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	10/10/2018	
Monitoring period number and duration of this monitoring period	4th monitoring period 01/07/2016 to 29/06/2018	
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	1,180,285[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	1,351,477

[1] Calculated based on 50% of value of 2016 (565,077*.05), 100% of value of 2017 (591,082) and the value of 2018 which was reported for 4 months transformed to 6 months (205,443/4*6)

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 **1,351,477 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

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

- Tool 05 "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion
- Tool Baseline emissions for modal shift measures in urban passenger transport Version 01

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[8], 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[9], 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[10]	Part of Line 3 (blue line)

Source: Verified Monitoring Report 2nd monitoring period, Table 3[11]

In total the project has 83 stations. Inderlok and Kirtinagar are shared stations Phase I and Phase II lines. Passengers from these stations are account at 50% for the project. Central Secretariat is shared with 2 Phase II lines and 1 Phase I line. Passengers are therefore accounted to 2/3 to Phase II. Dwarka Section 21 is connected to the airport line and therefore passengers are only counted at 50%.

The corridors consist of two broad gauge lines at 4.1 m centre to centre on elevated sections. For underground corridors, track centres are governed by spacing of tunnels and box design. Track structure on the main lines is broad gauge (1,676 mm) and standard gauge (1.435 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

[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] Station shared with Phase I line

[9] Station shared with Phase I line

[10] Station shared with airport link

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

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 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[12].

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.

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

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.

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 originally developed by Grütter Consulting AG[13]. It defines all responsibilities and procedures. Since approval of the 1st monitoring report staff of DMRC are realizing the monitoring of the parameters in accordance with the procedures applied formerly. This concerns passenger numbers and electricity traction consumption. All other parameters required are collected and managed by Grütter Consulting AG which authored the methodology ACM0016, the original PDD as well as the revised PDD and 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[14]

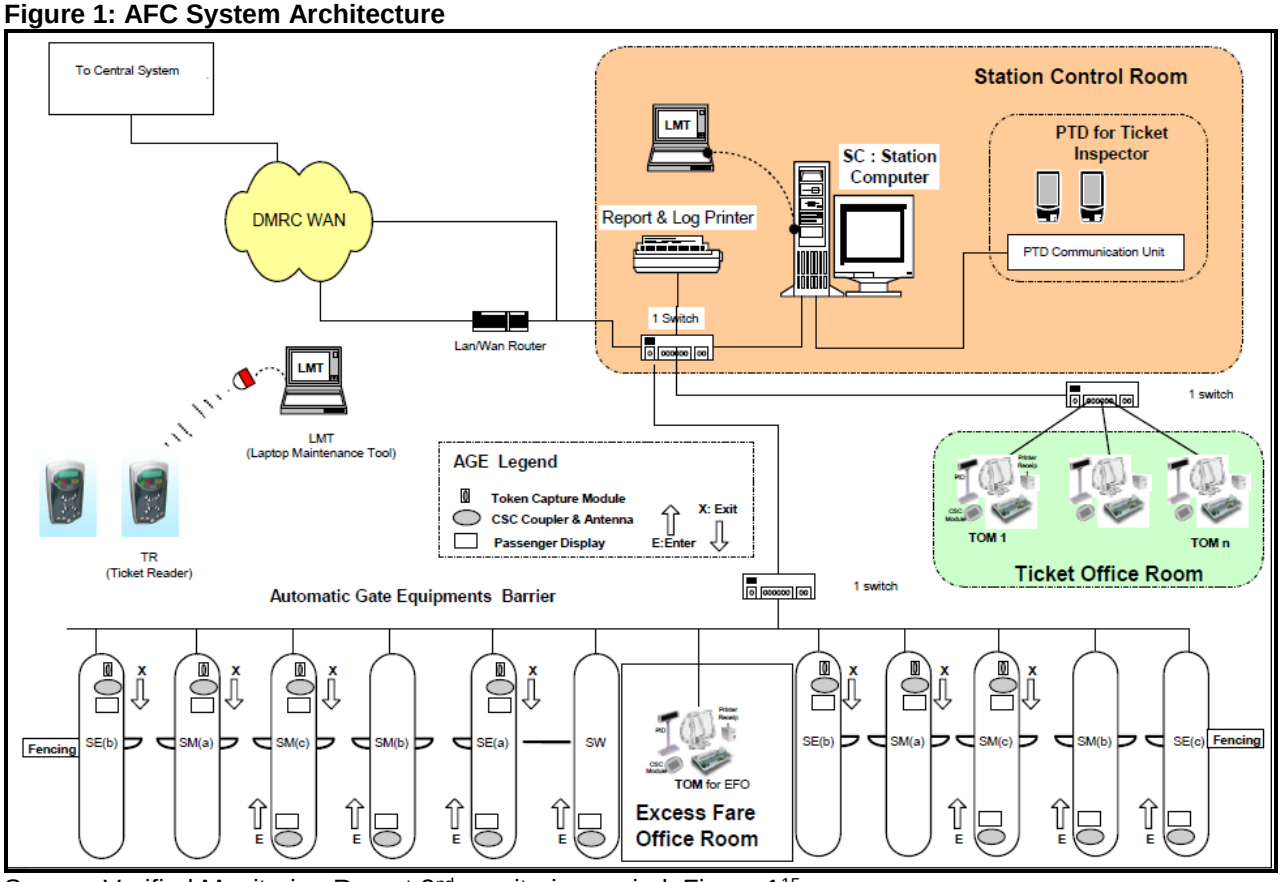
Passenger flow data is based on the AFC system (Automatic Fare Collection System) which consists of semiautomatic ticket vending machines, automatic entry-exit gates, station computer and a central server. The AFC realizes access control of passengers, ticket reading/writing, transaction collection and reports, stock management and equipment supervision. Components of the system are a Data Center (DC), Middle

