating a metro. Chapter 7.1.20 indicates: “It is necessary to encourage such modes of transport which are not heavily dependent on scarce land resources and to adopt construction procedures and practices which do not disfigure the land and do not create ecological problems.” The section on strategy states in 7.1.23. “The length and breadth and the quality of the highways must be improved greatly as part of a national grid to provide for speedy, efficient and economical carriage of goods and people. Road transport needs to be regulated for better energy efficiency and pollution control, while the mass transport network needs to be made viable through a rational tariff policy and a refurbishment of the fleet.” The Transport Department of the Government of NCT of Delhi in its Operating Plan for Delhi, 10.2002 with the title “Tackling Urban Transport” has a policy for mass transit in Delhi:”With the objective of achieving a balanced modal mix and to discourage personalized transport, it is proposed to augment mass

[10] Cited from Annual Plan 2006-07 in respect of Transport Sector, Transport Department, page 1, Transport Department of Govt. of NCT of Delhi

[11] Special Purpose Vehicle

[12] File 22, Economic Survey of Delhi 2005-2006, statement 8, p.141

transport by massive investments accompanied by institutional improvements. The focus, therefore, will be on increasing mass transport options by providing adequate, accessible and affordable modes like buses, mini-buses, electric trolley buses complemented by a network of a rail-based mass rapid transit systems like metro and commuter rail. Para transit modes like autos and taxis are envisaged to provide feeder services in designated areas catering to work and leisure trips. Non-motorized transport like bicycles and cycle rickshaws will be accommodated." The Master Plan of Delhi 2001 also included various options for Delhi urban transportation: "(The) Mass Transportation System (is) to be Multi Modal e.g. MRTS, Ring Rail and Road based public transportation system." Various MRTS options are thus included and no specific policy mandating metro exists. There are thus no concrete plans which lead to the construction of a metro in absence of the CDM and a multitude of transport options are assessed. The continuation of current practice with mixed traffic systems i.e. private as well as public transport means is thus the core strategy also for the future of Delhi. Implementing the metro in absence of the CDM is also studied in Alternative 5.

ALTERNATIVE 5: THE PROJECT WITHOUT CDM

The implementation of the proposed project activity in absence of the CDM is considered as non-feasible due to financial reasons. The details are given in chapter B5 and are not repeated here to avoid duplication.

Step 3: Determination of the baseline scenario

If Step 2 results in more than one possible alternative baseline scenario, the most likely baseline scenario is the scenario with the lowest baseline emissions. Alternatives 1 (BRT), 2 (LRT), 4 (Future metro in absence of the CDM) and 5 (project without CDM) are not feasible. The most probable alternative in the future in absence of the project is therefore a continuation of the current transport system. This is thus the baseline for this project.

Baseline Scenario

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. The baseline is a continuation of the current transport system consisting of various transport modes between which the population chooses:

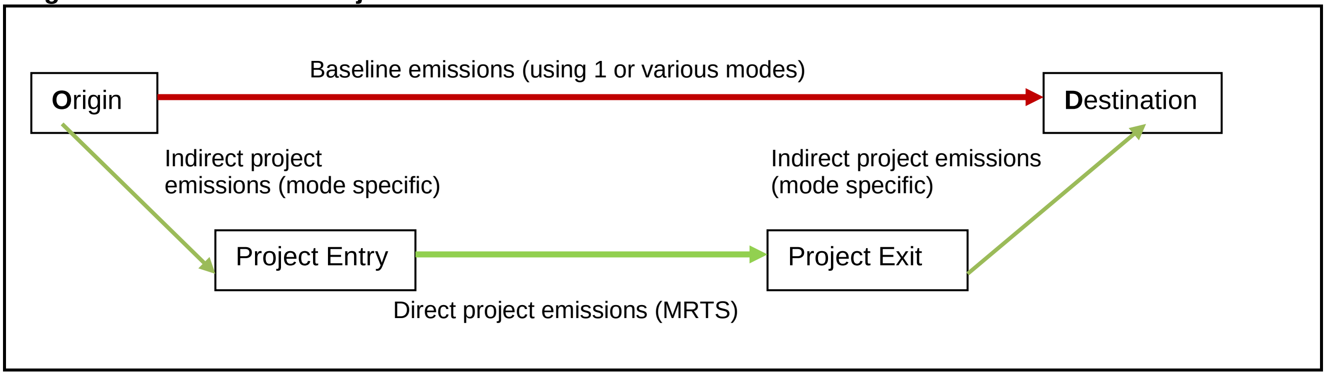
- NMT (Non-Motorized Traffic) with bikes and per foot;
- Private passenger car;
- Taxis;
- Motorcycles (two-wheelers);
- Motorized auto-rickshaws (used as taxis);
- Buses;
- Sub-urban rail.

Sub-urban rail does not compete with the proposed metro as it does not offer similar route destinations. However, users of the metro may potentially realize in the baseline or in the project case part of their trip on the suburban rail system. This mode is thus included as mode of transport. For all above listed transport modes the emissions per passenger kilometre (PKM) are calculated. To adjust for emission improvement under BAU, a technology improvement factor is applied.

Baseline emissions are calculated per passenger surveyed. For each passenger surveyed the individual baseline emissions are calculated and multiplied with the individual expansion factor thus getting the baseline emissions of all passengers of the specific week surveyed.

Figure 2 gives an overview of baseline and project emissions differentiated in indirect and direct project emissions.

Figure 2: Baseline and Project Emissions



B.5. Demonstration of additionality

The additionality of the project is determined using the “Tool for the demonstration and assessment of additionality (version 05.2, EB 39 Annex 10)”.

The project starting date is before the start of validation. Therefore, proof is given in table 5 that CDM was considered before the project starting date. The project starting date is defined in accordance with EB 41 Paragraph 67.

Table 5: CDM Project Chronology

Milestone	Date	Documentary Proof
Note Board of Directors of DMRC indicating that Kyoto Protocol (KP) should be used to offset additional costs of Metro Delhi	9.01.2001	File 24, Note Board of Directors
Note Chief Project Manager DMRC that additional costs for DMRC to provoke e.g. mode shift from buses and other modes of transport towards metro should be borne by Kyoto Protocol finance mechanisms	12.01.2001	File 25, Note
DMRC invitation to discuss access to CDM to offset additional costs of Metro Delhi	24.4.2002	File 26, invitation
Contact with CDM consultants	22.10.2003	File 27, letter
Meeting with CDM consultant	22.03.2004	File 28, letter
Environmental strategy for DMRC	09.02.2005	File 29, Letter Chief Engineer
Article on DMRC seeking carbon credits for mode shift (article based on interview with DMRC chief public relations officer Anuj Dayal)	06.04.2005	File 30, The Tribune, 6/4/2005 (row 4)
Contact with alternative CDM consultants	04.08.2005	File 31, Letter
Project start date: Signature date of 1st construction contract	10.11.2005	File 70, Contract
Ministry of Finance informs DMRC that CERs can be kept by DMRC and are not tied to Japanese credit for metro	01.03.2006	File 32, invitation
Order of CEO to identify CDM consultants	10.05.2006	File 33, order
Offer CDM consultant methodology and PDD development DMRC	29.09.2006	File 34, e-mail
Reminder Director General (MD) on success of MRT project with KP and that DMRC should identify consultant	21.12.2006	File 35, letter MD
Note of MD reminding of usage of Kyoto Protocol to make metro sustainable	16.01.2007	File 37, Letter MD
Grütter Consulting AG enters 1st methodology for MRTS (NM0229)	29.05.2007	NM0229; see UNFCCC website
Offer CDM services for DMRC by Grütter Consulting	10.7.2007	File 38, offer
2nd offer CDM services for DMRC by Grütter	22.10.2007	File 39, offer

Consulting		
Contract project development DMRC – Grütter Consulting	19.03.2008	File 40, contract
CDM methodology for rail-based Mass Rapid Transit by Grütter Consulting NM0266	30.03.2008	NM0266; see UNFCCC website
Data collection including realization of specific studies for DMRC (various studies)	May 2008 to August 2009	File studies Grütter Consulting
Methodology discussion with UNFCCC incl. various feedbacks of Grütter Consulting to UNFCCC	May 2008 to October 2009	Methodology Panel reports on NM0266 Approval EB 50 16.10.2009
GSC first version of the PDD	November 2009	UNFCCC website
GSC 2nd version of the PDD (current project)	May 2010	UNFCCC website

The major changes between the first PDD version of Delhi Metro and the new version has been the exclusion of the line 3 of Phase I as well as the exclusion of the 2 airport lines Airport – Dwarka Sector 21 and New Delhi – Airport. This was made due to having 2 different decision dates Line 3 and Phase II which is not compatible with one project starting date and due to claims of Delhi Airport Metro Express Pvt. Ltd. on property of the airport lines[13]. This has resulted in major changes of the PDD and therefore it was decided to webhost it again.

Prior project start, the board of DMRC already considered CDM as vital to cover for the additional costs of a metro shown in documents of the year 2001 and 2002 i.e. nearly 5 years prior project start. There are clear notes of the project participant that the project activity shall be formulated as a CDM activity (in 2001 the term Kyoto Protocol finance mechanism was used by the PP). Based on this DMRC started contacting potential consultants. Also, prior project starting date the project was included in the environmental strategy of DMRC. The project participant thus shows clearly awareness of the CDM prior to the project activity start date, and that the benefits of the CDM were a decisive factor in the decision to proceed with the project. Evidence to support this are a consideration of the decision by the MD with the full Power of the Board[14], to undertake the project as a CDM project activity.

The project starting date is the signature of the 1st construction contract for a Phase II line being 10/11/2005.

After project start the project participant has reliable evidence, that continuing and real actions were taken to secure CDM status for the project in parallel with its implementation. Actions taken include contacts with various consultants leading to the closure of a CDM development contract, newspaper articles, issues related to the property of CERs, the entry of a new methodology by the project participant (NM0229) which was rejected by the UNFCCC and a renewed entry of a methodology by the same project participant (NM0266). This 2nd proposal was finally accepted by EB 50 in October 2009. The project could not be entered earlier into validation due to the fact that no approved methodology for this case existed, with the first methodology for MRTS entered by Grütter Consulting in May 2007 (NM0229) subsequently being rejected by the Methodology Panel with a new methodology being submitted March 2008 (NM0266). The approval of this methodology took more than 1½ years thus delaying the entry to validation of the project. In this time all studies required for the PDD were conducted and the PDD was written to have the project ready for validation upon EB approval of the methodology.

STEP 1. IDENTIFICATION OF ALTERNATIVES TO THE PROJECT ACTIVITY CONSISTENT WITH CURRENT LAWS AND REGULATIONS

Sub-step 1a: Define alternatives to the project activity

All options are identified that meet the same requirement as the proposed project activity. Alternatives assessed are public transport systems which are complemented with other modes of transport such as passenger cars, taxis, motorcycles, motorized rickshaws and non-motorized transport:

1. The establishment of a BRT (Bus Rapid Transit);
2. The establishment of a LRT (Light Rail Transit);

[13] See File 76

[14] File 41, MD Board Powers

3. The continuation of the current public and individual transport systems, including (future) investments in road-based infrastructure if applicable;
4. The proposed project activity being implemented at a later date in the future, without being registered as a CDM project activity;
5. The project proposal not implemented as a CDM project activity i.e. the continuous construction of metro after Line 2.

All alternatives are consistent with current laws and regulations. Alternatives 1 and 2 have been assessed in chapter B.4. and have been discarded. Alternative 3 is the baseline situation. Alternative 4 has been discarded in chapter B4 respectively is identical with the alternative 5.

Alternative 5 is assessed in detail in the following paragraphs.

Step 2. Investment analysis

The investment analysis is realized in 2 sub-steps:

- Sub-step A making the complete investment analysis as prescribed in ACM0016 based on the information as available for the project proponent prior project starting date.
- Sub-step B: Plausibility check to assess the results received in step A. This includes assessing the financial results in relation with investment extensions of Phase II and assessing the financial results in view of performance experience with Metro Phase I corridors. This step is realized to assess if projections and assumptions used for the decision prior project start are reasonable in view of actual performance ex-post and if the results are robust taking into consideration information available ex-post decision taking.

Sub-step 2A. Investment Analysis

ACM0016 p.6 states:" Conduct an investment comparison analysis for all alternatives that are remaining after Step 1. Use the NPV as indicator." The remaining alternatives are a continuation of the current baseline transport system and the MRTS in absence of the CDM. A continuation of the current baseline system involves a multitude of actors and modes of transport with private passenger cars, taxis, motorized rickshaws, bikes and bus operators. While these realize investments in their modes of transport it is not only for the trips made by MRTS passengers. GOI (Government of India) or GNCTD (Government of National Capital Territory of Delhi) would not have to make specific investments in the baseline situation (road improvements or extensions would not only benefit the trips of potential MRTS passengers) thus no comparable investment for the baseline alternative can be identified. The project alternative is a clear investment and the NPV with and without CDM is therefore calculated.

Based on the approved methodology following elements are taken into consideration when applying the investment analysis:

- The investment analysis is undertaken from the perspective of the operator of the public transportation system of the city i.e. of DMRC, reflecting the costs and revenues from the perspective of the operator.
- The project operator is owned by GOI and partially by GNCTD[15]. Therefore, any subsidies or investments of the latter are included in the calculations, i.e. potential subsidies by GOI and GNCTD are considered as a capital investment by the project operator and are not subtracted from the total system costs. The project does not enjoy or given any subsidy / concession other than land cost which is included in the calculations performed. The extension corridors NOIDA and Gurgaon have received a subsidy (grant) for part of the investment from the respective local government. This grant has been deducted from the investment cost.
- In applying the investment comparison analysis, cost overruns of former investments in MRTS or reduced revenues of former MRTS investments compared to original projections, which make new investments less viable and riskier are considered in the investment analysis.

[15] For implementation and subsequent operation of Delhi MRTS (Mass Rapid Transit System), a company under the name DELHI METRO RAIL CORPORATION (DMRC) was registered on 03/05/1995 under the Companies Act, 1956. DMRC has equal equity participation from GOI (Government of India) and GNCTD (Government of National Capital Territory of Delhi).

India had prior to Metro Delhi only one metro in Kolkata which was opened to traffic in stretches between October 1984 and September 1995[16]. Kolkata metro had severe cost overruns on the one hand and much less passengers than expected on the other hand thus leading to huge losses. Based on a published report by Y.P. Singh, chief engineer MRTS, India[17] the estimated original cost was at 29 million USD at 1970-71 price level (222 million India Rupees with exchange rate of 7.5 INR per USD) while the actual cost was thereafter 326 million USD at 1993-94 price level (10,106 million INR with a price level of 31 INR per USD)[18] or 11x more than planned in USD (46x more in INR). Also, traffic projections were highly optimistic with expected numbers of 612 million passengers for 1990 and 630 million by 2001.[19] Actual passenger numbers were far lower with only transporting 1990-91 23 million passengers and 1999/2000 56 million passengers or only 9% of expected passengers[20]. Logically the net revenue (traffic earnings minus working expenses[21]) were highly negative with a deficit of around 657 million Rupees 2001-02[22] thus making the metro financially unviable. Kolkata metro is thus incurring huge annual operating losses, increasing every year. Instead of an annual deficit of 0.21 million USD[23] the actual deficit was between 1.09 (1990-91) and 13.68 million USD (2001-02)[24] i.e. the deficit was 5 to 65 times higher than expected. Similar data is reported by Kolkata Metro[25] in a Phase II design and construction report issued June 2000. The following table summarizes the planned versus actual performance of Kolkata metro prior project start. Kolkata metro was the only metro operational prior project starting date. Delhi Metro Phase I only entered in operations after project starting date and thus performance data of Phase I cannot be included. However, for plausibility checks actual performance data of Delhi Metro Phase I will be considered.

