Project design document form for CDM project activities

(Version 08.0)

Complete this form in accordance with the Attachment "Instructions for filling out the project design document form for CDM project activities" at the end of this form.

PROJECT DESIGN DOCUMENT (PDD)	
Title of the project activity	Metro Delhi, India
Version number of the PDD	Version 4.0
Completion date of the PDD	05/12/2016
Project participant(s)	Delhi Metro Rail Corporation Ltd. (private entity) Grütter Consulting AG (private entity)
Host Party	India
Applied methodology(ies) and, where applicable, applied standardized baseline(s)	ACM0016: Baseline Methodology for Mass Rapid Transit Projects; Version 04
Sectoral scope(s) linked to the applied methodology(ies)	Transport (sectoral scope 7)
Estimated amount of annual average GHG emission reductions	529,043

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

The objective of the project is the establishment and operation of an efficient, safe, rapid, convenient, comfortable and effective modern mass transit system ensuring high ridership levels in the city of Delhi, India. The city has in total around 14 million inhabitants[1] thus being the 2nd largest city in India. The Mass Rapid Transit System (MRTS) proposed is a partially elevated, partially underground and partially at-grade heavy duty metro with a length of 102 km expecting to transport on average in 2011 around 1.1 million passengers daily[2].

Picture 1: DMRC

The CDM project includes all corridors of Phase II except New Delhi – Airport and Airport – Dwarka Sector 21[3] of Metro Delhi managed by DMRC (Delhi Metro Rail Corporation Ltd.). Phase I is not included as CDM project. The PDD will make only reference to the sections of the metro included in the project if not stated otherwise.

The total length of metro tracks included in the project is 102 km[4]. For 2011 Metro Delhi expects to transport 1.1 million passengers per day[5] over an average trip length of around 14km[6]. The first section of

[1] Source: Directorate of Census Operations, Delhi, 2001; see Delhi Statistical Handbook 2007, page 2

[2] File 2, DMRC, 2009 includes only Phase II

[3] Different legal situation for these lanes as of recent

[4] File 2, DMRC, 2009

[5] File 2, DMRC, 2009

[6] File 4, DMRC, table 2.9, 2005

the first corridor of Phase II started construction September 2005. Phase II is expected to be fully operational by end 2010[7].

Core aspects of Metro Delhi are (for major details see section A.4.3.):

- 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.
- Daily 1.1 million passengers transported.

For implementation and subsequent operation of Metro Delhi MRTS (Mass Rapid Transit System), 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 geographical boundary of the project is the city of Delhi. Gases included are CO_2 and CH_4.

The **baseline situation** is a continuation of traditional modes of transport including buses, taxis, private cars, rickshaws, motorcycles and bikes. 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[8]. During the last two decades Delhi had an exponential growth in the vehicular population having more vehicles than the combined number in the other three metros of India viz. Mumbai, Chennai and Kolkata. 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[9]. 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[10]. 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. This is realized through following changes:

- Improved efficiency: metro has lower GHG emissions per passenger-kilometre compared to other modes of transport used in absence of the project.

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[7] File 2, DMRC, 2009

[8] http://www.transport.delhigovt.nic.in/info/info8.html

[9] Cited from Annual Plan 2006-07 in respect of Transport Sector, Transport Department, page 1, Transport Department of Govt. of NCT of Delhi, http://www.transport.delhigovt.nic.in/transport/plan_write_up_2006_07.pdf

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

- Mode switching: The MRTS is more attractive to clients due to reduced transport times, increased safety and reliability. It can thus attract private car, taxi or motorized rickshaw users with higher emission rates to switch to public transport.
- Load increase or change in occupancy: The MRTS has a centrally managed organisation dispatching trains not available in the current bus based mass transit system. The occupancy rate of vehicles can thus be increased due to organizational measures.

The project contributes to **sustainable development** in a significant manner in the environmental, social, economic and technological dimensions.

Environmental improvements are achieved through less GHG and other air pollutant emissions, specifically particle matter, SO_2 and NO_x. This is achieved through a more efficient transport system and through using electricity as energy source. See section D for major details.

The **social impact** of metro is basically improved social wellbeing as a result of less time lost in congestion, less respiratory diseases due to less particle matter pollution, and fewer accidents per passenger transported. An ex-post evaluation of the benefits of Phase I of metro also shows that the number of road accidents could be reduced by the metro[11].

Improved **economic performance** of the city basically due to less congestion and due to having a modern public transit system with its corresponding positive image. An ex-post evaluation of the benefits of Phase I of metro tried to quantify these economic benefits e.g. of reduced congestion and environmental pollution[12]. A monetary quantification of these benefits is complex and prone to discussions as developments of the same parameters also take place in absence of the project and a monetization of non-market traded benefits (e.g. estimation of the value of time savings) can lead to differing results depending on the approach used – nevertheless it is clear in a qualitative sense that the project contributes to economic benefits. Latter are basically public goods and cannot be captured effectively by metro through ticket charges as benefits are accrued by users as well as non-users of metro.

Technology-wise the metro is a modern and efficient mass transit means not used commonly in India. Before Metro Delhi India only had a metro in Calcutta with a very mixed success due not least to huge time delays, significant financial problems, relocation of underground utilities, court injunctions, etc.[13]

The project complies with all legal requirements of the environmental legislation of India. All environmental permits required have been granted. The project is compliant with national public transport regulations and strategies.

The project reduces on average 529,043 tCO_2per annum in the first crediting period.

A.2. Location of project activity

A.2.1. Host Party

India

A.2.2. Region/State/Province etc.

New Delhi

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[11] CRRI, Quantification of Benefits Achieved from the Implementation of Phase I of Delhi Metro, Table 6.13 p.121, 5.2007

[12] See former footnote

[13] See http://www.kolmetro.com/ and http://www.mtp.railnet.gov.in/history.html

A.2.3. City/Town/Community etc.

Delhi

A.2.4. Physical/Geographical location

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.[14]

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

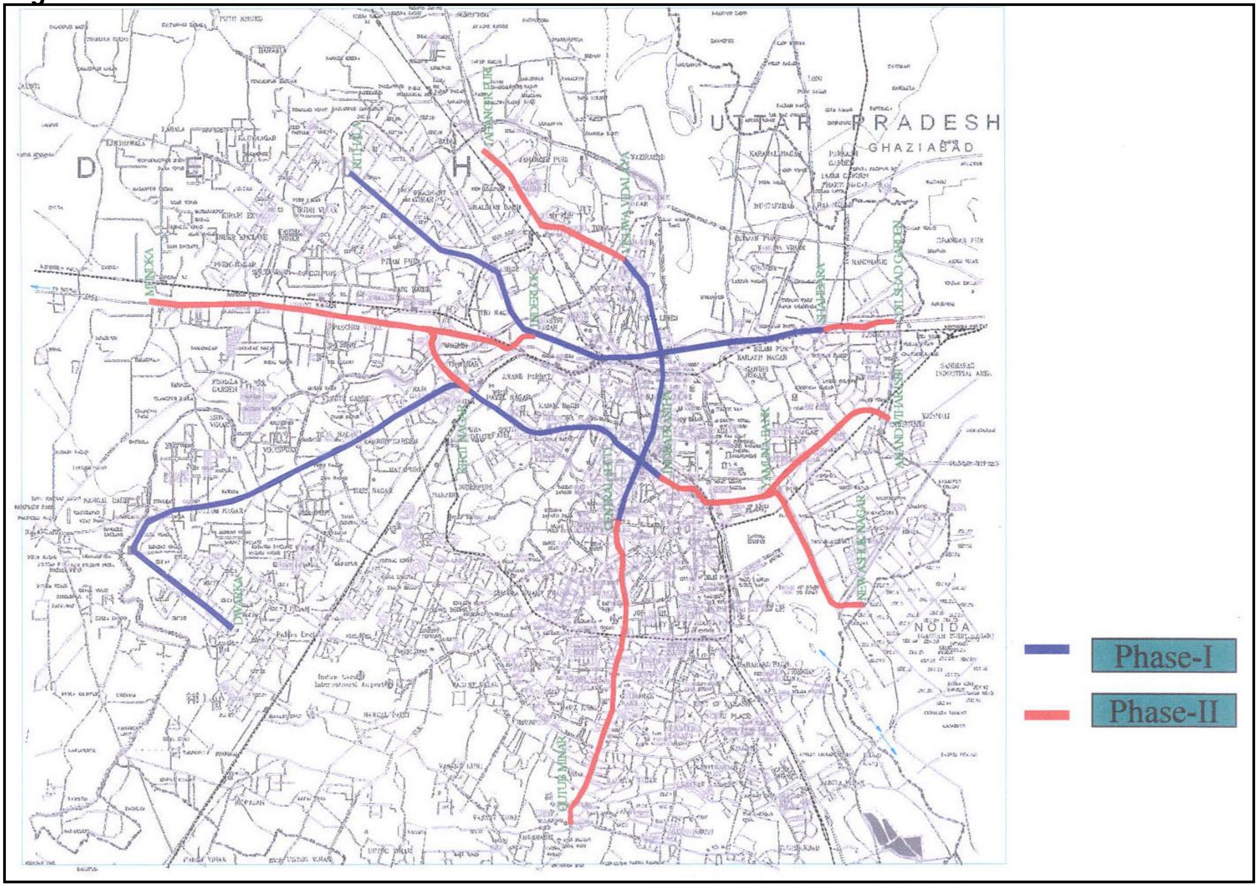

Table 1: Lines of Metro Delhi included in the PDD[15]

Line/Section	Length (km)
Shahdara – Dilshad Garden	3.1
Vishwavidyalaya – Jahangirpuri	6.4
Indraprastha – New Ashok Nagar	8.1
New Ashok Nagar – Noida	7.0
Inderlok – Kirtinagar – Mundka	18.5

[14] Delhi Statistical Hand Book 2007, page 1

[15] File 2

Yamuna Bank – Anand Vihar	6.2
Anand Vihar – Vaishali	2.6
Qutab Minar – Gurgaon	14.5
Central Secretariat – Qutab Minar	12.5
Central Secretariat – Badarpur	20.2
Dwarka Sector 9-21	2.8
Total	**101.67**

A.3. Technologies and/or 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[16]. 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 102 km[17]. The ultimate capacity of the metro is 75-80,000 passengers per hour per direction.

The total length of metro corridors as included in the "Revised Metro Master Plan for 2021" consists of 245 km of metro system to be established in 4 phases entering into operation 2005, 2011, 2016 and 2021[18]. Phase I consists of 3 corridors of total 55 km. Phase I changed various times during implementation with various amendments being made[19]. Under Phase II additional corridors have been proposed to be taken up with the approval of Delhi Government to cover large areas in view of the upcoming Common Wealth Games in 2010. The original DPR Phase II totalling 53 km included the following six corridors is listed in table 2.

Table 2: Corridors Included in Original DPR Phase II

Corridor	Length (km)
Vishwavidyalaya-Jhahangirpuri	6.4
Central Secretariate –QM	10.9
Shahadara-Dilshad Garden	3.1
Indraprastha-New Ashok Nagar	8.1
Yamuna Bank –Anand Vihar ISBT	6.2
Inderlok – Kirtinagar –Mundka	18.5

Source: DPR Phase II point 0.1.5 and table 0.3 (File 42)

Practically at the same time two additional corridors were designed and decided upon:

- Corridor New Ashok Nagar-Noida defined as Noida extension in its DPR[20] with a length of 7 km.
- QM-Gurgaon defined as Gurgaon Metro Corridor in its DPR[21] with a length of 14.47 km.

[16] 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.

[17] File 2

[18] DPR Phase II, point 0.1.5 (file 42)

[19] File 42, point 0.1.2 and 0.1.3

[20] DPR for Extension of Delhi Metro to Noida, prepared by DMRC, 11.2004 (File 73)

As of decision taking September 2005 around 75 km had thus been considered for Phase II. Comparable to the development of Phase I during the course of implementation of Phase II some extensions and changes were realized. The New Delhi - Airport and Dwarka Sector 21 corridors were handed over to a private company and are therefore not element of this PDD[22]. Updated DPRs were realized for the following corridors after September 2005:

- Central Secretariat – Badarpur with a length of 20.2 km defined as Central Secretariat – Badarpur corridor in its DPR, with date October 2006[23]
- For the minor extensions Dwarka Sector 9 – 21 (2.8km) and Anand Vihar – Vaishali (2.6km, July 2007) a project brief was realized[24].

Table 3 below lists all Phase II corridors (except the airport lines which are not part of this project due to property reasons), the construction start date and the expected commissioning.

Table 3: All Corridors Included of Phase II

Corridor	Length (km)	Construction start date	Expected Commissioning date
Shahadara-Dilshad Garden	3.09	April 2006	June 2008
Vishwavidyalaya-Jhahangirpuri	6.36	November 2005	February 09
Indraprastha-New Ashok Nagar[25]	8.07	November 2005	June 2009
New Ashok Nagar-Noida	7	July 2006	June 2009
Inderlok – Kirtinagar –Mundka	18.46	April 2006	September 2009
Yamuna Bank –Anand Vihar ISBT	6.17	June 2006	October 2009
Anand Vihar – Vaishali	2.6	June 2008	December 2009
QM-Gurgaon	14.47	November 2006	November 2009
Central Secretariate –QM	12.53	November 2006	June 2010
Central Secretariat – Badarpur	20.16	April 2007	May 2010
Dwarka Sector 9 – 21	2.76	March 2006	September 2010

Source: DPRs and DMRC, File 2

The proposed 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 will be laid to broad gauge (1,676 mm) and standard gauge (1.435mm) with 60-kg UIC wear resistant rails. On elevated alignment, the track will be 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 will take care of the ongoing monitoring of the metro service via various technical systems and will keep in contact by radio and telephone with the train drivers, the mobile personnel and the metro service vehicles. The control centre will also monitor 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 will also be 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.

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[21] DPR for Gurgaon Metro Corridor, prepared by DMRC, 12.2004 (File 74)

[22] See File 76 where Delhi Airport Express Metro Pvt. Ltd claims the CER ownership of these corridors.

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

[24] Files 77 and 81

[25] The Letter of Approval was issued 1.9.2005, however the contract was signed 10.11.2005 and from this date onwards real construction started. The contract is also a legally binding document with a financial commitment.

The metro runs partially underground, partially at grade and partially elevated. Each train will have between 4 and 6 cars and will run frequencies between 3 and 12 minutes depending on lines, time of the day and passenger demand. Trains have a length of around 22m per car, 3.2m wide and 3.9 m high. The capacity of a 4 car broad gauge train is 1178 passengers (186 of which seated), of a 6 car broad gauge train 1792 (of which 286 seated). For standard gauge train, the figures for 4 and 6 car are 1034 and 1574 respectively. In standard gauge trains, passengers seated are 186 (for 4 car) and 286 (for 6 car). For a typical average intersection of 1km, the running time will be on average 80 seconds to achieve a scheduled speed of 32 to 35km/h with dwell station times of 30 seconds. The maximum acceleration is thereby 0.78m/s and the maximum deceleration 1.0m/s. The necessary power for a train of 239t gross weight on a level and straight track would be about 1,450kW. For phase II it is projected that the first 36 Broad gauge + 04 standard gauge coaches are imported and the remaining around 388 broad gauge + 192 standard gauge coaches are manufactured in India with progressive indigenisation. The Broad gauge coaches are imported from Germany and standard gauge coaches are imported from South Korea.

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 will have automatic signalling in the section. Automatic train supervision will provide for high safety with trains running at close headway ensuring continuous safe train operations, and eliminate accidents due to drivers passing signals. 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. This allows for increased productivity of the rolling stock by increasing the line capacity and the train speeds and improves the maintenance of signalling and telecommunication equipment by monitoring the system status of trackside and train born equipment thus enabling preventive maintenance.

Operational integration with feeder lines is provided through synchronizing of metro services with feeder bus services and provision of adequate signage systems. The metro has a limited amount of property feeder bus lines to service core metro stations.

For efficient ticketing and passenger control an Automatic Farer Collection (AFC) is provided. The base AFC system will make use of contactless smart tokens for single and “Contact-less Smart Card Tickets” for multiple journey as well as working with multiple operators. AFC has the following advantages compared to manual fare collection systems:

- Less staff required;
- Less possibility of leakage of revenue;
- Fraudulent recycling of tickets by staff is avoided;
- Efficient and easy to operate;
- System enables quick fare changes;
- Management information is generated easily;
- System has multiple operator capabilities.

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 will be 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 will be automatically switched on and fed the stand by Generator Sets. In addition, all the trains will 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 ventilation and air conditioning arrangements in the tunnel and the underground stations are being so designed that emergency ventilation arrangements for the stations and tunnel will continue to be maintained from the standby Generator Sets in such exigencies.

Metro Delhi is a world class metro using state-of-the art metro technology. All equipment used is new. Partially equipment and know-how is imported. This is, e.g. in the case of rail cars progressively indigenized. Through the project a technology transfer thus takes place.

For a detailed technical description see also DMRC, Detailed Project Report for Phase-II Corridors of Delhi Metro, Rites Ltd., January 2005

A.4. Parties and project participants

Party involved (host) indicates host Party	Private and/or public entity(ies) project participants (as applicable)	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. The relevant documents have been submitted to the validator.

SECTION B. Application of selected approved baseline and monitoring methodology and standardized baseline

B.1. Reference of methodology and standardized baseline

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
- Tool05 “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

B.2. Applicability of methodology and standardized baseline

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

Table 4 relates the specific baseline methodology applicability conditions with the proposed project.