[13] File 11

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

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.

Figure 1: AFC System Architecture



Source: Verified Monitoring Report 2nd monitoring period, Figure 1[15]

PASSENGER SURVEYS

No passenger surveys were realized in this monitoring period in accordance with the registered PDD.

ELECTRICITY CONSUMPTION

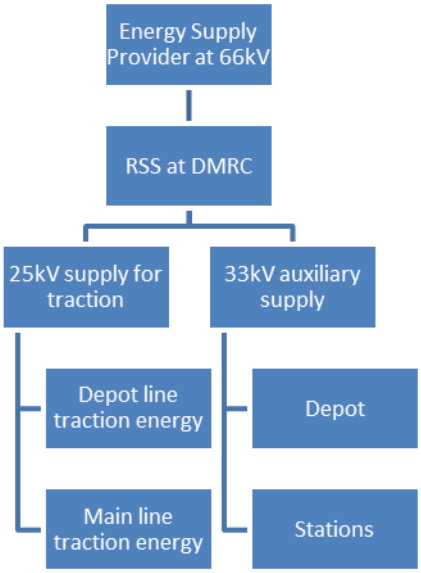
DMRC takes power from various distribution companies of Delhi and the National Capital Region. The electricity is received at 220KV, 132 KV or 66 KV level as per availability and contract agreement with the distribution companies. The electricity is stepped down at the RSS (Receiving Sub Station) of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

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

The following figure shows the energy path.

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

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 t o 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 Measurement methods and	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

procedures	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	DTC manages the urban bus fleet of Delhi. Data of all buses (not based on survey).

Measurement methods and procedures	Data for the year 2008. Entire urban bus fleet based on CNG.
Purpose of data	Baseline, project
Additional comment	

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	Northern Grid Based on average value for entire year 2009 from the National

Measurement methods and procedures	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 Measurement methods and	Recognized research institute in India; realized on various locations

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

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

The technology improvement factor IR used for cars, taxis, motorcycles, buses and motorized rickshaws is 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, Vahan 4.0 Database accessed 26.09.2018 for period 1.1.2017 to 31.12.2017 (File 4)
Value(s) of monitored parameter	Diesel: 42,277 (25.8%) Gasoline: 114,972 (62.6%) CNG: 21,330 (11.6%)
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 0.1% 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 2016, 2017 and 2018 (File 10, table 5) whilst in gasoline a share of 3.3% was used in 2016, 1.9% in 2017 and 3.2% in 2018. This bio-fuel share has been included to determine the new EF cars (File 10, table 4).