Table 6: Planned versus Actual Performance of Kolkata Metro

Parameter	Planned	Actual	Relation actual to projected	Comment	Sources
Kolkata investment (million INR)	1,403 in 1971/72 2,495 in 1974/75 8,634 in 1908/81 13,308 in 1990/91	17,066	+ 28%	The estimate of 1990/91 is the first detailed estimate and is recent. This estimate is thus taken instead of the original. With the original cost estimate cost overruns are in the order of factor 12. In relation to the detailed last estimate the cost overrun is 28%. Singh (2002) also came to a factor 11 of increased costs.	Kolkata metro (2000)[26] Singh (2002)[27] for control
Kolkata passenger numbers (millions)	1.32 per day (1995/96) 630 per annum (2000)	0.128 per day 55.8 per annum	- 90%	Both data sources (different years) have 90% less passengers than projected. The lower (more conservative) difference between actual and expected passengers is taken.	Kolkata metro (2000), Singh (2002)

[16] File 48, chapter 1

[17] Y.P. Singh, 2002, Performance of the Kolkata (Calcutta) Metro Railway: A Case Study, in Godard and Fatonzou (eds), Urban Mobility for All; see File 44

[18] Price level end 1993 1 USD = 0.0318066 INR

[19] Y.P.Singh, 2002 table 1 for 1990 and text below for 2001 based on Calcutta Mass Transit Study prepared 1971

[20] Y.P. Singh, 2002, Table 3.

[21] Working expenditure excludes depreciation and interest on capital

[22] Y.P. Singh, 2002, table 4

[23] Subsidy required at the recommended fare level of 30 Paise in the 1971 Calcutta Mass Transit Study report; see Y.P. Singh, 2002, p. 338

[24] Y.P. Singh, 2002, table 4

[25] File 48

[26] File 48

[27] File 44

Only passenger numbers and not the investment sur-cost is taken for inclusion of past experience thus being conservative (Kolkata metro had experienced investment cost overrun plus less passengers). The more value of 90% (see table above) less passengers is taken. The fare box revenue is adjusted accordingly and at the same time (to remain conservative) the operational costs are also reduced in the same magnitude to have a conservative assessment (costs will probably reduce in a minor magnitude as not all costs are variable ones but partially costs can be reduced e.g. by running less trains, less electricity consumption, less staff etc).Other income sources of metro[28] are not adjusted although latter would also potentially suffer as especially advertisement revenues tend to decline with lower ridership as outreach and attractiveness of advertisement is lower with less passengers.

Due to having only one example in India prior DMRC (Kolkata) the performance of latter might be exceptional. For this reason, the financial analysis is realized with 3 base cases:

- 90% less passengers than expected based on the historic experience in India with MRTS in line with ACM0016
- 80% less passengers than expected i.e. twice better than the historic experience.
- 70% less passengers than expected i.e. 3x better than the historic experience.

Thereafter a plausibility check is also performed with the relation between projected and actual passenger numbers of DMRC Phase I metro lines since 2006 (step 2B).

The experience of Kolkata with higher than expected costs and lower than expected passenger numbers is by no way singular: it's in fact the "normal" case in most metros worldwide. GTZ MRTS training module shows that mass cost overruns and less passengers are typical of rail-based systems with examples being Washington metro 85% cost overrun, Mexico City metro 60% cost overrun and 50% less passengers, Tyne and Wear metro 55% cost overrun and 50% less passengers, Miami metro 50% less passengers[29]. GTZ/ITDP (Institute for Transportation and Development Policy) as authors state „Higher cost options such as rail-technologies, also tend to demonstrate greater disparity between projected and actual costs" (p.16) and also identify reasons for such cost overruns being economic self-interest, technological complexity, psychological factors. These factors are especially relevant as stated for „projects that require tunneling, elevated structures, and advanced technology probably also incur greater cost variance" (p.17). Similar results are obtained by other international studies e.g. Flyvjerg et.al., Megaprojects and Risk, 2003, p. 25[30] where for a group of metros the actual passenger numbers are compared with projected numbers with relations of 5 to 50%. These all in countries which already previously established metros (UK, USA, France, Mexico) and thus had experience and where also serious consulting firms comparable to Rites have made the feasibility. The same source on page 14 also shows that many metros have had serious cost overruns. The risk of having thus projections which are far off the reality is real and has been experienced by numerous comparable projects not only in India. The complexity of making correct metro passenger projections is highlighted by the fact that for Delhi Metro Phase I the actual passenger numbers are only 20-26% of the projected passenger numbers (see section 2B), this although the same consulting company (RITES) made the projections for DMRC as for Kolkata metro i.e. a comparable "error" was made concerning projections.

The magnitude of the risk adjustment is thus evidenced by the host country experience and is plausible in the international context of metros as well as by the actual experience of DMRC with Phase I corridors. While CDM cannot eliminate this problem of projections it can alleviate substantially the financial risk involved with wrong projections and can thus make metros sustainable and feasible from a financial perspective.

The guidelines for the investment analysis as listed in the Annex of AM_Tool_01 Version 05.2 are followed.

The financial/economic indicator chosen is the NPV in accordance with the methodology. The financial analysis is based on the preferential interest rate for external debt as provided by JBIC (Japan Bank for

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[28] Property development and advertisement basically

[29] File 53, GTZ, Table 7

[30] File 54

International Cooperation) for 56% of the funding, while 0% is taken for the part of Government Funding[31]. This is used as discount rate. This effectively represents the lowest (most conservative) discount rate based on the 2 funding options identified in the DPR under table 10.2 (File 42). The first option includes JBIC funding at 1.3% interest rate (Table 10.1. DPR, File 42) while the domestic funding option would amount to a discount rate of 9.5% (see point 10.8.2. table 10.1 and 10.2. File 42). This corresponds to an estimate of the cost of financing for the project as assessed in the DPR. The JBIC route followed is the same route as followed in Phase I of DMRC (see DPR point 10.9.2. Option 1, File 42). The approach is conservative as this rate is lower than the domestic debt rate which would be 6-9%[32]. The same financing structure has also been identified for the NOIDA extension[33] as well as for the Gurgaon extension[34].

The principles used for all calculations and their compliance with EB guidance is shown in the following table.

Table 7: Investment Principles and EB Guidelines

EB Guideline[35]	Project
Points1 and 2: General introduction of Guidance	
Point 3: Period of assessment	The period of assessment taken is 30 years of full operations (total 37 years due to construction time and partial operation). This corresponds to the full technical life-time of rolling stock (see following point). This is also in accordance with time frame of DPR see table 9.5 This is a longer period than the maximum period suggested in the guidelines and thus conservative. The salvage value is taken into consideration.
Point 4: Salvage value	Salvage value: • For land the full original value is included as salvage value. • The rolling stock and traction have a lifetime of 30 years and signaling and electrical works 20 years.[36] • For construction works 30 years due also to requiring major repairs plus wear and tear.
Point 5: Depreciation and other non-cash items	Depreciation and other non-cash items such as amortization are not included when calculating the NPV. Taxes and duties have not been included as DMRC assumed, in accordance with the DPR Phase II (point 9.5.1) that the project is exempt from taxes and duties plus state regulation of exemption income tax for infrastructure investments for the initial 20 years[37].
Point 6: Time of assessment	All calculations are based on data available as of September 2005[38] i.e. at time of decision taking and prior project start. As of this time Phase II included of the lines identified in table 2 plus NOIDA plus Gurgaon extension for which DPRs were available (Files 42, 73 and 74).
Point 7: Cesation of implementation	Not relevant for project
Point 8: Provision of spreadsheet	Spreadsheet is provided
Point 9: Finance expenditures	Financing expenditures are not included when calculating the

[31] DPR table 10.1 (File 42). The DPR points out that no dividends shall be paid out to shareholders. DPR states that the project shall be exempted from payment of divided till the senior debt has been repaid (DPR, 2005, 9.5.4, File 42). The JBIC senior debt is for a 30 year period as stated in point 10.10 DPR. Thus it is appropriate to use the same rate for the 30-year period.

[32] DPR Phase II, table 10.1, File 42 states 9.5% and point 10.8.2. DPR states a potential rate of 6.5% p.a.

[33] DPR point 12.5.3.1 (File 73)

[34] DPR point 12.6.2.1. (File 74)

[35] Tool for the demonstration and assessment of additionality, Version 5.2. Annex: Guidance on the Assessment of Investment Analysis Version 02

[36] DPR Phase II, 2005, 9.4.6. The estimated technical life-span is based on Rites Ltd. which is independent of the project owner (File 42)

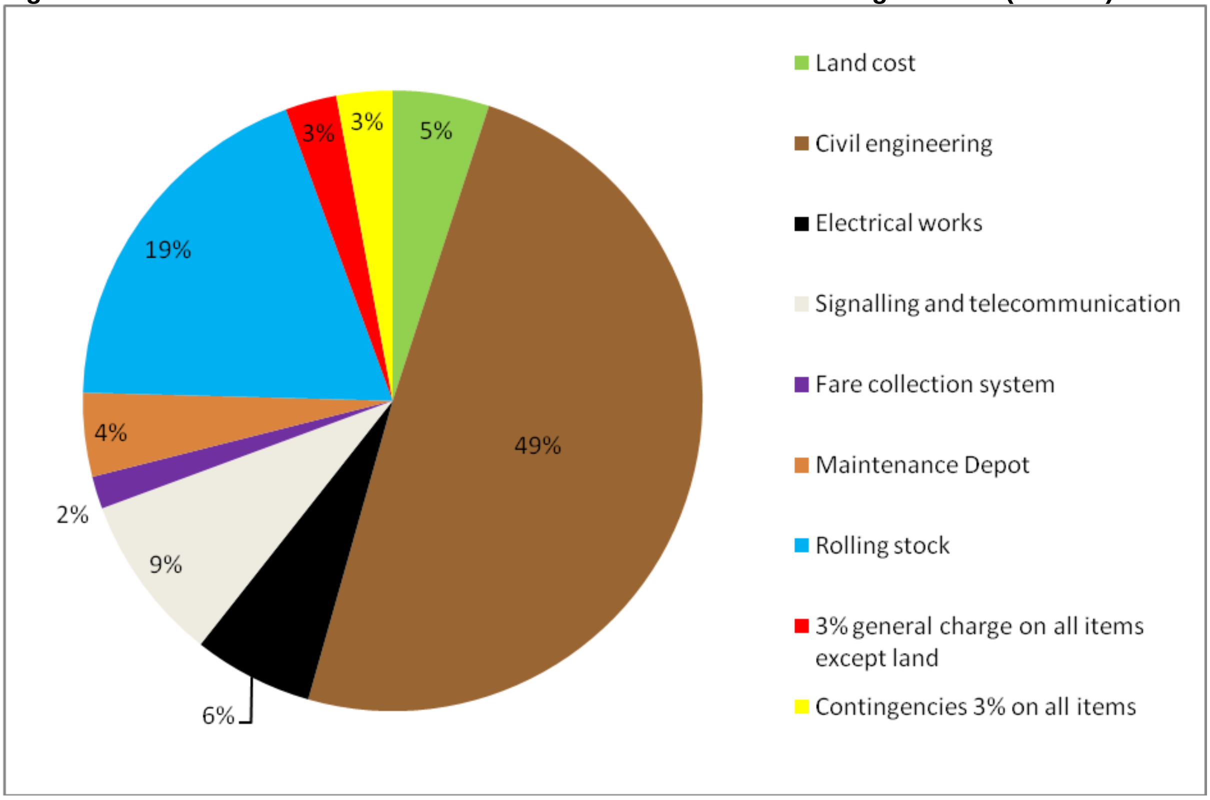
[37] File 43

[38] DPR report was available as of 2.2005

	NPV.
Point 10: Equity IRR	Not used by project as ACM0016 requires the usage of NPV.
Point 11-13: Benchmark	ACM0016 explicitly asks for a NPV. The financial/economic indicator chosen is thus the NPV in accordance with the methodology. The financial analysis is based on the preferential interest rate for external debt as provided by JBIC for 56% of investment and 0% for the remaining investment based not least on the fact that no dividends shall be paid to shareholders at least at the start. This is conservative as domestic lending rates would be 6-9%[39].
Point 14: Risk premiums	In accordance with ACM0016 which states that when applying the investment comparison analysis, cost overruns of former investments in MRTS or reduced revenues of former MRTS investments compared to original projections, which make new investments less viable and riskier, can be considered in the investment analysis (see discussion above)
Point 15: Benchmark analysis	Analysis is made based on NPV as required by ACM0016
Points 16 and 17: Sensitivity analysis	Sensitivity analysis is made assuming following changes: • 10% lower investment costs • 10% lower staff cost • 10% lower maintenance cost • 10% lower electricity cost • 10% increase in fare box revenues • 10% increase in other metro revenues These are all important cost/revenue variables and all variables which constitute more than 20% of cost respectively revenue in accordance with the Annex to the Tool points 16 and 17

Figures 3a to 3c show the investment cost distribution.

