Monitoring report form
(Version 05.1)

MONITORING REPORT		
Title of the project activity	Metro Delhi, India	
UNFCCC reference number of the project activity	4463	
Version number of the monitoring report	1.0	
Completion date of the monitoring report	31/10/2016	
Monitoring period number and duration of this monitoring period	3rd monitoring period 01/07/2014 to 30/06/2016	
Project participant(s)	Delhi Metro Rail Corporation Ltd. Grütter Consulting AG	
Host Party	India	
Sectoral scope(s)	Transport (sectoral scope 7)	
Selected methodology(ies)	ACM0016: Baseline Methodology for Mass Rapid Transit Projects; Version 04	
Selected standardized baseline(s)	NA	
Estimated amount of GHG emission reductions or net GHG removals by sinks for this monitoring period in the registered PDD	1,084,062[1]	
Total amount of GHG emission reductions or net GHG removals by sinks achieved in this monitoring period	GHG emission reductions or net GHG removals by sinks reported up to 31 December 2012	GHG emission reductions or net GHG removals by sinks reported from 1 January 2013 onwards
	0	1,397,150

[1] Calculated based on 50% of value of 2014, 100% of value of 2015 and 50% of value of 2016

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

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

Core aspects of Metro Delhi are:

- A new infrastructure consisting of 101.27 kilometres of state-of-the art metro with new trains, and pre-board ticketing using rechargeable electronic cards.
- Equipment and turnstiles at the entrance to each station will deduct the corresponding fare.
- Centralized coordinated train control providing monitoring and communications to schedule services and real-time response to contingencies.

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

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

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

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

Table 1 lists the relevant dates of the project activity.

Table 1: Relevant Dates of the Project Metro Delhi, India

Corridor	Construction start date	Commissioning date
Shahadara-Dilshad Garden	April 2006	04/06/2008
Vishwavidyalaya-Jhahangirpuri	November 2005	04/02/2009
Indraprastha-New Ashok Nagar / Yamuna Bank[2]	November 2005	13/11/2009
New Ashok Nagar /Yamuna Bank-Noida	July 2006	13/11/2009
Inderlok – Kirtinagar –Mundka	April 2006	02/04/2010

[2] 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.

Yamuna Bank –Anand Vihar ISBT	June 2006	07/01/2010
Anand Vihar – Vaishali	June 2008	14/07/2011
QM-Huda City Centre	November 2006	21/06/2010
Central Secretariate –QM	November 2006	03/09/2010
Central Secretariat – Badarpur	April 2007	14/01/2011
Dwarka Sector 9 – 21	March 2006	30/10/2010

Source: Verified Monitoring Report 2nd monitoring period, Table 1[3]

The project was registered as a CDM project as of 30/06/2011. For this monitoring period, all lines as described in the PDD were fully operational.

The project operated continuously during the entire crediting period.

The total emission reductions achieved in this monitoring period are **1,397,150 tCO_2**

A.2. Location of project activity

Host country

India

Region/State/Province

New Delhi

City/Town/Community

Delhi

Physical/Geographical location

The spatial extent of the project is in accordance with the methodology, the metropolitan area of Delhi. The spatial area includes the trip origins and destinations of passengers using Metro Delhi. The geographical coordinates of Delhi are 28°24’ to 28°53’ North and 76°50’ to 77°20’ East.

A.3. Parties and project participant(s)

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate whether 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.4. Reference of applied methodology and standardized baseline

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

Following tools were used:

- “Tool for the demonstration and assessment of additionality”, Version 05.2
- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”, Version 01

[3] https://cdm.unfccc.int/filestorage/0/b/NG5IAJ26ZY34T9C10EXHDVLSOUFR7B.pdf/MR%20DMRC%20vs.%201.0?t=d3J8b2ZjbmhhfDDhVc0SJhI7OmVRmsAuy0LE

- 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

A.5. Crediting period of project activity

Crediting period: 7 years renewable; starting date 30/06/2011

Crediting period corresponding to this monitoring period: 30/06/2011 to 29/06/2018

A.6. Contact information of responsible persons/entities

Responsible for this Monitoring Report is:
Jürg Grütter
Grütter Consulting AG
Thiersteinerstr 22, 4153 Reinach, Switzerland
jgruetter@transport-ghg.com, www.transport-ghg.com

The person/entity is a project participant.

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

The total length of metro tracks included in the project is 101.27 km. The following table lists all metro corridors part of the CDM project.

Table 2: Corridors of CDM Project Metro Delhi, India

Corridor	Length (km)	Commissioning date
Shahadara-Dilshad Garden	3.09	04/06/2008
Vishwavidyalaya-Jhahangirpuri	6.36	04/02/2009
Indraprastha-New Ashok Nagar	7.72	13/11/2009
New Ashok Nagar-Noida	7.00	13/11/2009
Inderlok – Kirtinagar –Mundka	18.47	02/04/2010
Yamuna Bank –Anand Vihar ISBT	6.17	07/01/2010
Anand Vihar – Vaishali	2.54	14/07/2011
Central Secretariate –QM- Gurgaon	27.00	21/06/2010 and 03/09/2010
Central Secretariat – Badarpur	20.16	14/01/2011
Dwarka Sector 9 – 21	2.76	30/10/2010
Total	**101.27**	

Source: Verified Monitoring Report 2nd monitoring period, Table 2[4]

In relation with the planning as listed in the PDD under Table 3 the commissioning date for most corridors was delayed which is not unusual in large scale infrastructure projects. However as of start of this monitoring period all corridors had been commissioned.

The same corridors as originally planned have been implemented (see Table 3 PDD). Line distance per corridor is the same as in the PDD with marginal differences of in total for all lines of 400 meters less than projected (0.4% of total).

The following table lists all stations of Phase II.

[4] https://cdm.unfccc.int/filestorage/0/b/NG5IAJ26ZY34T9C10EXHDVLSOUFR7B.pdf/MR%20DMRC%20vs.%201.0?t=d3J8b2ZjbmhhfDDhVc0SJhI7OmVRmsAuy0LE

Table 3: DMRC Stations of Phase II Corridors

Corridor	Stations	Line[5]
Shahadara-Dilshad Garden	Dilshad Garden, Jhilmil, Mansarowar Park, Shahdara	Part of Line 1 (red line)
Vishwavidyalaya-Jhahangirpuri	Jahangirpuri, Adarsh Nagar, Azadpur, Modal Town, GTB Nagar, Vishwavidyalaya	Part of Line 2 (yellow line)
Indraprastha-New Ashok Nagar	Indraprastha, Yamuna Bank (repeated station), Akshardham, Mayur Vihar 1, Mayur Viha 1 Extension, New Ashok Nagar	Part of Line 3 (blue line)
New Ashok Nagar-Noida	New Ashok Nagar, Noida Sector 15, Noida Sector 16, Noida Sector 18, Botanical Garden, Golf Course, Noida City Centre	Part of Line 3 (blue line)
Inderlok – Kirtinagar – Mundka	Inderlok[6], Ashok Park Main, Satguru Ram Singh Marg, Kirtinagar[7], Punjabi Bagh, Shivaji Park, Madi Pur, Paschim Vihar (East), Paschim Vihar (West), Peeragarhi, Udyog Nagar, Surajmal Stadium, Nangloi, Nangloi Railway Station, Rajdhani Park, Mundka	Line 5 (green line)
Yamuna Bank –Anand Vihar ISBT	Yamuna Bank, Laxmi Nagar, Nirman Vihar, Preet Vihar, Karkarduma, Anand Vihar ISBT	Part of Line 3 (blue line)
Anand Vihar – Vaishali	Anand Vihar ISBT, Kaushambi, Vaishali	Part of Line 3 (blue line)
QM-Gurgaon	Qutab Minar, Chhattarpur, Sultanpur, Ghitorni, Arjangarh, Guru Dronacharge, Sikandarpur, MG Road, IFFCO Chowk, Huda City Centre	Part of Line 2 (yellow line)
Central Secretariat –QM	Central Secretariat, Udyog Bhawan, Race Course, Jor Bagh, INA Market, AIIMS, Green Park, Hauz Khas, Malviya Nagar, Saket, Qutab Minar	Part of Line 2 (yellow line)
Central Secretariat – Badarpur	Central Secretariat, Khan Market, JLN Stadium, Jangpura, Lajpat Nagar, Moolchand, Kailash Colony, Nehru Place, Kalkaji Mandir, Govind Puri, Okhla, Jasola, Sarita Vihar, Mohan Estate,Toughlakabad, Badarpur	Line 6 (violet line)
Dwarka Sector 9 – 21	Dwarka Section 9, Dwarka Section 8, Dwarka Section 21	Part of Line 3 (blue line)

Source: Verified Monitoring Report 2nd monitoring period, Table 3[8]

In total the project has 83 stations.

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

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

The metro runs partially underground, partially at grade and partially elevated. Each train has between 4 and 6 cars and runs frequencies between 3 and 12 minutes depending on lines, time of the day and passenger

[5] See website for colour codes used by DMRC http://www.delhimetrorail.com/

[6] Station shared with Phase I line

[7] Station shared with Phase I line

[8] https://cdm.unfccc.int/filestorage/0/b/NG5IAJ26ZY34T9C10EXHDVLSOUFR7B.pdf/MR%20DMRC%20vs.%201.0?t=d3J8b2ZjbmhhfDDhVc0SJhI7OmVRmsAuy0LE

demand. 90 broad gauge (of which 89 with 6 cars and 1 with 4 cars) and 48 standard gauge (of which 46 with 4 cars and 2 with 6 cars) trains have been acquired (total 734 cars). 694 cars (95%) are indigenous and the rest are from Germany and South Korea. The seating capacity per car is between 42 and 50 persons and the standing capacity between 272 and 330 thus achieving a capacity of around 1,500 passengers per 4-car train and 2,260 for a 6-car train.

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

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

To ensure the highest degree of reliability and all time power availability for the underground Metro Corridor, 3 MRTS Power receiving stations are inter-connected for transfer of power from one to another through Fire Retardant Low Smoke (FRLS) cable feeders. These receiving stations are remote controlled from Centralized Operation Control Centre through Supervisory Control & Data Acquisition System (SCADA). In the unlikely event of total power failure due to simultaneous collapse of Northern Grid and IP Gas Turbine Power Station, emergency lighting in the tunnel and at the MRTS stations is automatically switched on and fed the stand by Generator Sets. In addition, all the trains also have modern Ni-Cd Batteries to continue to provide lighting and air conditioning even when the train is stopped in event of complete power failure. The ventilation and air conditioning arrangements in the tunnel and the underground stations are so designed that emergency ventilation arrangements for the stations and tunnel continue to be maintained from the standby Generator Sets in such exigencies[9].

No special events influencing CER calculations have been registered during the monitoring period. The relevant dates have been listed in Table 1. No event occurred during the monitoring period, which impacts the applicability of the methodology.

B.2. Post-registration changes

B.2.1. Temporary deviations from registered monitoring plan, applied methodology or applied standardized baseline

No temporary deviations have been applied during this monitoring period.

B.2.2. Corrections

No corrections to project information or parameters fixed at validation have been approved during this monitoring period or are submitted with this monitoring report.

B.2.3. Changes to start date of crediting period

No changes to the start date of the crediting period have been approved during this monitoring period or are submitted with this monitoring report.

[9] See PDD as well as Verified Monitoring Report 2nd monitoring period for more information and data sources

B.2.4. Inclusion of a monitoring plan to the registered PDD that was not included at registration

No monitoring plan has been included which was not included to the registered PDD.