Table 4: Applicability Conditions

Applicability condition	Project situation

The project constructs a new rail-based infrastructure or segregated bus lanes: a). For rail systems, the project needs to involve the construction of a new infrastructure (new rail lines); b). For BRTs, the project can be based on existing road infrastructure, but which separates physically bus lanes from mixed traffic. The methodology is applicable for the segregated BRT bus lanes or the rail-based MRTS replaces existing bus routes (e.g. through scrapping units or through closing or re-scheduling existing bus routes) operating under mixed traffic conditions.	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[26] as well as urban planning documents for multi-mode transport schemes coordinating bus and metro services[27].
Fuels including (liquified) gaseous fuels or biofuel blends, as well as electricity can be used in the baseline or project case. The following conditions[28] apply in case of biofuels: (a) The project buses shall use the same biofuel blend (same percentage of biofuel) as commonly used by conventional comparable urban buses in the country i.e. the methodology is not applicable if project buses use higher or lower blends of biofuels than those used by conventional buses; (b) The project buses shall not use a significantly higher biofuel blend than cars and taxis.	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: a). Operational improvements (e.g. new or larger buses) of an already existing and operating bus lane or rail-based MRTS; b). Bus lanes replacing an existing rail-based system i.e. the existing urban or suburban rail infrastructure shall remain fully (in its full length) operational; c). The implementation of air- and water-based	a). The MRTS is a new metro with new infrastructure. b). The MRTS is rail-based. c). No air or water-based transport is included. The MRTS is rail based.

[26] File 45

[27] File 46

[28] No provisions to calculate upstream emissions from the production of the fuels are provided in order to keep the methodology simple. Therefore, in order to ensure that the calculated emission reductions are conservative, this applicability condition aims to limit the use of the methodology to cases where the upstream emissions under the project activity are likely to be equal or lower than in the baseline scenario. Note that other methodologies involving fuel switch situations usually require the consideration of upstream emissions.

transport systems.	
The methodology is applicable for urban or suburban trips. It is not applicable for inter-urban transport.	The MRTS is purely urban transport.
The methodology is applicable if the most plausible baseline scenario is the continuation of the use of current modes of transport.	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

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	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 scenario	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

BASELINE IDENTIFICATION

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 (see Figure 1). 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[29]. 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[30]. 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[31]. 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[32]. This alternative faces 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[33]. 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.

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

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

[31] DPR, 2005, Table 0.4

[32] 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 (see http://www.dimts.in/rail.html), however investment costs will also increase strongly. The LRT thereafter resembles basically a metro.

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

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 (see Delhi Integrated Multi Modal Transit System Ltd. (DIMTS) on http://www.dimts.in/default.aspx

Table 6: Comparison BRTs, LRTs and Metros

Characteristic	BRT / Bus lane	LRT / Tram /Monorail	Metro
Passenger carrying capacity (phd)[34]	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 7: Passenger Carrying Capacity of Various BRTs, LRTs and Metros (phd)

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

[34] See examples following table

45,000 buses, 76,000 motorized rickshaws and nearly 4 million motorcycles[35]. 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[36]. 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[37] was set up in 2008 called Delhi Integrated Multi-Modal Transit System (DIMTS)[38]. 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.” [39] 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 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.” [40] 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.”[41] 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.

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[35] http://www.transport.delhigovt.nic.in/info/info8.html

[36] Cited from Annual Plan 2006-07 in respect of Transport Sector, Transport Department, page 1, Transport Department of Govt. of NCT of Delhi, http://www.transport.delhigovt.nic.in/transport/plan_write_up_2006_07.pdf

[37] Special Purpose Vehicle

[38] File 22, Economic Survey of Delhi 2005-2006, statement 8, p.141; see http://www.dimts.in/default.aspx

[39] See: http://planningcommission.nic.in/plans/planrel/fiveyr/index9.html

[40] See: http://web.iitd.ac.in/~tripp/delhibrts/brts/hcbs/hcbs/gnctpress1.htm

[41] See: http://delhi-masterplan.com/master-plan-2001/

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:

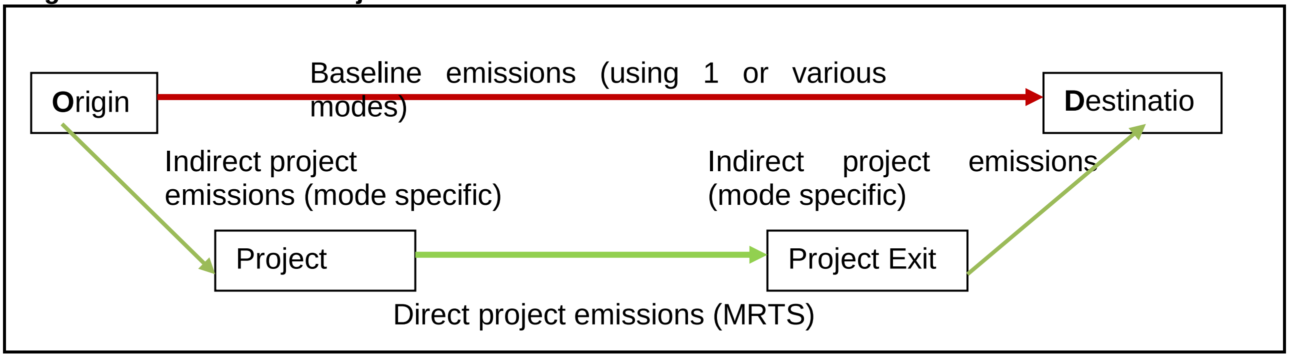
- NMT (Non-Motorized Traffic) with bikes and per foot;
- Private passenger car;
- Taxis;
- Motorcycles (two-wheelers);
- Motorized auto-rickshaws (used as taxis);
- Buses;
- Sub-urban rail.

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 3 gives an overview of baseline and project emissions, latter being differentiated in indirect and direct project emissions.

Figure 3: Baseline and Project Emissions



For formulas applied see section B.6.

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 8 that CDM was considered before the project starting date. The project starting date is defined in accordance with EB 41 Paragraph 67.

Table 8: 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 Consulting	22.10.2007	File 39, offer
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[42]. 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[43], 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);
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.

[42] See File 76

[43] File 41, MD Board Powers

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[44]. 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.

India had prior to Metro Delhi only one metro in Kolkata which was opened to traffic in stretches between October 1984 and September 1995[45]. 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[46] the estimated original cost was at 29 million

[44] 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).

[45] File 48, chapter 1

[46] 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

USD at 1970-71 price level (222 million India Rupees with exchange rate of 7.5 INR per USD[47]) 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)[48] 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.[49] 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[50]. Logically the net revenue (traffic earnings minus working expenses[51]) were highly negative with a deficit of around 657 million Rupees 2001-02[52] 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[53] the actual deficit was between 1.09 (1990-91) and 13.68 million USD (2001-02)[54] i.e. the deficit was 5 to 65 times higher than expected. Similar data is reported by Kolkata Metro[55] 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 9: 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)[56] Singh (2002)[57] for control
Kolkata passenger numbers (millions)	1.32 per day (1995/96) 630 per	0.128 per day 55.8 per annum	- 90%	Both data sources (different years) have 90% less passengers than projected. The lower (more conservative)	Kolkata metro (2000), Singh (2002)

[47] Exchange rate see: http://wapedia.mobi/en/Tables_of_historical_exchange_rates_to_the_USD based on Financial Guide FX Fundamentals Retrieved on July 6, 2007

[48] Price level end 1993 1 USD = 0.0318066 INR given by http://www.x-rates.com/d/USD/INR/hist1993.html

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

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

[51] Working expenditure excludes depreciation and interest on capital

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

[53] 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

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

[55] File 48

[56] File 48

[57] File 44

	annum (2000)			difference between actual and expected passengers is taken.	

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[58] 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[59]. 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[60] 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.

[58] Property development and advertisement basically

[59] File 53, GTZ, Table 7

[60] File 54

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 International Cooperation) for 56% of the funding, while 0% is taken for the part of Government Funding[61]. 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%[62]. The same financing structure has also been identified for the NOIDA extension[63] as well as for the Gurgaon extension[64].

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

Table 10: Investment Principles and EB Guidelines

EB Guideline[65]	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.[66] • 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

[61] 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.

[62] 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.

[63] DPR point 12.5.3.1 (File 73)

[64] DPR point 12.6.2.1. (File 74)

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

[66] 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)

	and duties plus state regulation of exemption income tax for infrastructure investments for the initial 20 years[67].
Point 6: Time of assessment	All calculations are based on data available as of September 2005[68] 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 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%[69].
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

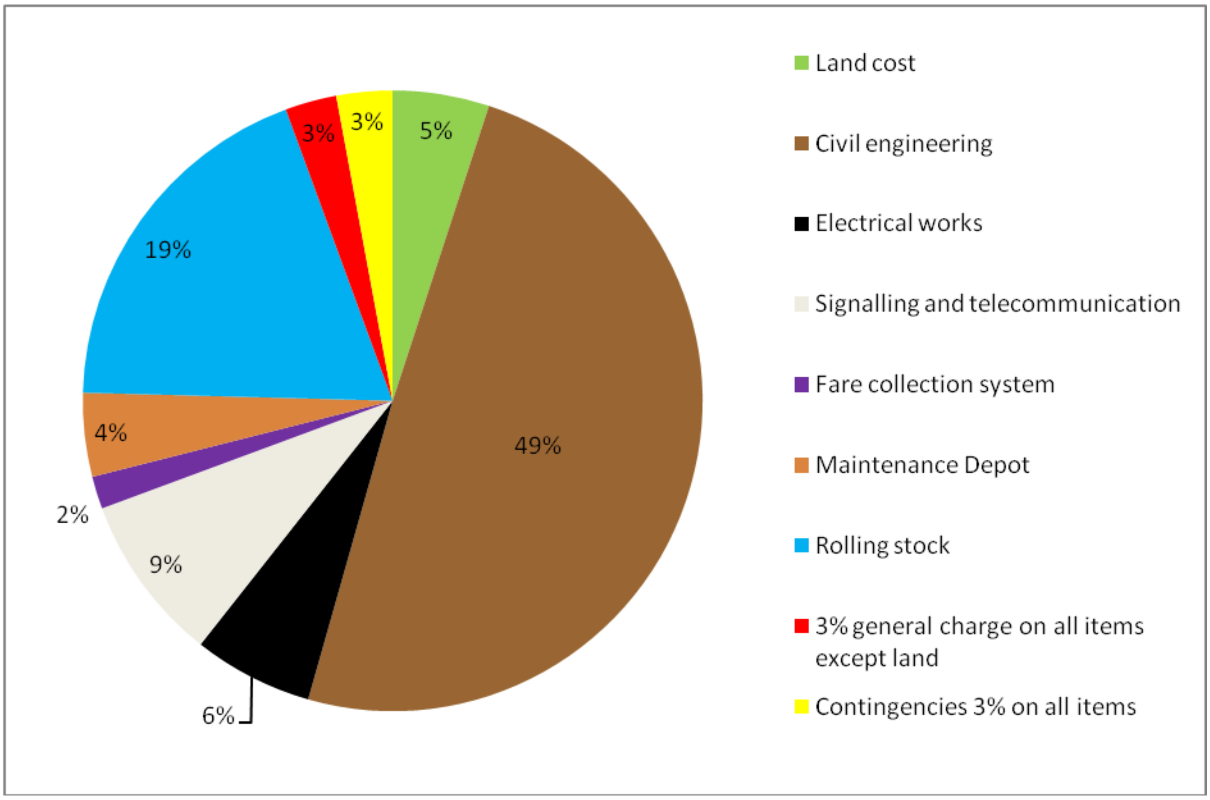
Figures 4a to 4c show the investment cost distribution.

Figure 4a: Investment Cost Distribution DMRC Phase II Corridors Original DPR (Table 2)

[67] File 43

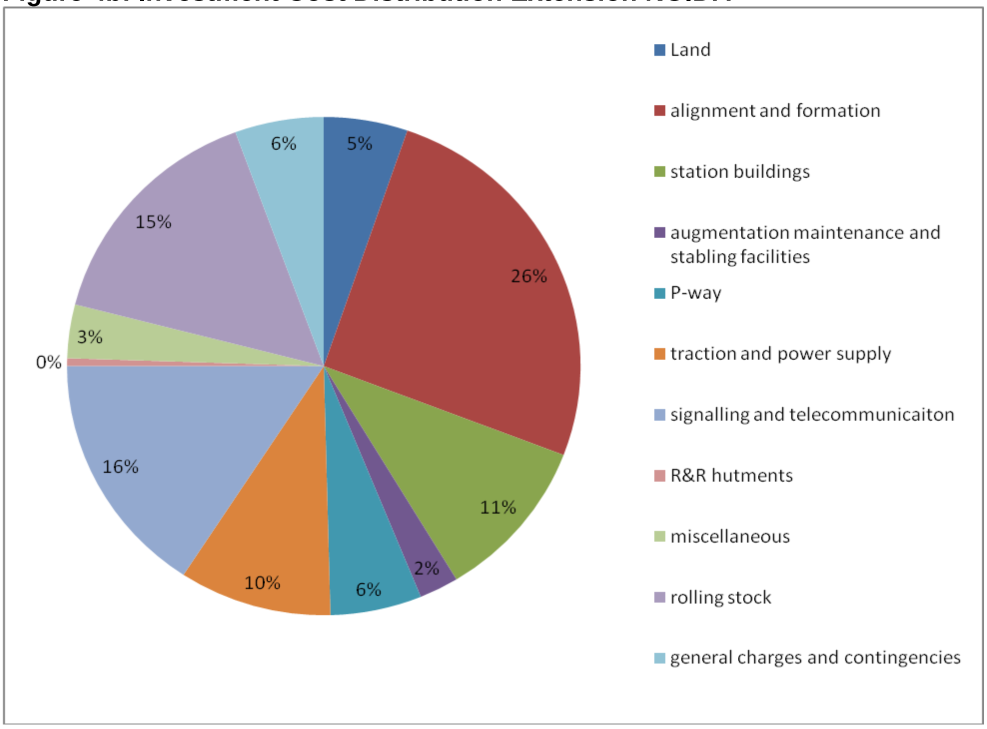
[68] DPR report was available as of 2.2005

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



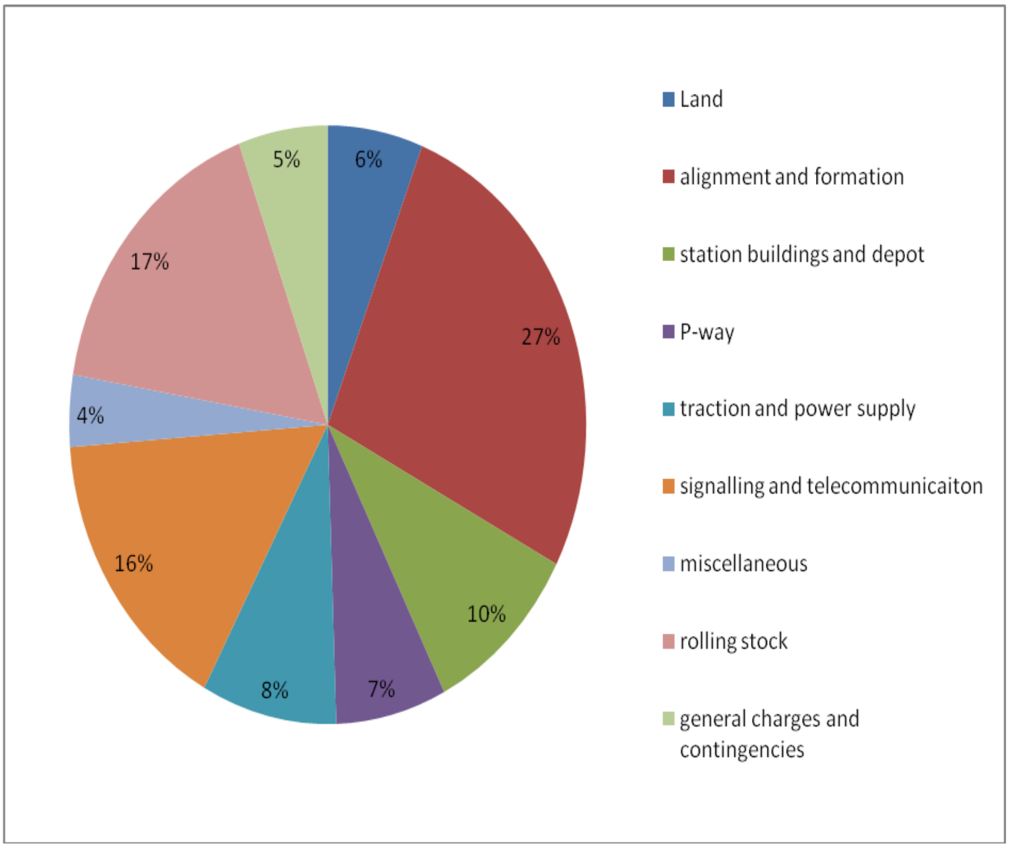
Source: DPR Phase II, 2005, Annex 8.1, (File 42)

Figure 4b: Investment Cost Distribution Extension NOIDA



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

Figure 4c: Investment Cost Distribution Extension Gurgaon



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

Table 11 shows the major parameters used for the financial assessment.

Table 11: 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 period)	7,246 million INR	File 42 Table 9.5, File 73 Table 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[70]
Discount rate		JBIC preferential rate of 1.3% for 56% of debt and rest at 0%;

[70] 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

	0.7%	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)[71]
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 12 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 12: 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 13 includes the sensitivity analysis.