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:	**$N_{x,M}$**
Unit	Vehicles
Description	Number of motorcycles (M) using fuel type *x*
Measured/calculated/default	Measured
Source of data	Government of National Capital Territory of Delhi, Transport Department, Vahan 4.0 Database accessed 26.09.2018 for period 1.1.2017 to 31.12.2017 (File 4)
Value(s) of monitored parameter	480,309 100% gasoline Less than 0.1% electric
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:	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, 2018 (File 1)
Value(s) of monitored parameter	1,010,909,961
Monitoring equipment	Turnpike controls at stations and electronic smart cards. Only passengers are included which enter stations of the lines include in the project. Passengers on stations with connections to Phase I lines or the airport link have been counted as 50% if it connects to 1 Line of Phase II and as 66% if the station connects to 2 lines of Phase II. 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:	

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	435,209,682
Monitoring equipment	Traction energy is recorded by DMRC per line. Files 12-14 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 4: Traction Energy (monitoring period)

Year	Total car-km	Phase II car-km	Total traction energy in kWh	Phase II traction energy in kWh
01/07/2016 to 31/12/2016	100,329,687	51,348,264	221,911,213	113,579,699
2017	210,919,641	104,428,510	449,323,810	222,360,819
01/01/2017 to 30/06/2017[16]	122,215,594	54,086,410	224,129,753	99,269,164
Total	433,464,922	209,863,184	895,364,776	**435,209,682**

Source: File 3 based on File 1

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 2016-17 EMU statistics, Northern Line suburban point 32.25 (File 7)
Value(s) of monitored parameter	2,231
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual, last available year period 2016-17
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

[16] The entire month is taken as no daily values are reported. This is conservative as the energy consumption is accounted for 30 days although emission reductions are only claimed for 29 days

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 2016-17 passenger revenue statistics, Northern Line suburban, statement 12, p. 75 (File 8)
Value(s) of monitored parameter	2,677,300
Monitoring equipment	None
Measuring/reading/recording frequency:	Annual, last available year period 2016-17
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 $EC_{EL,R}$

The parameters BTD, IPTD, FEX, P_{SPER}, OC_B, OC_T, OC_{TR}, and $N_{B,T,TR}$ are all not monitored in this monitoring period but only in years 1 and 4 based on the registered PDD.

D.3. Implementation of sampling plan

No sampling and no surveys were realized in the monitoring period.

The survey parameter results were updated based on the updated emission factors for 2016/2017 and 2018

Table 5: Survey Parameter Results

Survey	Parameter	07-12/2016		2017		01-06/2018	
		Baseline	Project	Baseline	Project	Baseline	Project
Survey 1 (04/2015)	Average emissions per passenger expanded gCO_2	2,408	613	2,386	611	2,383	601
	Cv (%)	1.03%	3.07%	1.03%	3.06%	1.03%	3.06%
	STDEV (per passenger)	24.7	18.8	24.5	18.7	24.5	18.4
	Lower 95% boundary gCO_2/passenger	2,360	576	2,338	574	2,335	565
	Upper 95% boundary gCO_2/passenger	2,457	650	2,434	648	2,431	637
Survey 2 (06/2015)	Average emissions per passenger expanded gCO_2	2,100	287	2,079	286	2,057	282
	Cv (%)	1.25%	2.55%	1.25%	2.54%	1.25%	2.55%
	STDEV (per passenger)	26.3	7.3	26.0	7.3	25.7	7.2
	Lower 95% boundary gCO_2/passenger	2,049	273	2,028	272	2,006	268
	Upper 95% boundary gCO_2/passenger	2,152	301	2,130	301	2,107	296

Source: File 2a/b

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:

$$\mathrm{BE}_{p,y} = \sum_i \mathrm{BTD}_{p,i,y} \cdot \mathrm{EF}_{PKM,i,y}$$

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 all vehicle categories except 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:

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

Where:

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

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, buses, 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 6: Share per Fuel Type Cars

Fuel Type	Registered PDD	Monitoring Period
Gasoline	81.8%	62.6%
Diesel	10.6%	25.8%
CNG	7.6%	11.6%

Source: Registered PDD section B.6.2., Monitored: File 4, Gov. of NCT, Transport Department, 2018

In the case of taxis, buses and motorized rickshaws due to government regulations all vehicles are CNG[17]. Motorcycles are all gasoline (see File 4). Therefore, no change of vehicle fuel share took place in these types of vehicles.

[17] 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)

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

Table 7: Bio-Fuel Share

	Diesel	Gasoline
2016	0.1%	3.3%
2017	0.1%	1.9%
2018	0.1%	3.2%

Source: USDA GAIN Report, 24/06/2016, Table 4 and 5 (File 10)

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

Table 8: 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 7	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.
$SFC_{B,CNG}$	Specific fuel consumption CNG buses	g/km	348.43	PDD B.6.2. based on year 2008
OC_B	Occupation rate buses	passengers	43	PDD B.6.2.
$EF_{CH4,CNG,B}$	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 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

All urban buses due to government regulations all vehicles are CNG[18].