B.2.5. Permanent changes from registered monitoring plan, applied methodology or applied standardized baseline

Permanent changes to the registered monitoring plan and an update of the applied methodology from Version 01 to Version 04 has been applied.

B.2.6. Changes to project design of registered project activity

No changes to the project design of the registered project activity has been realized.

B.2.7. Types of changes specific to afforestation or reforestation project activity

Not applicable

SECTION C. Description of monitoring system

The monitoring methodology is based on ACM0016 Version 04.

The monitoring plan has two aims: to ensure the environmental integrity of the project activity and to ensure that the data monitoring requirements are closely aligned with the current practice of the project operator.

A monitoring manual for the project was developed by Grütter Consulting AG[10]. It defines all responsibilities and procedures. DMRC was trained on the manual 06/2012[11]. For each data parameter, the information sources, units, frequency of measurement as well as data quality assurance processes are described in detail. Grütter Consulting AG is contractually responsible for the monitoring reports for all 7 years of the 1st crediting period.

The environmental section of DMRC is responsible for CDM project monitoring. This area responds directly to the Managing Director.

The identical procedure and steps have been applied in the prior monitoring periods verified successfully and with issuance of CERs.

PARAMETER PASSENGERS[12]

Passenger flow data is based on the AFC system (Automatic Fare Collection System) which consists of semiautomatic ticket vending machines, automatic entry-exit gates, station computer and a central server. The AFC realizes access control of passengers, ticket reading/writing, transaction collection and reports, stock management and equipment supervision. Components of the system are a Data Center (DC), Middle Ware Server (MS), Archiving Server (AS), Production Server (PS), Administration Console and Certificate Authority (AC&CA), Network Management Console (NMC), Local Workstations (LW) and a Firewall (F). AFC equipment at stations are a station computer, AFC gates, ticket office, Ticket Reader (TR), Portable Data Terminals (PTD), Gate Remote Control Unit (GRCU), emergency switch, network switch and power plant. The system architecture is shown in the following figure.

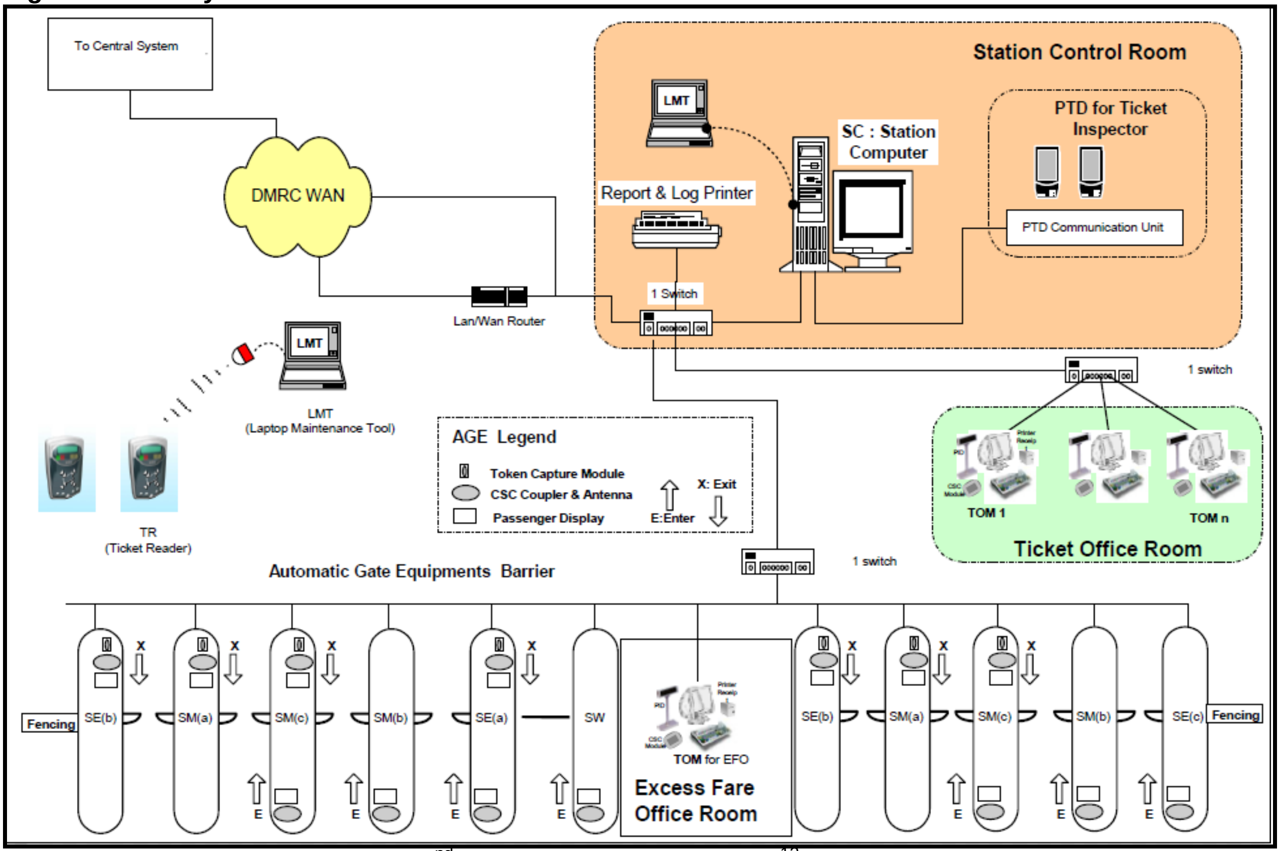
---

[10] File 11

[11] File 24

[12] See for data sources Verified Monitoring Report 2nd monitoring period

Figure 1: AFC System Architecture



Source: Verified Monitoring Report 2nd monitoring period, Figure 1[13]

PASSENGER SURVEYS

The passenger surveys were realized by Absolute Market Research and Consultants Private Ltd. contracted by Grütter Consulting AG[14]. The company has realized since more than 3 years numerous surveys in India and is thus in accordance with ACM0016 qualified companies for a professional survey execution[15]. The same company had been used also for the previous survey in 2014 (see verified 2nd monitoring report). The survey design is the same since the period 2011/2012. The survey objectives are:

- Determine the mode of transport passengers of the Metro would have used in absence of the project activity.
- Determine the distance per mode used in the baseline situation.
- Determine the project trip modes to/from the metro and their trip distance.

For all details concerning the survey see section D.3.

ELECTRICITY CONSUMPTION

DMRC takes power from various distribution companies of Delhi and the National Capital Region. The electricity is received at 220KV, 132 KV or 66 KV level as per availability and contract agreement with the distribution companies. The electricity is stepped down at the RSS (Receiving Sub Station) of DMRC to lower voltages in the following manner:

- 25 KV, 1 phase for traction requirement and
- 33 KV, 3 phase for auxiliary power requirements.

---

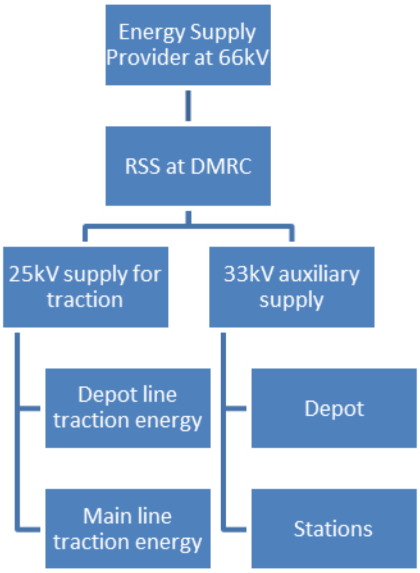
[13] https://cdm.unfccc.int/filestorage/0/b/NG5IAJ26ZY34T9C10EXHDVLSOUFR7B.pdf/MR%20DMRC%20vs.%201.0?t=d3J8b2ZjbmhhfDDhVc0SJhI7OmVRmsAuy0LE

[14] File 12

[15] File 13

The following figure shows the energy path.

Figure 2: DMRC Power Distribution System



The energy at 25KV is connected to overhead traction wires for running of trains. Total energy is read from 66 KV energy meters being the sum of all energy meters of RSS in that line. Traction energy is thereafter read from traction meter. Traction energy (TE) data is recorded every month by DMRC officials under the Operations & Maintenance Wing, Traction. The recordings are done manually. Both hard and soft copies of the traction data are stored by the Operations & Maintenance Wing, Traction. The car-kilometer are determined for Phase I, Phase II and Phase III based on section wise data per train based on dispatch data plus data if the train has 4 or 6 coaches thus determining exactly total car-km per month and Phase II car-km per month. The traction energy of the project (Phase II) is thereafter the total traction energy divided by the total car-km and multiplied with the Phase II car-km i.e. the specific electricity consumption per car-km is determined to calculate thereafter the Phase II electricity used for traction. The regenerative energy is used by other trains running on the same lines. Only minor energy which is not utilized during late hours goes back to DISCOM. The recorded energy of meters which is used for billing purpose does not include this export part and is thus conservative. The TE meters are located at the Receiving Sub Station (RSS). A full list of all calibrations realized including sites and calibration certificates is included in File 14.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante or at renewal of crediting period

Data / Parameter	$SFC_{C,G/D/CNG}$
Unit	g/km
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 Passenger car using CNG: Based on taxis using CNG, 2008
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 in accordance with the 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

Data / Parameter	**$N_{C,G/D/CNG}$**
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
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	**SFC_T**
Unit	g/km
Description	Specific fuel consumed of taxis
Source of data	Easy Cab, 2008
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 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	**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)
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
Value(s) applied	32.00
Choice of data or	Based on sample realizing measurements of fuel consumption. The lower 95%

Measurement methods and procedures	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)
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
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

Data / Parameter	**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
Value(s) applied	100%
Choice of data or Measurement methods and procedures	Official data source
Purpose of data	Baseline, project
Additional comment	

Data / Parameter	**SFC_B**
Unit	g/km
Description	Specific fuel consumed of buses
Source of data	Delhi Transport Corporation (DTC), 2009

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 will be monitored annually instead of applying a default technology improvement factor.

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

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 Centre
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
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
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

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
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
Value(s) applied	1.40
Choice of data or	Recognized research institute in India; realized on various locations

Measurement methods and procedures	
Purpose of data	Baseline, project
Additional comment	Excluding driver

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
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)
Purpose of data	Baseline, project, leakage
Additional comment	

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
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
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
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
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
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

Data / Parameter	**$NIZ_{C,T,BL}$**
Unit	Vehicles
Description	Number of cars/taxis on roads affected per annum in the baseline
Source of data	Grütter Consulting AG, 2009
Value(s) applied	See Table 4 below
Choice of data or Measurement methods and procedures	Visual counting on the identified roads. Based on measurements realized 6AM to 10PM both directions during 3 different days. No expansion factor for remaining hours. 365 days per annum. Exact locations of monitoring are defined for each affected road.
Purpose of data	Leakage
Additional comment	

Table 4: Number of Vehicles Baseline on Affected Roads (per annum)

Affected Road	Number of cars	Number of taxis
Mehrauli-Gurgaon Road	14,820,217	1,351,960
New Noida Link Road / Dadri Road	18,555,505	771,123
Rohtak Road	8,418,360	171,063
Aurangzeb Road	6,864,555	871,133
INA Market Road	10,317,455	1,143,180
Grand Trunk Road	7,079,297	307,695
Bhisham Pitamah Marg	6,615,990	301,612
Vikas Marg	7,844,093	583,757
Mathura Road	13,311,428	444,935

Data / Parameter	V_B
Unit	Km/h
Description	Vehicle baseline speed on affected roads.
Source of data	Grütter Consulting AG, 2009
Value(s) applied	**Table 5: Baseline Moving Speed on Affected Roads** (see table below)
Choice of data or Measurement methods and procedures	On-board measurements determining the average speed when circulating.
Purpose of data	Leakage
Additional comment	

Table 5: Baseline Moving Speed on Affected Roads

Affected Road	Average moving speed
Mehrauli-Gurgaon Road	31
New Noida Link Road / Dadri Road	36
Rohtak Road	40
Aurangzeb Road	50
INA Market Road	28
Grand Trunk Road	30
Bhisham Pitamah Marg	36
Vikas Marg	27
Mathura Road	35

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 and motorized rickshaws is not included as this is a default factor of the methodology.