[71] File 42

Table 13: 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[72]
- Extensions Dwarka Sector 9 – 21 (2.8 km) and Anand Vihar – Vaishali (2.6 km, July 2007)[73].

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[74].

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[75]. 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

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

[73] Files 77 and 81

[74] 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)

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

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.

Table 14: 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[76] 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[77].

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 15 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 15: 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

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

[77] File 47new sheet „plausibility“

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

Table 16: Indian Cities with over 1 Million Inhabitants and Existence of MRTS as of Project Starting Date[78]

City	Inhabitants (in millions)	MRTS system[79]
Agra	1.3	No MRTS
Ahmedabad	4.5	No MRTS[80]
Allahabad	1.0	No MRTS
Amritsar	1.0	No MRTS
Asansol	1.1	No MRTS
Bangalore	5.7	No MRTS[81]
Bhopal	1.5	No MRTS[82]
Chennai (Madras)	6.6	Elevated train[83]
Coimbatore	1.5	No MRTS
Delhi	12.9	Metro Phase I
Dhanbad	1.1	No MRTS
Faridabad	1.1	No MRTS[84]
Hyderabad	5.7	No MRTS[85]
Indore	1.5	No MRTS[86]
Jabalpur	1.1	No MRTS
Jaipur	2.3	No MRTS
Jamshedpur	1.1	No MRTS
Kanpur	2.7	No MRTS[87]
Kochi	1.4	No MRTS
Kolkata	13.2	Metro
Lucknow	2.2	No MRTS[88]

78 9/2005

79 Metro, LRT, BRT/bus lane

80 Ahmedabad plans a BRT but as of project start this was not yet operational

81 Metro is under construction and has realized a CDM tender for this project

82 BRT is under planning

83 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 (e.g. www.subways.net 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.

84 DMRC plans to cover the city with a metro extension

85 Metro is under planning; the current rail-service is commuter rail to suburbs

86 A BRT which has applied for CDM is planned but is not yet operational; See www.unfccc.int

87 Kanpur had trams until 1933; metro is under planning

88 Metro is under planning

Ludhiana	1.4	No MRTS[89]
Madurai	1.2	No MRTS
Meerut	1.2	No MRTS
Mumbai	16.4	Suburban train[90]
Nagpur	2.1	No MRTS
Nasik	1.2	No MRTS
Patna	1.7	No MRTS
Pune	3.8	No MRTS[91]
Rajkot	1.0	No MRTS[92]
Surat	2.8	No MRTS[93]
Vadodara	1.5	No MRTS
Varanasi	1.2	No MRTS
Vijayawada	1.0	No MRTS
Vishakhapatnam	1.3	No MRTS[94]

Source:
Population: Census 1.3.2001, see e.g. http://www.citypopulation.de/India-Agglo.html
For metros and elevated trains see city website of respective city; for links to these websites see Wikipedia e.g. http://en.wikipedia.org/wiki/Rajkot#Transport see also:
http://www.subways.net/india/index.htm

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. 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:

[89] Metro is under planning

[90] Metro and LRT under construction; metro also proposed as CDM project (see www.unfccc.int). Suburban train at least in some lines can be considered as MRTS

[91] BRT under development

[92] BRT under development

[93] BRT under development and metro under planning

[94] BRT under planning

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

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

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:

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

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:

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

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 $TD_{EL,i}$[95].

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

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

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

[95] 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.

(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 ($EF_{CO2,x,y}$). In the case of Delhi currently no biofuels are used.

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:

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

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)
$N_{x,i}$ 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 the data parameter $N_{x,i}/N_i$ approach 2 is used i.e. based on the number of vehicles per fuel type x as no reliable data on distance driven per fuel type x is available.

For train (idem for metro) using electricity the EF is calculated based on the Tool05 "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" baseline and or leakage emissions from electricity consumption" (equation 1).

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

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 and is listed in the following table.

Table 17: Default Technology Improvement Factors (per annum)

Vehicle category	Technology Improvement Factor IR
Passenger cars	0.99
Taxis	0.99
Motorcycles incl. rickshaws	0.99
Buses	0.99

Source: Tool18 Methodological tool, Baseline emissions for modal shift measures in urban passenger transport; data parameter 7

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.

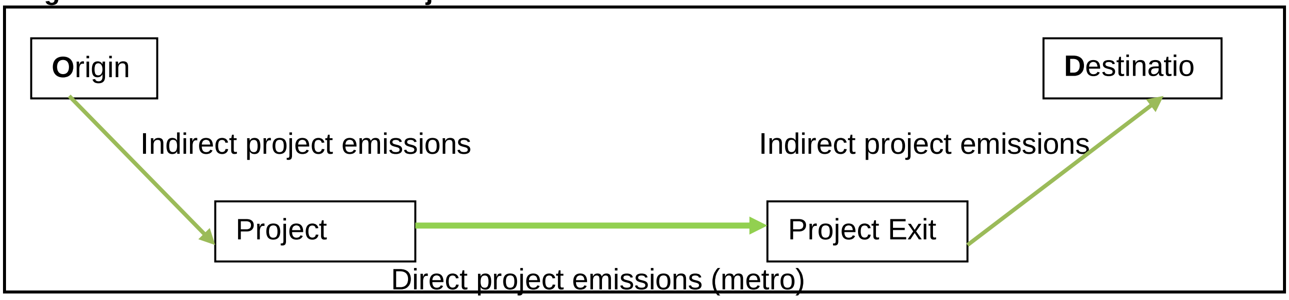
Baseline emissions are determined using equation 1 and 2 corresponding to the equations 1 and 2 of the methodology ACM0016 Version 04.0. Step 4 of the Methodological Tool “Baseline emissions for modal shift measures in urban passenger transport” with the 2 options is therefore not used (equation 2 of the methodology results in the same mathematical result as option 1 of the tool under step 4).

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).

Figure 5: Direct and Indirect Project Emissions



Project emissions are calculated as follows:

$$PE_y = DPE_y + IPE_y \quad (7)$$

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:

$$\mathrm{LE}_{\mathrm{LFB,y}} = \frac{1}{10^6} \cdot \mathrm{N}_{\mathrm{B,y}} \cdot \mathrm{AD}_{\mathrm{B}} \cdot \mathrm{EF}_{\mathrm{KM,B,y}} \cdot \left(1 - \frac{\mathrm{OC}_{\mathrm{B,y}}}{\mathrm{OC}_{\mathrm{B}}}\right) \quad \textbf{(11)}$$

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.[96]

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

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

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.

B.6.2. Data and parameters fixed ex ante

Data / Parameter	**$SFC_{C, G/D/CNG}$**
Unit	g/km

[96] Paragraph 74 of ACM0016 Version 04.0

Description	Specific fuel consumed of passenger cars using gasoline, diesel or CNG
Source of data	Passenger car with gasoline or diesel fuel: ADB, Breaking the Trend, Table 12, 2008 (File 23) Passenger car using CNG: Based on taxis using CNG, 2008 (File 9)
Value(s) applied	Cars gasoline: 53.98 Cars diesel: 48.59 Cars CNG: 64.00
Choice of data or Measurement methods and procedures	For gasoline and diesel cars based on national literature. This is conservative as only cars are considered and not SUVs which have a higher fuel consumption (31% more in gasoline and 43% more in diesel cars according to same source table 12) while representing according to the same report (table 13) for 2010 17% of all passenger vehicles. For CNG cars the value of taxi CNG vehicles is taken which is based on a large fleet. Taxi fleets manage new vehicles and maintain these well, thus the data is conservative.
Purpose of data	Baseline, project, leakage
Additional comment	To transform from litres to grams the specific weight of gasoline and diesel was taken based on Bharat Petroleum Corp. 2008 (File 18)

Data / Parameter	$\mathbf{N_{C,G/D/CNG}}$
Unit	%
Description	Percentage of passenger cars using fuel type: gasoline, diesel or CNG
Source of data	Department of Transport, Delhi, 2008 and Centre for Science and Environment (CSE), 2008 (File 7)
Value(s) applied	Gasoline: 81.8% Diesel: 10.6% CNG: 7.6%
Choice of data or Measurement methods and procedures	Official data adjusted in the case of CNG for converted vehicles
Purpose of data	Baseline, project
Additional comment	This data is monitored annually.

Data / Parameter	$\mathbf{SFC_T}$
Unit	g/km
Description	Specific fuel consumed of taxis
Source of data	Easy Cab, 2008 (File 9)
Value(s) applied	64 g/km CNG plus 6.07 g/km gasoline
Choice of data or Measurement methods and procedures	Easy Cab has a large fleet in Delhi which is very new (average age 1 year). The data is thus representative and better than a survey and very conservative as the fleet is very new.
Purpose of data	Baseline, project
Additional comment	To transform from litres to grams the specific weight of gasoline was taken based on Bharat Petroleum Corp. 2008 (File 18). All vehicles are dual fuel CNG and gasoline. They normally use CNG due to lower price. However in absence of CNG (e.g. no stations) cars use gasoline. Thus they have a CNG consumption plus a small gasoline consumption (in case no CNG station is available).

Data / Parameter	$\mathbf{N_T}$
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 (July 28, 1998 implemented by late 2002; see U. Narain et.al., The Impact of Delhi's CNG Program on Air Quality, RFF, 2007, Appendix A; File 60)
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, project
Additional comment	All CNG taxis are dual fuel (CNG and gasoline) but use basically CNG This data is monitored annually.

Data / Parameter	**SFC_{TR}**
Unit	g/km
Description	Specific fuel consumed of motorized auto-rickshaws
Source of data	Grütter Consulting AG, 2009 (File 36)
Value(s) applied	32.00
Choice of data or Measurement methods and procedures	Based on sample realizing measurements of fuel consumption. The lower 95% confidence interval was taken. The sample size required for a 95% confidence level and a 5% maximum error bound of a point estimation of simple random sample is 3 (due to the very low variance of data) while the actual sample size taken was 50 units.
Purpose of data	Baseline, project
Additional comment	

Data / Parameter	**N_{TR}**
Unit	%
Description	Percentage of motorized auto-rickshaws using CNG
Source of data	Supreme Court of India mandated that all commercial passenger vehicles including motorized auto-rickshaws be CNG powered (July 28, 1998 implemented by late 2002; see U. Narain et.al., The Impact of Delhi's CNG Program on Air Quality, RFF, 2007, Appendix A; File 60)
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, project
Additional comment	

Data / Parameter	**SFC_{M}**
Unit	g/km
Description	Specific fuel consumed of motorcycles
Source of data	Grütter Consulting AG, 2008 and 2009 (File 6)
Value(s) applied	13.43
Choice of data or Measurement methods and procedures	Based on sample realizing measurements of fuel consumption. The lower 95% confidence interval was taken. The sample size required for a 95% confidence level and a 5% maximum error bound of a point estimation of simple random sample is 23 while the actual

	sample size taken was 30 units.
Purpose of data	Baseline, project
Additional comment	To transform from litres to grams the specific weight of gasoline was taken based on Bharat Petroleum Corp. 2008 (File 18)

Data / Parameter	$\mathbf{N_M}$
Unit	%
Description	Percentage of motorcycles using gasoline
Source of data	ARAI, Emission Factor Development for Indian Vehicles, 2007 only reports gasoline motorcycles and scooters (File 61)
Value(s) applied	100%
Choice of data or Measurement methods and procedures	Official data source
Purpose of data	Baseline, project
Additional comment	

Data / Parameter	$\mathbf{SFC_B}$
Unit	g/km
Description	Specific fuel consumed of buses
Source of data	Delhi Transport Corporation (DTC), 2009 (File 12)
Value(s) applied	348.43
Choice of data or Measurement methods and procedures	DTC manages the urban bus fleet of Delhi. Data of all buses (not based on survey). Data for the year 2008. Entire urban bus fleet based on CNG.
Purpose of data	Baseline, project
Additional comment	

Data / Parameter	$\mathbf{N_B}$
Unit	%
Description	Percentage of buses using CNG
Source of data	Supreme Court of India mandated that in Delhi, all commercial passenger vehicles including buses be CNG powered (July 28, 1998 implemented by late 2002; see U. Narain et.al., The Impact of Delhi's CNG Program on Air Quality, RFF, 2007, Appendix A; File 60)
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, project
Additional comment	

Data / Parameter	$\mathbf{EC_{EL,R}}$
Unit	MWh
Description	Quantity of electricity consumed by the baseline rail system per annum
Source of data	Northern Railway, Delhi, 2008/2009 (File 16)

Value(s) applied	3,855
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.

Data / Parameter	**EF_{Grid}**
Unit	$kgCO_2$/kWh
Description	Emission factor for the grid
Source of data	Government of India, CEA, Version 5.0, 11-2009, NEWNE grid (File 1)
Value(s) applied	0.8409
Choice of data or Measurement methods and procedures	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	Baseline, project
Additional comment	

Data / Parameter	**TDL**
Unit	---
Description	Average technical transmission and distribution losses for providing electricity
Source of data	Powergrid corporation of India, 3.2010, http://www.nldc.in/NLDC/updateloss/webdata.htm (File 55)
Value(s) applied	3.91%
Choice of data or Measurement methods and procedures	Northern Grid Based on average value for entire year 2009 from the National Dispatch Center.
Purpose of data	Baseline, project
Additional comment	

Data / Parameter	**OC_C**
Unit	Passengers
Description	Average occupation rate of passenger cars
Source of data	Grütter Consulting AG, 2008 (File 8)
Value(s) applied	1.60
Choice of data or Measurement methods and procedures	Survey realized using upper 95% confidence interval. The sample size required for a 95% confidence level and a 5% maximum error bound of a point estimation of simple random sample is 454 while the actual sample size taken was 46,945 units. Procedure followed TORs for occupation rate studies described in methodology.
Purpose of data	Baseline, project
Additional comment	

Data / Parameter	**OC_T**
Unit	Passengers

Description	Average occupation rate of taxis
Source of data	Grütter Consulting AG, 2008 (File 10)
Value(s) applied	1.16
Choice of data or Measurement methods and procedures	Survey realized using upper 95% confidence interval. The sample size required for a 95% confidence level and a 5% maximum error bound of a point estimation of simple random sample is 1,537 while the actual sample size taken was 6,744 units. Procedure followed TORs for occupation rate studies described in methodology.
Purpose of data	Baseline, project
Additional comment	Excluding driver Is monitored also for determination of leakage occupation rate.

Data / Parameter	OC_M
Unit	Passengers
Description	Average occupation rate of motorcycles
Source of data	Central Road Research Institute (CRRI) Delhi, 2007, Table 3.4 (File 11)
Value(s) applied	1.40
Choice of data or Measurement methods and procedures	Recognized research institute in India; realized on various locations
Purpose of data	Baseline, project
Additional comment	

Data / Parameter	OC_{MR}
Unit	Passengers
Description	Average occupation rate of motorized auto-rickshaws
Source of data	Central Road Research Institute (CRRI) Delhi, 2007, Table 3.4 (File 11)
Value(s) applied	1.40
Choice of data or Measurement methods and procedures	Recognized research institute in India; realized on various locations
Purpose of data	Baseline, project
Additional comment	Excluding driver Is monitored also for determination of leakage occupation rate.

Data / Parameter	OC_B
Unit	Passengers and %
Description	Average occupation rate of buses
Source of data	Central Road Research Institute (CRRI) Delhi, 2007, Table 3.4 (File 14)
Value(s) applied	43 passengers and 57%
Choice of data or Measurement methods and procedures	Recognized research institute in India; realized on various locations Percentage based on 43 passengers on average and an average bus capacity of 75 passengers based on Leyland CNG buses used by DTC with capacities between 60 and 92 passengers (average 75; see File 21)
Purpose of data	Baseline, project, leakage
Additional comment	Is monitored also for determination of leakage occupation rate.

Data / Parameter	$P_{EL,R}$

Unit	Passengers
Description	Total passengers transported by baseline suburban rail-system per year
Source of data	Northern Railway, Delhi, 2008/2009 (File 16)
Value(s) applied	2,887,200
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.

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 17)
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

Data / Parameter	AD_B
Unit	Km
Description	Average annual distance driven of buses (kilometre)
Source of data	Delhi Transport Corporation (DTC), 2008 (File 19)
Value(s) applied	53,325
Choice of data or Measurement methods and procedures	Based on total distance driven of 183 million km and the average fleet of the same year of 3,439 units
Purpose of data	Leakage
Additional comment	Used for leakage load factor change buses if calculation is required. Data is updated if leakage occurs in occupation rate buses with the same source.

Data / Parameter	AD_T
Unit	Km
Description	Average annual distance driven of taxis
Source of data	Easy Cab, 2008 (File 9)
Value(s) applied	91,250
Choice of data or Measurement methods and procedures	Based on records of taxi company with 250km per car per day and 365 days per year.
Purpose of data	Baseline, project
Additional comment	Used for leakage load factor change taxis if calculation is required

Data / Parameter	AD_{TR}
Unit	Km
Description	Average annual distance driven of motorized rickshaws
Source of data	Report Expert Committee on Auto Rickshaw for GOI, p.10, 2003 (File 20)
Value(s) applied	43,800
Choice of data or Measurement methods and procedures	Based on 120 km per vehicle per day and 365 days per year.
Purpose of data	leakage
Additional comment	Used for leakage load factor change motorized rickshaws if calculation is required

PBL_B and $TDBL_{P,B}$ are not required as the average number of passengers on the bus was monitored directly. DD_B is not required as the specific fuel consumption based on total distance and total fuel consumed is reported by the Delhi Bus Operator.