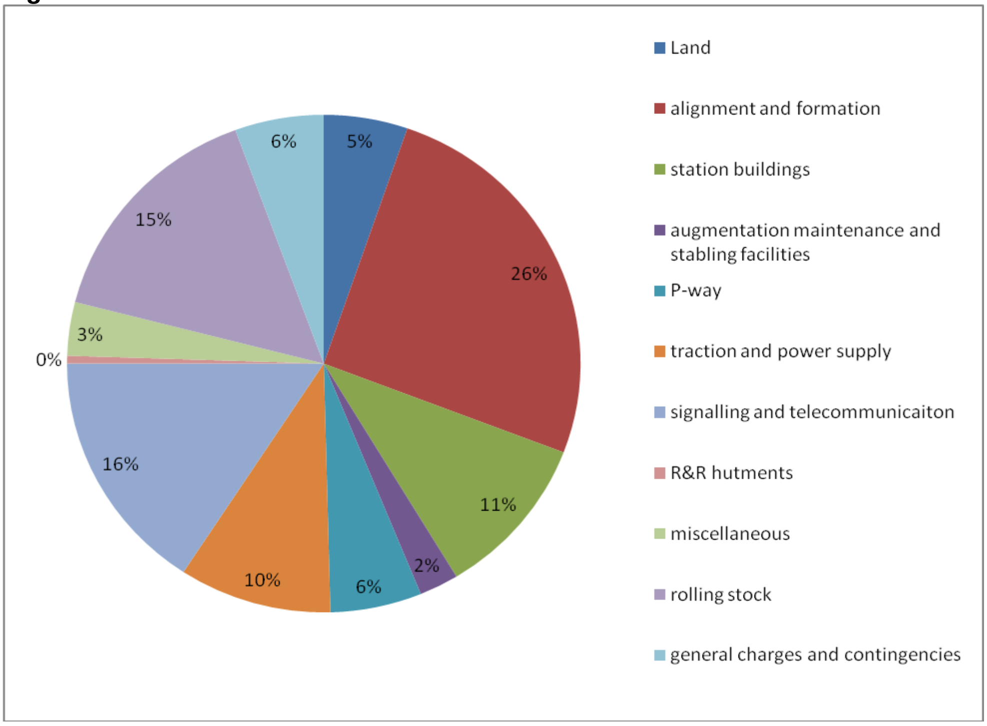
Figure 3a: Investment Cost Distribution DMRC Phase II Corridors Original DPR (Table 2)



Source: DPR Phase II, 2005, Annex 8.1, (File 42)

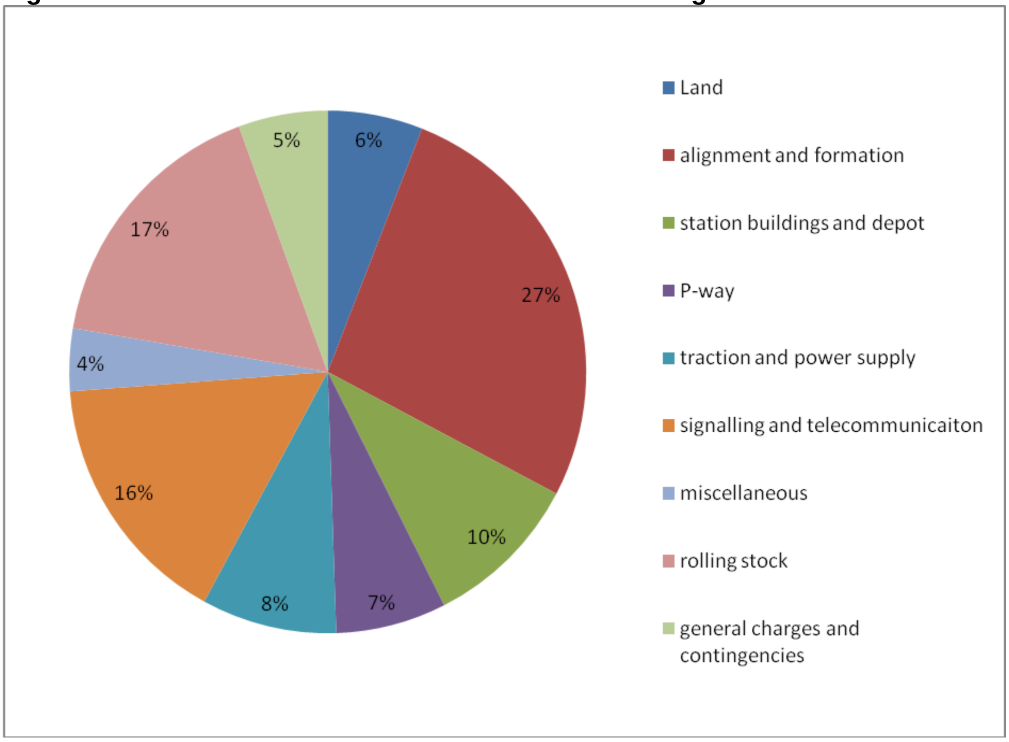
[39] DPR Phase II, table 10.1, File 42

Figure 3b: Investment Cost Distribution Extension NOIDA



Source: DPR, 11.2004, Table 10.2 (File 73)

Figure 3c: Investment Cost Distribution Extension Gurgaon



Source: DPR, 11.2004, Table 10.2. (File 74)

Table 8 shows the major parameters used for the financial assessment.

Table 8: Major Parameters for Financial Assessment

Parameter	Value	Source
Investment	100,442 million INR plus replacement and expansion investments in later years plus escalation factor	File 42 Table 9.1. and 9.13, File 73 Table 10.2, File 74 table 10.2
Staff cost (annual average entire	7,246 million INR	File 42 Table 9.5, File 73 Table

period)		12.2, File 74 Table 12.2a and 12.2b
Maintenance cost (annual average entire period)	10,298 million INR	File 42 Table 9.5, File 73 Table 12.2, File 74 Table 12.2a and 12.2b
Energy cost (annual average entire period)	3,297 million INR	File 42 Table 9.5, File 73 Table 12.2, File 74 Table 12.2a and 12.2b
Fare box revenue (annual average entire period)	38,120 million INR	File 42 Table 9.13, File 73 Table 12.5, File 74 Table 12.5a/b
Advertisement and property development revenue (annual average entire period)	994 million INR	File 42 Table 9.13, File 73 Table 12.5, File 74 Table 12.5a/b
Price of CERs	1,244 INR / ton	EEX/Bluenext[40]
Discount rate	0.7%	JBIC preferential rate of 1.3% for 56% of debt and rest at 0%; see Table 10.1. DPR, extension Gurgaon same financing pattern except for grant (see DPR 12.6.2.1) idem for extension NOIDA (see DPR point 12.5.3.1) (see also text above)[41]
Grant/Subsidy	11,804 million INR	Grants by local governments for extension NOIDA (File 73, point 12.6) and Gurgaon (File 74 point 12.7)

Source: DPRs of Phase II lines: File 47new based on DPR Phase II, 1/2005 (File 42), DPR NOIDA, 11/2004 (File 73) and DPR Gurgaon, 12/2004 (File 74)

Table 9 shows the financial profitability of the investment in absence of the CER. The 3 cases are thereby shown with 90%, 80% and 70% less passengers than expected.

Table 9: NPV Base Cases

Case	NPV in million INR
Base case (90% less passengers than projected)	-114,694
Adjusted base case 1 (80% less passengers than projected)	-69,239
Adjusted base case 2 (70% less passengers than projected)	-23,783

Source: File 47new, Financial spreadsheet

The NPV is in all cases negative i.e. the project runs a significant risk of not being financially feasible

Table 10 includes the sensitivity analysis.

[40] EEX for EU-ETS (File 49) price early September 2005 and Bluenext for CER to EU-ETS relation (File 50); Interbank exchange rate to INR for early September 2005

[41] File 42

Table 10: NPV Base Case and Sensitivity to Parameter Changes Excluding CER Revenues

Case	NPV in million INR
Base case	-114,694
Case 1: 10% lower investment cost	-96,039
Case 2: 10% lower staff cost	-112,797
Case 3: 10% lower maintenance cost	-111,988
Case 4: 10% lower energy cost	-113,821
Case 5: 10% higher fare box revenue	-104,673
Case 6: 10% higher other revenues	-112,054

Source: File 47new, Financial spreadsheet

In all cases the NPV is negative. The most significant change to the NPV occurs with a lower than expected investment and with higher fare box revenues. The plausibility check in 2B shows that the investment cost in practice is not lower than anticipated. Also, historical experience in general suggest higher investment costs and not lower ones (see table 9). If the fare box revenue increases by 10% e.g. due to more passengers then costs would also increase as more trains and thus more maintenance and more energy consumption. Thus, the NPV in case of increased passengers would not increase proportional. Therefore, also the projected change of fare box revenues (provoked either through more passengers or through higher tariffs – latter again would have its impact on passenger numbers due to price elasticity of demand) is optimistic as more passengers would also lead to higher operational costs and thus would partially swipe out the additional revenues.

From above calculations it is thus clear that the project in absence of the CDM is financially non-feasible.

Sub-step 2B. Plausibility Check

NPV with Final Total Investment

After decision taking Phase II metro was extended by the following stretches:

- Central Secretariat – Badarpur defined as Central Secretariat – Badarpur corridor in its DPR, with date October 2006[42]
- Extensions Dwarka Sector 9 – 21 (2.8 km) and Anand Vihar – Vaishali (2.6 km, July 2007)[43].

The investment of the Badarpur Corridor was 32,704 million INR (File 75, Table 13.1), the investment of the extension of Dwarka 2,752 million INR (File 81, Annex 2) and the investment of the extension Anand Vihar 2,461 million INR (File 77, table 7). Thus total investment increased by 38% while the length of metro lines increased by 34% i.e. nearly identical. However also passenger numbers, revenues and operational costs increased. Therefore the NPV has been calculated for the base case again based on the total investment for all lines of Phase II included in the project, the total expected revenues of all lines and the total expected operational costs of all lines[44].

The base case NPV for the full investment of Phase II and full operational cost/revenue projections is -133,025 million INR compared to the original Phase II NPV of – 114,694 million INR. This means that with all costs and benefits included after extensions of Phase II the NPV gets even more negative[45]. Thus the original projections made proof to be conservative and the extensions realized have not improved but worsened the NPV.

NPV with Adjustment of Passenger Numbers Based on DMRC Phase I

This plausibility check is performed to assess if the risk adjustment based on the experience of Kolkata metro is, based on ex-post data of DMRC Phase I, justified or not. The following table shows the relation between actual and projected passenger numbers of DMRC Phase I corridors.

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[42] DPR for Central Secretariat – Badarpur corridor, prepared by DMRC, 10.2006 (File 75)

[43] Files 77 and 81

[44] The investment cost, revenues and operational costs of the Dwarka extension were not included as no separate cost/income statements for this section was available. However, the incidence of this 2.8 km extension is considered as marginal (less than 2% of total investment)

[45] File 47 new, sheet „finance with final data“

Table 11: Projected versus Actual Passenger Numbers of DMRC Phase I Corridors

Year	actual passengers per day	projected passengers per day	actual as % of projected
2006	492,750	2,497,300	20%
2007	621,830	2,759,517	23%
2008	767,662	3,049,266	25%
2009	889,094	3,369,439	26%

Source: File 67new based on DPR Extension Line 3, Phase I, 2005 (File 79) for projections Phase I[46] and DMRC operations department for actual passenger numbers

At maximum the relation between actual and projected passenger numbers for Phase I is 26%. This is less than the adjusted base case II calculated ex ante in section 2A (30% of expected passengers was assumed in this case). With the best case of Phase I (actual passengers are 26% of projected) the NPV of DMRC Phase II is - 41,965 million INR i.e. the NPV is still clearly negative[47].

Thus, taking into consideration actual performance of DMRC with Phase I the NPV of Phase II remains negative. Thus, the assumptions taken in the NPV calculation with a base case and two adjusted base cases proof to be conservative and in line with the context and experience of metros in India including DMRC Phase I. The conclusion reached is thus that the risk adjustment factor used for determination of the project NPV is plausible and compatible not only with Kolkata metro but also with the most recent experience of DMRC on Phase I corridors.

The conclusion is thus that in absence of the CDM the project faces the clear risk of having a negative NPV and thus not being financially feasible.

Impact of CDM

Table 12 shows the NPV with and without revenues from the sale of carbon offsets for the three base cases assessed. Clearly the NPV and thus the financial risk is significantly reduced. In the adjusted base case 2 the NPV is virtually 0. Under an ex-post perspective based on the experience of Phase I DMRC this case seems to be also the most probable as actual data show in this direction.

Table 12: NPV with and without carbon finance

	NPV (million INR)
NPV with carbon finance base case (10% of projected passengers)	-91,430
NPV with carbon finance adjusted base case 1 (20% of projected passengers)	-45,975
NPV with carbon finance adjusted base case 1 (30% of projected passengers)	-520

Source: File 47new, Financial spreadsheet

The access to CDM finance is thus decisive to reduce the risk of the metro and to achieve financial sustainability.

CDM makes a clear difference between potentially high deficits making the metro unsustainable and a metro which does not make huge profits but operates without deficit and is thus financially manageable.

Step 3. Common practice analysis

Sub-step 4a. Analyze other activities similar to the proposed project activity:

The investment analysis shall be complemented with an analysis of the extent to which the proposed project type has already diffused in host country. This test is a credibility check to complement the investment analysis (Step 2). All cities or urban areas with more than 1 million habitants which have already implemented a MRTS, including metros (underground, elevated or surface level), LRT (Light Rail Transit) including trams, and BRT (Bus Rapid Transit system) including bus lanes are listed. The proposed project

[46] Latest available projections for Phase I and thus most realistic and in line with actual construction of Phase I corridors

[47] File 47new sheet „plausibility“

activity is regarded as common practice if MRTS have already been implemented in 50% of the cities with more than 1 million habitants in the host country without using the CDM.

Table 13 shows cities in India with more than 1 million inhabitants and MRTS systems implemented by these cities.

Table 13: Indian Cities with over 1 Million Inhabitants and Existence of MRTS as of Project Starting Date[48]

City	Inhabitants (in millions)	MRTS system[49]
Agra	1.3	No MRTS
Ahmedabad	4.5	No MRTS[50]
Allahabad	1.0	No MRTS
Amritsar	1.0	No MRTS
Asansol	1.1	No MRTS
Bangalore	5.7	No MRTS[51]
Bhopal	1.5	No MRTS[52]
Chennai (Madras)	6.6	Elevated train[53]
Coimbatore	1.5	No MRTS
Delhi	12.9	Metro Phase I
Dhanbad	1.1	No MRTS
Faridabad	1.1	No MRTS[54]
Hyderabad	5.7	No MRTS[55]
Indore	1.5	No MRTS[56]
Jabalpur	1.1	No MRTS
Jaipur	2.3	No MRTS
Jamshedpur	1.1	No MRTS
Kanpur	2.7	No MRTS[57]
Kochi	1.4	No MRTS
Kolkata	13.2	Metro
Lucknow	2.2	No MRTS[58]
Ludhiana	1.4	No MRTS[59]
Madurai	1.2	No MRTS
Meerut	1.2	No MRTS
Mumbai	16.4	Suburban train[60]
Nagpur	2.1	No MRTS
Nasik	1.2	No MRTS
Patna	1.7	No MRTS

[48] 9/2005

[49] Metro, LRT, BRT/bus lane

[50] Ahmedabad plans a BRT but as of project start this was not yet operational

[51] Metro is under construction and has realized a CDM tender for this project

[52] BRT is under planning

[53] In fact, this is an extension of the suburban rail and not a metro e.g. the trains have no automatic doors. However, some sources consider it as a metro due to the fact that there is a specific elevated line where only these trains run on i.e. the line is not shared with various trains.

[54] DMRC plans to cover the city with a metro extension

[55] Metro is under planning; the current rail-service is commuter rail to suburbs

[56] A BRT which has applied for CDM is planned but is not yet operational

[57] Kanpur had trams until 1933; metro is under planning

[58] Metro is under planning

[59] Metro is under planning

[60] Metro and LRT under construction; metro also proposed as CDM project. Suburban train at least in some lines can be considered as MRTS

Pune	3.8	No MRTS[61]
Rajkot	1.0	No MRTS[62]
Surat	2.8	No MRTS[63]
Vadodara	1.5	No MRTS
Varanasi	1.2	No MRTS
Vijayawada	1.0	No MRTS
Vishakhapatnam	1.3	No MRTS[64]

Source:
Population: Census 1.3.2001
For metros and elevated trains see city website of respective city; for links to these websites see Wikipedia

In total India had at the project starting date 35 cities with a population of 1 million and more. Of these the only other metro next to Delhi in India is in Kolkata. Mumbai has as MRTS sub-urban rail which at least in some lines is a MRTS and Chennai an elevated train which is also considered by some sources as a MRTS. All other cities have as modes of transport the traditional bus services, rickshaws, taxi services, private cars, motorcycles and NMT. 4 out of 35 cities (including Delhi) represent 11% of cities with more than 1 million inhabitants and thus far less than the benchmark of 50% provided by the methodology. The project is thus clearly not common practice in India.

The steps realized above clearly show that the project activity is not the baseline and is not a viable alternative under BAU.