D.2. Data and parameters monitored

Data/parameter:	**$NCV_{G/D}$**
Unit	MJ/kg
Description	Net calorific value of gasoline and diesel
Measured/calculated/default	Default
Source of data	India Oil Corporation Ltd. (File 9)
Value(s) of monitored parameter	Gasoline: 43.9 Diesel: 42.7
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	Not applicable
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. The IPCC default values for Gasoline are between 42.5 and 44.8. The reported value is therefore inside the IPCC uncertainty range. The IPCC default values for Diesel are between 41.4 and 43.3. The reported value is therefore inside the IPCC uncertainty range.
Purpose of data:	Baseline and Project
Additional comments:	Same value as recorded in baseline. Therefore, no need to adjust emission factor of vehicles.

Data/parameter:	**NCV_{CNG}**
Unit	MJ/m^3
Description	Net calorific value of CNG
Measured/calculated/default	Default
Source of data	India Oil Corporation Ltd. (File 9)
Value(s) of monitored parameter	35.6
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	Not applicable
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. The IPCC default values for CNG are between 46.5 and 50.4 MJ/kg. The density of CNG in India is 0.717 kg/m^3 (File 8) and therefore the reported value for India is 49.7 MJ/kg. The reported value is therefore inside the IPCC uncertainty range.
Purpose of data:	Baseline and Project
Additional comments:	Same value as recorded in baseline. Therefore, no need to adjust emission factor of vehicles.

Data/parameter:	**$EF_{CO2,G/D/CNG}$**
Unit	gCO_2/MJ
Description	CO_2 emission factor for gasoline, diesel and CNG
Measured/calculated/default	Default
Source of data	IPCC 2006, table 1.4, lower 95% confidence interval
Value(s) of monitored parameter	Gasoline: 67.5 Diesel: 72.6 CNG: 54.3
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	Not applicable
QA/QC procedures:	No new values
Purpose of data:	Baseline and Project
Additional comments:	Same value as recorded in baseline. Therefore, no need to adjust emission factor of vehicles.

Data/parameter:	**$EF_{KM,B,CH4}$**
Unit	gCO_{2eq}/km
Description	CH_4 emission factor of CNG buses per kilometre in CO_{2eq}
Measured/calculated/default	Default
Source of data	IPCC 2006, table 3.2.4. and IPCC, 2013 http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html
Value(s) of monitored parameter	192.9

Monitoring equipment	None
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	Value of 7,715 mg CH_4 of IPCC is multiplied with the GWP of 25 for CH_4 to calculate CO_{2eq}
QA/QC procedures:	none
Purpose of data:	Baseline and Project
Additional comments:	

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}
Measured/calculated/default	Default
Source of data	IPCC 2006, table 3.2.4. (average of upper and lower boundary) and IPCC, 2013 http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html
Value(s) of monitored parameter	11.8
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	Average of 725 mg and 215 mg CH_4 of IPCC is multiplied with the GWP of 25 for CH_4 to calculate CO_{2eq}
QA/QC procedures:	none
Purpose of data:	Baseline and Project
Additional comments:	

Data/parameter:	**$N_{x,C}$**
Unit	Vehicles
Description	Number of passenger cars (C) using fuel type *x*
Measured/calculated/default	Measured
Source of data	Government of National Capital Territory of Delhi, Transport Department, 2014 (File 4)
Value(s) of monitored parameter	Diesel: 64,458 (42.2%) Gasoline: 73,111 (48.0%) CNG: 14,827 (9.7%)
Monitoring equipment	Registration statistics
Measuring/reading/recording frequency:	Latest available data not elder as 3 years
Calculation method (if applicable):	Relevant is only the percentage distribution per fuel and not the absolute figures as the relative share is used to determine the emission factor per kilometre. LPG vehicles constitute less than 1% of total and are thus not considered. Electric vehicles constitute less than 0.1% of total and are thus not considered.
QA/QC procedures:	None
Purpose of data:	Baseline, Project

Additional comments:	The emission factor is calculated based on relative values per fuel. The corresponding relative value for fuels used by cars in the baseline was (see section above): Gasoline: 81.8% Diesel: 10.6% CNG: 7.6% Percentages have changed and therefore the baseline emission factor for passenger cars and the EF per PKM for cars is re-calculated in Section E1 based on ACM0016 Vs 04. 0.1% of bio-fuels are used in diesel in the years 2014, 2015 and 2016 (USDA GAIN report, 24/06/2016, table 4, File 10) whilst in gasoline a share of 1.4% was used in 2014, 2.3% in 2015 and 1.9% in 2016. This bio-fuel share has been included to determine the new EF cars (USDA GAIN report, 24/06/2016, table 4, File 2).

Data/parameter:	**$N_{x,T}$**
Unit	Vehicles
Description	Number of Taxis (T) using fuel type *x*
Measured/calculated/default	Measured
Source of data	The 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 15)
Value(s) of monitored parameter	Not required as 100% CNG due to Supreme Court Decision
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	Relevant is only the percentage distribution per fuel and not the absolute figures as the relative share is used to determine the emission factor per kilometre.
QA/QC procedures:	None
Purpose of data:	Baseline, Project
Additional comments:	The Supreme Court Decision was already valid as of baseline determination and therefore no change relative to baseline fuel composition of taxis. The emission factor of taxis is therefore not re-calculated.

Data/parameter:	**$N_{x,TR}$**
Unit	Vehicles
Description	Number of motorized auto-rickshaws (TR) using fuel type *x*
Measured/calculated/default	Measured
Source of data	The 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 15)
Value(s) of monitored parameter	Not required as 100% CNG due to Supreme Court Decision
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual

Calculation method (if applicable):	Relevant is only the percentage distribution per fuel and not the absolute figures as the relative share is used to determine the emission factor per kilometre.
QA/QC procedures:	None
Purpose of data:	Baseline, Project
Additional comments:	The Supreme Court Decision was already valid as of baseline determination and therefore no change relative to baseline fuel composition of motorized rickshaws. The emission factor of motorized auto-rickshaws is therefore not re-calculated.

Data/parameter:	$\mathbf{N_{x,M}}$
Unit	Vehicles
Description	Number of motorcycles (M) using fuel type *x*
Measured/calculated/default	Measured
Source of data	Government of N.C.T of Delhi, Transport Department, cited in Delhi Statistical Handbook 2015 (File 16)[16]
Value(s) of monitored parameter	5,681,265 100% gasoline
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	Relevant is only the percentage distribution per fuel and not the absolute figures as the relative share is used to determine the emission factor per kilometre. Current market share of electric motorcycles is marginal (see UNEP, Promoting Low Carbon Transport in India, 2014, Figure 4.2., File 17)
QA/QC procedures:	None
Purpose of data:	Baseline, project
Additional comments:	ACM0016 states that the share of fuels per vehicle category must be identified and if relevant the emission factor must be re-calculated. Percentages have not changed and therefore the baseline emission factor for motorcycles needs not be recalculated.

Data/parameter:	**P**
Unit	Passengers
Description	Total passengers transported by the project
Measured/calculated/default	Measured
Source of data	DMRC, 2016 (File 1)
Value(s) of monitored parameter	1,028,453,740
Monitoring equipment	Turnpike controls at stations and electronic smart cards. Only passengers are included which enter stations of the lines include in the project. See Section C for detailed description.
Measuring/reading/recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Controlled with income
Purpose of data:	Project and Baseline
Additional comments:	

[16] http://www.delhi.gov.in/wps/wcm/connect/doit_des/DES/Our+Services/Statistical+Hand+Book/

Data/parameter:	EC_{PJ}
Unit	kWh
Description	Electricity consumed by MRTS (trains)
Measured/calculated/default	Measured and calculated
Source of data	DMRC, 2016 (File 3)
Value(s) of monitored parameter	431,212,171
Monitoring equipment	Traction energy is recorded by DMRC per line. File 14 lists all calibration certificates of the TE meters, all of which have been calibrated during the monitoring period.
Measuring/reading/recording frequency:	Continuously, aggregated monthly
Calculation method (if applicable):	Traction energy is read from traction meter. The car-km for phase I, phase II and phase III are calculated for all lines. TE for Phase II is Total TE consumed for each line minus the TE consumed by Phase I and III based on car-km distances for each phase i.e. the specific electricity consumption per car-km is calculated and thereafter Phase II energy consumption is based on the specific value multiplied with car-km of Phase II. The table below shows the total traction energy consumption Phase II energy consumption based on total energy/total car-km * car-km Phase II.
QA/QC procedures:	Control with electricity invoices for total energy.
Purpose of data:	Project
Additional comments:	

Table 6: Traction Energy (monitoring period)

Year	Total car-km	Phase II car-km	Total traction energy in kWh	Phase II traction energy in kWh
01/07/2014 to 31/12/2014	79,694,618	41,658,932	201,797,793	105,511,509
2015	168,678,153	87,883,813	404,139,788	210,810,144
01/01/2016 to 30/06/2016	98,071,199	50,071,123	224,954,052	114,890,518
Total	346,443,970	179,613,868	830,891,633	**431,212,171**

Source: File 3 based on File 1

Data/parameter:	SFC_B
Unit	g/km
Description	Specific fuel consumed of buses
Measured/calculated/default	Measured
Source of data	Delhi Transport Corporation (DTC) Operational Statistics, 12/2015 Table 1.8 A.III (File 6)
Value(s) of monitored parameter	429
Monitoring equipment	None
Measuring/reading/recording frequency:	Annually based on last available report for period 2014 to 2015
Calculation method (if applicable):	The report states 2.33km per kg. This is equivalent to 429 g/km
QA/QC procedures:	External report based on total registered fuel consumed and total distance driven all DTC buses.
Purpose of data:	Baseline, Project and Leakage
Additional comments:	All buses are CNG

Data/parameter:	**$EC_{EL,R}$**
Unit	MWh
Description	Quantity of electricity consumed by the baseline rail system per annum
Measured/calculated/default	Measured
Source of data	India Railways, IR Yearbook 2014-15 EMU statistics, Northern Line suburban point 32-25 (File 7)
Value(s) of monitored parameter	2,816
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual, last available year period 2014-15
Calculation method (if applicable):	Not applicable
QA/QC procedures:	
Purpose of data:	Baseline and Project
Additional comments:	Required to establish the emission factor per PKM for suburban rail

Data/parameter:	**$P_{EL,R}$**
Unit	Passengers
Description	Total passengers transported by baseline rail-system per year
Measured/calculated/default	Measured
Source of data	Indian Railways, IR Yearbook 2014-15 passenger revenue statistics, Northern Line suburban, statement 12, p. 75 (File 8)
Value(s) of monitored parameter	3,055,900
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual, last available year period 2014-15
Calculation method (if applicable):	None
QA/QC procedures:	
Purpose of data:	Baseline and Project
Additional comments:	Required for the emission factor suburban rail system; same year and source as $EC_{EL,R}$

Data/parameter:	**$BTD_{p,i}$**
Unit	Kilometre
Description	Baseline trip distance of the cluster *p* of surveyed passengers using mode *i*
Measured/calculated/default	Measured
Source of data	Absolute Market Research and Consultants Private Ltd. (File 2 and 18)
Value(s) of monitored parameter	Calculated for each passenger surveyed for each mode used in the baseline trip. See for values per passenger per mode File 2
Monitoring equipment	None
Measuring/reading/recording frequency:	Year 1 and 4 of crediting period
Calculation method (if applicable):	Based on distance between starting and ending point of trip using mode *i* in the baseline determined through electronic maps.
QA/QC procedures:	See Section D.3. for survey details
Purpose of data:	Baseline

Additional comments:	See Section D.3. for survey details Distance is not required and not calculated if NMT (Non-Motorized Transit) is used as latter has an emission factor of 0 (the trip distance is only required to calculate the emissions caused).