The technology improvement factor IR used for cars, taxis, motorcycles, buses and motorized rickshaws is 0.99.

B.6.3. Ex ante calculation of emission reductions

BASELINE EMISSIONS

Details of the calculation are found in Annex 3.

Table 22: Estimated Baseline Emissions (tCO_2)

2011	2012	2013	2014	2015	2016	2017	2018
494,074	775,888	812,296	850,413	890,319	932,097	975,836	340,542

2011 includes 8 months and 2018 4 months.

PROJECT EMISSIONS

Details of the calculation are found in Annex 3.

Table 23: Estimated Project Emissions (tCO_2)

2011	2012	2013	2014	2015	2016	2017	2018
188,997	298,498	314,307	330,966	348,520	367,020	384,753	135,099

2011 includes 8 months and 2018 4 months.

LEAKAGE EMISSIONS

It is assumed ex-ante that leakage will be 0. However, the corresponding parameters will be monitored in accordance with the methodology and leakage is thus monitored.

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 ($t CO_2e$)
2011 (8 months)	494,074	188,997	0	305,077
2012	775,888	298,498	0	477,389

2013	812,296	314,307	0	497,989
2014	850,413	330,966	0	519,448
2015	890,319	348,520	0	541,799
2016	932,097	367,020	0	565,077
2017	975,836	384,753	0	591,082
2018 (4 months)	340,542	135,099	0	205,443
Total	**6,071,464**	**2,368,160**	**0**	**3,703,304**
Total number of crediting years	7			
Annual average over the crediting period	867,352	338,309	0	529,043

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data / Parameter	**$NCV_{G/D}$**
Unit	MJ/kg
Description	Net calorific value of gasoline and diesel
Source of data	Bharat Petroleum Corporation, 2008 (File 18)
Value(s) applied	Gasoline: 43.9 Diesel: 42.7
Measurement methods and procedures	Based on national values
Monitoring frequency	Annual
QA/QC procedures	Verify if the value is within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall outside this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements.
Purpose of data	
Additional comment	

Data / Parameter	**NCV_{CNG}**
Unit	MJ/m^3
Description	Net calorific value of CNG
Source of data	Bharat Petroleum Corporation, 2008 (File 18)
Value(s) applied	35.6
Measurement methods and procedures	Based on national values
Monitoring frequency	Annual
QA/QC procedures	Verify if the value is within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall outside this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements.
Purpose of data	
Additional comment	

Data / Parameter	**$EF_{CO2,G/D/CNG}$**
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	
Additional comment	

Data / Parameter	$EF_{KM,B,CH4}$
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	192.9
Measurement methods and procedures	IPCC value as no national measurements exist
Monitoring frequency	Any future revision of the IPCC Guidelines is taken into account.
QA/QC procedures	
Purpose of data	
Additional comment	The methodology requires that CH_4 emissions of vehicles using gaseous fuels are included. Value of 7,715 mg CH_4 of IPCC is multiplied with the GWP of 25 for CH_4 to calculate CO_{2eq}

Data / Parameter	$EF_{KM,C/T/TR,CH4}$
Unit	gCO_{2eq}/km
Description	CH_4 emission factor of CNG cars. Taxis and motorized 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	11.8
Measurement methods and procedures	IPCC value as no national measurements exist
Monitoring frequency	Any future revision of the IPCC Guidelines is taken into account.
QA/QC procedures	
Purpose of data	
Additional comment	The methodology requires that CH_4 emissions of vehicles using gaseous fuels are included. 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}

Data / Parameter	$N_{x,C/T/TR}$
Unit	Vehicles
Description	Number of passenger cars (C), taxis (T) and motorized auto-rickshaws (TR) using fuel type *x*
Source of data	Centre of Science and Environment based on Department of Transport, Delhi and Indraprastha Gas Limited, the CNG supplier in Delhi
Value(s) applied	No change projected
Measurement methods and procedures	Registration statistics
Monitoring frequency	Annual; latest available data not elder than 3 years
QA/QC procedures	
Purpose of data	
Additional comment	Required to check if passenger cars, taxis or motorized rickshaws use

	different fuels than those used for calculating the baseline parameter.

Data / Parameter	**P**
Unit	Passengers
Description	Total passengers transported by the project
Source of data	DMRC
Value(s) applied	**Table 24: Million Passengers per Year** 2011: 387; 2012: 613; 2013: 648; 2014: 686; 2015: 725; 2016: 767; 2017: 811; 2018: 286 For 2011 8 months and for 2018 4 months For projections based on File 2
Measurement methods and procedures	Turnpike controls at stations and electronic smart cards. Only passengers are included which enter stations of the lines include 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. line 1 and line 3 have a joint station passengers are distributed 50:50 of that station between line 1 and line 3.
Monitoring frequency	Continuously, aggregated at least annually
QA/QC procedures	
Purpose of data	
Additional comment	

Table 24: Million Passengers per Year

2011	2012	2013	2014	2015	2016	2017	2018
387	613	648	686	725	767	811	286

Data / Parameter	**EC_{PJ}**
Unit	MWh
Description	Electricity consumed by MRTS (trains)
Source of data	DMRC
Value(s) applied	**Table 25: Electricity Consumed per Year (tsd MWh)** 2011: 130; 2012: 206; 2013: 218; 2014: 230; 2015: 243; 2016: 257; 2017: 270; 2018: 95 For 2011 8 months and for 2018 4 months For projections based on File 3
Measurement methods and procedures	Traction energy is recorded by DMRC per line.
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	
Additional comment	Used to calculate together with the emission factor grid the DPE as per the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

Table 25: Electricity Consumed per Year (tsd MWh)

2011	2012	2013	2014	2015	2016	2017	2018
130	206	218	230	243	257	270	95

Data / Parameter	**$N_{B,T,TR}$**
Unit	Buses, Taxis, Motorized Rickshaws
Description	Number of buses, taxis and motorized rickshaws circulating in the city
Source of data	Department of Transport, Delhi and BTC, Delhi
Value(s) applied	
Measurement methods and procedures	None as no change in occupation rate of taxis, buses and auto-rickshaws is previewed
Monitoring frequency	Year 1 and 4 of the crediting period if required i.e. if a change of occupation rate is registered
QA/QC procedures	
Purpose of data	
Additional comment	

Data / Parameter	**$OC_{B,T,TR}$**
Unit	% for buses passengers for taxis and motorized auto-rickshaws
Description	Average occupancy rate of buses, taxis and motorized auto-rickshaws
Source of data	Municipal transit authorities or Survey realized by project proponent or 3rd party (vintage max 3 years) as 1st option
Value(s) applied	For taxis and motorized rickshaws based on visual occupation studies excluding the driver. For details concerning measurement procedures see guidelines in Annex 3. Survey realized using upper 95% confidence interval. Procedure follows TORs for occupation rate studies described in methodology.
Measurement methods and procedures	No change of occupation rate previewed to baseline. Practical experience of a comparable MRTS (Transmilenio Bogota, which has a comparable outreach) has shown no negative change (reduced occupation rate) of occupation rates of baseline vehicles. See verification report TransMilenio 2009 (published on www.unfccc.int).
Monitoring frequency	Year 1 and 4 of the crediting period
QA/QC procedures	The actual sample size required for a 95% confidence level and a 5% maximum error bound of a point estimation of simple random sample must be higher than the required sample size based on the measured standard deviation.
Purpose of data	
Additional comment	

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 procedures	For projection purposes a survey was realized on existing metro lines recording for each passenger the baseline trip distance per mode used (File 5).
Monitoring frequency	The survey is realized in the years 1 and 4 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	$\mathbf{IPTD_{p,i}}$
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	For projection purposes a survey was realized on existing metro lines recording for each passenger the project trip distance per mode used (File 5).
Monitoring frequency	The survey is realized in the years 1 and 4 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	$\mathbf{EC_{EL,R}}$
Unit	MWh
Description	Quantity of electricity consumed by the baseline rail system per annum
Source of data	Northern Railway, Delhi
Value(s) applied	
Measurement methods and procedures	Same value as for baseline assumed for projection purposes
Monitoring frequency	Annually
QA/QC procedures	
Purpose of data	
Additional comment	Required to establish the emission factor per PKM for suburban rail

Data / Parameter	$\mathbf{P_{EL,R}}$
Unit	Passengers
Description	Total passengers transported by baseline rail-system per year
Source of data	Northern Railway, Delhi
Value(s) applied	Passengers for commuter rail system of Northern Railways entering Delhi; Based on daily average and 365 days per annum
Measurement methods and procedures	Same value as for baseline assumed for projection purposes
Monitoring frequency	Annually
QA/QC procedures	
Purpose of data	
Additional comment	Required to establish the emission factor per PKM for suburban rail

Data / Parameter	$\mathbf{P_{SPER}}$
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	Not required for projection
Monitoring frequency	The survey is realized in the years 1 and 4 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	$\mathbf{FEX_p}$
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	Not required for projection
Monitoring frequency	The survey is realized in the years 1 and 4 of the crediting period
QA/QC procedures	
Purpose of data	
Additional comment	

$TC_{PJ,}$ DD_{PJ} and SFC_{PJ} are not monitored as the project uses only electricity as fuel. DPE is monitored through the EC used for calculating the emission from using electricity according to the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

B.7.2. Sampling plan

For the survey on mode of transport see the Annex 3.

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. DMRC is ISO 14001 and OSHA 18001 certified and has thus experience with data management and data quality control.

A monitoring manual for the project has been developed by Grütter Consulting AG and can be reviewed by the validator. It defines all responsibilities and procedures. For each data parameter the information sources, units, frequency of measurement as well as data quality assurance processes are described in detail. Also steps are provided how to proceed in case of problematic data. The staff will be trained on usage of the manual. Grütter Consulting AG is contractually responsible for the monitoring reports for all 7 years of the 1st crediting period. Grütter Consulting AG will take the role of data quality control and quality assurance. Grütter Consulting AG is the author of the methodology used for this project and a consultancy specialized in GHG transport projects since 1992. It is in charge of numerous comparable CDM transport projects and has thus a profound know-how on monitoring such types of projects. See Annex 4 for details of the manual.

The survey design as well as the statistical analysis of the survey will be realized by Grütter Consulting AG which has a staff exclusively and highly qualified for survey design and statistical analysis. The survey realization will be done by an external specialized company with quality control through the India office of Grütter Consulting AG. Grütter Consulting AG and its staff also developed the methodology including the survey design included in the methodology and is thus highly competent to perform this important task. Also all other data not under direct control of DMRC (load factor studies, speed studies, congestion

studies) will be performed by Grütter Consulting AG. Through managing worldwide numerous Mass Transit projects in various cities data values obtained are also cross-checked to improve data reliability.

B.8. Date of completion of application of methodology and standardized baseline and contact information of responsible persons/ entities

Completion date: 20/04/2010

The PDD as well as the methodology used for this PDD was developed by Grütter Consulting AG. Staff involved in the elaboration of this PDD include Dr. Jürg M. Grütter, CEO Grütter Consulting AG, Rohini Balasubramanian, India Country Manager Grütter Consulting AG and Andres Mendoza, survey statistical expert of Grütter Consulting AG.

Grütter Consulting AG is responsible for the baseline determination of the project and author of the methodology used for this project.

Contact person: Jürg M. Grütter
jgruetter@gmail.com
www.transport-ghg.com

Grütter Consulting AG is also project participant as listed in Annex 1.

The PDD was realized in collaboration with DMRC.

SECTION C. Duration and crediting period

C.1. Duration of project activity

C.1.1. Start date of project activity

10/11/2005

The project starting date corresponds to the construction start of the 1st section of Phase II[97]. All other sections and lanes had later construction starts. Also all lanes had much later commissioning dates.

C.1.2. Expected operational lifetime of project activity

Infrastructure minimum 30 years

C.2. Crediting period of project activity

C.2.1. Type of crediting period

Renewable

C.2.2. Start date of crediting period

01/05/2011 or after registration whichever is later

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[97] File 70

C.2.3. Length of crediting period

7 years, 0 months

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[98]. 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. The Tender document clearly mentions the environmental and safety manuals[99] 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.[100] 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

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[98] File 63

[99] File 64

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

the atmosphere to form secondary pollutants. Typical transboundary air pollutants are carbon monoxide, PM10, non-methane VOCs[101] 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.
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[102].

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.

[101] Volatile Organic Components

[102] File 71

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[103]. 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[104]. Due to reduced vehicle-kilometres fuel usage is reduced[105] 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[106] minus 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. Solicitation of comments from local stakeholders

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[107].

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

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[103] Chapter 1.3.3.

[104] 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)

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

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

[107] See for the following File 66

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[108].

E.3. Report on 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 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

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

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

Appendix 1. Contact information of project participants and responsible persons/ entities

Project participant and/or responsible person/ entity	☒ Project participant ☒ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	Grütter Consulting AG
Street/P.O. Box	Thiersteinerstr. 22/5
Building	
City	Reinach
State/Region	BL
Postcode	4153
Country	Switzerland
Telephone	591 2278 84 74
Fax	
E-mail	jgruetter@gmail.com
Website	www.transport-ghg.com
Contact person	
Title	CEO
Salutation	
Last name	Grütter
Middle name	Michael
First name	Jürg
Department	
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Direct fax	
Direct tel.	591 2278 84 74
Personal e-mail	jgruetter@gmail.com

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	Delhi Metro Rail Corporation Ltd.
Street/P.O. Box	13, Fire Brigade Lane, Barakhamba Road
Building	Metro Bhawan
City	New Delhi
State/Region	New Delhi
Postcode	110001
Country	India

Telephone	+9111-23417915
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E-mail	saverma@dmrc.org
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Contact person	S A Verma
Title	Dy CEO
Salutation	Mr
Last name	Verma
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First name	Sant
Department	Environment
Mobile	+919811106868
Direct fax	+911122483219
Direct tel.	+911122483219
Personal e-mail	saverma_rs@yahoo.com

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. The relevant documents have been submitted to the validator.

Appendix 3. Applicability of methodology and standardized baseline

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

A.1. BASELINE EMISSIONS

A.1.1. Formulas

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

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)
p	Surveyed passenger
y	Year of the crediting period

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

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

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

Where:

$EF_{PKM,i,y}$	Emission factor per passenger-kilometre of suburban rail for year *y* (grCO_2/PKM)
$TE_{EL,y}$	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

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

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

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

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	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

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

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	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

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

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

A.1.2. Data Used

Table A.1. Baseline Parameters

Parameter	Description	Value	Unit	Source
$EF_{grid,CM}$	Emission factor of Indian grid	0.8409	tCO_2/MWh	File 1, GOI, NEWNE grid, 2009
TDL	Average technical transmission and distribution losses for providing electricity	3.91%	percentage	File 55, Powergrid corporation of India, 2010
$EC_{EL,R}$	Quantity of electricity consumed by the suburban rail	3,855	MWh	File 16, Northern Railway, 2008/2009
$P_{EL,R}$	Passengers transported by the suburban rail	2,887,200	Passengers	File 16, Northern Railway, 2008/2009
$TD_{EL,R}$	Average trip distance of passengers using the suburban rail	29	km	File 17, Grütter Consulting AG, 2008
$SFC_{C,G}$	Specific fuel consumption gasoline cars	7.1	l/100km	File 23, ADB, 2008
$SFC_{C,D}$	Specific fuel consumption diesel cars	5.9	l/100km	File 23, ADB, 2008
$SFC_{C,CNG}$	Specific fuel consumption CNG cars	6.4	kg/100km	File 9, Easy Cab, 2008
SFC_T	Specific fuel consumption taxis	6.4 CNG plus 0.8 gasoline	kg/100km / l/100km	File 9, Easy Cab, 2008
SFC_M	Specific fuel consumption motorcycles	1.8	l/100km	File 6, Grütter Consulting AG, 2008/2009
SFC_B	Specific fuel consumption buses	34.8	kg/100km	File 12, DTC, 2009
SFC_{MR}	Specific fuel consumption motorized rickshaws	3.2	kg/100km	File 36, Grütter Consulting AG, 2009
NCV_G	Net calorific value gasoline	43.9	MJ/kg	File 18, Bharat Petroleum Corp., 2008
NCV_D	Net calorific value diesel	42.7	MJ/kg	File 18, Bharat Petroleum Corp., 2008
NCV_{CNG}	Net calorific value CNG	35.6	MJ/m^3	File 18, Bharat Petroleum Corp., 2008
$EF_{CO2,G}$	CO_2 emission factor gasoline	67.5	gCO_2/MJ	IPCC 2006, table 1.4, lower 95% confidence interval
$EF_{CO2,D}$	CO_2 emission factor diesel	72.6	gCO_2/MJ	IPCC 2006, table 1.4, lower 95% confidence interval
$EF_{CO2,CNG}$	CO_2 emission factor CNG	54.3	gCO_2/MJ	IPCC 2006, table 1.4, lower 95% confidence interval
$EF_{CH4,CNG}$	CH_4 emission factor of CNG buses	162.0	gCO_2/km	IPCC 2006, table 3.2.4
$EF_{CH4,CNG}$	CH_4 emission factor of CNG light vehicles	9.9	gCO_2/km	IPCC 2006, table 3.2.4 (average)
	Specific weight gasoline	0.759	kg/l	File 18, Bharat Petroleum Corp., 2008
	Specific weight diesel	0.83	kg/l	File 18, Bharat Petroleum Corp., 2008
	Specific weight CNG	0.717	kg/m^3	File 18, Bharat Petroleum Corp., 2008

IR	Technology improvement factor	0.99	no unit	Methodology table 2[109]
	Share gasoline cars	82%	%	File 7, Department of Transport, Delhi, 2008
	Share diesel cars	11%	%	File 7, Department of Transport, Delhi, 2008
	Share CNG cars	8%	%	File 7, Department of Transport, Delhi, 2008
OC_C	Occupation rate cars	1.6	passengers	File 8, Grütter Consulting AG, 2008
OC_T	Occupation rate taxis	1.16	passengers	File 10, Grütter Consulting AG, 2008
OC_M	Occupation rate motorcycles	1.4	passengers	File 11, CRRI, 2007
OC_{MR}	Occupation rate motorized rickshaws	1.4	passengers	File 11, CRRI, 2007
OC_B	Occupation rate buses	43	passengers	File 14, CRRI, 2007
MS	Share of passengers using mode *i* for the baseline trip	See table A2	%	File 5, DMRC survey, 2008
P	Passengers transported by the project	See table A5	passengers	File 2, DMRC, 2009
$BTD_{PS,i}$	Baseline trip distance of the surveyed passenger using mode *i*	Value per passenger surveyed	km	File 5, DMRC survey, 2008

Table A2. Mode Share of Surveyed Passengers[110]

Mode	Share of passengers using this mode
Passenger car	46%
Taxi	13%
Bus	40%
Motorcycle	12%
NMT incl. induced	1%
Rickshaw	33%
Rail	0%

Table A3. Emissions per Kilometre of Modes (gCO_2/km)

Mode	2011	2012	2013	2014	2015	2016	2017	2018
Passenger car	156	154	153	151	150	148	147	145

[109] For buses this is monitored, for all other vehicles the default technology factor is taken. For projection purposes also for buses the default improvement factor is taken.