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

BASELINE EMISSION CALCULATIONS

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

The following steps are made:

Step 1: Conduct a survey, following the procedures presented in Annex 3, 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 (as defined in Annex 3), 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.

PROCEDURE

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

[61] BRT under development

[62] BRT under development

[63] BRT under development and metro under planning

[64] BRT under planning

Where:

BE_y	Baseline emissions in the year *y* (g CO_2)
$BE_{p,y}$	Baseline 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 baseline emission per surveyed passenger is calculated based on the mode used, the trip distance per mode and the emission factor per mode:

$$BE_{p,y} = \sum_{i} BTD_{p,i,y} \cdot EF_{PKM,i,y} \quad (2)$$

Where:

$BE_{p,y}$	Baseline emissions per surveyed passenger *p* in the year *y* (g CO_2)
$BTD_{,p,i,y}$	Baseline 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* (g CO_2/PKM)
i	Relevant vehicle category
p	Surveyed passenger
y	Year of the crediting period

(1) Identification of the relevant vehicle categories (modes of transport)

The baseline is a continuation of the current transport system consisting of various transport modes between which the population chooses:

- NMT (Non-Motorized Traffic) with bikes and per foot;
- Private passenger car;
- Taxis;
- Motorcycles;
- Motorized auto-rickshaws (used as taxis);
- Buses;
- Suburban rail.

The survey includes also induced traffic i.e. trips which in absence of the project would not have been made.

Suburban rail is included as the methodology captures total emissions from the trip origin to the trip destination. This may be based partially on suburban rail. The MRTS will however not compete for passengers with suburban rail as no comparable traffic routes are offered. Also, the pilot survey realized on DMRC showed that no passengers used the sub-urban rail to and from the metro nor would they have used the sub-urban rail as baseline mode of transport. However sub-urban rail is included in the baseline as some passengers in the metro sections of Phase II might use it later. All possible vehicle categories are thus included in the baseline emission calculations.

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

Passenger-kilometre (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.

For the suburban rail (electricity-based vehicle category), the following equation is used:

$$EF_{PKM,i,y} = \frac{TE_{EL,i,y}}{P_{EL,i,y} \cdot TD_{EL,i}} \quad (3)$$

Where:

$EF_{PKM,i,y}$	Emission factor per passenger-kilometre of suburban rail for year *y* (gCO_2/PKM)
$TE_{EL,i,y}$	Total emissions from suburban rail for year *y* (tCO_2)
$P_{EL,i,y}$	Total passengers transported per year by suburban rail for year *y* (passengers)
$TD_{EL,i}$	Average trip distance of passengers using suburban rail prior to project start (km)
i	Suburban rail
y	Year of the crediting period

The total emissions from suburban rail is calculated using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". When applying the tool, the parameter $EC_{BL,k,y}$ in the tool is taken as the amount of electricity used by suburban rail for the year *y*, consistent with the transportation of $P_{EL,i}$ passengers along the average distance $TD_{EL,i}$[65].

For all other fuel-based vehicle categories, the emission factor per PKM is calculated as:

$$EF_{PKM,i,y} = \frac{EF_{KM,i,y}}{OC_i} \quad \textbf{(4)}$$

Where:

$EF_{PKM,i}$	Emission factor per passenger-kilometre of vehicle category *i* in the year *y* (g CO_2/PKM)
$EF_{KM,i}$	Emission factor per kilometre of vehicle category *i* in the year *y* (g CO_2/km)
OC_i	Average occupation rate of vehicle category *i* prior project start (passengers)
i	Relevant vehicle category
y	Year of the crediting period

(2.1.) Determination of the average occupation rate (OC_i)

The average occupation rate of vehicle category *i* is determined based on visual occupation studies. In the case of taxis, the driver is not included. Formula (5) of the methodology is not required as also for buses the occupation rate has been determined based on visual occupation studies.

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

Relevant fuel types, for each vehicle category, have to be identified. The emission factor per kilometre is re-calculated annually based on the recorded share of fuels per category. In case biofuel blends are used the biofuel share of the blend is accounted for with zero emission factor ($EF_{CO2,x,y}$). Buses operating in Delhi are all large units. Formula (8) of the methodology is thus not used. No BRT bus lane was operational prior to project start.

The emission factor per kilometre is not constant but annually updated. Rail-based vehicles must monitor annually the electricity consumption plus passengers transported (see formula 3).

All other vehicle categories except suburban rail apply the following formula:

$$EF_{KM,i,y} = (IR_i)^{t+y-1} \cdot \frac{\sum_x \left(SFC_{i,x} \cdot NCV_{x,y} \cdot EF_{CO2,x,y} \cdot N_{x,i}\right)}{N_i} \quad \textbf{(5)}$$

Where:

$EF_{KM,i,,y,}$	Emission factor per kilometre of vehicle category *i* in the year *y* (g CO_2/km)
$SFC_{x,i}$	Specific fuel consumption of vehicle category *i* using fuel type *x* prior project start (g/km)
$NCV_{x,y}$	Net calorific value of fuel *x* in the year *y* (J/g)
$EF_{CO2,x,y}$	Carbon emission factor for fuel type *x* in the year *y* (g CO_2/J)
$N_{x,i}$	Number of vehicles of category *i* using fuel type *x* prior to project start (units)

[65] The trip distance is only monitored prior project start. The electricity consumed and the passengers transported are monitored annually to track technological improvements in the rail-based system leading to changes in the emission factor per passenger transported.

$N_{x,i}$ Number of vehicles of category *i* prior to project start (units)
IR_i^{t+y} Technology improvement factor for the vehicle of category *i* per year *t+y* (ratio)
i Relevant vehicle category
x Fuel type
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 CDM project
y Year of the crediting period

For train (idem for metro) using electricity the EF is calculated based on the Tool 05 “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” baseline and or leakage emissions from electricity consumption” (equation 1).

$$EF_{KM,i} = SEC_{KM,i} \times EF_{grid,CM} \times (1 + TDL) \quad \textbf{(6)}$$

Where:
$EF_{KM,i}$ Emission factor per kilometre of vehicle category *i* (train/metro) (gCO_2/km)
$SEC_{KM,i}$ Quantity of electricity consumed per kilometre of vehicle category *i* train/metro (kWh/km)
$EF_{grid,CM}$ Emission factor for electricity generation in the grid based on combined margin (gCO_2/kWh)
TDL Average technical transmission and distribution losses for providing electricity

The alternative of the Combined Margin (CM) is chosen, determined ex-ante for the entire crediting period. The CM is calculated based on the “Tool to calculate the emission factor for an electricity system”, Version 01.1 and the Tool05 “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation. Scenario A of this tool applies as the electricity consumed is from the grid. Option A1 is used to calculate the emission factor of the grid based on the CM.

The technology improvement factor is taken from the methodology.

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. 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.

Project passengers are those which enter stations of the project metro lines as included in the PDD. For stations shared by a non-project metro line (e.g. currently metro lines of Phase I) as well as a project metro line the passengers are distributed proportionally i.e. if the station is used by a line of Phase I plus a project metro line then the passengers are distributed 50:50, if the station is used by metro lines 1, 2 of Phase I plus a project line then the passengers are distributed 66:33 i.e. 33% are considered as project passengers.

PROJECT EMISSION CALCULATIONS

Project emissions are based on the electricity consumed by the metro for train traction (direct project emissions) plus emissions caused by project passengers from their trip origin to the entry station of the metro and from the exit station of the metro to their final destination (indirect project emissions).

Project emissions are calculated as follows:

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

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 (DPE_y)

The project activity involves an electricity-based transport system. The emissions from electricity consumption are based on the Tool05 “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation Only electricity consumed for train propulsion is included in rail-based MRTS.

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 plus 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 (Global Positioning System) (identical to baseline trip determination). The emission factors per passenger-kilometre used for indirect project emissions are identical to the baseline passenger-kilometre factors ($EF_{PKM,i,y}$).

Following core steps are realized:

Step 1: Realize a survey in which for each surveyed passenger the trip distance per mode used to/from the MRTS is determined.

Step 2: Calculate for each surveyed passenger his indirect project emissions.

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

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

The detailed corresponding formulas are included in Annex 3.

$$IPE_y = \frac{P_y}{P_{SPER}} \sum_p \left(IPE_{p,y} \cdot FEX_{p,y} \right) \quad \textbf{(8)}$$

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.

$$IPE_{p,y} = \sum_i IPTD_{p,i,y} \times EF_{PKM,i,y} \quad \textbf{(9)}$$

Where:

$IPE_{p,y}$	Indirect project emissions per surveyed passenger *p* in the year *y* (g CO_2)
$BTD_{,p,i,y}$	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* (g CO_2/PKM)
i	Relevant vehicle category
p	Surveyed passenger
y	Year of the crediting period

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. For the entire survey design see Annex 3. The same method of expansion factors is used as outlined in the baseline section.

Indirect project emissions are only included for the project passengers. Passengers transported are based on passengers entering stations. Project passengers are those which enter stations of the project metro lines as included in the PDD. For stations used by a non-project metro line (e.g. currently metro lines Phase I) as well as a project metro line the passengers are distributed proportionally.

LEAKAGE EMISSION CALCULATIONS

Leakage emissions 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; and,
- Emissions due to reduced congestion on affected roads, provoking higher average vehicle speed, plus a rebound effect.
- Upstream emissions of gaseous fuels ($LE_{UP,y}$).

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

Leakage emissions are calculated as follows:

$$LE_y = LE_{LFB,y} + LE_{LFT,y} + LE_{CON,y} + LE_{UP,y} \quad \textbf{(10)}$$

Where:

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

IFor each component leakage is only included if it has a positive value.

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 and 4 of the crediting period. 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:

$$LE_{LFB,y} = \frac{1}{10^6} \cdot N_{B,y} \cdot AD_B \cdot EF_{KM,B,y} \cdot \left(1 - \frac{OC_{B,y}}{OC_B}\right) \quad \textbf{(11)}$$

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* (g CO_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)
y	Year of the crediting period

The occupancy rate of buses is monitored through visual occupation studies (see Annex 3).

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 and 4 of the crediting period. This leakage is calculated as:

$$LE_{LFT,y} = \max(N_{T,y} \cdot AD_T \cdot EF_{KM,T,y} \cdot \left(1 - \frac{OC_{T,y}}{OC_T}\right) \cdot \frac{1}{10^6};0) \quad \textbf{(12)}$$

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 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 which in absence of latter would have taken a taxi.

The occupancy rate of taxis is monitored through visual occupation studies counting the number of passengers (see Annex 3).

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 baseline emissions section, substituting *i* for T (taxis).

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

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.[66]

DMRC has not taken away any existing road space. Therefore, based on ACM0016 Version 04.0 no monitoring is required. In Equation 11 of the methodology RS_{BL} (road space baseline) is identical to RS_{PJ} (road space project). Therefore ARS (additional road space available) cannot be negative.

Upstream emissions from gaseous fuels

Upstream leakage of gaseous fuels shall be only included if the project vehicles consume more gaseous fuels than baseline vehicles. Project metro only consumes electricity. Therefore, in the baseline more gaseous fuels are used than in the project situation. Upstream emissions from gaseous fuels are therefore not considered.

EMISSION REDUCTIONS

[66] Paragraph 74 of ACM0016 Version 04.0

$$ER_y = BE_y - PE_y - LE_y \quad (13)$$

Where:

ER_y	Emission reductions in year *y* (t CO_2e/yr)
BE_y	Baseline emissions in year *y* (t CO_2e/yr)
PE_y	Project emissions in year *y* (t CO_2/yr)
LE_y	Leakage emissions in year *y* (t CO_2/yr)

If for a certain year $LE_y < 0$, then leakage is not be included in the calculation of emissions reductions. If $LE_y > 0$, then it is included

Validity of the current baseline for the next crediting period

The following parts are based on the Methodological Tool Version 03.0.1 "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period"

Step 1.1. Compliance with mandatory policies: The current baseline complies with all relevant mandatory national and/or sectoral policies which have come into effect after the submission of the project activity for validation and are applicable at the time of requesting renewal of the crediting period. All baseline road modes are legally allowed to operate in Delhi and continue to operate as they have done also prior CDM project registration. The baseline therefore complies with all relevant national and sectoral policies.

Step 1.2. Impact of circumstances existing at the time of requesting renewal of the crediting period on the current baseline emissions, without reassessing the baseline scenario: The baseline scenario identified at the validation of the project activity was the continuation of the current practice. This requires an assessment of the changes in market characteristics. The baseline scenario identified in the registered PDD (see registered PDD step 3, page 15) is a continuation of existing modes of transport including bus, car, taxi, motorcycle, 3-wheelers, sub-urban rail or Non-Motorized Transport. All of these modes continue to operate also 2019 i.e. currently in Delhi. All baseline transport modes continue to operate and are allowed to operate in Delhi. No regulation exist that such transport modes are not allowed to operate. Market characteristics have not changed the baseline scenario of available modes. Which mode passenger might use can change over time: this is monitored through the surveys which ask passengers for their mode of preference in absence of the metro. Vehicle renewal takes place and this can involve also change of fuel types or emission factors of baseline vehicles. This does however not change the baseline scenario which are the different modes which can be used by passengers but only the emission factors used for baseline modes of transport which are thus re-assessed and fixed newly for the 2nd crediting period. The market characteristic of the baseline scenario is therefore still valid.

Step 1.3. Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested. As mentioned under steps 1 and 2 the same baseline modes of transport (e.g. cars, motorcycles, buses) operate. However, vehicles are continuously renewed with potential changes in their GHG emissions. The baseline emission factors used per mode of transport are thus updated.

Step 1.4. Assessment of the validity of the data and parameters: Data and parameters that were only determined at the start of the crediting period and are not monitored during the crediting period are updated (see Section B.6.2.).

Based on steps 1.1. to 1.4. Data and parameters fixed ex ante are updated.

Based on the approved methodology ACM0016 the following steps also need to be taken with the implementation of the 2nd crediting period:

1. When a renewable crediting period is chosen, project participants shall use a four-step model, or equivalent, of the transportation system of the project city for the purpose of modelling the modal split, share of passengers who shifted from electricity-based or road-based vehicle category i, Si or share of passenger-kilometers who shifted from electricity-based or road-based vehicle category i, SDi, and an average trip distances travelled by passengers who shifted from electricity-based or road-based vehicle category Di for the second and third crediting periods. For the determination of the baseline emissions, the most conservative value shall be used between estimates of baseline emissions based on the modelled parameters and the parameters determined via passenger surveys.

For projection purposes of the emission reductions of the 2nd crediting period the results of a 3rd party city modelling with/without Delhi metro was compared with the survey results (last survey realized). Transport models are far less precise as they do not differentiate between metro users and non-metro users concerning their baseline trip. Also, transport models only include 1 mode from trip origin to trip destination (not various as in the survey), and do not include trip distance and mode sued to/from the metro. Their precision level is therefore limited. However, this is only used to determine conservative factors for the projections. ACTUAL emission reductions will be based on 2 surveys being conducted (as in the 1st crediting period), one in 2020 and one in 2023. These surveys will be used to determine, as in the 1st crediting period, the actual emission reductions.