Data/parameter:	**$IPTD_{p,i}$**
Unit	Kilometre
Description	Indirect project trip distance of the surveyed passenger using mode *i*
Measured/calculated/default	Measured
Source of data	Absolute Market Research and Consultants Private Ltd. (File 2 and 18)
Value(s) of monitored parameter	Calculated for each passenger surveyed for each mode used to and from the metro. See for values per passenger per mode File 2
Monitoring equipment	None
Measuring/reading/recording frequency:	Year 1 and 4 of crediting period
Calculation method (if applicable):	Based on distance between starting point and entry point of metro and exit point of metro and end trip point using mode *i* in the baseline determined through electronic maps.
QA/QC procedures:	See Section D.3. for survey details
Purpose of data:	Project
Additional comments:	See Section D.3. for survey details Distance is not required and not calculated if NMT (Non-Motorized Transit) is used as latter has an emission factor of 0 (the trip distance is only required to calculate the emissions caused).

Data/parameter:	**FEX_p**
Unit	None
Description	Expansion factor for each surveyed passenger *p* surveyed (each surveyed passenger has a different expansion factor)
Measured/calculated/default	Calculated
Source of data	Grütter Consulting based on passenger data DMRC (per hour per station for the survey week and for the year) and survey results of Absolute Market Research and Consultants Private Ltd, (File 2 and 18)
Value(s) of monitored parameter	Calculated for each passenger surveyed; see File 2
Monitoring equipment	None
Measuring/reading/recording frequency:	Year 1 and 4 of crediting period
Calculation method (if applicable):	See Section D.3. for survey details
QA/QC procedures:	See Section D.3. for survey details
Purpose of data:	Baseline and Project
Additional comments:	See Section D.3. for survey details

Data/parameter:	**P_{SPER}**
Unit	Passengers
Description	Number of passengers in the period of the survey (1 week)
Measured/calculated/default	measured
Source of data	DMRC, File 19
Value(s) of monitored parameter	Value per station per hour per day for each survey week

Monitoring equipment	Turnpike controls at stations and electronic smart cards.
Measuring/reading/recording frequency:	The survey is realized in the years 1 and 4 of the crediting period
Calculation method (if applicable):	Emissions are calculated per passenger and then expanded to the total; the number of passengers per station per hour and per day is required for FEX
QA/QC procedures:	See Section D.3. for survey details
Purpose of data:	Baseline and Project
Additional comments:	See Section D.3. for survey details

Data/parameter:	**OC_B**
Unit	%
Description	Average occupancy rate of buses
Measured/calculated/default	Measured and calculated
Source of data	Delhi Transport Corporation (DTC) Operational Statistics, 12/2015 Table 1.4 No. 22 (File 6)
Value(s) of monitored parameter	85% (year 2014-15)
Monitoring equipment	None
Measuring/reading/recording frequency:	Year 1 and 4 of the crediting period
Calculation method (if applicable):	Reported by 3rd Party based on bus statistics
QA/QC procedures:	None as based on report
Purpose of data:	Leakage
Additional comments:	The baseline rate was 57% and therefore lower. The methodology states that leakage is only included if the load factor drops. This is not the case and therefore no leakage for change of occupation rate buses is included.

Data/parameter:	**OC_T**
Unit	passengers
Description	Average occupancy rate of taxis
Measured/calculated/default	Measured and calculated
Source of data	Grütter Consulting, 2015 (File 19a and 19b)
Value(s) of monitored parameter	2.72
Monitoring equipment	None
Measuring/reading/recording frequency:	Year 1 and 4 of the crediting period
Calculation method (if applicable):	Based on visual occupation study using the average figure
QA/QC procedures:	Survey realized using upper 95% confidence interval. The sample size required for a 95% confidence level and a 10% maximum error bound (relative precision level) of a simple random sample is 137 while the actual sample size taken was 2,393 units. The procedure followed the TORs for occupation rate studies described in methodology. The same procedure was followed as for the baseline study. Baseline study see File 19c.
Purpose of data:	Leakage
Additional comments:	The load factor taxis has improved and not worsened. The methodology states that leakage is only included if the load factor drops. This is not the case and therefore no leakage for change of occupation rate taxis is included.

Data/parameter:	OC_{TR}
Unit	Passengers
Description	Average occupancy rate of motorized auto-rickshaws
Measured/calculated/default	Measured and calculated
Source of data	Grütter Consulting, 2015 (File 20a and 19b)
Value(s) of monitored parameter	1.46
Monitoring equipment	none
Measuring/reading/recording frequency:	Year 1 and 4 of the crediting period
Calculation method (if applicable):	Based on visual occupation study using the average figure
QA/QC procedures:	The sample size required for a 95% confidence level and a 10% maximum error bound (relative precision level) of a simple random sample is 213 while the actual sample size taken was 7,172 units. The procedure followed the TORs for occupation rate studies described in methodology. The same procedure was followed as for the baseline study. Baseline study see File 20b.
Purpose of data:	Leakage
Additional comments:	The load factor motorized auto-rickshaws has improved and not worsened. The methodology states that leakage is only included if the load factor drops. This is not the case and therefore no leakage for change of occupation rate motorized rickshaws is included.

The parameters $N_{B,T,TR}$ are not required as no downward change in the occupation rate of buses, taxis and motorized rickshaws has been registered in year 4.

D.3. Implementation of sampling plan

Sampling is used for the following parameters:

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

A. SURVEY

The methodological design of the survey is presented in detail. The 2 surveys were made by an external survey company.

Table 7: Technical Summary Data Sheet of the Survey Strategy and Sample Design Metro Delhi Passenger Survey

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

Sample design	Two staged probabilistic design: • First stage: stratified – simple random sampling (SRS); • Second stage: systematic sampling based on passengers flow per station. Stratum: Lines and Stations. Sub stratum: Days in the week and hours.
Relative error level (CV)[17]	For the survey a global desired level of precision (relative standard error or coefficient of variation – CV) between 5% and 10% for the parameters of interest is targeted, which implies at the same time having precision levels of 90/10. Results obtained are based on a 95% confidence level using the more conservative boundary.
Coverage	Urban area where the Metro Delhi operates.
Size of Universe	Generally, in one day Metro Delhi transports around 1.4 million passengers on the Phase II lines[18].
Sample size	The sample size is around 2,000 surveys in each survey.
Pilot Test	The pilot test corresponds to a survey realized July 2008 during an entire week in a continuous manner. 804 passengers of Delhi Metro were interviewed. Since the project start 6 surveys (2 per annum) have already been carried out which allowed to adjust the survey sample size based on the calculated CV.
Sample frequency	2x annually during an entire week (compulsory based on the methodology is for year 4 only 1 survey).
Method of information collection	The information is obtained through the face-to-face application of the established questionnaire on a random base.

Survey Objective

The survey objective is to determine:

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

Survey Realization

The surveys were realized by Absolute Market Research and Consultants Private Ltd. contracted by Grütter Consulting AG[19].

Target Population

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

Geographical Coverage

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

[17] 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.

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

[19] File 12 contract and File 13 with information on the survey company

Sample Frequency

The surveys were realized 15-21 of April 2015 and 15-21 June 2015. The surveys took place during an entire week. The selected weeks do not correspond to a public holiday and are representative for the average demand for transport services in the considered year.

Sample Frame

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

Survey Design

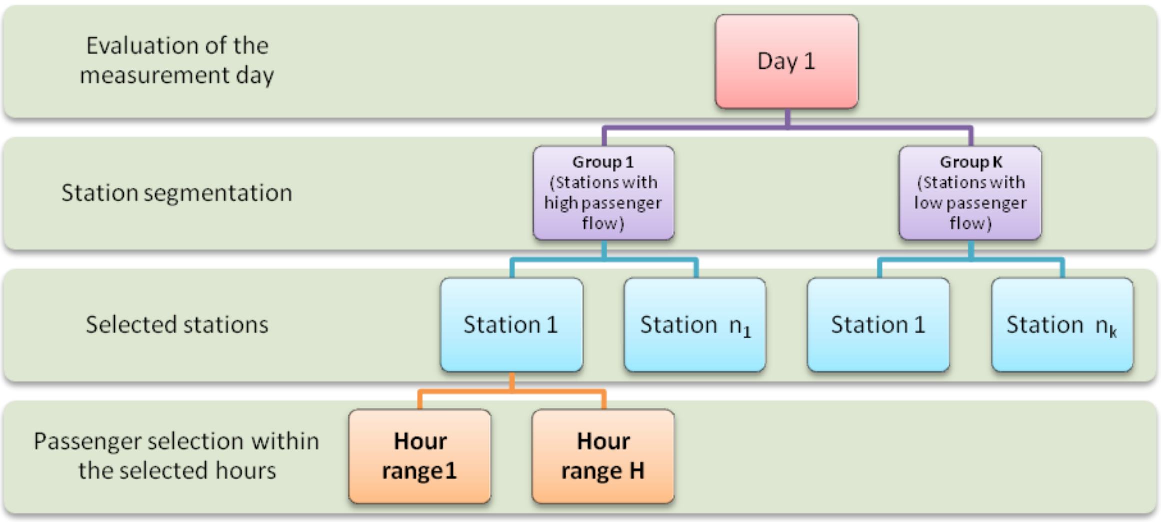
The survey was conducted among Delhi Metro commuters at DMRC phase-2 stations. The survey design was identical to the 6 surveys realized since 2011. To get a better representation and complete coverage of target population, this target sample was distributed among stations, days and time slots:

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

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

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

Figure 3: Survey Stratification Model



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

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

The sampling fraction of the day is the ratio between the total traffic flow of that day and total traffic flow of the week. The sample of one day is allocated to the pre-defined stratum (stations and time slots). Sampling Fraction for n1 station at t1 hour = (Traffic flow at n1 station during t1 hour for total week) / (total traffic follow of the week)

Sample Selection

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

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

Method for Information Collection

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

Sample Size Determination

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

Data Analysis and Calculation

For each surveyed passenger, the distance trip per transport mode is determined for the baseline as well as for the project, with the help of Google map. Trip distances need to be determined for each surveyed passenger. The following procedures are applied:

- For Cycle/by Foot, distance calculation is not required as the applied EF is "0".
- For users of buses, passenger cars, taxis, motorcycles, motorized rickshaws and other modes of motorized transport based on the shortest possible geographical distance based on electronic maps.