[110] Passengers can use more than 1 mode for their trip and therefore the cumulative percentage is more than 100%

Taxi	194	193	191	189	187	185	183	181
Motorcycle	39	39	38	38	37	37	37	36
Motorized Rickshaw	94	93	92	91	91	90	89	88
Bus	1,069	1,058	1,047	1,037	1,027	1,016	1,006	996

Technology improvement factor:

- Passenger cars: Data year 2008 thus improvement factor for 3 years for 2011 data
- Taxis: Data year 2008 thus improvement factor for 3 years for 2011 data
- Motorcycle: Data year 2009 thus improvement factor for 2 years for 2011 data
- Motorized rickshaw: Data year 2009 thus improvement factor for 2 years for 2011 data
- Data year 2008 thus improvement factor for 3 years for 2011 data projected

Table A4. Emissions per Passenger-Kilometre of Modes (gCO_2/PKM)

Mode	2011	2012	2013	2014	2015	2016	2017	2018
Passenger car	97	96	96	95	94	93	92	91
Taxi	168	166	164	163	161	159	158	156
Motorcycle	28	28	27	27	27	27	26	26
Motorized Rickshaw	67	67	66	65	65	64	63	63
Bus	25	25	24	24	24	24	23	23
Suburban rail	41	41	41	41	41	41	41	41

A.1.3. Results

Table A5. Baseline Emissions

Parameter	unit	2011	2012	2013	2014	2015	2016	2017	2018
Passengers transported	passengers	386,569,310	613,195,568	648,454,313	685,740,436	725,170,511	766,867,816	810,962,715	285,864,357,
Baseline emissions per passenger	gCO_2/passenger	1,278	1,265	1,253	1,240	1,228	1,215	1,203	1,191
Total baseline emissions	**tCO_2**	**494,074**	**775,888**	**812,296**	**850,413**	**890,319**	**932,097**	**975,836**	**340,542**

2011 8 months and 2018 4 months

A.2. PROJECT EMISSIONS

A.2.1. Formulas

$$PE_y = DPE_y + IPE_y$$

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)
y	Year of the crediting period

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

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

A.2.2. Data Used

Table A6. Project Parameters

Parameter	Description	Value	Unit	Source
$EF_{grid,CM}$	Emission factor of Indian grid	0.8409	tCO_2/MWh	File 1, GOI, NEWNE grid, 2009
TDL	Average technical transmission and distribution losses for providing electricity	3.91%	percentage	File 55, Powergrid corporation of India, 2010
$EC_{M,y}$	Quantity of electricity consumed by the metro (trains only)	See table A7	MWh	File 3, DMRC., 2009
$EF_{PKM,i}$	Emission factor per passenger-kilometre of mode "i"	See table A3	gCO_2/PKM	See table A.1. (the same emission factors are used in the baseline and the project case)
$IPTD_{PS,i}$	Indirect project trip distance of the surveyed passenger using mode "i"	Value per passenger surveyed	km	File 5, DMRC survey, 2008
P	Passengers transported by the project	See table A7	passengers	File 2, DMRC, 2009

Table A7. Passengers Transported and Electricity Consumed

Parameter	2011	2012	2013	2014	2015	2016	2017	2018
Passengers	386,569,310	613,195,568	648,454,313	685,740,436	725,170,511	766,867,816	810,962,715	285,864,357
Electricity consumption (MWh)	129,826	205,822	217,542	229,936	243,042	256,902	269,542	95,014

2011 8 months and 2018 4 months

A.2.3. Results

Table A8. Project Emissions

Parameter	Unit	2011	2012	2013	2014	2015	2016	2017	2018
Direct project emissions	tCO_2	113,439	179,843	190,084	200,913	212,365	224,476	235,520	83,021
Indirect project emissions per passenger	gCO_2/passenger	195	194	192	190	188	186	184	182
Indirect project emissions	tCO_2	75,558	118,655	124,223	130,052	136,155	142,544	149,233	52,079
Total project emissions	**tCO_2**	**188,997**	**298,498**	**314,307**	**330,966**	**348,520**	**367,020**	**384,753**	**135,099**

2011 8 months and 2018 4 months

A.3. LEAKAGE EMISSIONS

A.3.1. Formulas

$$LE_y = LE_{LFB,y} + LE_{LFT,y} + LE_{Con,y} + LE_{UP,y}$$

Where:

LE_y	=	Leakage emissions in year *y* (t CO_2)
$LE_{LFB,y}$	=	Leakage emissions due to change of load factor of buses in year *y* (t CO_2)
$LE_{LFT,y}$	=	Leakage emissions due to change of load factor of taxis in year *y* (t CO_2)
$LE_{CON,y}$	=	Leakage emissions due to change in congestion in year *y* (t CO_2)
$LE_{UP,y}$	=	Leakage emissions due to upstream emissions of gaseous fuels in year *y* (t CO_2)

No leakage is projected.

A.4. EMISSION REDUCTIONS

A.4.1. Formulas

$$ER_y = BE_y - PE_y - LE_y$$

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)

A.4.2. Results

Table A11. Emission Reductions in tCO_2

Parameter	2011	2012	2013	2014	2015	2016	2017	2018	Total
Baseline emissions	494,074	775,888	812,296	850,413	890,319	932,097	975,836	340,542	6,071,464
Project emissions	188,997	298,498	314,307	330,966	348,520	367,020	384,753	135,099	2,368,159
Leakage emissions	-	-	-	-	-	-	-	-	-
Emission Reductions	**305,077**	**477,389**	**497,989**	**519,448**	**541,799**	**565,077**	**591,082**	**205,443**	**3,703,305**

2011 8 months and 2018 4 months

Appendix 5. Further background information on monitoring plan

A.6. TORs OCCUPATION RATE STUDIES

A.6.1. TAXIS

The actual number of passengers is counted in a given point within a given time period. The counting is based on visual occupation counting the number of passengers occupying the vehicle excluding the driver. The procedures to establish visual occupation are:

1. Locations, days and times for field study are defined, avoiding days immediately after or before a holiday. Atypical seasons (school or university vacations) should be avoided. Details for the studies are:

    a. Sites:

        i. Sansad Marg, Connaught Place, opposite Janter Manter

        ii. Panchkuian Road (near metro pillar 26) towards Connaught Place

    b. Time: 7 AM top 7 PM

    c. Days: 3 weekdays each site

2. Field data is collected. Coverage of the occupation counts should be higher than 95% of the number of taxis that cross the checkpoint. 100% coverage is desired. To control this outcome a separate vehicle count is advised. Data can be adjusted with the actual count;

3. Occupation is the number of passengers using the vehicle. The driver is not counted. Taxis without passengers are counted as zero occupation;

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

A.6.2. Motorized Rickshaws

The actual number of passengers excluding the driver of motorized rickshaws is counted in a given point within a given time period. The counting is based on visual occupation counting the number of passengers occupying the motorized rickshaw.

Procedures to establish visual occupation:

1. Locations, days and times for field study are defined, avoiding days immediately after or before a holiday. Atypical seasons (school or university vacations) should be avoided. The locations are (if these roads are not used anymore then alternative roads with high taxi traffic are identified):

    a. Panchkuian Road (Ekant Hotel) in direction Jhandewalan to C.P. and C.P. to Jhandewalan

b. Sansad Marg (Jantar Mantar) in direction C.P. to Parliament House and Parliament House to C.P.
c. Patel Road (Vivek Cinema) in direction Shadipur to Pusha and Pusha to Shadipur
d. Najafgarh Road (Janakpuri District Centre) in direction Uttam Nagar to Subhash Nagar and Subhash Nagar to Uttam Nagar
e. GT Road Sahadra (Shyamlal College) in direction Sahadra to Seelampur and Seelampur to Sahadra
f. Vikas Marg (ITO Barrage) in direction ITO to Laxmi Nagar and Laxmi Nagar to ITO

Measurements are made on 1 weekday between 7AM and 7PM. Categories are 0, 1, 2, 3, 4 and 5 or 5+ passengers. This is in accordance with the baseline study to ensure data comparability;

2. Field data is collected. Coverage of the occupation counts should be higher than 95% of the number of motorized rickshaws that cross the checkpoint. 100% coverage is desired. To control this outcome a separate vehicle count is realized.

3. Occupation is the number of passengers using the motorized rickshaws. The driver is not counted. Motorized rickshaws without passengers are counted as 0 occupation;

4. The total number of motorized rickshaws and the total number of passengers is reported. The average occupation rate of motorized rickshaws is the total number of passengers divided by the total number of motorized rickshaws in which counts were performed.

A.6.3. Buses

The actual number of passengers excluding the driver of buses is counted in a given point within a given time period. The counting is based on visual occupation counting the number of passengers occupying the bus.

Procedures to establish visual occupation:

1. Locations, days and times for field study are defined, avoiding days immediately after or before a holiday. Atypical seasons (school or university vacations) should be avoided. The locations are (if these roads are not used anymore then alternative roads with high taxi traffic are identified):

   a. Panchkuian Road (Ekant Hotel) in direction Jhandewalan to C.P. and C.P. to Jhandewalan
   b. Sansad Marg (Jantar Mantar) in direction C.P. to Parliament House and Parliament House to C.P.
   c. Patel Road (Vivek Cinema) in direction Shadipur to Pusha and Pusha to Shadipur
   d. Najafgarh Road (Janakpuri District Centre) in direction Uttam Nagar to Subhash Nagar and Subhash Nagar to Uttam Nagar
   e. GT Road Sahadra (Shyamlal College) in direction Sahadra to Seelampur and Seelampur to Sahadra
   f. Vikas Marg (ITO Barrage) in direction ITO to Laxmi Nagar and Laxmi Nagar to ITO

2. Measurements are made for all weekdays between 7AM and 7PM. This is in accordance with the baseline study to ensure data comparability;

3. The number of passengers on the bus are either estimated or occupation categories are defined (usually 5 or 6) and the bus capacity is defined (if various bus sizes exist it must be recorded with each measurement to which bus category the bus belongs).

4. Field data is collected. Coverage of the occupation counts should be higher than 95% of the number of buses that cross the checkpoint. 100% coverage is desired. To control this outcome a separate vehicle count is realized.

5. Occupation is the number of passengers using the bus. The occupation rate in percentage is the number of buses divided by the bus carrying capacity. The percentage data is required in case the bus carrying capacity has changed significantly since the baseline and/or different bus sizes/carrying capacities are used in Delhi.

6. The total number of buses and the total number of passengers is reported.

A.8. PASSENGER SURVEY DESIGN

The methodological design of the survey is presented in detail. Following points are discussed:

1. Survey objective
2. Target population
3. Sample frame
4. Sample design
5. Relative error level
6. Geographical coverage
7. Sample frequency
8. Sample size
9. Selection method of the sample
10. Methodology for information collection and estimation of the parameter
11. Data verification and validation including QA and QC
12. Survey realization
13. Calculation of trip distance in the survey
14. Default questionnaire

Whenever the DMRC is extended the survey distribution is realized new and data of the new survey is used for calculating emissions reductions from the moment of the DMRC extension.

Technical Summary Data Sheet of the Survey
Strategy and sample design in the Metro Delhi passenger survey

Parameter	Main parameters: • Baseline emissions; • Indirect project emissions. Secondary parameters and inputs: • Proportion of passengers proportion 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 Metro Delhi.
Sample frame	Passenger flow in all the stations of 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: Stations. Sub stratum: Days in the week and hours.
Relative error level (CV)[111]	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, which implies at the same time having precision levels of 90/10 is targeted. Results obtained are based on a 95% confidence level using the more conservative boundary.
Coverage	Urban area where Metro Delhi operates.
Size of Universe	Generally, in one day Metro Delhi mobilizes between 600,000 and 750,000 passengers.

[111] 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.

Sample size	The sample size is 8,000 surveys in the measuring week with a re-test sample size of around 50% of the original sample[112].
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. The sample was distributed according to the average flow along the 3 operating lines of DMRC at the moment of the survey.
Sample frequency	The survey is realized in the years 1 and 4 of the crediting period
Method of information collection	The information will be obtained through the face-to-face application of the established questionnaire on a random base.
Consistency of the survey results	The internal consistency of the results of the survey must be carefully checked. The reliability will be measured using the Cronbach's alpha. A reasonable coefficient is over 0.7, values over 0.9 should be rechecked to avoid redundancy of data. In case the survey does not demonstrate internal consistency in their results, it will be rejected and another survey could be arranged.

1. Survey Objective

The survey objective is to determine:

- The baseline emissions caused by passengers which use Delhi Metro and in absence of latter would have used other modes of transport to realize their trip;
- The indirect project emissions of passengers using Delhi Metro which correspond to the emissions caused from the trip origin to Delhi Metro entry station and from Delhi Metro exit station to the final destination.

2. 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.

3. Sample Frame

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

4. Sample Design

A two staged probabilistic design is applied:

- First stage: Stratified – Simple Random Sampling (SRS);
- Second stage: Systematic sampling based on passengers flow per station.

The stratification model used is represented by the following scheme, where the process for a specific day is shown, applies routinely for the seven measurement days.

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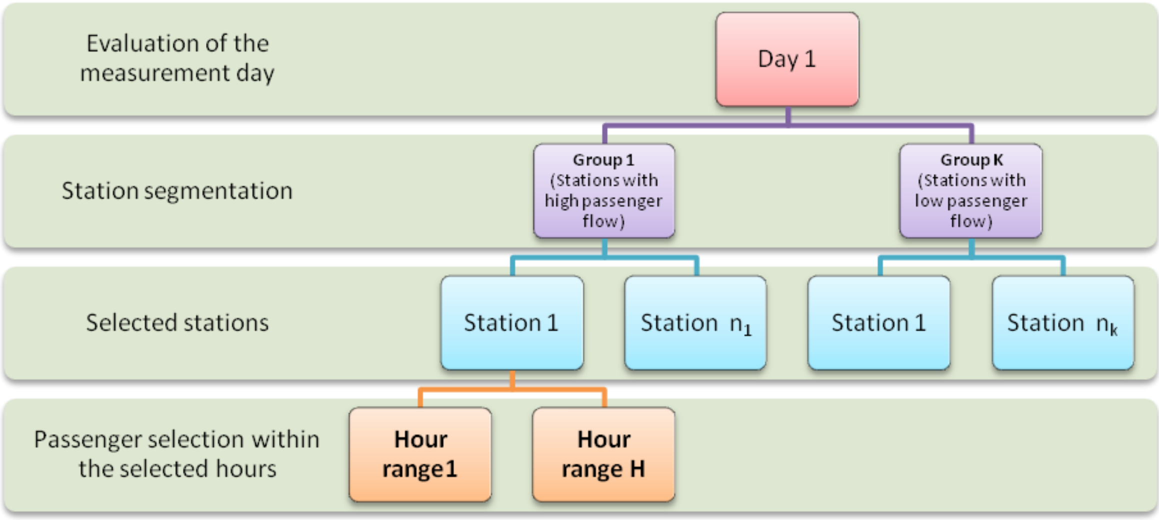
[112] The re-test sample size is determined based on the variances encountered in the original sample



Main strata (Stations): First a cluster analysis is performed that groups the stations depending on the passenger flow per station to provide information for busier stations and less frequented stations. In practical terms three groups of stations are created: stations with a high, medium and low passenger volume. In the case of large heterogeneity of passenger flows an additional group is included to control this variability.

Sub strata: Sub strata are built from the passenger flow information reported per day and hour. Sub strata are formed in such a manner that information is taken for the seven days of the week, and within each day, hours ranges are arranged according to the passenger flow.

The sample is distributed in each day according to the average passenger flow per day and within the day, as per the users per day or hour range. Within each day, a random station selection process is carried out within the defined strata, in such a way that during the evaluation week the possibility for all stations to be visited is created. The station grouping is carried out according to a multi-variant cluster analysis, using as classification variable the passenger flow reported daily by station.