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 9: Parameters for Determination EF_{PKM} Suburban Rail

Parameter	Description	Unit	Monitoring Period	Source
EC_{EL}	Electricity consumption per annum	MWh	2,231	File 7
P_{EL}	Passengers transported per annum	passengers	2,677,300	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 2016, 2017 and 2018 per mode.

Table 10: EF per PKM per Mode (gCO_2/pkm)

Mode	2016	2017	2018
Passenger cars	91	90	89
Taxis	160	159	157
Motorized rickshaws	65	65	64
Motorcycles	31	31	30
Bus	24	24	24
Sub-urban rail	25	25	25

Source: File 5

Baseline Results

Table 11: Baseline Emission Calculation

Parameter	07-12/2016	2017	01-29.06/2018
Passengers	273,598,164	516,080,944	221,230,853
Baseline emissions per passenger (lower 95% confidence interval)[19] in gCO_{2e}	2,205	2,183	2,171
Baseline emissions tCO_2	**603,148**	**1,126,605**	**480,182**

Source: CER spreadsheet

The total baseline emissions of the monitoring period are **2,209,935 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)

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

[18] 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)

[19] Average of 2 surveys

Where:

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

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

Where:

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

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 12: Project Parameters

Parameter	Description	Unit	Value	Source
EC_{PJ}	Traction electricity consumption project	kWh	435,209,682	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 13: Parameters for Indirect Project Emission Calculation

Parameter	07-12/2016	2017	01-29.06/2018
Passengers	273,598,164	516,080,944	221,230,853
Indirect project emissions per passenger (upper 95% confidence interval)[20] in gCO_{2e}	476	475	467
Indirect Project Emissions tCO_2	**130,096**	**244,880**	**103,204**

[20] Average of 2 surveys

Source: CER spreadsheet

Table 14: Project Emissions in tCO_{2e}

Parameter	07-12/2016	2017	01-29.06/2018
Direct project emissions	99,244	194,294	86,739
Indirect project emissions	130,096	244,880	103,204
Total Project Emissions	**229,340**	**439,175**	**189,944**

Source: CER spreadsheet

The total project emissions of the monitoring period are **858,458 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. No leakage monitoring therefore took place in this monitoring period.

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

The project could have a negative impact on the load factor of taxis. Taxis include cars as well as motorized rickshaws realizing taxi services. For both types of services the load factor change is monitored separately. Load factor changes are monitored for the entire city as taxis operate all over the city and are not confined to deliver their services in certain areas. The load factor of taxis is monitored in the years 1 and 4 of the crediting period. No leakage monitoring therefore took place in this monitoring period.

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.[21]

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.).

[21] 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	2,209,935	858,458	0	0	1,351,477	1,351,477

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)	1,180,285[22]	1,351,477

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

Emission reductions are 15% 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. Emission reductions for the 2 years are near-to identical for the last 2 years previously verified (period 07/2014-06/2016 with 1,373,275 tCO2).

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

Table 15: Comparison Projected and Actual Emissions per Passenger Baseline in gCO_{2e}/passenger

Parameter	07-12/2016	2017	01-06/2018
Projected in PDD	1,215	1,203	1,191
Actual Monitored	2,205	2,183	2,171
Increase Actual in % of Projected	81%	81%	82%

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 on average of the period 473 gCO2 per passenger instead of projected 184gCO2 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 16: Comparison Emission Reduction per Passenger in gCO_{2e}/passenger[23]

Parameter	07-12/2016	2017	01-06/2018
Projected in PDD	1,029	1,019	1,009
Actual Monitored	1,729	1,708	1,704
Increase Actual in % of Projected	68%	68%	69%

[22] Calculated based on 50% of value of 2016 (565,077*.05), 100% of value of 2017 (591,082) and the value of 2018 which was reported for 4 months transformed to 6 months (205,443/4*6)

[23] Baseline minus Indirect Project Emissions

Total emission 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 17: Comparison Number of Passengers

Parameter	07-12/2016	2017	01-06/2018
Projected in PDD	362,585,256[24]	810,962,715	388,296,534[25]
Actual Monitored	273,598,164	516,080,944	221,230,853
Increase Actual in % of Projected	-25%	-26%	-43%

The passenger numbers which are relevant for the revenue of the metro are thus in total 35% 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.

[24] 50% of value entire year in PDD

[25] PDD is for 4 months; transformed to 6 months by factor 6/4

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

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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).
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