The expansion factor is calculated in two stages[20]. In the first stage the expansion factor is calculated according to the sample design, this is called the "expansion factor of design", and in the second stage this factor is adjusted in accordance with the passenger flow of the survey week and subsequently with the total passenger flow in the year. The expansion factor of design (FEX_Design) is the inverse of the probability of selection of a passenger. According to the sample design, the probability of selection of a passenger is the resultant from the multiplication of two probabilities: 1. The probability of the selection of the station in the day in which the passenger was surveyed, and 2. The probability of selection of the passenger in

[20] See for calculations Files 2a/b sheet FEX

accordance with the passenger flow within the hour range in which the passenger was surveyed:

- The first probability takes into account the groups of stations (main strata) and the random selection of stations of each group per day. Thus, the probability of selection per day for each station is 1 in this case; as all 84 stations of DMRC-Phase 2 were covered for each day of the survey.
- The second probability is calculated as the total selected passengers within the hour range in the station divided by the passenger flow in the same hour range.

The expansion factor of design is adjusted (also called post-stratified sampling) with the passenger flow of the survey week and with the total passenger flow in the year:

- The adjustment per week is elaborated based on the total passenger flow in the survey week according to the day, groups of stations and hour range. For each combination of day, groups of stations and hour range the following process is realized:

$$Factor(adjust\_week)_{DGH} = \frac{Flow\_week_{DGH}}{\sum_{k=1}^{n_{DGH}} (FEX_{design})_k}$$

$$FEX\,(Week\_end)_k = FEX\,(Design)_k \times Factor(adjust\_week)_{DGH}$$

Where:

DGH	combination of day, groups of stations and hour range
k	k^{th} individual passenger selected and surveyed in the station *sp*, per day, per groups of stations and hour range
sp	stations of the system
n_{DHG}	total number of passengers selected per day, per groups of stations and per hour range
$Flow\_week_{DGH}$	total number of passengers in the station *sp*, per day, per groups of stations and per hour range within the survey week
FEX (Week_end)	Expansion factor adjusted according to the weekly flow of passengers
FEX $(Design)_k$	Expansion factor of sample design for each for each surveyed passenger
Factor $(adjust\_week)_{DGH}$	Factor adjusted according to the weekly flow of passengers

- The adjustment per year is calculated based on the adjusted expansion factor per week obtained and the total number of passenger per station per year with the following equations:

$$Factor(adjust\_year)_{sp} = \frac{Flow\_year_{sp}}{\sum_{k=1}^{n_{sp}} (FEX\,(Week\_end)_k)}$$

$$FEX\,(year_{End})_k = FEX\,(Week\_end)_k \times Factor(adjust\_year)_{sp}$$

Where:

sp	stations of the system
k	k^{th} individual passenger selected and surveyed in the station *sp*
n_{sp}	total number of passengers selected in the station *sp*
$Flow\_year_{sp}$	total number of passenger in the station *sp* in the year
FEX $(year_{End})_k$	Expansion factor for each surveyed passenger *k* adjusted according to the weekly and yearly flow of passengers
$Factor(adjust\_year)_{sp}$	Factor adjusted according to the yearly flow of passengers in the station *sp*

The share per the mode of transport is differentiated by the modes of transport that the surveyed passengers would have used:

- Baseline Trip Modes: In the absence of the project
- Project Trip Modes: from their trip origin to the entry station of the project and from the exit station of the project to their final destination.

For calculating the frequency for each used mode of transport the share per used mode of transport using

the expansion factor is estimated as follows:

$$S(Mode\_i) = \frac{\sum_{k=1}^{n_{Mi}} FEX(year_{End})_k}{\sum_{k=1}^{n} FEX(year_{End})_k}$$

Where:

S (Mode i)	share per mode of transport
k	k^{th} individual passenger selected
n_{Mi}	total number of passengers using mode i^{th}
n	total number of passengers selected
i	mode of transport

Estimation of Total Baseline and Indirect Project Emissions

The estimation of the total baseline and the total indirect project emissions considers the emissions per passenger according to the distance per mode and the number of passengers that represent the selected passenger over the passenger flow (expansion factor).

The emissions are calculated as follows:

$$BE = \sum_{k=1}^{n} BE_k \times FEX(year_{End})_k$$

$$IPE = \sum_{k=1}^{n} IPE_k \times FEX(year_{End})_k$$

Where:

BE	Total baseline emissions
IPE	Total indirect project emissions
BE_k	Total baseline emissions per surveyed passenger *k*
IPE_k	Total indirect project emissions per surveyed passenger *k*
$FEX(year_{End})_k$	Expansion factor for each surveyed passenger *k*
n	total number of passengers selected
k	k^{th} individual passenger selected

Relative Error Level and Confidence Intervals

The error levels (estimated variance and variation coefficient) for the parameters of total baseline emissions and total indirect project emissions are calculated according to the methodology. Based on these results the confidence intervals are determined with a confidence level of 95%.

$$CI(BE) = BE \pm Z_{1-\alpha/2} \times \sqrt{Var(BE)}$$

$$CI(IPE) = IPE \pm Z_{1-\alpha/2} \times \sqrt{Var(IPE)}$$

Where:

CI(BE)	confidence interval of 95% for total baseline emissions
CI(IPE)	confidence interval of 95% for total indirect project emissions
$Z_{1-\alpha/2}$	percentile of normal distribution for a 95% confidence interval ($\alpha = 5\%$)
Var(BE)	estimated variance for total baseline emissions
Var(IPE):	estimated variance for total indirect project emissions

Finally, for total baseline emissions the lower 95% boundary is taken and for the indirect project emissions the upper 95% boundary is taken to have a conservative calculation of emission reductions.

Table 8: Survey Parameter Results

Survey	Parameter	07-12/2014		2015		01-06/2016	
		Baseline	Project	Baseline	Project	Baseline	Project
Survey 1 (04/2015)	Average emissions per passenger expanded gCO_2	2,449	639	2,418	632	2,397	624
	Cv (%)	1.02%	3.02%	1.02%	3.02%	1.02%	3.01%
	STDEV (per passenger)	25.1	19.3	24.8	19.1	24.6	18.8
	Lower 95% boundary gCO_2/passenger	2,400	601	2,369	595	2,349	587
	Upper 95% boundary gCO_2/passenger	2,498	676	2,466	670	2,446	661
Survey 2 (06/2015)	Average emissions per passenger expanded gCO_2	2,137	299	2,107	297	2,092	293
	Cv (%)	1.25%	2.52%	1.25%	2.51%	1.25%	2.51%
	STDEV (per passenger)	26.7	7.5	26.3	7.5	26.1	7.4
	Lower 95% boundary gCO_2/passenger	2,085	284	2,055	282	2,041	278
	Upper 95% boundary gCO_2/passenger	2,190	314	2,158	312	2,143	307

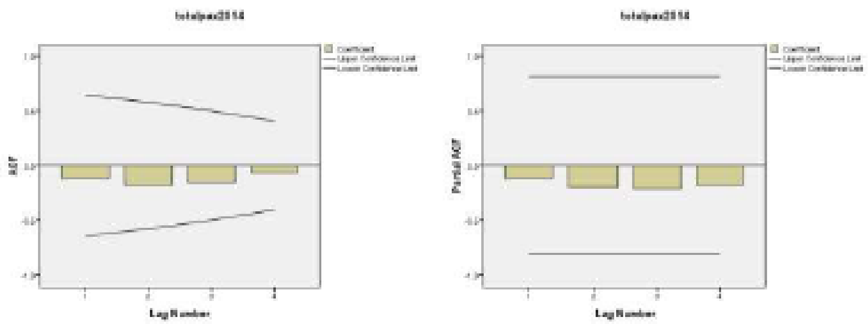
Source: File 2a/b

STATISTICAL TESTS SURVEY[21]

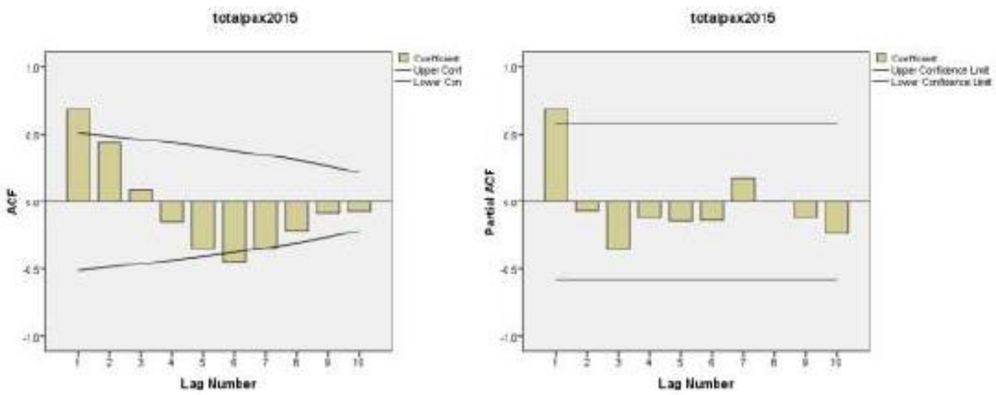
The test and re-test is used – amongst others - to identify if the system has seasonality.

To evaluate the seasonality of passenger flows an analysis of the autocorrelation functions and partial autocorrelation of the residuals for the first difference of the time series (removing the trend component of the series) is realized. The analysis is done for the seasons from July/2014 to December/2014, from January/2015 to December/2015 and from January/2016 to June/2016.
The results are presented in the following Figures.

Seasonality from July/2014 to December/2014

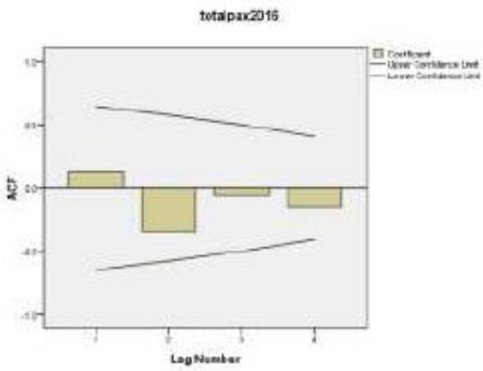


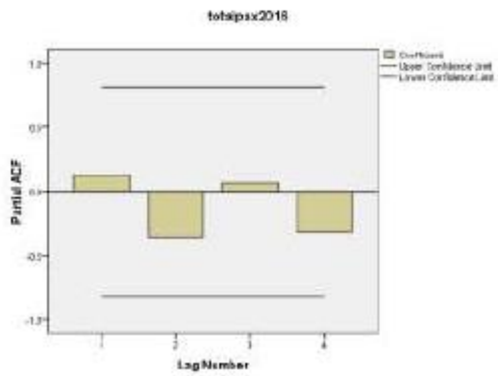
Seasonality from January/2015 to December/2015



[21] See Tests in File 21

Seasonality from January/2016 to June/2016





When the lag functions exceed either limit of the confidence interval associated, this indicates that this order is the seasonality of the series. Thus, if the last lag exceeds the confidence limits this indicates that the series has a semi-annual seasonality. In the case of passenger data of DMRC (July/2014 to December/2014) and January/2016 to June/2016, all legs are under the confidence interval so no repetition of a series and no seasonality can be observed. In the case of passenger data of DMRC Jan/2015 to June/2015, the boundary line cuts the lag however only very slightly. However, this was not observed in the year before nor in the year thereafter and is therefore not considered as relevant.

Evaluation of Data Consistency

For the assessment of consistency a mean difference test is performed through a t – Student test, where the differences presented between both measurements are evaluated, for:

- Proportion of users that use each type of modes of transport and
- 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. The test is carried out for average emissions, which implicitly compares the use of transport modes and the average distance per mode, since these are the parameters used for estimation of total emission and average emissions per passenger. The mean difference test for the average emissions between the initial sample and test-retest is performed with a t-Student test corresponding to parametric statistical methods and assuming that the two populations are independent and come from a normal distribution. With robust sample sizes, as is the case with a sample of more than 4,000 surveys, the normal distribution assumption comes under the Central Limit Theorem. Therefore, it becomes unnecessary to carry out tests on the empirical distribution of the sample with methods such as the Mann Whitney non-parametric U test and the Wilcoxon T test.