5. Relative Error Level

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, which implies at the same time having precision levels of 90/10.

It is considered that the result of an estimate is:

- Statistically robust if its coefficient of variation is less than 5%;
- Practical acceptable if its coefficient of variation is between 5% and 10%;
- Of low precision if its coefficient of variation is higher than 10% and less than 15%;
- It is not considered as robust if its coefficient of variation is higher than 15%.

For the results obtained a 95% confidence level is calculated taking the (conservative) lower boundary for baseline emissions and the (conservative) upper boundary for indirect project emissions. The parameters determined in the survey are thus quantified at the 95% confidence level following the Annex 2 (EB 22 report Annex 2, D, page 3): “Methodologies employing sampling to derive parameters in estimating emissions reductions shall quantify these parameter uncertainties at the 95% confidence level”.

6. Geographical Coverage

The geographical coverage is the urban area of Delhi where Delhi Metro operates (project boundary).

7. Sample Frequency

The survey is realized minimum once annually plus an annual re-test thus achieving 2 samples per annum. The survey shall take place during an entire week. The selected week shall not correspond to a public holiday and shall be representative for the average demand for transport services in the considered year.

To guarantee that there is no seasonality and if there was, the way in which it would be approached, the following steps are taken:

1. In the first year and while the system is stabilized, a single measurement is taken and a second measurement is carried out in a later period (test-retest method), with a sample size of less than half of the initial survey.

2. With the passenger flows data of the first, and with the comparison between the first survey and the test-retest, it is defined if there is any seasonality degree in the year. If there is evidence of the same, within each period where there are apparent differences, independent surveys are performed and at the end, the results are compared regarding the emissions difference and the parameters on the use of modes of transport and the average travel distance.

3. If there are no significant differences between the analysis periods, the measurements of later years will be done only once a year, on the contrary, they will be carried out in the periods in which seasonality is identified.

4. Independent from the result, at least one measurement in a whole week will always be performed, and the application of the test-retest method. The two measurements are done in different periods, one in the first semester of the year and the other in the second semester.

The criteria for identifying if there is or not seasonality is:

- A test of mean comparison is carried out between the data reported on the flow of passengers between months, and in the same way, within the weeks of each month;

- A further test consists in the application of a times series model SARIMA, where it is estimated if there is any seasonality degree in the passengers flows, either weekly or monthly. Through the functions of auto-correlation and partial auto-correlation, it is identified if there is any pattern in the data.

8. Sample Size

8a). Analysis of Pilot Test Survey

The main objective of the pilot test is to obtain first hand information to adjust the sampling design as well as to justify the size of the sample. The pilot test corresponds to a survey realized during an entire week of July 2008 with 804 passengers of Delhi Metro. The sample was distributed according to the passenger flow per day and station of DMRC during a normal week in the 3 lines operating at that time of DMRC.

Based on a Cluster analysis stations which can be grouped were identified.

The results of the pilot test are used to determine the size of the sample. The estimated coefficient variation for the baseline and the project emissions was calculated for this purpose. On the other hand to get precise results for each potential mode of transit it is necessary to have a sufficiently large sample to also have a representative sample of the least used transport mode (in this case passenger cars). Therefore the sample size must be sufficiently large to have an acceptable level of error for mode proportions of 1%.

8b). Sample Size Determination

For the calculation of the sample size, a global desired level of precision (relative standard error or coefficient of variation – CV) between 5% and 10% for the parameters of interest, which implies at the same time having precision levels of 90/10, i.e. a minimum confidence level of 90% and a maximum precision level of 10% was determined.

In general determining the sample size is done by simulation following the Särndal methodology (1992), in which a CV is fixed and the sample size is found by solving n of the formula of the estimator variance according to the design used in each case.

$$CV = \left(\frac{\sqrt{V(\hat{t}_y)}}{\hat{t}_y} \right) \cdot 100$$

Where $\hat{t}_y$ is the estimate of the average for parameter of interest *y* and $V(\hat{t}_y)$ is the variance of this estimate.
The stratification structure complies with the principles of independence and invariance, reason for which in the formula for the CV of this study, the estimated variance of the estimator results from adding those obtained in each stratum.

The main parameter of interest is the distance per mode of transport for each passenger. The distance per mode is **one** parameter i.e. D(i) indicating distance of mode i used by the passenger.

However an important parameter to determine the sample size is the percentage of passengers which use mode (i). This is relevant as only few passengers of the new system would have used certain modes such as passenger cars (the large majority of users come from conventional public transport). However even if their share is low they could still have an impact on emission reduction calculations due to their high emission factor. For the survey to be reliable it needs a sufficient number of respondents also in modes used less frequently. The sample size determination is thus influenced strongly by the share of passengers per mode to have the desired precision level for this variable and therefore also for our main parameter of interest being the **distance per mode**. To determine the sample size ex-ante therefore a pre-survey is conducted and/or data from comparable other projects is taken.

In practical terms, the procedure for determining the sample size is:

1. The results of the pilot test are taken as reference for the simulation (mean and standard deviation); This is especially important concerning share of modes for passengers as this determines the sample size to a considerable extent as some modes have a low frequency (e.g. passenger cars, potentially taxis and motorcycles).

2. Simulation is subject to the modification of standard deviations larger than the one found in the pilot test, with the objective of obtaining an optimum sample size even under high variability conditions (limitation of the maximum variability level);

3. The simulation process is first done under a SRS design (Simple Random Sampling), and under the multistage design (see the formulae described in section 10) and thereafter the design effect (Deff) is simulated corresponding to the ratio between the variance of a multi-stage design, and the variance of a SRS design;

4. Finally, based on the simulation and the presentation of different scenarios corresponding to different sampling sizes and various assumptions about the standard deviations of parameters of interest (for instance by using a deff factor between 2 and 3), the sample size that best adjusts to the expected error levels is taken.

Design Effect (Deff):

$$\mathrm{Deff}(p,\hat{t}_y) = \frac{V_p(\hat{t}_y)}{V_{MAS}(\hat{t}_y)} = \frac{\sum\sum_U \Delta_{kl}\breve{y}_k\breve{y}_l}{N^2\left(\frac{1}{n}-\frac{1}{N}\right)S_{yU}^2}$$

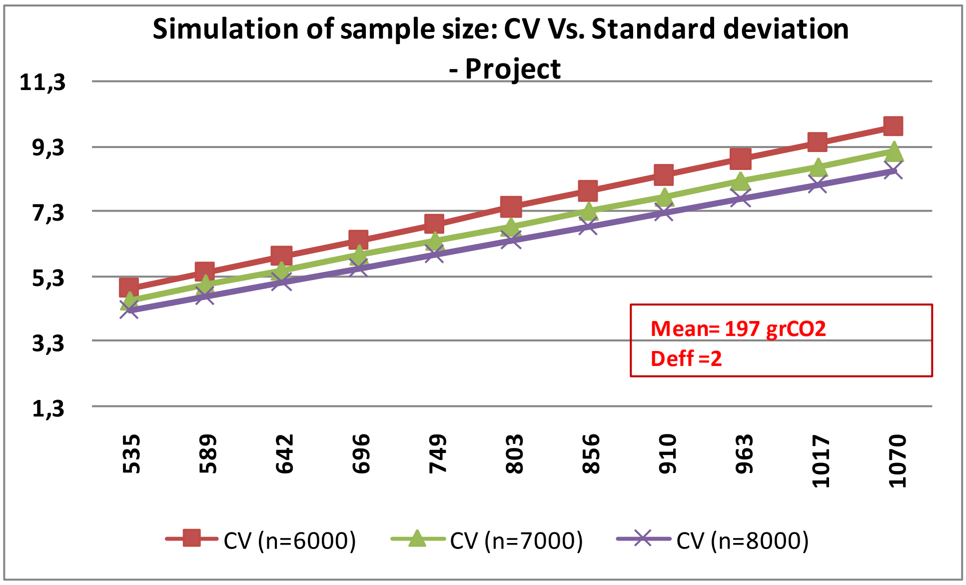
The ratio between the variance of the particular design and the variance under a SRS design, is called the design effect (Deff). In this way, when Deff is less than 1 it implies that the selected design has more precision than the SRS one, and when it is larger than 1, the proposed design is less efficient than the SRS one. In the simulation case, the Deff value was assumed between 1 and 3.5, in such a way that the sample size is considered under the worst scenario i.e. when the variance associated to the multi-stage design was factor 2.5 fold the SRS. Sample size simulation were performed considering the variation coefficient (less than 10%), the design effects (deff) (value between 1.5 and 3.5) and the lowest frequencies for the modal proportions (between 5 and 10%) to be estimated.

Based on the pilot test the simulation of the simple size for average baseline and project emissions per passenger trip and thereafter the simulation for mode shares is realized to ensure representativeness for both aspects.

The simulation of the sample size starts off from the standard deviation (SD) of the pilot test and then augments this progressively by 10% up to doubling it. Also in these scenarios a deff of 2 is taken in accordance with the 4 stratus identified when grouping stations. The simulation results indicate that even with an extreme scenario of the SD, the estimated coefficient variation is not higher than 5% concerning the average baseline and 12% concerning the average project emissions if the sample size is between 6,000 and 8,000 Metro users.

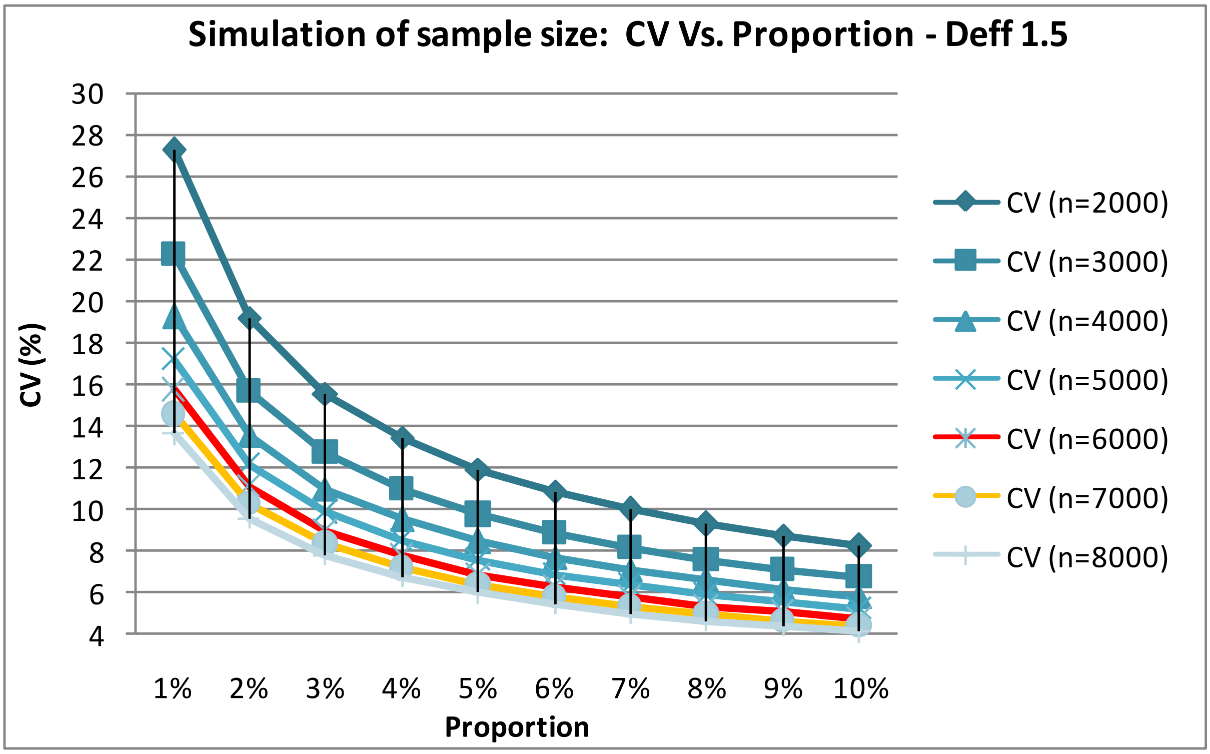
On the other hand simulation results concerning the sample or proportions of mode users to obtain a acceptable level of representativeness (CV minor to15%) a sample size of 8,000 Metro users is required.

The sample size of 8,000 users of Metro is thus sufficient to cover both aspects of the survey.



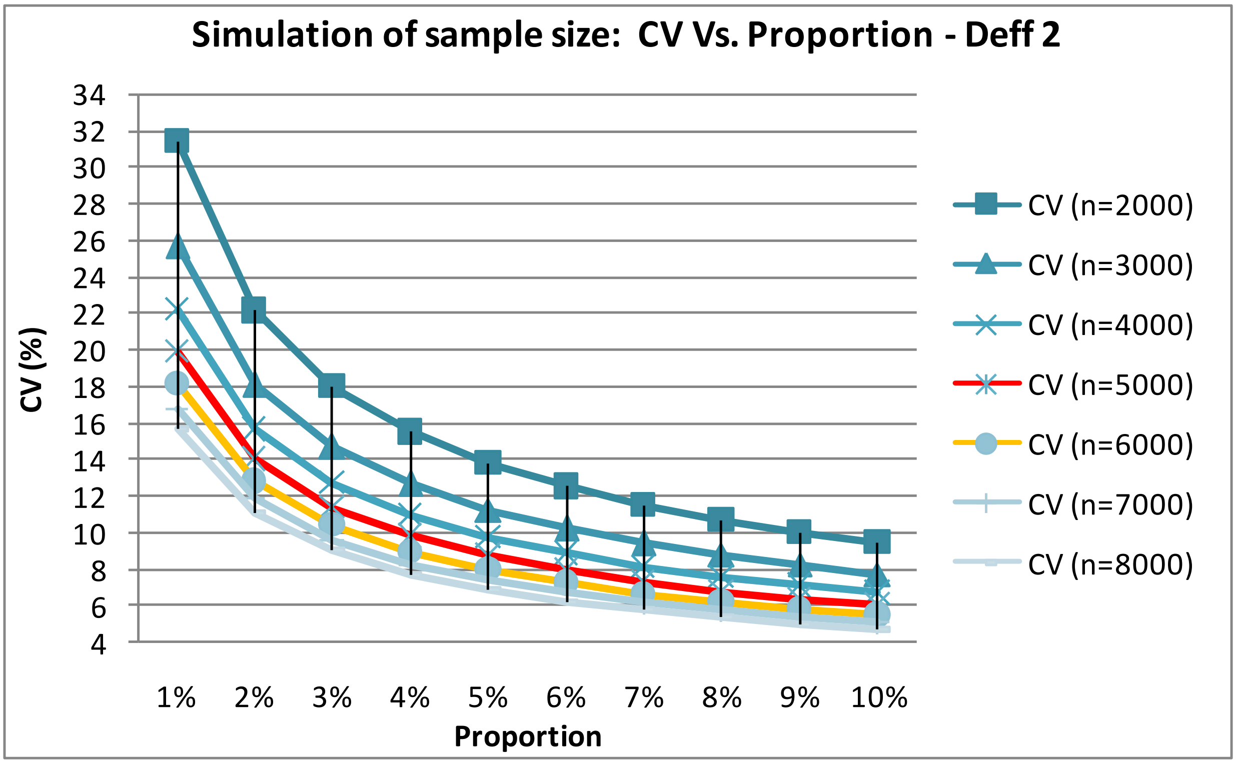
The graphs below provided for illustrative purposes only present the result of such simulations. They show that a sample size of 6,000-8,000 would be sufficient even facing extreme scenarios such as with a deff of 3.5.