The modelling results are based on a report of Climtrans: Prof. Dr. Sanjay Gupta Sandhya Damenija, School of Planning and Architecture New Delhi, May, 2017: Rapid Assessment of Travel Patterns in Delhi – Horizon Year 2030 and 2050 (File R13). The planning horizon 2030 is taken as this corresponds to the 2nd crediting period. Method 3 of forecast is taken from the report which is based on an also increasing bus fleet (in line with the proposal of the government as mentioned in the report p. 21), a forecast of the 2030 motorization and trip rate of Delhi using the population trend from 1980 to 2014 and the modal split are estimated based on metro ridership with the inclusion of metro expansion phases.

To make projections a emission reduction factor per passenger needs to be derived. The surveys have this factor determined based on average baseline emissions per passenger minus average indirect project emissions per passenger. The transport model comes to this result with the following steps:

Step 1: Determine the baseline mode shares of metro passengers which would have used in absence of the metro other modes of transport.
Step 2: Determine the average trip distance per mode of metro users.
Step 3: Based on the emission factor per mode calculate the emission reductions.

The following table shows the results (see for details including calculations and exact referencing to report File R14).

Table 14: Model Results (for 2030)

Parameter	Bus	Car[67]	2-wheeler	Rickshaw
Share of metro passengers which would have used other baseline modes in absence of metro	8%	39%	37%	15%
Average total trip length of metro passengers which would have used other modes in absence of metro in km	22.0	25.7	19.4	22.9
Emission factor per pkm per mode in gCO_{2e}/pkm	27	124	50	55

Based on above figures the average baseline emissions per passenger is: 1,842 gCO_{2e}/passenger. The emission reductions are based on the avoided emissions of passengers which would have used other modes in absence of the metro.

The average baseline emissions based on the survey is 2,448 gCO_{2e}/passenger.

No indirect project emissions are determined in the transport model and therefore the value of the surveys is taken.

For projection purposes the lower and therefore more conservative transport model value is taken (1,842 gCO_{2e}/passenger). However, surveys will be conducted to establish the actual monitored value which will be taken to determine the CERs.

2. Percentage or share of vehicle-kilometers or vehicles in vehicle category i using fuel type n in year y of the second or third crediting period, Ni,n,y/Ni,y, or parameters used to estimate this share Ni,y and Ni,n,y, which are the number of vehicle-kilometers or vehicles in vehicle category i, and the number of vehicle-kilometers or vehicles in vehicle category i using fuel type n in year y, can be based on data from municipal transit authorities 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.

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[67] Passenger car and taxi

Data used has been updated.

3. Furthermore, project participants shall apply the latest approved version of the tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period".

The tool has been applied (see above) and ex ante data and parameters have been updated.

B.6.2. Data and parameters fixed ex ante

Data/Parameter	$SFC_{C/T, G/D}$
Data unit	g/km
Description	Specific fuel consumed of passenger cars (C) and taxis (T) using gasoline or diesel
Source of data	UNFCCC CDM Tool 18 Methodological tool: Baseline emissions for modal shift measures in urban passenger transport
Value(s) applied	Gasoline car/taxi: 44 g/km Diesel car/taxi: 42 g/km
Choice of data or measurement methods and procedures	The globally applicable default value based on the tool is taken as no updated surveys of fuel consumption of cars or taxis is available for Delhi (alternative 1) nor national/international literature with comparable surroundings (alternative 2). IPCC default values have not been updated in 2006 and are therefore outdated (alternative 3) and design data plus detailed registration data is not available per vehicle models and years (alternative 4). Therefore alternative 5 is chosen with globally applicable default values. Globally applicable default values based on tool: 1. Gasoline car/taxi 6 l/100km 2. Diesel car/taxi 5 l/100km Specific weight of fuels: a). Density of gasoline: 0.741 kg/l b). Density of diesel: 0.844 kg/l Source: IEA (2005), Energy Statistics Manual, Table A3.8 (File R1) Calculation: (default value/100) * specific weight *1000 = specific fuel consumption in g/km
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	$SFC_{C/T, CNG}$
Data unit	g/km
Description	Specific fuel consumed of passenger cars (C) and taxis (T) using CNG
Source of data	EEA (2018), EMEP/EEA air pollutant emission inventory guidebook 2016 – Update July 2018, Table 3-15 (File R2)
Value(s) applied	63 g/km
Choice of data or measurement methods and procedures	Alternative 2 taken Based on the UNFCCC CDM Tool 18 Methodological tool: Baseline emissions for modal shift measures in urban passenger transport: No updated surveys of fuel consumption of cars or taxis is available for Delhi (alternative 1). International literature is taken using the lowest available value (alternative 2). IPCC default values have not been updated in 2006 and therefore outdated (alternative 3), design data plus detailed registration data is not available per vehicle models and years (alternative 4) and the UNFCCC has no globally applicable default value for CNG vehicles (alternative 5).
Purpose of data	Baseline and project emissions
Additional comment	The COPERT model of EEA is also used by IPCC

Data/Parameter	**SFC_M**
Data unit	g/km
Description	Specific fuel consumed of motorcycles
Source of data	UNFCCC CDM Tool 18 Methodological tool: Baseline emissions for modal shift measures in urban passenger transport
Value(s) applied	15
Choice of data or measurement methods and procedures	The globally applicable default value based on the tool is taken as no updated surveys of fuel consumption of motorcycles is available for Delhi (alternative 1) nor national/international literature with comparable surroundings (alternative 2). IPCC default values have not been updated in 2006 and are therefore outdated (alternative 3) and design data plus detailed registration data is not available per vehicle models and years (alternative 4). Therefore alternative 5 is chosen with globally applicable default values. Globally applicable default values based on tool: 2 l/100km Density of gasoline: 0.741 kg/l Source: IEA (2005), Energy Statistics Manual, Table A3.8 (File R1) Calculation: (default value/100) * specific weight *1000 = specific fuel consumption in g/km
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	**SFC_{TR}**
Data unit	g/km
Description	Specific fuel consumed of motorized auto-rickshaws
Source of data	Reynolds et.al. (2011) Determinants of PM and GHG emissions from natural gas-fuelled auto-rickshaws in Delhi; Transportation Research Part D Transport and Environment 16(2): 160-165 March 2011, table 3 lower value 4-stroke and 2-stroke (File R3)
Value(s) applied	35
Choice of data or measurement methods and procedures	Based on the UNFCCC CDM Tool 18 Methodological tool: Baseline emissions for modal shift measures in urban passenger transport: No updated surveys of fuel consumption of auto-rickshaws is available for Delhi (alternative 1). National literature is taken using the lowest available value (alternative 2). IPCC default values have not been updated in 2006 and therefore outdated (alternative 3), design data plus detailed registration data is not available per vehicle models and years (alternative 4) and the UNFCCC has no globally applicable default value for CNG vehicles (alternative 5). The lower value between 4-stroke and 2-stroke vehicles is taken to be conservative.
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	**SFC_B**
Data unit	g/km
Description	Specific fuel consumed of buses
Source of data	Delhi Transport Corporation (DTC), Operational Statistics March 2019, Table 1-8 (File R4)
Value(s) applied	459
Choice of data or measurement methods and procedures	Based on the UNFCCC CDM Tool 18 Methodological tool: Baseline emissions for modal shift measures in urban passenger transport: alternative 1 is chosen based on official published data of Delhi. DTC manages the urban bus fleet of Delhi. Data of all buses (not based on survey). Data for the year 2017-18. Entire urban bus fleet based on CNG. Value expressed in km per kg and transformed to g per km Value reported by DTC: 2.18 km per kg Transform from km per kg to g per km: 1/2.18*1000 = 459
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	**$N_{C,G/D/CNG}$**
Data unit	%
Description	Percentage of passenger cars using fuel type: gasoline, diesel or CNG
Source of data	Department of Transport, Delhi, VAHAN 4.0 Database accessed 26.09.2018 (File R5)
Value(s) applied	Gasoline: 62.6% Diesel: 25.8% CNG: 11.6%
Choice of data or measurement methods and procedures	official registration statistics
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	**$N_{T,CNG}$**
Data unit	%
Description	Percentage of taxis using CNG
Source of data	Supreme Court of India mandated that all commercial passenger vehicles including taxis be CNG powered; see https://scroll.in/article/807463/delhi-has-relied-on-cng-to-control-its-pollution-in-the-past-but-will-it-work-this-time (File R10)
Value(s) applied	100%
Choice of data or measurement methods and procedures	Official regulation of Delhi asking for public transport vehicles to be CNG
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	$N_{TR,CNG}$
Data unit	%
Description	Percentage of motorized auto-rickshaws using CNG
Source of data	Department of Transport, Delhi, VAHAN 4.0 Database accessed 26.09.2018 (File R5)
Value(s) applied	100%
Choice of data or measurement methods and procedures	Official regulation of Delhi asking for public transport vehicles to be CNG
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	$N_{M,G}$
Data unit	%
Description	Percentage of motorcycles using gasoline
Source of data	Department of Transport, Delhi, VAHAN 4.0 Database accessed 26.09.2018 (File R5)
Value(s) applied	100%
Choice of data or measurement methods and procedures	Official registration statistics; less than 1% of motorcycles are electric.
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	$N_{B,CNG}$
Data unit	%
Description	Percentage of buses using CNG
Source of data	Department of Transport, Delhi, VAHAN 4.0 Database accessed 26.09.2018 (File R5) and Delhi Transport Corporation (DTC), Operational Statistics March 2019, Table 1-8 (File R4)
Value(s) applied	100%
Choice of data or measurement methods and procedures	Official regulation of Delhi asking for public transport vehicles to be CNG
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	**EF_{Grid}**
Data unit	$kgCO_2/kWh$
Description	Emission factor of the grid
Source of data	Government of India, Central Electricity Authority, CO2 Baseline Database for the Indian Power Sector, version 13.0, June 2018, Table S-1 (File R7)
Value(s) applied	0.92
Choice of data or measurement methods and procedures	Combined Margin; official data; follow procedures as in “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”, newest version of tool
Purpose of data	Project emissions
Additional comment	

Data/Parameter	**TDL**
Data unit	%
Description	Average technical transmission and distribution losses for providing electricity
Source of data	Power Systems Operation Corporation Ltd. 2019 (File R7)
Value(s) applied	2.6%
Choice of data or measurement methods and procedures	Highest of 12 values reported for Northern Grid; official reported value
Purpose of data	Project emissions
Additional comment	

Data/Parameter	**$OC_{C,T,M}$**
Data unit	Passengers
Description	Average occupation rate of passenger cars (C), taxis (T) and motorcycles
Source of data	UNFCCC CDM Tool 18 Methodological tool: Baseline emissions for modal shift measures in urban passenger transport
Value(s) applied	Car: 2 Taxi: 1.1 (excluding driver) Motorcycle: 1.5
Choice of data or measurement methods and procedures	The default value based on the tool is taken as no updated official reports or studies available for Delhi (alternative 1).
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	**OC_{TR}**
Data unit	Passengers
Description	Average occupation rate of motorized rickshaws
Source of data	Lotus, 2019 (File R9a)
Value(s) applied	1.6
Choice of data or measurement methods and procedures	UNFCCC CDM Tool 18 Methodological tool: Baseline emissions for modal shift measures in urban passenger transport; No study of municipality available (alternative 1), no default value from tool available (alternative 2); survey of occupation rate for Delhi realized by 3rd Party (alternative 3) The survey was performed July 2019 in Delhi. The statistical analysis shows: AV Average: 1.62 passengers SD Standard deviation: 1.1 CIW (Confidence interval width): 0.12 Sample size: 1,285 rickshaws Required sample size: $N = \frac{1.96^2 \times \left(\frac{SD}{AV}\right)^2}{0.1^2}$ N = 178 rickshaws Actual sample size = 1,285 units i.e. the actual sample size is much higher than the required sample size. See also UNFCCC sample size calculator (File R9b) Reliability test: $R = \frac{0.5 \times (CIW)}{AV} \times 100\ \%$ R= 4% which is far better than the minimum required of 10% (see UNFCCC Guideline “Sampling and surveys for CDM project activities and programmes of activities” Version 04.0
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	**OC_B**
Data unit	Passengers
Description	Average occupation rate of buses
Source of data	UNFCCC CDM Tool 18 Methodological tool: Baseline emissions for modal shift measures in urban passenger transport
Value(s) applied	42.4
Choice of data or measurement methods and procedures	The default value based on the tool is taken as no updated official reports or studies available for Delhi (alternative 1): 80% for South Asia. The average capacity of DTC buses used in Delhi is 53 passengers (33 seated and 20 standing) (see File R11) Calculation: 80% * 53 = 42.4
Purpose of data	Baseline and project emissions
Additional comment	

Data / Parameter	**$EC_{EL,R}$**

Unit	MWh
Description	Quantity of electricity consumed by the baseline rail system per annum
Source of data	India Railways, IR Yearbook 2017-18, Northern Line suburban point 32.25, page 404
Value(s) applied	2,636
Choice of data or Measurement methods and procedures	Electric consumption for commuter rail system of Northern Railways entering Delhi
Purpose of data	Baseline, project
Additional comment	Is monitored annually if survey shows that passengers use suburban rail

Data / Parameter	**$P_{EL,R}$**
Unit	Passengers
Description	Total passengers transported by baseline suburban rail-system per year
Source of data	India Railways, IR Yearbook 2017-18 passenger revenue statistics, Northern Line suburban, statement 12, p.75 (File R15)
Value(s) applied	2,557,000
Choice of data or Measurement methods and procedures	Passengers for commuter rail system of Northern Railways entering Delhi
Purpose of data	Baseline, project
Additional comment	Is monitored annually if survey shows that passengers use suburban rail

Data / Parameter	**$TD_{EL,R}$**
Unit	Km
Description	Average trip distance of baseline urban rail passengers prior project start on rail system
Source of data	Grütter Consulting AG, 2008 (File R16)
Value(s) applied	29
Choice of data or Measurement methods and procedures	Same year as for data passenger on rail system and electricity consumption of rail system Upper 95% confidence interval
Purpose of data	Baseline, project
Additional comment	Only rail trip distance not total trip distance

AD_B, AD_T, and AD_{TR} are not required anymore as potential leakage from change in occupation rate of taxis and buses is only calculated in the years 1 and 4.

The technology improvement factor IR of 0.99 is used for buses. All other vehicle fuel consumption data is based on global default values of the UNFCCC tool and not for a specific year.