For 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. The test applied is performed in two steps. The first step determines whether the variability between measurements is similar or different, for which a test of variances is performed between the two measurements. The second step according to the results of the variances test is done with a mean difference test (average emissions per passenger) between the two measurements to the homogeneity of variances (similar variances) or heterogeneity of variances (different variances).

Step 1: Hypothesis Test for Homogeneity of Variances

The hypothesis proposed system is as follows:

$$H_0: \sigma_1^2 = \sigma_2^2 \quad \text{Vs.} \quad H_A: \sigma_1^2 \neq \sigma_2^2$$

The test statistic is:

$$f_c = \frac{s_1^2}{s_2^2}, \text{where } \ f_c \sim F(n-1, m-1)$$

Where:

$s_1^2 y s_2^2$	variance sample for the first and second measurements, respectively
n and m	sample sizes of the first and second measurements, respectively

Decision criterion:

H_0 is rejected if $f_c < f_{\frac{\alpha}{2}}(n-1, m-1)$, where $\alpha = 0{,}05$

where $f_{\frac{\alpha}{2}}$: corresponds to the $\frac{\alpha}{2}$ percentile of the Fisher's probability distribution

Step 2: <u>Hypothesis Test for Mean Difference</u>

a. Under homogeneity of variances between both samples

The hypothesis proposed system is as follows:

$H_0: \mu_1 = \mu_2 \quad \text{Vs.} \quad H_A: \mu_1 \neq \mu_2$

The test statistic is:

$$T_c = \frac{\overline{X}_n - \overline{Y}_m}{\sqrt{\left(\frac{1}{n} + \frac{1}{m}\right) S_p}}, \text{ where } T_c \sim t(m+n-2)$$

Where:

$$S_p = \frac{\sum_{i=1}^{n}(X_i - \overline{X}_n)^2 + \sum_{i=1}^{m}(Y_i - \overline{Y}_m)^2}{n+m-2}$$

n and m	simple sizes of the first and second measurements, respectively
X_n and Y_m	average emissions of the first and second measurements, respectively

Decision criterion:

H_0 is rejected if $|T_c| > t_{1-\frac{\alpha}{2}}(n+m-2)$, where $\alpha = 0{,}05$

Where:

$t_{1-\frac{\alpha}{2}}$	corresponds to the $1 - \frac{\alpha}{2}$ percentile of the T-Student's probability distribution

b. Under heterogeneity of variances between both samples

The hypothesis proposed system is as follows:

$H_0: \mu_1 = \mu_2 \quad \text{Vs.} \quad H_A: \mu_1 \neq \mu_2$

The test statistic is:

$$T_c = \frac{\overline{X}_n - \overline{Y}_m}{\sqrt{\left(\frac{s_{1,n}^2}{n} + \frac{s_{2,m}^2}{m}\right)}}, \text{ donde } T_c \sim t(f-1)$$

Where:

$f = \min\{m; n; m+n-2\}$

n and m — sample sizes of the first and second measurements, respectively
X_n and Y_m — average emissions of the first and second measurements, respectively
s_1^2 and s_2^2 — variance sample for the first and second measurements, respectively

Decision criterion:

H_0 is rejected if $|T_c| > t_{1-\frac{\alpha}{2}}(f-1)$, where $\alpha = 0,05$

Where.

$t_{1-\frac{\alpha}{2}}$ corresponds to the $1-\frac{\alpha}{2}$ percentile of the T-Student's probability distribution

The following Tables show the results for the tests of variances and mean difference, respectively. The result of the test for variances indicates that two measurements have equal variances for the project emissions and different variances for baseline emissions. Due to these results a test of mean difference under equal variance assumed (project line) and another under equal variance not assumed (project) was realized. Results indicate that surveys are consistent.

Table 9: Results of Test for Equality of Variances in 2014

Parameter	H_0: The variance of the BE is idem 1st and 2nd measurement in 2014	H_0: The variance of the IPE is idem 1st and 2nd measurement in 2014
F- Value	1.439	329.040
Sig	0.23	0.000
Decision	Variance is statistically similar between both measurements	Variance is statistically different between both measurements

Table 10: Results of Test for Mean Difference

Parameter	H_0: The average baseline emission per passenger is idem 1st and 2nd measurement in 2014	H_0: The average indirect project emissions per passenger is idem 1st and 2nd measurement in 2014
t- value	7.43	14.564
Sig	0.000	0.000
Decision	Average baseline emissions per passenger are statistically different for both measurements	Average indirect project emissions per passenger are statistically different for both measurements

Table 11: Results of Test for Equality of Variances in 2015

Parameter	H_0: The variance of the BE is idem 1st and 2nd measurement in 2015	H_0: The variance of the PE is idem 1st and 2nd measurement in 2015
F- Value	1.379	327.502
Sig	0.240	0.000
Decision	Variance is statistically similar between both measurements	Variance is statistically different between both measurements

Table 12: Results of Test for Mean Difference

Parameter	H_0: The average baseline emission per passenger is idem 1st and 2nd measurement in 2015	H_0: The average indirect project emissions per passenger is idem 1st and 2nd measurement in 2015
t- value	7.418	14.492
Sig	0.000	0.000
Decision	Average baseline emissions per passenger are statistically different for both measurements	Average indirect project emissions per passenger are statistically different for both measurements

Table 13: Results of Test for Equality of Variances in 2016

Parameter	H_0: The variance of the BE is idem 1st and 2nd measurement in 2016	H_0: The variance of the PE is idem 1st and 2nd measurement in 2016
F- Value	1.409	330.140
Sig	0.235	0.000
Decision	Variance is statistically similar between both measurements	Variance is statistically different between both measurements

Table 14: Results of Test for Mean Difference

Parameter	H_0: The average baseline emission per passenger is idem 1st and 2nd measurement in 2016	H_0: The average indirect project emissions per passenger is idem 1st and 2nd measurement in 2016
t- value	7.423	14.586
Sig	0.000	0.000
Decision	Average baseline emissions per passenger are statistically different for both measurements	Average indirect project emissions per passenger are statistically different for both measurements

To evaluate the users' proportion per modes of transport, the Pearson's Chi Square test is realized, where categories are defined for each mode of transport. The test Pearson's Chi Square is used to evaluate whether the two measurements are related in terms of distribution in the use of modes. Below is the system of hypotheses, the test statistic and the decision criteria.

The hypothesis proposed system is as follows:

H_0: the measurements are not related Vs. H_A: the measurements are related

The test statistic is:

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{\left(O_{ij}-E_{ij}\right)^2}{E_{ij}}, \text{where } \chi^2 \sim \chi(r-1, c-1)$$

Where:

O_{ij}	the observed frequency of row *i* and column *j*
E_{ij}	the expected frequency of row *i* and column *j*
r and c	number of categories in the rows and columns, respectively (degrees of freedom)

Decision criterion:

H_0 is rejected if $\chi^2 < \chi_{1-\alpha}(r-1, c-1)$, where $\alpha = 0{,}05$

Where:

$\chi_{1-\alpha}$ corresponds to the $1-\alpha$ percentile of the Chi-Square probability distribution

The following Tables show the contingency tables and the results of the Chi-Square. The results indicate that, for the baseline as well as for the project, the two measurements show distribution patterns using similar modes (rejection of the null hypothesis). This confirms the consistency of results considering that the two measurements come from the same population. Differences in the use of some modes affect the estimation of emissions.

Table 16: Results of Pearson´s Chi Square Test for Modes Used in the Baseline

Vehicle type	Mode		phase 1	phase 2	total
Bus	1	count	8	9	17
		expected count	8.608493	8.391507	17
suburban rail	2	count	0	0	0

		expected count	0	0	0
Taxis	3	count	71	70	141
		expected count	71.39985	69.60015	141
Passenger cars	4	count	1802	1769	3571
		expected count	1808.29	1762.71	3571
Motorcycles	5	count	86	67	153
		expected count	77.47644	75.52356	153
Motorized rickshaws	6	count	96	96	192
		expected count	97.22533	94.77467	192
Cycle	7	count	0	0	0
		expected count	0	0	0
		total	2063	2011	4074

Table 17: Pearson's Chi Square Test

Pearson's Chi Square	**2.066965**
p-value	**0.990364**

Calculated p-value (or Asymp. Sig) is 0.99 > α=0.05 as a reason Ho is accepted.

Table 18: Results of Pearson´s Chi Square Test for Modes Used in the Project- Exit Station to Destination (Cross-tabulation)

Mode exit destination * phase Crosstabulation

			phase		
			1	2	Total
Mode exit destination	0	Count	0	2011	2011
		Expected Count	1018.3	992.7	2011.0
	1	Count	284	0	284
		Expected Count	143.8	140.2	284.0
	3	Count	21	0	21
		Expected Count	10.6	10.4	21.0
	4	Count	305	0	305
		Expected Count	154.4	150.6	305.0
	5	Count	209	0	209
		Expected Count	105.8	103.2	209.0
	6	Count	1014	0	1014
		Expected Count	513.5	500.5	1014.0
	7	Count	230	0	230
		Expected Count	116.5	113.5	230.0
Total		Count	2063	2011	4074
		Expected Count	2063.0	2011.0	4074.0

Table 19: Results of Pearson´s Chi Square Test for Modes Used in the Project- Origin to Entry Station (Cross-tabulation)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.074E3[a]	6	.000
Likelihood Ratio	5.647E3	6	.000
Linear-by-Linear Association	3.207E3	1	.000
N of Valid Cases	4074		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.37.

Pearson's Chi Square Test

The mode used from origin to project entry of phase 1 and phase 2 are not independent. Assymp.sig.=0.000<0.05 →rejected Ho

Table 20: Results of Pearson´s Chi Square Test for Modes Used from origin to entry station of Project

Mode origin entry * phase Crosstabulation

			phase		
			1	2	Total
Mode origin entry	1	Count	298	284	582
		Expected Count	294.7	287.3	582.0
	3	Count	104	21	125
		Expected Count	63.3	61.7	125.0
	4	Count	217	304	521
		Expected Count	263.8	257.2	521.0
	5	Count	314	209	523
		Expected Count	264.8	258.2	523.0
	6	Count	1108	796	1904
		Expected Count	964.2	939.8	1904.0
	7	Count	22	397	419
		Expected Count	212.2	206.8	419.0
Total		Count	2063	2011	4074
		Expected Count	2063.0	2011.0	4074.0

Table 21: Results of Pearson´s Chi Square Test for Modes Used in the Exit- station to Destination

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.772E2[a]	5	.000
Likelihood Ratio	555.335	5	.000
Linear-by-Linear Association	23.275	1	.000
N of Valid Cases	4074		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 61.70.

The mode used from origin to project entry of phase 1 and phase 2 are not independent. Assymp.sig.=0.000<0.05→rejected Ho

All results after the test showed that Ho was rejected. It presents that both the baseline and project show the distribution modes and phases are related. This confirms the consistency of results considering that the two measurements come from the same population.

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.

Although the Cronbach Alpha is a measurement to measure the reliability of a measurement scale or assessment tool, this measure can be adapted for the analysis of reliability and consistency of the comparative results of two or more measurements. In this case, this tool is used to assess whether the two measurements under the same instrument and methodological approach are concordant and consistent results in the estimation of emissions before and after the project. This involves the comparison of results for the two measurement periods on the same unit of analysis. For this purpose, and considering that the application of the instrument is made to different users for both measurements the units of analysis are stations of DMRC. Thus, the comparison reduces the contrast between the average emissions for the two measurement periods.