Simulation of Sample Size with Deff 1.5



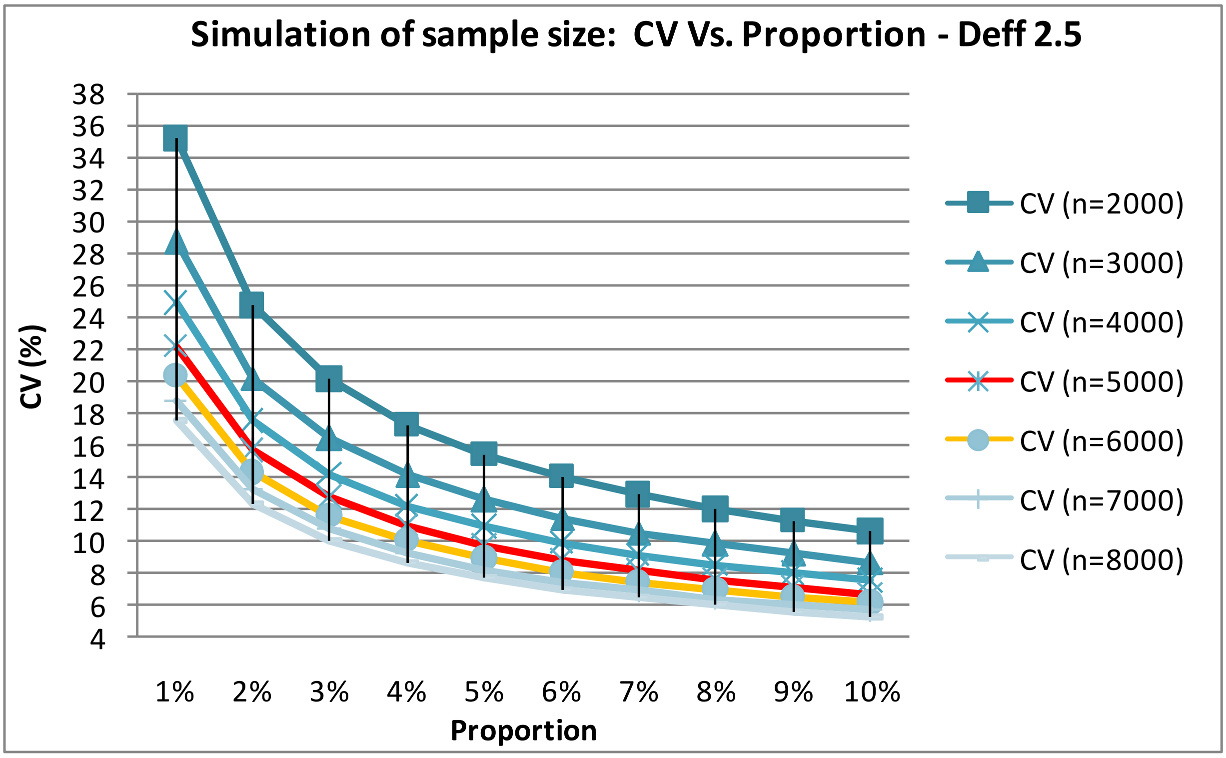
Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	27.2	22.2	19.3	17.2	15.7	14.5	13.6
2%	19.2	15.6	13.5	12.1	11.1	10.2	9.6
3%	15.6	12.7	11.0	9.8	9.0	8.3	7.8
4%	13.4	10.9	9.5	8.5	7.7	7.2	6.7
5%	11.9	**9.7**	8.4	7.5	6.9	6.4	6.0
6%	10.8	8.8	7.7	6.8	6.3	5.8	5.4
7%	10.0	8.1	7.1	6.3	5.8	5.3	5.0
8%	9.3	7.6	6.6	5.9	5.4	5.0	4.6
9%	8.7	7.1	6.2	5.5	5.0	4.6	4.3
10%	8.2	6.7	5.8	5.2	4.7	4.4	4.1

Simulation of Sample Size with Deff 2.0



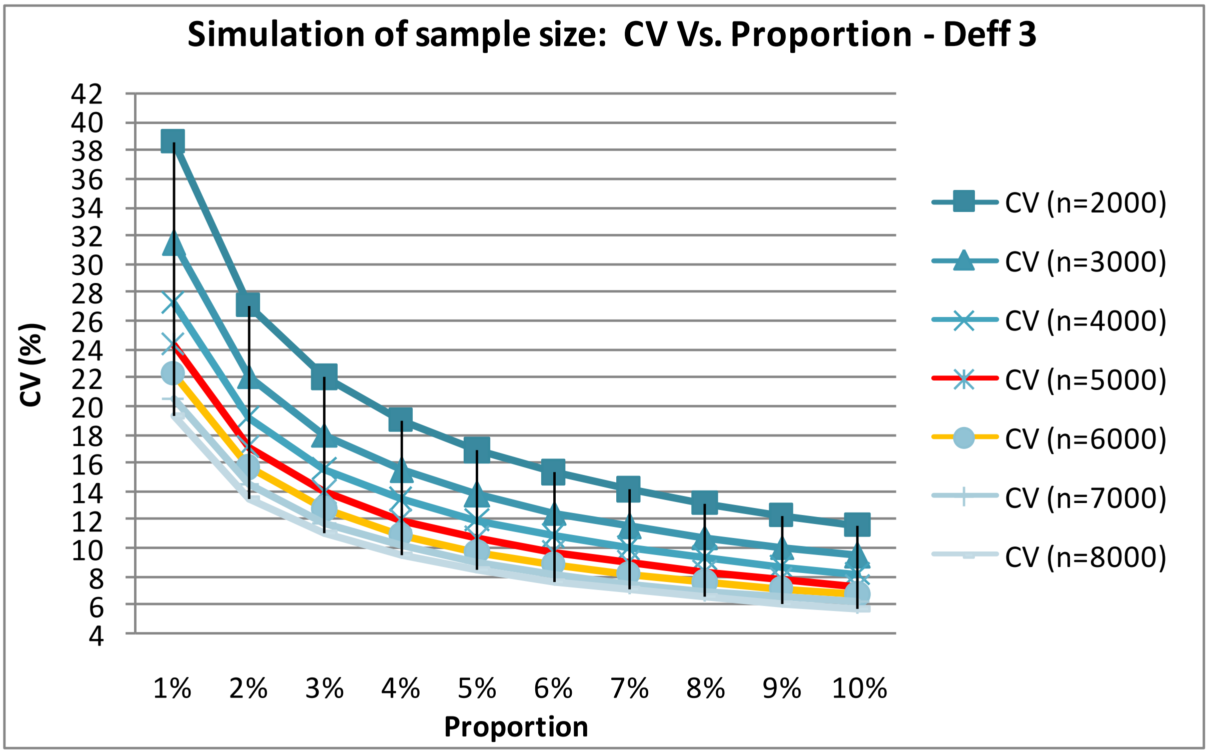
Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	31.5	25.7	22.2	19.9	18.1	16.8	15.7
2%	22.1	18.1	15.6	14.0	12.8	11.8	11.1
3%	18.0	14.7	12.7	11.4	10.4	9.6	9.0
4%	15.5	12.6	10.9	9.8	8.9	8.3	7.7
5%	13.8	11.2	**9.7**	8.7	8.0	7.4	6.9
6%	12.5	10.2	8.8	7.9	7.2	6.7	6.2
7%	11.5	9.4	8.1	7.3	6.6	6.2	5.8
8%	10.7	8.8	7.6	6.8	6.2	5.7	5.4
9%	10.1	8.2	7.1	6.4	5.8	5.4	5.0
10%	9.5	7.7	6.7	6.0	5.5	5.1	4.7

Simulation of Sample Size with Deff 2.5



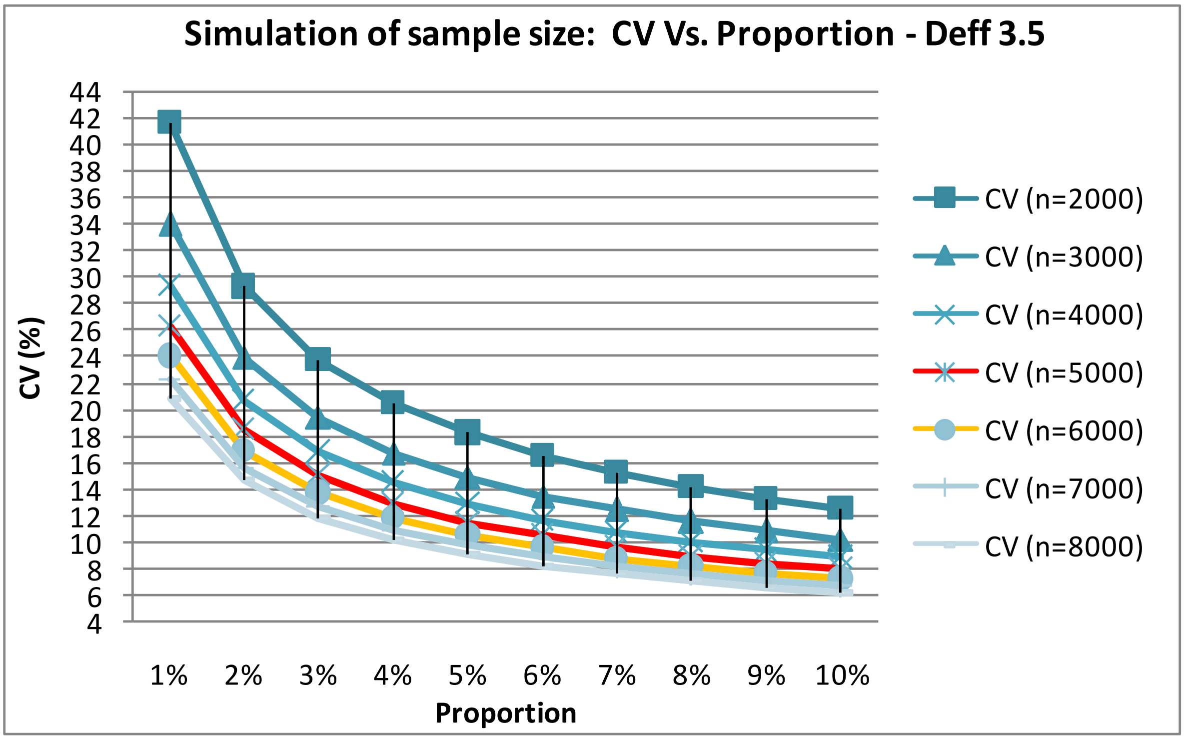
Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	35.2	28.7	24.9	22.2	20.3	18.8	17.6
2%	24.7	20.2	17.5	15.6	14.3	13.2	12.4
3%	20.1	16.4	14.2	12.7	11.6	10.7	10.0
4%	17.3	14.1	12.2	10.9	10.0	9.2	8.6
5%	15.4	12.6	10.9	**9.7**	8.9	8.2	7.7
6%	14.0	11.4	9.9	8.8	8.1	7.5	7.0
7%	12.9	10.5	9.1	8.1	7.4	6.9	6.4
8%	12.0	9.8	8.5	7.6	6.9	6.4	6.0
9%	11.2	9.2	7.9	7.1	6.5	6.0	5.6
10%	10.6	8.7	7.5	6.7	6.1	5.7	5.3

Simulation of Sample Size with Deff 3.0



Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	38.5	31.4	27.2	24.4	22.2	20.6	19.2
2%	27.1	22.1	19.2	17.1	15.6	14.5	13.5
3%	22.0	18.0	15.6	13.9	12.7	11.8	11.0
4%	19.0	15.5	13.4	12.0	10.9	10.1	9.5
5%	16.9	13.8	11.9	10.7	**9.7**	9.0	8.4
6%	15.3	12.5	10.8	9.7	8.8	8.2	7.7
7%	14.1	11.5	10.0	8.9	8.1	7.5	7.0
8%	13.1	10.7	9.3	8.3	7.6	7.0	6.6
9%	12.3	10.1	8.7	7.8	7.1	6.6	6.1
10%	11.6	9.5	8.2	7.3	6.7	6.2	5.8

Simulation of Sample Size with Deff 3.5



Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	41.6	34.0	29.4	26.3	24.0	22.2	20.8
2%	29.3	23.9	20.7	18.5	16.9	15.6	14.6
3%	23.8	19.4	16.8	15.0	13.7	12.7	11.9
4%	20.5	16.7	14.5	13.0	11.8	10.9	10.2
5%	18.2	14.9	12.9	11.5	10.5	**9.7**	9.1
6%	16.6	13.5	11.7	10.5	9.6	8.8	8.3
7%	15.2	12.4	10.8	9.6	8.8	8.1	7.6
8%	14.2	11.6	10.0	9.0	8.2	7.6	7.1
9%	13.3	10.9	9.4	8.4	7.7	7.1	6.6
10%	12.5	10.2	8.9	7.9	7.2	6.7	6.3

9. Selection Method of the Sample

Stations, hours and passengers must be selected for the sample. 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. A control is realized if the sample matches the total population in various of these parameters to ascertain that the sample reflects truly the population with all its characteristics.

9a). Selection of Stations and Evaluation Hours

Given that there is a complete list of stations that are part of each established group (stratum), 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.

Algorithm of the Negative Coordinated Method

N: Universe size
n: Sample size to be selected.

A value 0<π<1 is fixed and for each one of the universe elements random events $\xi_1,\ldots,\xi_N$ are carried out uniformly distributed (0,1). Which ones belong to the sample is decided as follows:

- ✓ If $\xi_k < \pi$ then k belongs to the sample.
- ✓ If $\xi_k \geq \pi$ then k does not belong to the sample.

In this way the probabilities of being part of the sample of the first and second order are $\pi_k = \pi, \pi_{kl} = \pi^2$

Since the expectation of the simple size is equal to $\sum_U \pi_k$ in the SRS design, it complies with $E(n_s) = \sum_U \pi_k = n$ therefore the departure point is from an expected sample size equal to n, further it is said that $\pi_k = \pi = n/N$ and from that value, the selection is carried out.

9b). Selection of Passengers

Given that there is no reference frame or list frame for the identification of MRTS users, the selection of the sample in the last stage will be performed according to the systematic sampling design, replicated identically for each stratum and considering the following steps:

1. 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;

2. Systematic selection of passengers: every n passenger entering the station, starting with the random number. In this way, if the random number is 20, the first passenger selected is the 20th that enters the station, the 2nd n+20 and thus successively every n passenger. The number n, called selection interval will be determined based on the passenger flow per hour and the sample distribution of the specific measurement day.

10. Methodology for Information Collection and Estimation of the Parameter

10a). General Considerations on Information Collection

The information will be obtained through the face-to-face application of the established questionnaire.
According to the selected days and hour range, each survey interviewer will carry out the number of established surveys. Given that the selection of people is done randomly in a time range, the start point, that is, the person number from which the contact begins is random and is defined by the appointed pollster supervisor.

The random selection of individuals, as well as the sufficiency in the sample size, enables obtaining dispersion and representation of the study population through the sample. Further, it allows controlling factors that may affect the user type, in terms of use of modes of transport and distance in these travels. Some of these such as the social-economic level, the residence zone, owning a vehicle, among others, are represented within the selected sample.

In measurements of later years, when any of the modes of transport to which the survey refers, are extinct at the moment of applying the survey or simply to clarify the issue or modes of transport to which the question refers to, photos or graphs with an amplified size can be used, to guarantee the correct interpretation of the question.

10b). Method of Estimation and Expansion Factors

In accordance with the sample strategy and with the sample design specified in section 4 there exist 2 stages in the method of estimation and selection of sampling observation units:

1. Selection of stations (SRS design)
2. Selection of passengers in accordance with the systematic design taking as auxiliary information the flow of passengers in the range of hours defined.

Having in mind that the design used in each stratum is identical the probabilities of inclusion will be calculated in an equivalent basis in each stratum.

First stage

$$\pi_{Ii} = \frac{n_{Ihsp}}{N_{Ihsp}},$$

π_{Ii} : Probability of inclusion in the sample in the first stage (I).

n_{Ihsp} : Number of stations *sp* selected in the stratum h (3 stratus are created i.e. high, medium and low passenger flow)

N_{Ihsp} : Total number of stations s*p* in the stratum h*.*

sp: stations of the system

Second stage

$$\pi_{k/i} = \frac{n_{ihsp}}{N_{ihsp}},$$

$\pi_{k/i}$: Probability of inclusion of the individual passenger *k* in the sample in the second stage (i), given the selection of the first stage (I).

n_{ihsp} : Number of passengers selected in the station s*p,* in stratum *h.*
N_{ihsp} : Total number of passengers in the station s*p,* in stratum *h*

The general formula to calculate the expansion factor is:

$f_I = \frac{1}{\pi_k}$, where k indicates the k^th element of the sample.

Thus the expansion factors are:

First stage

$$f_I = \frac{N_{Ihsp}}{n_{Ihsp}},$$

where n_{Ihsp} and N_{Ihsp} are as previously defined.

Second stage

$$f_i = \frac{N_{ihsp}}{n_{ihsp}},$$

where n_{ihsp} and N_{ihsp} are established according to the total flow of passengers in the station sp during the day.

Estimator of the total for the variable of interest[113]:

$$\hat{t}_\pi = \sum_h \frac{N_{Ihsp}}{n_{Ihsp}} \sum_{s_I} \hat{t}_{i\pi} \ ,$$

$\hat{t}_\pi$ corresponds to π Estimator of sample designs without replacing sample units, see Särndal et al. (1992)

where

$$\hat{t}_{i\pi} = \frac{N_{ihsp}}{n_{ihsp}} \sum_{s_i} y_{ksp}$$

Where "s_i" represents the sample of passengers in the second phase and "*k*" the information of the kth individual selected

Estimator of the variance:

$$\hat{V}(\hat{t}_\pi) = \sum_h \left[\frac{N_{Ihsp}}{n_{Ihsp}} \left(n_{Ihsp} - N_{Ihsp}\right) S^2_{\hat{t}s_I} + \frac{N_{Ihsp}}{n_{Ihsp}} \left(\sum_{s_I} \frac{N_{ihsp}}{n_{ihsp}} \left(n_{ihsp} - N_{ihsp}\right) S^2_{s_i} \right) \right],$$

where

$$S^2_{\hat{t}s_I} = \frac{1}{n_{Ihsp} - 1} \sum_{s_I} \left[\hat{t}_{i\pi} - \left(\sum_{s_I} \hat{t}_{i\pi} / n_{Ihsp}\right)\right]^2, \quad \text{and} \quad S^2_{ys_I} = \frac{1}{n_{ihsp} - 1} \sum_{s_i} \left(y_{ksp} - \bar{y}_{ksp}\right)^2$$

(i)

The parameter (R) is not used to calculate directly BE or IPE or the distance per mode of transport which is the main parameter and the one required for calculating BE and IPE. It is

[113] The variables of interest used to calculate totals correspond to the trip distances per mode of passengers of the
MRTS (the parameter is not distance alone it is trip distance per mode) both in the baseline situation (for BE) and in the project situation (for IPE).

however fundamental to determine the required simple size as proportions of passengers using various transport modes are required for the simple size determination as well as eventually for leakage calculations. (R) is also required for various other parameters where proportions are determined in the survey (e.g. income category). These other parameters are not used directly to determine BE or IPE but are important information sources to assess if the survey has any bias or if other factors such as gender or income influence the outcome. The parameter (R) is therefore used for survey information gathered based on proportions.