B.6.3. Ex ante calculation of emission reductions

Baseline Emissions

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

Where:

BE_y	Baseline emissions in the year *y* (g CO_2)
$BE_{p,y}$	Baseline 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)

$$BE_{p,y} = \sum_{i} BTD_{p,i,y} \cdot EF_{PKM,i,y}$$

Where:

$BE_{p,y}$	Baseline emissions per surveyed passenger *p* in the year *y* (g CO_2)
$BTD_{,p,i,y}$	Baseline 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* (g CO_2/PKM)
i	Relevant vehicle category
p	Surveyed passenger
y	Year of the crediting period

$$EF_{PKM,i,y} = \frac{EF_{KM,i,y}}{OC_i}$$

Where:

$EF_{PKM,i}$	Emission factor per passenger-kilometre of vehicle category *i* in the year *y* (g CO_2/PKM)
$EF_{KM,i}$	Emission factor per kilometre of vehicle category *i* in the year *y* (g CO_2/km)
OC_i	Average occupation rate of vehicle category *i* prior project start (passengers)
i	Relevant vehicle category
y	Year of the crediting period

$$EF_{KM,i,y} = (IR_i)^{t+y} \cdot \frac{\sum_{x} \left(SFC_{i,x} \cdot NCV_{x,y} \cdot EF_{CO2,x,y} \cdot N_{x,i} \right)}{N_i}$$

Where:

$EF_{KM,i,,y,}$	Emission factor per kilometre of vehicle category *i* in the year *y* (g CO_2/km)
$SFC_{x,i}$	Specific fuel consumption of vehicle category *i* using fuel type *x* prior project start (g/km)
$NCV_{x,y}$	Net calorific value of fuel *x* in the year *y* (J/g)
$EF_{CO2,x,y}$	Carbon emission factor for fuel type *x* in the year *y* (g CO_2/J)
$N_{x,i}$	Number of vehicles of category *i* using fuel type *x* prior to project start (units)
$N_{x,i}$	Number of vehicles of category *i* prior to project start (units)
IR_i^{t+y}	Technology improvement factor for the vehicle of category *i* per year *t+y* (ratio)
i	Relevant vehicle category
x	Fuel type
t	Years of annual improvement (dependent on age of data per vehicle category)
y	Year of the crediting period

The EF i.e. also cars, taxis, buses, motorcycles and motorized rickshaws is updated based on ACM0016:

- If the bio-fuel share changes;
- If the share of fuel types used per vehicle category changes;
- If NCV or EF data changes.

The following table shows the bio-fuel shares projected for the 2nd crediting period are based on the last approved monitoring report for the period 2016-2018.
:

- Diesel: 0.1%
- Gasoline: 3.2%

The following table shows projected EF for baseline modes of transport.

Table 15: EF per PKM per Mode (gCO_2/pkm)

Detail	2018	2019	2020	2021	2022	2023	2024
Emission factor per pkm car	64	64	64	64	64	64	64
Emission factor per pkm taxi	145	145	145	145	145	145	145

Emission factor per pkm motorcycle	28	28	28	28	28	28	28
Emission factor per pkm rickshaw	55	55	55	55	55	55	55
Emission factor per pkm bus	27	27	27	27	27	26	26

Source: CER Sheet

Constant passenger numbers (based on the average recorded previous years) and constant modes shares as well as trip distances per mode are assumed for the entire 2nd crediting period for the purpose of projections of baseline emissions.

Baseline emissions are projected with the transport model estimates of baseline emissions per passenger which is lower than the average of the last 2 surveys.

Baseline Results

Table 16: Projected Baseline EmissionsParameter	**Unit**	**2018 6 months**	**2019**	**2020**
Passengers	Passengers	259,201,031	518,402,062	518,402,062
Baseline emission factor based on transport model	gCO_2/passenger	1,842	1,842	1,842
Baseline emissions	tCO_2	477,448	954,897	954,897

2022	**2023**	**2024**	**2025 (6 months)**	**Average**	**Total**
518,402,062	518,402,062	518,402,062	259,201,031	481,373,344	3,369,613,405
1,842	1,842	1,842	1,842	1,842	
954,897	954,897	954,897	477,448	954,897	6,684,276

Source: CER spreadsheet

Project Emissions

Project emissions are calculated as follows:

$$\mathrm{PE_y} = \mathrm{DPE_y} + \mathrm{IPE_y}$$

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)

$$DPE_y = EC_{PJ,y} \times EF_{grid,CM} \times (1 + TDL)$$

Where:

DPE_y	Direct project emissions in the year *y* (tCO_2)
$EC_{PJ,y}$	Quantity of electricity consumed of project for traction energy (MWh)
$EF_{grid,CM}$	Emission factor for electricity generation in the grid based on combined margin (tCO_2/MWh)
TDL	Average technical transmission and distribution losses for providing electricity

$$IPE_y = \frac{P_y}{P_{SPER}} \sum_p \left(IPE_{p,y} \cdot FEX_{p,y} \right)$$

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

$$IPE_{p,y} = \sum_i IPTD_{p,i,y} \times EF_{PKM,i,y}$$

Where:

$IPE_{p,y}$	Indirect project emissions per surveyed passenger *p* in the year *y* (g CO_2)
$BTD_{,p,i,y}$	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* (g CO_2/PKM)
i	Relevant vehicle category
p	Surveyed passenger
y	Year of the crediting period

Constant passenger numbers and electricity usage of metro (based on the average recorded previous years) and constant modes shares as well as trip distances per mode to/from the metro (indirect project emissions) are assumed for the entire 2nd crediting period for the purpose of projections of baseline emissions.

Table 17: Projected Project Emissions

Parameter	**Unit**	**2018 6 months**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025 (6 months)**	**Average**	**Total**
Passengers	passengers	259,201,031	518,402,062	518,402,062	518,402,062	518,402,062	518,402,062	518,402,062	259,201,031	481,373,344	3,369,613,405
Electricity usage	kWh	110,273,530	220,547,060	220,547,060	220,547,060	220,547,060	220,547,060	220,547,060	110,273,530	192,978,678	1,543,829,420
Indirect project emission factor per passenger	gCO_2/passenger	445	445	445	445	445	444	444	444	445	
Project emissions	**tCO_2**	**219,434**	**438,868**	**438,868**	**438,868**	**438,868**	**438,090**	**438,090**	**219,045**	**438,590**	**3,070,130**

For details see CER spreadsheet.

Leakage Emissions

Leakage emissions 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; and,
- Emissions due to reduced congestion on affected roads, provoking higher average vehicle speed, plus a rebound effect.
- Upstream emissions of gaseous fuels ($LE_{UP,y}$).

Determination of emissions due to change of load factor of buses, taxis or rickshaws

The load factor of buses, taxis and rickshaws is only monitored in the years 1 and 4 in accordance with the methodology. This has its logic as the leakage was to determine if the project has a short- or medium-term impact on load factors of other modes of transport. Long-term changes cannot be attributed to the metro in a cause-effect manner but are due to urban development affecting and transportation changes affecting

transport modes (e.g. rising of ride-hailing services). No leakage monitoring therefore takes place in the 2nd crediting period and leakage is taken as 0.

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

DMRC has not taken away any existing road space. Therefore, based on ACM0016 Version 04.0 no monitoring is require and leakage is taken as 0.

Upstream emissions from gaseous fuels

Upstream leakage of gaseous fuels shall be only included if the project vehicles consume more gaseous fuels than baseline vehicles. Project metro only consumes electricity. Therefore, in the baseline more gaseous fuels are used than in the project situation. Upstream emissions from gaseous fuels are therefore not considered and leakage is taken as 0.

Leakage for each year and entire period: 0

B.6.4. Summary of ex ante estimates of emission reductions

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
2018 (6 months)	477,448	219,434	0	258,014
2019	954,897	438,868	0	516,029
2020	954,897	438,868	0	516,029
2021	954,897	438,868	0	516,029
2022	954,897	438,868	0	516,029
2023	954,897	438,090	0	516,029
2024	954,897	438,090	0	516,029
2025 (6 months)	477,448	219,045		258,403
Total	6,684,276	3,070,130	0	3,614,146
Total number of crediting years	7			
Annual average over the crediting period	954,897	438,590	0	516,307

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data/Parameter	**$NCV_{G/D/CNG}$**
Data unit	MJ/kg
Description	Net calorific value of gasoline, diesel and CNG
Source of data	IPCC 2006, table 1.2, lower 95% confidence interval
Value(s) applied	Gasoline: 42.5 Diesel: 41.4 CNG: 46.5
Measurement methods and procedures	No national value; IPCC default value lower 95% confidence interval
Monitoring frequency	Any future revision of the IPCC Guidelines is taken into account.
QA/QC procedures	--
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	**$EF_{CO2,G/D/CNG}$**
Data unit	gCO_2/MJ
Description	CO_2 emission factor for gasoline, diesel and CNG
Source of data	IPCC 2006, table 1.4, lower 95% confidence interval
Value(s) applied	Gasoline: 67.5 Diesel: 72.6 CNG: 54.3
Measurement methods and procedures	No national value; IPCC default value lower 95% confidence interval
Monitoring frequency	Any future revision of the IPCC Guidelines is taken into account.
QA/QC procedures	--
Purpose of data	Baseline and project emissions
Additional comment	

Data/Parameter	**$EF_{KM,B,CH4}$**
Data unit	gCO_{2eq}/km
Description	CH_4 emission factor of CNG buses per kilometre in CO_{2eq}
Source of data	IPCC 2006, table 3.2.4.
Value(s) applied	193
Measurement methods and procedures	IPCC value as no national measurements exist. Value of 7,715 mg CH_4 of IPCC is multiplied with the GWP of 25 for CH_4 to calculate CO_{2eq}
Monitoring frequency	Any future revision of the IPCC Guidelines is taken into account.
QA/QC procedures	--
Purpose of data	Baseline and project emissions
Additional comment	The methodology requires that CH_4 emissions of vehicles using gaseous fuels are included.

Data/Parameter	**$EF_{KM,C/T/TR,CH4}$**
Data unit	gCO_{2eq}/km
Description	CH_4 emission factor of CNG cars, taxis and auto-rickshaws per kilometre in CO_{2eq}
Source of data	IPCC 2006, table 3.2.4. (average of upper and lower boundary)
Value(s) applied	12
Measurement methods and procedures	IPCC value as no national measurements exist
Monitoring frequency	Any future revision of the IPCC Guidelines is taken into account. Average of 725 mg and 215 mg CH_4 of IPCC is multiplied with the GWP of 25 for CH_4 to calculate CO_{2eq}
QA/QC procedures	--
Purpose of data	Baseline and project emissions
Additional comment	The methodology requires that CH_4 emissions of vehicles using gaseous fuels are included.

Data/Parameter	**$N_{x,C/T/TR}$**
Data unit	Vehicles
Description	Number of passenger cars (C), taxis (T) and rickshaws (TR) using fuel type *x*
Source of data	Department of Transport, Delhi
Value(s) applied	No change projected to ex-ante fixed value

Measurement methods and procedures	Registration statistics
Monitoring frequency	Annual; latest available data not elder than 3 years
QA/QC procedures	--
Purpose of data	Baseline and project emissions
Additional comment	Required to check if passenger cars, taxis or motorized rickshaws use different fuels than those used for calculating the ex-ante baseline value.

Data/Parameter	**P**
Data unit	Passengers
Description	Total passengers transported by the project
Source of data	DMRC
Value(s) applied	518,402,062
Measurement methods and procedures	Turnpike controls at stations and electronic smart cards. Only passengers are included which enter stations of the lines included in the project. Passengers entering line 1 and line 2 stations of Phase I are not included. In case line 1 and/or line 2 have joint stations with project lines the entering passengers are allocated proportionally i.e. if e.g. a Phase 1 line has a joint station with a Phase II line the passengers are distributed 50:50 between the 2 phases.
Monitoring frequency	Continuously, aggregated at least annually
QA/QC procedures	Comparison with previous years
Purpose of data	Baseline and project emissions
Additional comment	For projection purposes a constant value is assumed based on the average number of passengers in the years 2015-2017.

Data/Parameter	EC_{PJ}
Data unit	MWh
Description	Electricity consumed by MRTS (trains)
Source of data	DMRC
Value(s) applied	220,547
Measurement methods and procedures	Traction energy is recorded by DMRC. Attribution to phase II based on car-km (phase II car-km in relation to total car-km).
Monitoring frequency	Continuously, aggregated at least annually
QA/QC procedures	Control with electricity invoices. The electricity meters are calibrated by the local electricity board of the state government and are sealed. They can only be opened by officials of the electricity board therefore the project owner cannot realize independent calibrations. There is also a check meter with controls realized by the local electricity department in case of large variations between readings.
Purpose of data	Baseline and project emissions
Additional comment	For projection purposes a constant value is assumed based on the average electricity usage in the years 2015-2017.

Data / Parameter	$BTD_{p,i}$
Unit	Kilometre
Description	Baseline trip distance of the cluster *p* of surveyed passengers using mode *i*
Source of data	Survey realized by external survey company
Value(s) applied	Based on the survey asking the modes of transit used and the trip distances in absence of the project.
Measurement methods and	See following section; same as surveys in 1st crediting period

procedures	
Monitoring frequency	The survey is realized in the years 2020 and 2023 of the crediting period
QA/QC procedures	See Annex 3 for the survey design Emissions are calculated per passenger and then expanded to the total passengers transported based on the expansion factor per passenger.
Purpose of data	
Additional comment	

Data / Parameter	**$IPTD_{p,i}$**
Unit	Kilometre
Description	Indirect project trip distance of the surveyed passenger using mode *i*
Source of data	Survey realized by external survey company
Value(s) applied	Based on the survey asking the modes of transit used and the trip distances from trip origin to entry station of the MRTS and from exit station of the MRTS to trip destination.
Measurement methods and procedures	See following section; same as surveys in 1st crediting period
Monitoring frequency	The survey is realized in the years 2020 and 2023 of the crediting period
QA/QC procedures	See Annex 3 for the survey design
Purpose of data	
Additional comment	See Annex 3 for the survey design Emissions are calculated per passenger and then expanded to the total passengers transported based on the expansion factor per passenger.

Data / Parameter	**P_{SPER}**
Unit	Passengers
Description	Number of passengers in the time period of the survey (1 week)
Source of data	DMRC
Value(s) applied	Turnpike controls at stations and electronic smart cards. Only passengers are included which enter stations of the lines include in the project. Passengers entering stations of Phase I are not included. In case Phase I lines have joint stations with project lines the entering passengers are allocated proportionally i.e. if e.g. line 1 and Phase II line x have a joint station passengers of that station are distributed 50:50 between the two lines.
Measurement methods and procedures	See following section; same as surveys in 1st crediting period
Monitoring frequency	The survey is realized in the years 2020 and 2023 of the crediting period
QA/QC procedures	Emissions are calculated per passenger and then expanded to the total passengers transported based on the expansion factor per passenger.
Purpose of data	
Additional comment	

Data / Parameter	**FEX_p**
Unit	None
Description	Expansion factor for each surveyed passenger *p* surveyed (each surveyed passenger has a different expansion factor)
Source of data	Calculation by Grütter Consulting AG
Value(s) applied	See Annex 3
Measurement methods and procedures	See following section; same as surveys in 1st crediting period
Monitoring frequency	The survey is realized in the years 2020 and 2023 of the crediting period
QA/QC procedures	
Purpose of data	
Additional comment	

Data / Parameter	**$EC_{EL,R}$**
Unit	MWh
Description	Quantity of electricity consumed by the baseline rail system per annum
Source of data	India Railways annual report, latest published version
Value(s) applied	Same value as for baseline assumed for projection purposes

Measurement methods and procedures	Annual report from India Railways
Monitoring frequency	Annually
QA/QC procedures	None
Purpose of data	Baseline and project emissions
Additional comment	Required to establish the emission factor per PKM for suburban rail in case the survey shows there are passengers from suburban rail (not the case in previous surveys)

Data / Parameter	**$P_{EL,R}$**
Unit	Passengers
Description	Total passengers transported by baseline rail-system per year
Source of data	India Railways annual report, latest published version
Value(s) applied	Same value as for baseline assumed for projection purposes
Measurement methods and procedures	Annual report from India Railways
Monitoring frequency	Annually
QA/QC procedures	None
Purpose of data	Baseline and project emissions
Additional comment	Required to establish the emission factor per PKM for suburban rail in case the survey shows there are passengers from suburban rail (not the case in previous surveys)

$N_{B,T,TR}$ $OC_{B,T,TR}$ are not required anymore as potential leakage from change in occupation rate of taxis and buses is only calculated in the years 1 and 4.