If a correlation between BE and IPE exists, 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:

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

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.

The following Table presents the results for the two versions of Cronbach Alpha. According to these results it is evident that the instrument and its results (measurements) are consistent and reliable for measuring emissions. It has been empirically established that values above 0.7 means adequately consistent measurements.

Table 22: Results of Cronbach Alpha Test

Measurement	Baseline	Project
Cronbach Alpha (Method of linear correlation)	0.797	0.757

The result of Cronbach alpha test for baseline and project are 0.797 and 0.757 respectively. These evidences prove clearly that the instrument and its results (measurements) are consistent for measuring emissions. According to method of linear correlation, the Cronbach alpha value of baseline and project are higher than 0.7. Thus, it implies that there is adequate consistency between the two measurements for both baseline and project.

Conclusion Survey

Following the results above, the statistical analysis shows that the emissions for both baseline and indirect project emissions are statistically different between two measurements. However, the Cronbach's alpha presents that these differences are not due to the inconsistency or methodological error and due to changes of use of transport modes only. This implies that the measurements for the project and baseline are fully reliable and consistent.

B. OCCUPATION RATE TAXIS

Sampling Design

The sampling design is based on ACM0016 which is also included in the registered PDD as Annex A.6.1. The PDD details the sites, the time and the days for sampling. This to ensure that the baseline occupation rate is comparable to the monitored project occupation rate. Both occupation rate studies where performed with the same principles[22].

The objective of the study is to determine the occupancy rate of taxis. The actual number of passengers is counted in a given point within a given time period. Only taxis are included. Only 4-wheel taxis are included. Only persons aged 2 and above are counted i.e. infants are excluded. The counting is based on visual occupation i.e. counting the number of passengers occupying the vehicle excluding the driver. The procedures to establish visual occupation are:

- 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 study is done on weekdays.
- The occupation rates are: 0 passengers (only taxi driver), 1, 2, 3, 4, 5 or more passengers.
- Field data is collected. Coverage of the occupation counts should be higher than 95% of the number of taxis that cross the checkpoint. One hundred per cent coverage is desired.
- Occupancy is the number of passengers using the vehicle. The occupancy is determined of all taxis passing the control points.
- 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.

The study was carried out from 17/12/2-14 to 24/12/2014 with 3 days per site. The selected sites were Sansad Marg, Connaught Place, opposite to Janter Manter and Panchkuin Road (opposite Metro pillar 26), towards Connaught Place, idem to the baseline sites.

Collected Data

Data collected is the number of passengers per taxi. The following table shows the results.

Table 23: Results Occupation Rate Study Taxis, 2014[23]

Number of passengers	Number of taxis with the indicated number of passengers	percentage
0 passenger	339	14%
1 passenger	412	17%
2 passengers	391	16%
3 passengers	372	16%
4 passengers	367	15%
5 passengers	340	14%

[22] See File 19a/b for project study and File 19c for baseline study

[23] File 19a/b

> 5 passengers	172	7%

Analysis of Collected Data

The following table shows the analysis of the collected data.

Table 24: Calculations Occupation Rate Taxis, 2014[24]

Parameter	Value
Total number of passengers	6,510
Total number of taxis	2,393
Average occupation rate	2.72
Standard deviation	1.6
Standard error of average	0.033
Upper and lower 95% confidence interval	2.66 and 2.79

Demonstration of Confidence and Precision

The sampling size has been checked for a 95% confidence interval and a 10% relative precision level, based on the following formulae:

$$N = \frac{1.96^2 \times \left(\frac{SD}{AV}\right)^2}{0.1^2}$$

Where:

N	sample size
SD	Standard deviation
AV	Average (mean)
1.96	95% confidence interval
0.1	relative precision level

The required sample size calculated ex-post based on actual SD is 137 units whilst the actual sample size was 2,393 units i.e. around 17x more thus showing compliance with the confidence level and precision level required.

To check the reliability of the sample the relative precision level is calculated using the following formulae:

$$R = \frac{0.5 \times (CIW)}{AV} \times 100\%$$

Where:

R	Reliability (relative precision level)
CIW	width of confidence interval
AV	Average (mean)

CIW is the difference of the upper and the lower 95% confidence interval as listed in table 24 being 0.13. Reliability or the relative precision level is therefore 2% which is far better than the 10% required by the methodology.

C. OCCUPATION RATE MOTORIZED RICKSHAWS

Sampling Design

The sampling design is based on ACM0016 which is also included in the registered PDD as Annex A.6.2. The PDD details the sites, the time and the days for sampling. This to ensure that the baseline occupation rate is comparable to the monitored project occupation rate. Both occupation rate studies where performed

[24] File 19a

with the same principles[25].

The objective of the study is to determine the occupancy rate of motorized rickshaws. The actual number of passengers is counted in a given point within a given time period. Only motorized rickshaws are included. Only persons aged 2 and above are counted i.e. infants are excluded. The counting is based on visual occupation i.e. counting the number of passengers occupying the vehicle excluding the driver. The procedures to establish visual occupation are:

- 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 study is done on weekdays.
- The occupation rates are: 0 passengers (only driver), 1, 2, 3 passengers.
- Field data is collected. Coverage of the occupation counts should be higher than 95% of the number of motorized rickshaws that cross the checkpoint. One hundred per cent coverage is desired.
- Occupancy is the number of passengers using the vehicle. The occupancy is determined of all motorized rickshaws passing the control points.
- 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.

The study was carried out 17/18/19/22/23 December 2014, 1/9/10/11/12/13/16//17/18/19/20/21/23 February 2015 with 3 days per site. The selected sites were Sansad Marg, Panchkuin Road, Vikas Marg, GT Road, Patel Road, and Najafgarh Road, idem to the baseline sites.

Collected Data

Data collected is the number of passengers per motorized rickshaw. The following table shows the results.

Table 25: Results Occupation Rate Study Motorized Rickshaw, 2014-5[26]

Number of passengers	Number of motorized with the indicated number of passengers	percentage
0 passenger	1,762	25%
1 passenger	1,919	27%
2 passengers	1,888	26%
3 passengers	1,603	22%

Analysis of Collected Data

The following table shows the analysis of the collected data.

Table 26: Calculations Occupation Rate Motorized Rickshaws, 2014-5[27]

Parameter	Value
Total number of passengers	10,504
Total number of motorized rickshaws	7,172
Average occupation rate	1.46
Standard deviation	1.1
Standard error of average	0.013
Upper and lower 95% confidence interval	1.44 and 1.49

Demonstration of Confidence and Precision

The sampling size has been checked for a 95% confidence interval and a 10% relative precision level, based on the following formulae:

[25] See File 20a and 19b for project study and File 20b for baseline study

[26] File 19b

[27] File 19b

$$N = \frac{1.96^2 \times \left(\frac{SD}{AV}\right)^2}{0.1^2}$$

Where:

N	sample size
SD	Standard deviation
AV	Average (mean)
1.96	95% confidence interval
0.1	relative precision level

The required sample size calculated ex-post based on actual SD is 213 units whilst the actual sample size was 7,172 units i.e. around 33x more thus showing compliance with the confidence level and precision level required.

To check the reliability of the sample the relative precision level is calculated using the following formulae:

$$R = \frac{0.5 \times (CIW)}{AV} \times 100\%$$

Where:

R	Reliability (relative precision level)
CIW	width of confidence interval
AV	Average (mean)

CIW is the difference of the upper and the lower 95% confidence interval as listed in table 26 being 0.05. Reliability or the relative precision level is therefore 2% which is far better than the 10% required by the methodology.

SECTION E. Calculation of emission reductions or GHG removals by sinks

E.1. Calculation of baseline emissions or baseline net GHG removals by sinks

PROCEDURE

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

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)

The expansion factor is applied to each surveyed passenger in accordance with the survey sample design to get the total baseline emissions of the period (week) surveyed. The average of the baseline emissions per passenger of the period (week) of the two surveyed periods (week) are calculated and multiplied with the total passengers transported in the monitoring period. For baseline emissions, the lower limit of the 95% confidence interval is taken for the expanded baseline emissions per passenger.

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

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

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

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

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

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

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

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

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

For buses the following formula applies as option (1) of the methodology was chosen in the PDD i.e. annual determination of the EF:

$$EF_{KM,i,y} = \frac{\sum_x \left(SFC_{i,x,y} \cdot NCV_{x,y} \cdot EF_{CO2,x,y} \cdot N_{x,i}\right)}{N_i}$$

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)
i	Relevant vehicle category
x	Fuel type
y	Year of the crediting period

For all other vehicle categories except buses and suburban rail option (2) was chosen with the EF being fixed for the crediting period but with an annual improvement factor (IR) and therefore the following formula applies:

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

Where:

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

For train (idem for metro) using electricity the EF is calculated as.

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

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

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

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

Determination of EF Cars, Motorized Rickshaws, Taxis and Motorcycles for Monitoring Period

The following table shows the share per fuel type baseline in the registered PDD and as monitored.

Table 27: Share per Fuel Type Cars

Fuel Type	Registered PDD	Monitoring Period
Gasoline	81.8%	48.8%
Diesel	10.6%	42.2%
CNG	7.6%	9.7%

Source: Registered PDD section B.6.2., Monitored: File 4, Gov. of NCT, Transport Department, 2014

In the case of taxis and motorized rickshaws due to government regulations all vehicles are CNG[28]. Motorcycles are all gasoline. Therefore, no change of vehicle fuel share took place in these types of vehicles.

The following table shows the bio-fuel shares for each year of the monitoring period.

Table 28: Bio-Fuel Share

	Diesel	Gasoline
2014	0.1%	1.4%
2015	0.1%	2.3%
2016	0.1%	1.9%

Source: USDA GAIN Report, 24/06/2016, Table 2 and 4 (File 10)

The following table lists all parameters used for the calculations of the new EF for cars, taxis and motorized rickshaws.

[28] The Supreme Court of India mandated that all commercial passenger vehicles including taxis and motorized 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 15)

Table 29: Parameters for Determination EF Cars, Taxis and Motorized Rickshaws Monitoring Period

Parameter	Description	Unit	Value	Source
$SFC_{C,G}$	Specific fuel consumption gasoline cars	g/km	53.98	PDD B.6.2. based on year 2008
$SFC_{C,D}$	Specific fuel consumption diesel cars	g/km	48.59	PDD B.6.2. based on year 2008
$SFC_{C,CNG}$	Specific fuel consumption CNG cars	g/km	64.0	PDD B.6.2. based on year 2008
$N_{C,G}/N_C$	Share gasoline, diesel, CNG cars	%	See table 27	File 4
OC_C	Occupation rate cars	passengers	1.60	PDD B.6.2.
NCV_G	Net calorific value gasoline	MJ/kg	43.9	File 9
NCV_D	Net calorific value diesel	MJ/kg	42.7	File 9
NCV_{CNG}	Net calorific value CNG	MJ/m^3	35.6	File 9
$EF_{CO2,G}$	Emission factor CO_2 gasoline	gCO_2/MJ	67.5	IPCC 2006, table 1.4
$EF_{CO2,D}$	Emission factor CO_2 diesel	gCO_2/MJ	72.6	IPCC 2006, table 1.4
$EF_{CO2,CNG}$	Emission factor CO_2 CNG	gCO_2/MJ	54.3	IPCC 2006, table 1.4
$EF_{CH4,CNG,C}$	Emission factor CH_4 of CNG cars	gCO_{2eq}/km	11.8	PDD B.7.1. based on IPCC, 2006, table 3.2.4
$SFC_{TR,CNG}$	Specific fuel consumption CNG motorized rickshaws	g/km	32.0	PDD B.6.2. based on year 2009
$SFC_{T,CNG}$	Specific fuel consumption CNG taxis	g/km	64.0	PDD B.6.2. based on year 2008
$SFC_{T,G}$	Specific fuel consumption CNG taxis of gasoline (dual-fuel vehicles)	g/km	6.07	PDD B.6.2. based on year 2008
OC_{TR}	Occupation rate motorized rickshaws	passengers	1.40	PDD B.6.2.
OC_T	Occupation rate taxis	passengers	1.16	PDD B.6.2.
None	Specific weight of gasoline	kg/l	0.759	File 9
None	Specific weight of CNG	kg/m^3	0.717	File 9
ITR	Technology improvement factor	no unit	0.99	ACM0016

Buses

Based on the PDD the EF buses is updated based on updated data of SFC. The following table includes all data required for the calculation of EF buses.