Estimator for the variable of interest:

$$\hat{R} = \frac{\hat{t}_{y\pi}}{\hat{t}_{z\pi}},$$

where $\hat{t}_{y\pi}$ and $\hat{t}_{z\pi}$ are totals

R represents the relation between the two variables, which in the particular case is a proportion, where $\hat{t}_{z\pi}$ estimates the universe of the study (N).

The parameter (R) is not used to calculate directly BE or IPE or the distance per mode of transport which is the main parameter and the one required for calculating BE and IPE. It is however fundamental to determine the required simple size as proportions of passengers using various transport modes are required for the simple size determination as well as eventually for leakage calculations. (R) is also required for various other parameters where proportions are determined in the survey (e.g. income category). These other parameters are important information sources to assess if the survey has any bias or if other factors such as gender or income influence the outcome. The parameter (R) is therefore used for survey information gathered based on proportions.

Variance Estimator:

$$\hat{V}(\hat{R}) = \sum_{h} \left[\frac{N_{Ihsp}}{n_{Ihsp}} \left(n_{Ihsp} - N_{Ihsp} \right) S^2_{\hat{t}us_I} + \frac{N_{Ihsp}}{n_{Ihsp}} \left(\sum_{s_I} \frac{N_{ihsp}}{n_{ihsp}} \left(n_{ihsp} - N_{ihsp} \right) S^2_{u_{ki}} \right) \right]$$

Where:

$$u_{kshp} = \frac{y_{ksp} - \hat{R} z_{ksp}}{\hat{t}_{z\pi}},$$

Thus it is established that:

$$S^2_{\hat{t}us_I} = \frac{1}{n_{Ihsp} - 1} \sum_{s_I} \left[\hat{t}_{ui} - \left(\sum_{s_I} \hat{t}_{ui} / n_{Ihsp} \right) \right]^2, \quad \text{and} \quad S^2_{u_k} = \frac{1}{n_{ihsp} - 1} \sum_{s_i} \left(u_{ksp} - \bar{u}_{ksp} \right)^2$$

Based on the formerly described formulas and based upon if it is a total or a proportion the parameter $\hat{t}_{\pi}$ and associated the variance $\hat{V}(\hat{t}_{\pi})$ is determined.

To calculate the confidence interval a normal distribution is assumed (sufficient sample size) using the formula for a 95% confidence interval:

$$\hat{t}_{\pi} \pm Z_{0.975} * \sqrt{\hat{V}(\hat{t}_{\pi})}$$

$\hat{t}_{\pi}$ represents BE y IPE, both calculated separately. For BE the lower confidence interval is taken and for IPE the upper one.

Summarized to calculate the expansion factor the following data is required next to the data resultant from the survey:

- Number of stations;
- Passenger flow per station per hour, day and week;
- Selection rate of passengers surveyed per hour per station (i.e. each *n* passenger was selected for an interview)

Based on this information the total baseline and the total indirect project emissions for DMRC for the survey week can be calculated with a confidence interval of 95%. For the total baseline emissions the lower 95% boundary is taken and for the indirect project emissions the upper 95% boundary to have a conservative calculation of emission reductions. For total annual or period baseline (indirect project) emissions the baseline (indirect project) emission per passenger of the survey week is calculated and thereafter multiplied with the total passengers transported by DMRC per annum or period.

11. Data Verification and Validation Including QA and QC

11a). 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[114] 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.

12. 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.

12a) Pre-Operation Phase

This phase is characterized by the development of all the activities previous to the execution of the field operation and it is divided in:

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

1. Drafting of the manual on information collection and basic concepts. The manual on information collection and basic concepts covers in general terms the profile of the field personnel, the questionnaire structure, the instructions and specifications for filling in the questionnaire, the definitions and basic concepts of the study and the instructions and formats used.
2. Selection and training of field personnel. The selection and training of the field personnel is performed on concepts of filling in of questionnaires, in order to select the most adequate survey interviewers for the development of the field work.

A pre-test is performed with the aim of familiarizing the supervisors with the instrument of information collection and establishing in general terms the acceptance degree of the population facing the instrument's application. The pre-test is also to assure that respondents understand what DMRC is as they might not have taken a similar system before, to ensure that all the concepts are clearly defined and the questions are not ambiguously phrased and avoid interviewer errors. Interviewers may misread the question or twist the answers in their own words and thereby introduce bias. The pre-test has to detect and minimize this potential error.

The results of the pre-test will be documented and will be taken into consideration for the modification of the final instrument and for the preparation of the model of information collection.

12b) Validation Process of the Information

A supervisor should be used in the field to carry out the field verifications, guaranteeing the validity of the gathered information as well as the attained coverage.

13. 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 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 survey is

reviewed in the language of users of the project, not translated directly from the CDM methodology

A.9. PASSENGER SURVEY USED

The survey was tested on the DMRC with around 800 passengers and questions have been adapted accordingly following the guidelines of the methodology.

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

A.10. LIST OF DOCUMENTS USED/CITED

File 1a: Combined Margin; Government of India, Ministry of Power, Central Electricity Authority, CO_2 Baseline Database Version 5.0, 11.2009
File 1b: Combined Margin; Government of India, Central Electricity Authority, CO_2 Baseline Database Version 5.0, User Guide, 11.2009
File 2: Passenger ridership; DMRC, 2009 Includes individual files 2a to 2g (for each lane)
File 3: Traction energy used; DMRC, 2009
File 4: Trip distance on metro; DPR Phase II corridors, table 2.9, 2005
File 5: Passenger survey metro users; Grütter Consulting AG, 2008
File 6: Sample monitoring specific fuel consumption motorcycles; Grütter Consulting AG, 2008/2009

File 7: Distribution of fuel usage of passenger cars in Delhi; Department of Transit Delhi and Centre for Science and Environment CSE, 2008
File 8: Occupation rate survey passenger cars Delhi; Grütter Consulting AG, 2008
File 9: Specific fuel consumption and distance driven per day taxis; Easy Cab, 2008
File 10: Occupation rate survey taxis Delhi; Grütter Consulting AG, 2008
File 11: Occupation rates motorcycles and motorized rickshaws in Delhi; Central Road Research Institute (CRRI) Delhi, Quantification of the benefits achieved from Phase I implementation of Delhi Metro, p.46, 2007
File 12: Specific fuel consumption buses; Delhi Transport Corporation DTC, table 2.6, 2009
File 13: Number of buses; Delhi Transport Corporation DTC, table 2.3, 2008
File 14: Occupation rate of buses in Delhi; Central Road Research Institute (CRRI) Delhi, Quantification of the benefits achieved from Phase I implementation of Delhi Metro, p.46, 2007
File 15: Emission standards for vehicles in Delhi, Resources for the Future RFI, The Impact of Delhi's CNG Program on Air Quality, 2007, table 2 based on CPCB, 2001
File 16: Electricity used and passengers transported suburban rail; Northern Railway, Delhi Division, Division Rail Manager, 2008
File 17: Survey trip distance passengers suburban rail; Grütter Consulting AG, 2008
File 18: NCV of fuels in India; Bharat Petroleum Corporation Ltd, 2008
File 19: Distance driven of buses per annum; Delhi Transport Corporation DTC, table 2.4, 2008
File 20: Distance driven of motorized rickshaws per year; Government of India, Group of Experts, Report of Expert Committee on the matter of Auto-Rickshaws Fare Revision, page 10, 2003
File 21: Capacity of buses; Ashok Leyland, 2009
File 22: Government of the National Capital Territory of Delhi, Economic Survey of Delhi 2005-06, chapter 12, 2007
File 23: Specific fuel consumption gasoline and diesel cars in Delhi; Asian Development Bank ADB, Breaking the Trend: Visioning and Backcasting for Transport in India and Delhi by Halcrow Group Ltd. and Oxford University, 2008
File 24: DMRC note for Board of Directors, DMRC/MD/1/2001, 9.1.2001
File 25: DMRC note, DMRC/CO/14/PFM/152/Envt/99, 12.1.2001
File 26: DMRC letter, 24.4.2002
File 27: RITES letter, 22.10.2003
File 28: DMRC letter, 22.3.2004
File 29: DMRC letter, 9.2.2005
File 30, Tribune, 6.4.2005
File 31, Letter Ries, 4.8.2005
File 32, Ministry of Finance letter, 1.3.2006
File 33: DMRC note, 10.5.2006
File 34: e-mail E&Y, 29.6.2006
File 35, letter DMRC, 21.12.2006
File 36: Specific fuel consumption rickshaws: Grütter Consulting AG, 2009
File 37, Note DMRC, 16.1.2007
File 38: Grütter Consulting offer to DMRC, 10/07/2007
File 39: Carbotech offer to DMRC, 22/10/2007
File 40: Grütter Consulting and DMRC PD contract, 19/03/2008
File 41, DMRC, extract meeting minutes 12.1.1998
File 42, DPR for Phase II corridors, Rites, 2005
File 43, Income tax exemptions, 2010
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MONITORING INFORMATION

Some additional details are given concerning the monitoring manual prepared by Grütter Consulting AG for DMRC.

The objective of this manual is to collect all required data by the Monitoring and Verification Protocol in a manner that guarantees an optimal quality of monitoring. This manual therefore establishes which procedures are needed to follow, the structural organization and also the key elements of the required data.

This manual is intended for all personnel in charge of data gathering and processing for the DMRC project. It was written by Jürg M. Grütter, Grütter Consulting AG.

The manual is divided into the following parts:
- Structure and Responsibilities: establishes who is responsible for monitoring
- Data: Includes an overview of all data required for monitoring

Organizational Structure and Responsibilities

The **responsibilities** of **DMRC** are:

1. Deliver all information required for monitoring.
2. Perform data and information quality control according to this manual.
3. File all documents in the manner and timing that this manual demands.

Grütter Consulting AG is responsible for the monitoring reports for the entire crediting period.

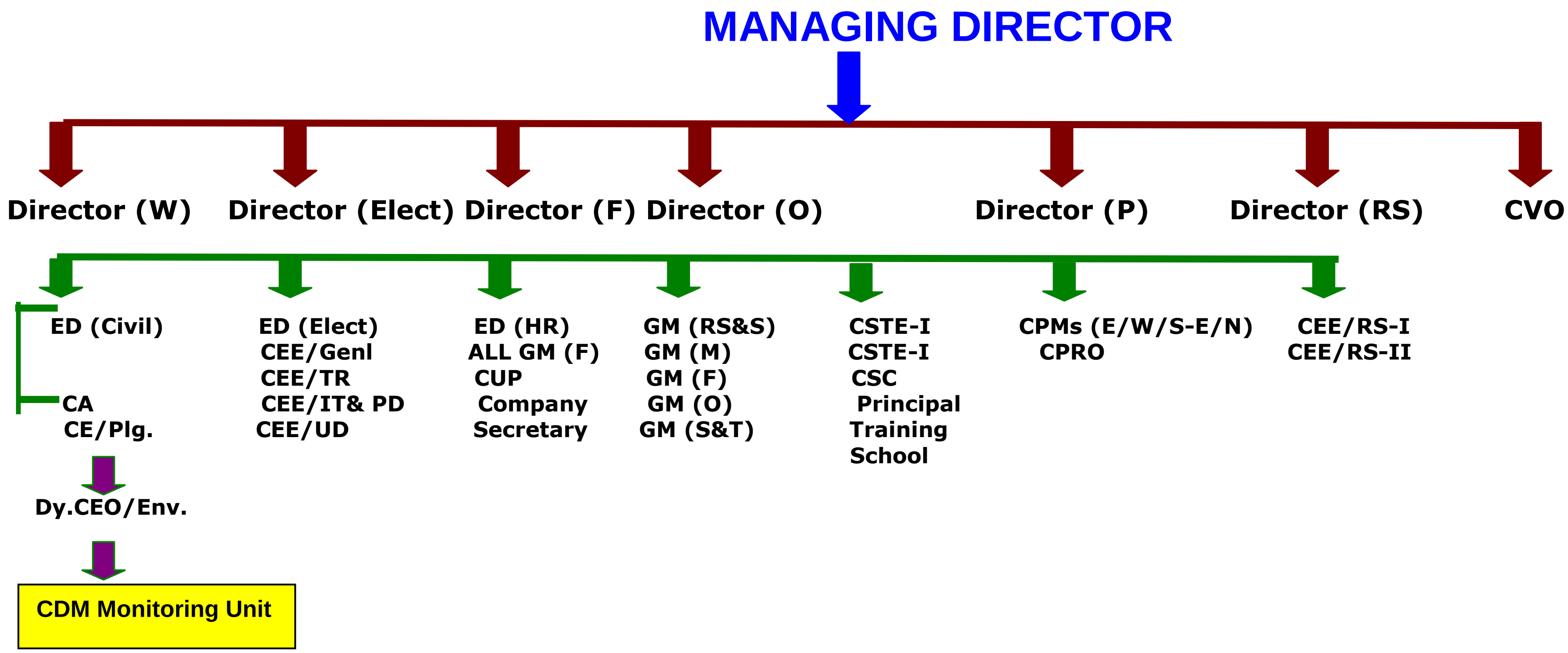
The India office of Grütter Consulting AG is responsible for data quality control and data collection. The HQ under direct responsibility of the CEO will be in charge of the monitoring report and the final check.

Core responsibilities of Grütter Consulting AG are:

1. Collect in the required frequency all data for the monitoring of the CDM project.
2. Check data quality and collect, if required, additional data
3. File all documents in the manner and timing that this manual demands.
4. Realize an annual monitoring report.
4. Answer all inquiries and additional information requests by the DOE for the verification report of the CERs. Furthermore, reply to all inquiries received during the process of issuance by UNFCCC.

All data must be filed electronically. Hard copy reports and mails are to be scanned to have an electronic copy. Every year an electronic file is created and named “DMRC CDM Monitoring year …”. At least two (2) copies are kept in the form of CDs or DVDs or other data recording devices in separate places. All documents are to be saved for minimum two (2) years after the last CERs were emitted.

Figure 1: Organizational Structure CDM Part DMRC



- CPM-Chief Project Manager)
- CA- Chief Architect
- GM(Legal)- General Manager (Legal)
- CPRO- Chief Public Relation Officer
- CEE-Chief Electrical Engineer
- CPO- Chief Personnel Officer
- Dy. CEO- Dy. Chief Environmental Officer

- GM(O&RS)- General Manager (Operations & Rolling Stock)
- GM(M) – General Manager (/Maintenance)

- CSTE- Chief Signal & Telecom Engineer
- CVO – Chief Vigilance Officer
- CSC – Chief Security Commissioner
- GM(F) – General Manager (Finance)
- ED- Executive Directors
-
-

For each data a sub-chapter or control spreadsheet has been realized. Table 1 summarizes all data required for monitoring.

Index	Indicator	Gathering frequency	Data source
1	Fuel types used by cars, taxis and motorized rickshaws	Annual	Department of Transport
2	Passengers transported	Monthly	DMRC
3	Traction electricity consumption	Annual	DMRC
4	Passenger survey for indirect project and baseline emission per passenger and mode share baseline	Annual	Grütter Consulting AG – realized by external survey company
5	Number of buses, taxis and motorized rickshaws	Year 1, 4	Department of Transport
6	Occupation rate buses, taxis and motorized rickshaws	Year 1, 4	Department of Transport or survey
10	Net Calorific Value	Annual	Bharat Petroleum Corp.
11	Emission factors of fuels	Annual	IPCC
13	Electricity consumption suburban rail	Annual	Northern Railway
14	Passengers transported suburban rail	Annual	Northern Railway

AS EXAMPLE FUEL CONSUMPTION PASSENGER CARS

Parameter

$N_{x,C/T/TR}$

Monitored Data

The fuel type consumed by cars, taxis and motorized rickshaws in Delhi needs to be recorded.

Data Unit

Percentage of fuel type per vehicle category.

Measurement Frequency

Annual. Data can be maximum 3 years old.

Information Source

For cars: Department of Transport, Centre of Science and Environment and Indraprastha Gas Limited, the CNG supplier in Delhi.

For taxis and motorized rickshaws a regulation exists that only allows the usage of CNG as fuel. Thus check if this regulation is still in force.

Quality Control

Check with values of previous year.

Comment

Baseline data parameter specific fuel consumption cars (SFC_C), taxis and rickshaws is adjusted according to the fuel mixture used. For rickshaws and taxis no change is previewed as long as the regulation concerning usage of gaseous fuels in Delhi remains in place.

Appendix 6. Summary of post registration changes

The update to the Version 04 of ACM0016 which is requested to reduce monitoring requirement of the MRTS results in following changes in the PDD:

1. The Passenger survey is only conducted in the year 1 and 4.
2. Leakage monitoring of load factor buses and taxis is only realized in the year 1 and 4
3. The leakage from congestion change is not included as no road space is quit by the metro
4. Leakage due to upstream emissions in case project vehicles consume more gaseous fuels than baseline vehicles has been included. However, the project uses less gaseous fuels than the baseline as the metro runs with electricity.
5. The new methodology does not require a sensitivity analysis of parameters.
6. The PDD refers to the “tool to calculate project or leakage emissions from fossil fuel combustion” and “Baseline emissions for modal shift measures in urban passenger transport”
7. The specific fuel consumption of buses is determined ex-ante and not monitored annually based on the tool “Baseline emissions for modal shift measures in urban passenger transport”. The same tool requires the application of a technology improvement factor for all vehicles including buses. This has been applied.