B.7.2. Sampling plan

The same sampling plan is used as in the last survey of the 1st monitoring period.

Sampling is used for the following parameters:

1. Passenger survey to determine indirect project emissions as well as baseline emissions. This includes the parameters MS_i, FEX, BTD, and IPTD.
2. Occupation rate surveys for taxis and motorized rickshaws

A. SURVEY

The methodological design of the survey is presented in detail.

Table 18: Technical Summary Data Sheet of the Survey Strategy and Sample Design Metro Delhi Passenger Survey

Parameters	Main parameters: • Baseline emissions; • Indirect project emissions. Secondary parameters and inputs: • Proportion of passengers using each mode of transport, with the project and in absence of the project; • The average distance travelled by these modes with the project and in absence of the project.
Target population	Passengers over 12 years using the Metro Delhi.
Sample frame	Passenger flow in all the stations Phase II of the Metro Delhi.

Sample design	Two staged probabilistic design: • First stage: stratified – simple random sampling (SRS); • Second stage: systematic sampling based on passengers flow per station. Stratum: Lines and Stations. Sub stratum: Days in the week and hours.
Relative error level (CV)[68]	For the survey a global desired level of precision (relative standard error or coefficient of variation – CV) between 5% and 10% for the parameters of interest is targeted, which implies at the same time having precision levels of 90/10. Results obtained are based on a 95% confidence level using the more conservative boundary.
Coverage	Urban area where the Metro Delhi operates.
Size of Universe	Generally, in one day Metro Delhi transports around 1.4 million passengers on the Phase II lines[69].
Sample size	The sample size is around 2,000 surveys in each survey.
Pilot Test	The pilot test corresponds to a survey realized July 2008 during an entire week in a continuous manner. 804 passengers of Delhi Metro were interviewed. Since the project start 6 surveys (2 per annum) have already been carried out which allowed to adjust the survey sample size based on the calculated CV.
Sample frequency	2x annually during an entire week (compulsory based on the methodology is for year 4 only 1 survey).
Method of information collection	The information is obtained through the face-to-face application of the established questionnaire on a random base.

Survey Objective

The survey objective is to determine:

- The baseline emissions caused by passengers which use Metro Delhi Phase II and in absence of latter would have used other modes of transport to realize their trip;

- The indirect project emissions of passengers using Metro Delhi Phase II which correspond to the emissions caused from the trip origin to the metro entry station and from the metro exit station to the final destination.

Target Population

The target population are passengers over 12 years of age. Smaller children are excluded due to problems in answering the questions. Also, smaller children in general are accompanied by their parents or an adult and thus have the same trip sequence as the adult person.

Geographical Coverage

The geographical coverage is the area where metro Delhi operates (project boundary).

Sample Frequency

The surveys take place during an entire week. The selected weeks do not correspond to a public holiday and are representative for the average demand for transport services in the considered year.

Sample Frame

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[68] Relative error level refers to the coefficient of variation (CV), which is calculated as the ratio between the standard deviation of the average and the population average.

[69] See File 1 based on numbers of passengers 2015 and 365 days per annum

The simple frame is the passenger flow in all the stations of Phase II Metro Delhi. Data for the passenger frame is obtained from the system manager.

Survey Design

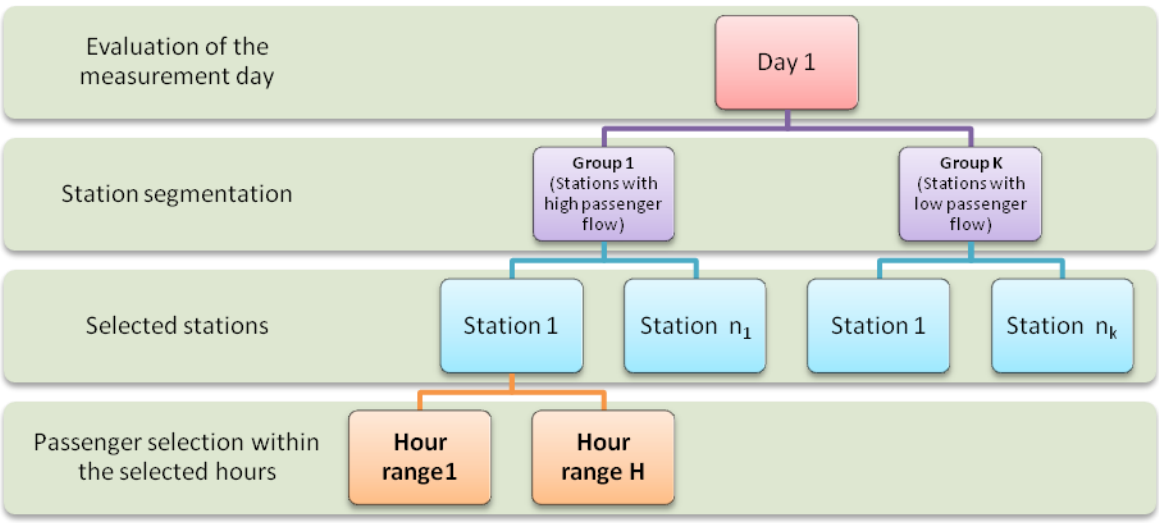
The survey was conducted among Delhi Metro commuters at DMRC phase-2 stations. The survey design is identical to previously realized surveys. To get a better representation and complete coverage of target population, this target sample was distributed among stations, days and time slots:

- **Target Population:** DMRC Commuters (Above 12 years)
- **Total Sample Size:** 2,000 per survey
- **Sampling Frame:** Passenger flow at the stations (as per the passenger flow data given)
- **Coverage:** 84 Metro stations of DMRC phase-2
- **Sampling Method: Two stage stratified sampling**
  - **Stratum:** Stations
  - **Sub-Stratum:** Days in the weeks & hours
  - Proportionate allocation of passenger flow among these stratum

At first the relevant stratums i.e. “station” & “timeslots” and their actual representation in the population were identified. After stratification, a probability sample was determined for each stratum. The proportionate allocation was used for determining the sample size of each stratum, i.e. the sample size for each stratum (station/timeslot) is proportionate to the population size of that stratum. Thus, each stratum has a “sampling fraction”.

The given weekly passenger was partitioned into groups i.e. stations, days and timeslots. The stratification model used is represented by the following scheme, where the process for a specific day is shown which applies routinely for the seven measurement days.

Figure 3: Survey Stratification Model



The stations were stratified into three strata i.e. heavy, medium and low traffic. This stratification was done through the 3-cluster solutions. On the basis of that distribution, the sampling fraction for each stratum was determined.

For the timeslot stratification, the average hourly traffic flow for all 7 days was calculated. The timeslots were classified based on the variations in the average traffic flow. On the average traffic flow data, a 5-cluster solution was performed and the 5 time slots (stratums) were defined. Proportionate allocation uses the sampling fraction in each of the strata that is proportional to that of the total population. The size of the sample in each stratum is taken in proportion to the size of the stratum.

The sampling fraction of the day is the ratio between the total traffic flow of that day and total traffic flow of the week. The sample of one day is allocated to the pre-defined stratum (stations and time slots). Sampling

Fraction for n1 station at t1 hour = (Traffic flow at n1 station during t1 hour for total week) / (total traffic follow of the week)

Sample Selection

The selection method guarantees a random and non-biased selection process especially important in face-to-face interviews. The random distribution allows that the sample mirrors the total population in any other non-observed variables such as age, gender, religion, personal preferences etc. The selection of stations is carried out according to a SRS design, through the negative coordinated algorithm. The same happens for the defined hour ranges: within each range a specific hour is selected under this method for the sample selection. Given that there is no reference frame or list frame for the identification of DMRC users, the selection of the sample in the last stage is performed according to the systematic sampling design, replicated identically for each stratum and considering the following steps:

- A random starting point is generated according to the statistics tables of uniform distribution between 1 and the average flow of passengers in the evaluation hour;
- Systematic selection of passengers: every n passenger entering the station, starting with the random number. In this way, if the random number is 10, the first passenger selected is the 10^{th} that enters the station, the 2^{nd} n+10 and thus successively every n passenger. The number n, called selection interval is determined based on the passenger flow per hour and the sample distribution of the specific measurement day.

Method for Information Collection

The information is obtained through the face-to-face application of the established questionnaire. In a briefing session, the questionnaire was explained in the detail and mock sessions were taken by the supervisors to ensure the understanding of interviewers.

Sample Size Determination

The results of the 6 surveys since 2011 were used to determine the size of the sample. The estimated coefficient variation for the baseline and the project emissions was calculated for this purpose. The sample size of 2,000 users of Metro showed to be sufficient based on the CV and the statistical analysis of the surveys realized previously.

Data Verification and Validation Including QA and QC

Criteria for Evaluating Data Consistency

Considering that in each one of the years there will be at least two measurements, the weekly measurement and the test-retest, through these the consistency on information collection is guaranteed.

The assessment of consistency can be carried out by three supplementary statistical methods:

1. A mean difference test is performed through a t – Student test, where the differences presented between both measurements are evaluated, for: 1.Proportion of users that use each type of modes of transport and 2. Average trip travel distance.

   To perform the mean difference test, it is necessary to determine beforehand, if the two samples come from the same population. Thereafter a F test is carried out to determine the variability difference between one and the other. To assess that data used to estimate the study parameters follow the same distribution the Mann Whitney non-parametric U test and the Wilcoxon T test can be used.

2. To evaluate the users proportion per modes of transport, the Pearson's Chi Square can be used, where categories are defined for each mode of transport.

3. Globally and internally in each survey realized, consistency of data reported in the survey may be assessed through the Cronbach alpha coefficient. In practice it is assumed that values higher than 0.7 in the coefficient indicate an adequate consistency degree. Values over 0.9 should be rechecked to avoid redundancy of data.

For the internal consistency the Cronbach alpha coefficient is used whilst to test for consistency between different periods of measurement the first two options of testing are used.

The Cronbach alpha coefficient will be calculated for each stratum established as these a priori control the variations in the responses and therefore the control eliminates biases which could be generated due to hetereogenity and inconsistency in information.

With the goal of evaluating the possible correlation between BE and IPE a hypothesis test based on the Pearson or Spearman coefficient is made. The parameter to determine the existence of correlation is the *p* value. If the *p* value is less than 0.05 (significance value) it is concluded that the correlation is significant.

If a correlation between BE and IPE exists[70] the variance associated to the estimator (defined as the difference between the two parameters) would have a covariance different from 0. If the variables *x* and *y* are correlated then:

$$Var(X-Y) = Var(X) + Var(Y) - 2\,Cov(X,Y)$$, where COV (X,Y) is not 0.

If the correlation is significant complex estimators and alternative methods of variance need to be used which do not guarantee however that the estimators are unbiased and have a minimal variance. On the other hand if the correlation is non-significant the estimation of the two parameters BE and IPE separately leads to the same result as calculating them jointly.

Realizing the estimation of BE and IPE guarantees that even in the case of correlation we have no problem with the bias in the variance of the estimators i.e. even if we determine correlation the results are correct and no additional step needs to be taken. In the case of having no correlation we could also determine directly the difference between BE and IPE per passenger reaching the same result (in the case of correlation it is necessary in all cases to make the estimation of BE and IPE separately).

Therefore it is preferable, as suggested in these procedures, to calculate the two parameters separately and to determine for each one an unbiased level of error. Additionally for each parameter separate confidence levels can thus be constructed. If the two confidence intervals overlap we have an indication of non-significant differences between BE and IPE.

Survey Realization

The survey must be realized through a company with minimum 3 years of experience in comparable surveys in the respective country to ensure a professional survey execution. Following principles are to be followed in the survey realization:

- Non-responses should be recorded;
- Record and store all original surveys;
- Surveys are conducted at DMRC stations when people wait for DMRC-boarding. It should be avoided to realize the survey with people de-boarding the DMRC as latter will not want to invest time in a survey thus potentially giving wrong answers.

Calculation of Trip Distance in the Survey

Trip distances need to be determined for each surveyed passenger. The following procedures are applied:

- For NMT, others and induced traffic this is not required as the applied EF is "0"
- For users of buses either
  - the shortest possible geographical distance based on electronic maps or measuring the distance between the two points with GPS or a comparable mean or through distance measurement on maps.

  or
  - Measuring the actual distance from the bus entry station to the bus exit station based on (electronic) route maps of the bus operators with official distances or measuring e.g. with GPS the distances between the involved stations
- For users of passenger cars, taxis, motorcycles, motorized rickshaws and other modes of motorized transport except buses based on the shortest possible geographical distance based on electronic

[70] This is however not expected and empirical data from surveys realized have shown no correlation.

maps or measuring the distance between the two points with GPS or a comparable mean or through distance measurement on maps.

- For non-project rail systems based on official or GPS distances between the entry and exit station of the rail-systems.

A default questionnaire to be used is included below. This questionnaire should be used by all projects except if valid arguments exist to change the questionnaire and to adapt it to local circumstances. The questionnaire must be realized in the local language. The questionnaire needs to be adapted to national or local circumstances, the wording needs to be checked locally and local test-runs should be performed to ensure that the questions are simple, easily understood, cannot be misinterpreted and lead to reliable results. The questionnaire used in included in the Annex.

B.7.3. Other elements of monitoring plan

The environmental section of DMRC is responsible for CDM project monitoring. This area responds directly to the Managing Director. Grütter Consulting AG realizes the data quality control and quality assurance and formulates the monitoring reports. This is the same procedure as during the 1st crediting period.

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

10/11/2005

C.2. Expected operational lifetime of project activity

30 years

C.3. Crediting period of project activity

C.3.1. Type of crediting period

Renewable, 2nd crediting period

C.3.2. Start date of crediting period

2nd crediting period: 2018/06/30

C.3.3. Duration of crediting period

7 years, 0 months, 0 days

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

The Notification of the Ministry of Environment and Forests dated 14.9.2006 lists all project types which need environmental clearance. Metros do not require that and are therefore not listed[71]. The metro thus does not require an environmental permit or clearance for construction and operation. Permits are required for certain construction activities realized by the contractors. The contractors are selected over a tendering process.

[71] File 63

The Tender document clearly mentions the environmental and safety manuals[72] for a particular project. The tender document will also clearly specify the monitoring process by DMRC depending on the contract. DMRC also have the metro act to enforce to the contractors. They also control the contractors through payment releases, for e.g. only if the job executed is certified by DMRC quality control team will part of the payment be released. DMRC also has a penalty clause in the tender document and in the contract.

DMRC is the 1st metro worldwide to receive ISO14001 certification. The DMRC Corporate Culture already specifies that the Metro construction should not lead to ecological or environmental degradation. One example of this policy is that for every tree cut during the construction ten trees have been planted in advance by DMRC as compensatory afforestation. Around 26,000 trees have been planted at Sultanpur Dabas, Isapur , Kakrola, Kharkhari and Revla Khanpur.