Table 30: Parameters for Determination EF_{PKM} Buses

Parameter	Description	Unit	Monitoring Period	Source
$SFC_{B,CNG}$	Specific fuel consumption CNG buses	g/km	429	File 6
OC_B	Occupation rate buses	passengers	43	PDD B.6.2.
NCV_{CNG}	Net calorific value CNG	MJ/m^3	35.6	File 9
$EF_{CO2,CNG}$	Emission factor CO_2 CNG	gCO_2/MJ	54.3	IPCC 2006, table 1.4
$EF_{CH4,CNG,B}$	Emission factor CH_4 of CNG buses	gCO_{2eq}/km	192.9	PDD B.7.1. based on IPCC, 2006, table 3.2.4
None	Specific weight of CNG	kg/m^3	0.717	File 9

All urban buses due to government regulations all vehicles are CNG[29].

[29] The Supreme Court of India mandated that all commercial passenger vehicles including taxis and motorized 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 15)

Suburban Rail

Based on the PDD the EF suburban rail is updated based on updated data of passengers and electricity consumption. The following table includes all data required for the calculation of EF suburban rail.

Table 31: Parameters for Determination EF_{PKM} Suburban Rail

Parameter	Description	Unit	Monitoring Period	Source
EC_{EL}	Electricity consumption per annum	MWh	2,816	File 7
P_{EL}	Passengers transported per annum	passengers	3,055,900	File 8
TD_{EL}	Average trip distance of passenger	km	28.8	PDD B.6.2.
$EF_{grid,CM}$	Emission factor of the grid based on the Combined Margin	tCO_2/MWh	0.8409	PDD B.6.2.
TDL	Transmission losses grid	None	3.91%	PDD B.6.2.

The following table summarizes the EF_{PKM} used for 2014, 2015 and 2016 per mode.

Table 32: EF per PKM per Mode (gCO_2/pkm)

Mode	2014	2015	2016
Passenger cars	92	91	90
Taxis	164	162	161
Motorized rickshaws	67	66	65
Motorcycles	32	32	31
Bus	31	31	31
Sub-urban rail	28	28	28

Source: File 5

Baseline Results

Table 32: Baseline Emission Calculation

Parameter	07-12/2014	2015	07-12/2016
Passengers	249,134,989	515,522,458	263,796,293
Baseline emissions per passenger (lower 95% confidence interval)[30] in gCO_{2e}	2,243	2,212	2,195
Baseline emissions tCO_2	**558,686**	**1,140,336**	**579,033**

Source: CER spreadsheet

The total baseline emissions of the monitoring period are **2,278,055 tCO_{2eq}**

E.2. Calculation of project emissions or actual net GHG removals by sinks

Project emissions are calculated as follows:

$$PE_y = DPE_y + IPE_y$$

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)

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

Where:

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

[30] Average of 2 surveys

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

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

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. The expansion factor is applied to each surveyed passenger in accordance with the survey sample design to get the total indirect project emissions of the period (week) surveyed. The average of the indirect project emissions per passenger of the period (week) of the two surveyed periods (week) are calculated and multiplied with the total passengers transported in the monitoring period. For indirect project emissions the upper limit of the 95% confidence interval is taken for the expanded indirect project emissions per passenger.

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

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

The following table lists the parameters required for calculating DPE.

Table 33: Project Parameters

Parameter	Description	Unit	Value	Source
EC_{PJ}	Traction electricity consumption project	kWh	431,212,171	File 1
$EF_{grid,CM}$	Emission factor of the grid based on the Combined Margin	kgCO_2/kWh	0.8409	PDD B.6.2.
TDL	Transmission losses grid	None	3.91%	PDD B.6.2.

The following table lists the parameters required for calculating IDPE. For IDPE the same EF_{PKM} are used as for the baseline.

Table 34: Parameters for Indirect Project Emission Calculation

Parameter	07-12/2014	2015	07-12/2016
Passengers	249,134,989	515,522,458	263,796,293
Indirect project emissions per passenger (upper 95% confidence interval)[31] in gCO_{2e}	495	491	484
Indirect Project Emissions tCO_2	**123,322**	**253,122**	**127,677**

Source: CER spreadsheet

Table 35: Project Emissions in tCO_{2e}

Parameter	07-12/2014	2015	07-12/2016
Direct project emissions	92,194	184,202	100,389

[31] Average of 2 surveys

Indirect project emissions	123,322	253,122	127,677
Total Project Emissions	**215,516**	**437,323**	**228,066**

Source: CER spreadsheet

The total project emissions of the monitoring period are **880,905 tCO_{2eq}**

For details see CER spreadsheet.

E.3. Calculation of leakage

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 ($LE_{UP,y}$).

Leakage emissions are calculated as follows:

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

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

If LE_y < 0, then leakage is not included
If LE_y > 0, then leakage is included

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. The monitored value is 85% (File 6) and the baseline value 57% (PDD B.6.2.). The load factor has therefore not decreased and no leakage from load factor change of buses is included.

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. The monitored value is 2.72 (File 19a and 19b) and the baseline value 1.16 (PDD B.6.2.). The load factor has therefore not decreased and no leakage from load factor change of taxis is included.

Determination of emissions due 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.[32]

DMRC has not taken away any existing road space. Therefore, based on ACM0016 Version 04.0 no monitoring is required (see PDD section B.6.1.).

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 (see PDD section B.6.1.).

[32] Paragraph 74 of ACM0016 Version 04.0

E.4. Summary of calculation of emission reductions or net GHG removals by sinks

Item	Baseline emissions or baseline net GHG removals by sinks (t CO_2e)	Project emissions or actual net GHG removals by sinks (t CO_2e)	Leakage (t CO_2e)	GHG emission reductions or net GHG removals by sinks (t CO_2e) achieved in the monitoring period		
				Up to 31/12/2012	From 01/01/2013	Total amount
Total	2,278,055	880,905	0	0	1,397,150	1,397,150

E.5. Comparison of actual emission reductions or net GHG removals by sinks with estimates in registered PDD

Item	Values estimated in ex ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO_2e)	1,084,062[33]	1,397,150

E.6. Remarks on difference from estimated value in registered PDD

Emission reductions are 29% higher than the PDD estimated. At the time of PDD writing a survey was realized of passengers on Phase I metro lines, as Phase II lines were not yet operational. This means that results were a gross estimate.

The major reason for increased Emission Reductions are the higher emissions per passenger in the baseline shown in the following table:

Table 36: Comparison Projected and Actual Emissions per Passenger Baseline in gCO_{2e}/passenger

Parameter	07-12/2014	2015	07-12/2016
Projected in PDD	1,240	1,228	1,215
Actual Monitored	2,243	2,212	2,195
Increase Actual in % of Projected	81%	80%	81%

Reasons for higher baseline per passenger emissions are an increased mode shift due to the existence of a network with the possibility of making the entire trip on metro makes which the metro more attractive for taxi and car users. At the same time due to economic growth more persons have access to a private car than at the time of the original survey realized for projection reasons 2009. Also city growth results in increased distances travelled (this is also due to the increase of the network as the 1st survey could only be realized when Phase I was operating of DMRC). The increased network, distances and availability of private cars is also reflected in that indirect project emissions (emission to/from the metro) are 491 gCO2 per passenger instead of projected 188gCO2 per passenger. The result is however, that emission reductions per passenger are significantly higher than projected as can be seen from the following table.

Table 37: Comparison Emission Reduction per Passenger in gCO_{2e}/passenger[34]

Parameter	07-12/2014	2015	07-12/2016
Projected in PDD	1,050	1,040	1,031
Actual Monitored	1,748	1,721	1,711
Increase Actual in % of Projected	66%	65%	66%

The emission reduction increase of 29% is therefore fully explained through the increase of emission reduction per passenger transported due to, as mentioned, more mode shift and longer trips. Total emission

[33] Calculated based on 50% of value of 2014, 100% of value of 2015 and 50% of value of 2016

[34] Baseline minus Indirect Project Emissions

reductions have not increased in the same amount as the emission reductions per passenger due to the lower than expected passenger numbers of the metro as can be seen from the following table.

Table 37: Comparison Number of Passengers

Parameter	07-12/2014	2015	07-12/2016
Projected in PDD	342,870,218[35]	725,170,511	383,433,908[36]
Actual Monitored	249,134,989	515,522,458	263,796,293
Increase Actual in % of Projected	-27%	-29%	-31%

The passenger numbers which are relevant for the revenue of the metro are thus around 30% lower than expected. The higher emission reduction per passenger does not result in increased earnings of the metro (the metro cannot charge the passenger more because he is moving from a car instead of a bus) and therefore does not influence additionality calculations.

Increased GHG reductions in the monitoring period compared to projected emission reductions are clearly explained by higher than projected average emission reductions per transported passenger and not by higher project activity (in fact project activity i.e. passenger numbers is lower than expected). Project financial feasibility and additionality is therefore not affected by this increase in emission reductions.

[35] 50% of value entire year in PDD

[36] 50% of value entire year in PDD

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

Project participant and/or responsible person/ entity	☒ Project participant ☒ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Grütter Consulting AG
Street/P.O. Box	Thiersteinerstr 22/5
Building	
City	Reinach
State/region	
Postcode	4153
Country	Switzerland
Telephone	++442088763599
Fax	
E-mail	jgruetter@transport-ghg.com
Website	www.transport-ghg.com
Contact person	
Title	CEO
Salutation	Mr.
Last name	Grütter
Middle name	Michael
First name	Jürg
Department	
Mobile	++447534241558
Direct fax	
Direct tel.	++447534241558
Personal e-mail	jgruetter@gmail.com

Project participant and/or responsible person/ entity	☒ Project participant ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Delhi Metro Rail Corporation Ltd.
Street/P.O. Box	Fire Brigade Lane, Barakhamba Road,
Building	Metro Bhawan
City	New Delhi
State/region	Delhi
Postcode	110001
Country	India
Telephone	+91-011- 22484743
Fax	+91-011- 22484743
E-mail	saverma@dmrc.org
Website	www.delhimetrorail.com
Contact person	S.A.Verma
Title	Additional General Manager

Salutation	Mr.
Last name	Verma
Middle name	Adhar
First name	Sant
Department	Environment
Mobile	09811106868
Direct fax	+91-011- 22484743
Direct tel.	+91-011- 22484743
Personal e-mail	saverma_rs@yahoo.com

\- - - - -

Document information

Version	*Date*	*Description*
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01	28 May 2010	EB 54, Annex 34. Initial adoption.

Decision Class: Regulatory
Document Type: Form
Business Function: Issuance
Keywords: monitoring report