DMRC has prepared an EIA for each line and section. The EIA was made by RITES Ltd.[73] The potential environmental impacts of the metro are listed in chapter D.2. The Terms of Reference for the EIA were drawn up in accordance with the guidelines for EIA studies issued by Ministry of Environment and Forests (MoEF), Government of India (GOI) for Transport Projects. Schedules I list the projects that need environmental clearance from MoEF. However rail projects are exempted from this list and hence environmental clearance. The EIA has been conducted by RITES as per TOR and the requirements of the Environmental Appraisal Committee (EAC) constituted by MoEF for transport projects. The EIA also consulted the following Acts, Rules and Standards:

- Water (Prevention and Control of Pollution) Act 1974, amended in 1978 and 1988;
- Forest (Conservation) Act 1980 Amended in 1988;
- Air (Prevention and Control of Pollution) Act 1981 amended 1988;
- Environmental Impact Assessment Guidelines, MoEF, GOI Notification 1994;
- Notification of 10th April 1997, MoEF;
- Environmental (Protection) Act 1986;
- Guidelines for Rail/Road/Highways projects, Ministry of Environment & Forests, Government of India (1981);
- National Policy on Resettlement and Rehabilitation of Project Affected Families (2003).

A summary of major results of the EIA is included in chapter D.2.

A positive impact on potential transboundary air pollution can be expected due to reduced emissions of air pollutants due to reduced fuel usage and minor vehicle kilometres (PM and NO_x basically). Transboundary air pollution is a particular problem for pollutants that are not easily destroyed or react in the atmosphere to form secondary pollutants. Typical transboundary air pollutants are carbon monoxide, PM10, non-methane VOCs[74] and NO_x (resulting potentially in ground-level ozone which again is a major component of smog) or sulphur dioxide (SO_2 together with NO_x are primary precursors of acid rain).

DMRC will earmark 2% of annual CER revenue for sustainable development activities. DMRC will plan expenditure for this amount every year which will lead to sustainable development towards society or community. Activities include:

1. Include all DMRC construction and operation activities under a certified EMS system.
2. Improve landscaping / greening the surplus area.
3. Improving facilities for the cycle and cycle rickshaws near metro stations.
4. Work with NGOs and conduct free awareness programme on environment and climate change.
5. Tree plantation.
6. Work with schools to raise awareness on conservation of natural resources.
7. Capacity building/ workshops within DMRC on environment.

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[72] File 64

[73] File 65: EIA for Phase II Corridors of Delhi Metro, 8-2005, Rites Ltd.

[74] Volatile Organic Components

8. Encourage use of non -conventional energy for lighting.

9. Promote sustainable transport through exhibits and participating in fairs/conferences etc.

A monitoring plan for these activities has been drafted specifying activity, objective, finance, outputs, outcomes, time-lines and involved risks[75].

D.2. Environmental impact assessment

The project complies with all legal requirements of the environmental legislation of the Government of India. Permits have been granted for the establishment of the metro in general, section and lane construction and operations.

An EIA report has been realized which lists potential positive and negative impacts in various areas (see former chapter) as well as mitigation measures to be taken as well as their costs. For this purpose an Environmental Management Plan and an Environmental Monitoring Plan is laid out.

Environmental impacts are separated by the EIA in 4 areas:

1. Impacts due to project location
2. Impacts due to project design
3. Impacts due to project construction
4. Impacts due to project operations

Potential impacts due to project location are:

- Rehabilitation and resettlement of around 660 families due to land acquisition of the project.
- Drainage and utility problems due to potential dislocation or disruption during construction activities.

Potential impacts due to project design are that entry and exit stations, ventilation and lighting, and risk of earthquake need to be incorporated in the design of the project.

Impact due to project construction includes pollution during construction (e.g. potential water pollution), traffic diversion during construction, excavated soil disposal, dust generation, increased water demand, and impact due to the supply of construction material.

The impacts due to metro operations are basically noise and air pollution related. Due to reduced traffic of buses, passenger cars, taxis and motorized rickshaws compared to the baseline noise emissions should be lower, especially in underground sectors of metro. Measurements made before and after metro shows that the noise impact of metro is marginal and over-layered by the impact of additional traffic[76]. An ex-post environmental report was realized to identify the impact of the metro on these two major operational factors. The baseline is thereby a continuation of current traffic modes, while the project situation is the metro. Based on mode shift a reduction of vehicles and vehicle-kilometres can be observed[77]. Due to reduced vehicle-kilometres fuel usage is reduced[78] thus resulting also in a reduction of corresponding emission loads and an improved air quality. While the reduction of pollutants comparing baseline with project can be quantified this cannot be translated directly to ambient air quality as latter is influenced by many other factors such as growth in travel, other pollutant sources (e.g. industrial) as well as emission control regulations e.g. implementation of Euro II and Euro III standards or the compulsory usage of CNG in public transit vehicles. Comparing baseline with project situation the impact of metro in pollution loads by the year 2011 is[79] minus

[75] File 71

[76] Chapter 1.3.3.

[77] File 33; Quantification of Benefits from the Implementation of Phase I of Delhi Metro, Traffic Planning and Environment Division, 5-2007, Executive Summary, Table 1.2(a) and 1.2(b)

[78] File 51; Quantification of Benefits from the Implementation of Phase I of Delhi Metro, 5-2007, Table 1.3(a) and 1.3(b)

[79] File 32; EIA chapter 5, table 5.11 taking 1/3 of impact Phase I (corresponding to lane 3 of Phase I)

3,200 CO, minus 3,800t HCs, minus 4,500t NO_x, and minus 100t PM. For local air quality the most relevant pollutants are PM as latter results in major health problems (respiratory diseases) and HCs/NO_x which result in ground-level ozone pollution (see Table 1.10.b). Overall the project results in a positive environmental impact basically in the area of reduced air pollution.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

Stakeholder involvement is basically during construction and during operation. Main stakeholders identified include the general public (as users of the metro) and persons living near construction sites of the metro[80].

Persons Living Near to Construction Sites

Persons living near to construction sites are potentially affected by these activities. DMRC organized interfaces with the affected communities near to the construction sites. The interface system worked like a Public Grievance and Redressal Forum. After getting feedback from the concerned departments, reply is given to the parties within a short period of time. Important is in this context also the Right to Information Act. Interactive programmes were organized before, during and at post construction stages. More than 100 community interaction programs have been realized up to the moment.

General Public

They are the users of the public transport system and the prime beneficiaries due to a reduced travel time, less congestion (also relevant for users of private vehicles) and an improved air quality. Communication with the general public followed various ways including for example street plays and associating children for experimental joyrides next to more traditional communication means. Commuters were asked concerning satisfaction with metro services in terms such as speed, convenience, cleanliness, safety, ambience and cost of service.

To propagate metro DMRC also has a telephone helpline with more than 2,800 calls per month, participated in exhibitions and made a radio programme with interactive phone-in.

DMRC established effective interaction with a myriad of stakeholders including groups such as government agencies, media, environmental organizations, businessmen, commuters, residents associations, labour etc.

E.2. Summary of comments received

At construction sites basically concerns are about disruptions of services, congestion and other inconveniences of daily life related to the direct (e.g. noise, dust) or indirect (e.g. congestion) construction impacts. Grievances of the citizens were recorded and reports were made for immediate relief.

Surveys realized show that commuters are very satisfied with metro services with the overwhelming majority being very satisfied or satisfied with all aspects such as cost, safety, convenience, speed etc[81].

E.3. Consideration of comments received

For construction activities DMRC reduced the magnitude of inconveniences on the one hand by a proactive information policy thus allowing people to take counter-measures and on the other hand by reducing to a minimum construction time and reacting rapidly with repairs e.g. if pipes were broken during construction. Examples include that all traffic diversions were planned in advance and a scientific study was conducted.

Also alternative roads, traffic signals and road widening were ensured before effecting diversions. All public utilities like telephone cables, sewer lines, electricity cables and water pipelines which directly affect the lives

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[80] See for the following File 66

[81] File 66, Japan Bank for International Cooperation JBIC, Research Study for Public Relations Activities statistic 77 on page 6

of the common man were diverted well in advance to avoid inconvenience. It was done through media reports, advertising and community interaction programmes.

Important in this context was that people were well and timely informed about work plans and potential inconveniences including advance information on disruptions and deviations of public utility services such as electricity or water supply. Also, more than 3,000 site visits were organized for all segments of stakeholders at metro construction sites

SECTION F. Approval and authorization

Letter of approvals of India and Switzerland were sent together with the original PDD during registration.

Appendix 1. Contact information of project participants

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Fax	---
E-mail	jgruetter@gmail.com
Website	www.transport-ghg.com
Contact person	Jurg Grutter

Organization name	Delhi Metro Rail Corporation Ltd
Country	India
Address	13, Fire Brigade Lane, Barakhamba Road, Metro Bhawan, 110001 New Delhi, India
Telephone	+9111-23417915
Fax	+9111-23417915
E-mail	saverma@dmrc.org
Website	www.delhimetrorail.com
Contact person	S.A. Verma

Appendix 2. Affirmation regarding public funding

The Project activity is partially financed by the Government of Japan through JBIC. The funding however is separate from and is not counted towards the financial obligations of the aforesaid party.

Appendix 3. Applicability of methodologies and standardized baselines

All information for assessing the applicability conditions for using the methodology are listed in Section B2. No further information is deemed necessary.

Appendix 4. Further background information on ex ante calculation of emission reductions

All background information for determining the ex ante calculation for emission reductions are listed in Section B6.3. No further information is deemed necessary.

Appendix 5. Further background information on monitoring plan

PASSENGER SURVEY USED

The survey was used on all surveys conducted in the 1st crediting period.

SECTION A: Data Concerning Surveyor

Survey ID (correlative number): …………………………….
Interviewer:……………………………

Date: .-…………………………………
Time:…………………………………….
Point (station) where interview was performed:…………………………..

Survey response/completeness:
☐ Survey was fully completed
☐ Survey was fully or partially not responded

Comments/Observations of surveyor:…………………………..

SECTION B: General Data of Interviewed Person

This section can also be filled out at the end of the interview!

Age of surveyed person:
☐ 12-17 years ☐ 18-25 years ☐ 26-35 years ☐ 36-45 years ☐ 46-55 years ☐ 56-65 years ☐ over 65 years

Gender of the surveyed person
☐ female ☐ male

Socio-economic level of the surveyed person
☐ < 1 minimum wage ☐ 1-2 minimum wages ☐ 2-4 minimum wages ☐ 4-6 minimum wages ☐ > 6 minimum wages

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SECTION C: Trip Data of Interviewed Person

Question 1

"Describe the trip you are currently realizing"

1.1. Your trip origin (home, office, others) Address:………………………………
1.2. Your entry station of Metro (station name):……………………
1.3. Your exit station of Metro (station name):……………………
1.4. After exiting Metro you go where ? Address:……………………………………

Notes: ………………………………………………………………………………………………

Explanations for the interviewer:
- *The question refers to the current trip the passenger is making.*
- *The trip origin and the trip destination must be identified with a clear address. Use a map if it is unclear. If the person does not know or does not want to disclose this information then stop at this point.*
- *The* Metro *stations identified in 1.2 and 1.3. must be listed with their official names.*

Question 2

"How did you reach the Metro entry station?"

Tick 1: ☐ Bus ☐ Train ☐ Taxi ☐ Car ☐ Motorcycle ☐ Auto ☐ Cycle or walk

Explanations for the interviewer:
- *Only tick 1 answer (the mode used for the longest stretch of this trip segment)*

Question 3

"How will you reach your office/home/other place after exiting the Metro station?"

Tick 1: ☐ Bus ☐ Train ☐ Taxi ☐ Car ☐ Motorcycle ☐ Auto ☐ Cycle or walk

Explanations for the interviewer:
- *Only tick 1 answer (the mode used for the longest stretch of this trip segment)*

Question 4

"Assuming that Metro Phase II would not exist: Would you have made the trip you are currently doing anyway or would you have stayed at home/office/origin??"

☐ I would have stayed at home/office/origin ➔*The questionnaire is terminated*
☐ I would have made the trip" ➔ *Continue below (question 5)*

Explanations for the interviewer:

- *The purpose of this question is to know if the passenger made this trip only because the metro exists. In absence of the metro he would not have made any trip and would have stayed at his point of origin.*

Question 5

"Have you moved your home or workplace since 2009?"
☐ No ➔*continue below (question 6)*
☐ Yes: "Has the availability of the Metro Phase II been an important factor when choosing the location of your new home or new workplace?"
  ☐ No ➔ *continue below (question 6)*
  ☐ Yes ➔ "What was your former trip starting point and trip destination at the time before you moved your home or workplace ?"
  Starting point address:………………………….
  Destination point address: ………………………..

Question 6

"Assuming that Metro Phase II you are currently using would not exist: How would you have made the same trip you are doing now??"

From Home/Office/Others (Address) ……… ….. to point (Address) …………… by *………………

From point (Address)……………… …………... to point (Address) …………….by *……………..

From point (Address)……………… …………... to point (Address) …………….by *……………...

From point (Address)……………… …………... to point (Address) …………….by *……………..

*can be
☐ Bus
☐ Train
☐ Taxi
☐ Car
☐ Motorcycle
☐ Auto
☐ Cycle or per foot
It can NOT be Metro

Explanations for the interviewer:

- *For each segment of the trip make a separate answer*

Question 7

"Have you used a taxi in the last 6 months?"
☐ Yes ☐ No

Question 8

"Do you have a car / car pool / access to company car and have you used a car / car pool or company car in the last 6 months?"
☐ Yes ☐ No

Question 9

“Do you have a motorcycle / scooter or share a motorcycle / scooter and have you used this in the last 6 months?”
☐ Yes ☐ No

Question 10

“Have you used an auto-rickshaw during the last 6 months?”
☐ Yes ☐ No

Appendix 6. Summary report of comments received from local stakeholders

All information concerning comments from local stakeholders are listed in Section E2 and File 66.

Appendix 7. Summary of post-registration changes

PRC-4463-002: Permanent changes from the monitoring plan or the monitoring methodology
Approval on 26 February 2017

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Document information

Version	*Date*	*Description*
11.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Make editorial improvements.
10.1	28 June 2017	Revision to make editorial improvement.
10.0	7 June 2017	Revision to: • Improve consistency with the “CDM project standard for project activities” and with the PoA-DD and CPA-DD forms; • Make editorial improvement.
09.0	24 May 2017	Revision to: • Ensure consistency with the “CDM project standard for project activities” (CDM-EB93-A04-STAN) (version 01.0); • Incorporate the “Project design document form for small-scale CDM project activities” (CDM-SSC-PDD-FORM); • Make editorial improvement.
08.0	22 July 2016	EB 90, Annex 1 Revision to include provisions related to automatically additional project activities.
07.0	15 April 2016	Revision to ensure consistency with the “Standard: Applicability of sectoral scopes” (CDM-EB88-A04-STAN) (version 01.0).

Version	*Date*	*Description*
06.0	9 March 2015	Revision to: • Include provisions related to statement on erroneous inclusion of a CPA; • Include provisions related to delayed submission of a monitoring plan; • Provisions related to local stakeholder consultation; • Provisions related to the Host Party; • Make editorial improvement.
05.0	25 June 2014	Revision to: • Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the "Guidelines for completing the project design document form" (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1; • Change the reference number from F-CDM-PDD to CDM-PDD-FORM; • Make editorial improvement.
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the project design document form for CDM project activities" (EB 66, Annex 8).
03.0	26 July 2006	EB 25, Annex 15
02.0	14 June 2004	EB 14, Annex 06b
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.

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