

CDM-MP65-A14

Draft Large-scale Consolidated Methodology

ACM0016: Mass Rapid Transit Projects

Version 04.0 - Draft

Sectoral scope(s): 07



DRAFT



United Nations
Framework Convention on
Climate Change

COVER NOTE

1. Procedural background

1. The methodology ACM0016 is applicable to project activities that reduce emissions through the construction and operation of a mass rapid transit (MRT) system for urban transport. The revision was initiated in response to two requests from the Executive Board of the clean development mechanism (CDM) (hereinafter referred to as the Board).
2. The Board, at its sixty-seventh meeting (EB 67, para 107), noted that some methodologies allow project participants to select only a 10-year crediting period, while paragraph 49 of the “Modalities and procedures for a clean development mechanism” (decision 3/CMP.1, Annex) allow project participants to select a crediting period from two alternative approaches:
 - (a) A maximum of seven years, which may be renewed at most two times;
 - (b) A maximum of 10 years with no option of renewal.
3. Therefore, the Board requested the Methodologies Panel (Meth Panel) to consider this issue in relevant methodologies, with the view to: (i) enable project participants to select the crediting period from the two approaches and (ii) if needed, review the tool “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period”. The revision to this methodology addresses the request from the Board and introduces provisions to enable project participants to select a crediting period from two alternative approaches, a non-renewable 10 year crediting period and renewable 7 year crediting period.
4. The Board, at its seventy-fifth meeting, requested the Meth Panel to improve the current approach of demonstrating additionality by not using certified emission reductions (CER) revenues and to explore other possible means of demonstrating additionality and identifying baselines. The revision to this methodology addresses this request and provides an alternative approach to demonstration of additionality with the use of a penetration rate and emissions or energy benchmark.

2. Purpose

5. The purpose of the revision of this regulatory document is address requests of the Board related to enabling project participants to select a crediting period and providing an alternative approach to additionality demonstration that is not based on using CER revenues.

3. Key issues and proposed solutions

6. Not applicable.

4. Impacts

7. The revision to this methodology will enhance its usability via proving an approach to additionality demonstration that does not rely on CER prices and offering two alternatives to project participants to select the crediting period.

5. Subsequent work and timelines

8. The Meth Panel, at its 65th meeting, agreed on the draft revised methodology. After receiving public inputs on the document, the Meth Panel will continue working on the draft revised methodology, at its 66th meeting, for recommendation to the Board at a future meeting of the Board.

6. Recommendations to the Board

9. Not applicable (call for public input).

TABLE OF CONTENTS	Page
1. INTRODUCTION	6
2. SCOPE, APPLICABILITY, AND ENTRY INTO FORCE	6
2.1. Scope.....	6
2.2. Applicability	6
2.3. Entry into force.....	7
3. NORMATIVE REFERENCES	7
3.1. Selected approach from paragraph 48 of the CDM modalities and procedures.....	8
4. DEFINITIONS	8
5. BASELINE METHODOLOGY	10
5.1. Project boundary.....	10
5.2. Procedure for the identification of the most plausible baseline scenario and demonstration of additionality	12
5.2.1. Step 1: Country level assessment.....	15
5.2.2. Step 2: City level assessment.....	15
5.2.3. Step 3: Project System level assessment	16
5.3. Baseline emissions	19
5.3.1. Identification of the relevant vehicle categories (modes of transport).....	21
5.3.2. Determination of the emission factor per passenger-kilometre ($EF_{PKM,i,y}$)	22
5.4. Project emissions.....	26
5.4.1. Determination of direct project emissions (DPE_y)	27
5.4.2. Determination of indirect project emissions (IPE_y)	28
5.5. Leakage	29
5.5.1. Determination of emissions due to a change in load factor of buses ($LE_{LFB,y}$)	30
5.5.2. Determination of emissions due to a change in load factor of taxis ($LE_{LFT,y}$).....	31
5.5.3. Determination of emissions due reduced congestion ($LE_{CON,y}$)	32

5.6.	Emission reductions.....	38
5.7.	Crediting period	39
5.8.	Data and parameters not monitored	39
6.	MONITORING METHODOLOGY	47
6.1.	Data and parameters monitored	47
APPENDIX 1.	GUIDELINE FOR THE ESTABLISHMENT OF LOAD FACTOR STUDIES FOR BUSES BASED ON VISUAL OCCUPATION	55
APPENDIX 2.	GUIDELINE FOR THE ESTABLISHMENT OF LOAD FACTOR STUDIES FOR BUSES BASED ON BOARDING-ALIGHTING SURVEYS	56
APPENDIX 3.	GUIDELINE FOR THE ESTABLISHMENT OF LOAD FACTOR STUDIES FOR TAXIS/MOTORCYCLES OR PASSENGER CARS	57
APPENDIX 4.	METHODOLOGICAL DESIGN OF SURVEY MRTS.....	58

1. Introduction

1. The following table describes the key elements of the methodology.

Table 1. Methodology key elements

Typical project(s)	Establishment and operation of rail-based or bus-based mass rapid transit systems in urban or suburban regions for passenger transport by replacing a traditional urban bus-driven public transport system
Type of GHG emissions mitigation action	Energy efficiency. Displacement of more-GHG and, if gaseous fuels are used, CH ₄ -intensive transport modes (existing fleet of buses operating under mixed traffic conditions) by less-GHG-intensive ones (newly developed rail-based systems or segregated bus lanes)

2. Scope, applicability, and entry into force

2.1. Scope

2. The scope of this methodology includes the establishment and operation of rail-based or bus-based mass rapid transit systems in urban or suburban districts of a host city.

2.2. Applicability

3. This methodology applies to project activities that establish and operate **an mass rapid transit systems (MRTS)**.
4. For **bus rapid transit (BRTs)** with feeder plus trunk routes the methodology “AM0031: **Bus rapid transit systems**” is more suitable. AM0031 is for BRTs where passengers can realize their entire trip on the project system. BRTs without feeder lines, i.e. passengers realize their trip partially on the project system and partially on conventional buses, cannot use AM0031 but can use this methodology. The methodology is applicable under the following conditions:
 - (a) The project constructs a new rail-based infrastructure or segregated bus lanes:
 - (i) For rail systems, the project needs to involve the construction of a new infrastructure (new rail lines);
 - (ii) For BRTs, the project can be based on existing road infrastructure, but which separates physically bus lanes from mixed traffic;
 - (b) The segregated BRT bus lanes or the rail-based MRTS replaces existing bus routes (e.g. through scrapping units or through closing or re-scheduling existing bus routes) operating under mixed traffic conditions;
 - (c) The methodology is not applicable for operational improvements (e.g. new or larger buses) of an already existing and operating bus lane or rail-based MRTS;

- (d) The methodology is not applicable for bus lanes replacing an existing rail-based system i.e. the existing urban or suburban rail infrastructure must remain fully (in its full length) operational;
 - (e) The methodology is applicable for passenger transport only;
 - (f) Any fuels including (liquified) gaseous fuels or biofuel blends, as well as electricity can be used in the baseline or project case. The following condition¹ apply:
 - (i) For biofuels, project buses must use the same biofuel blend (same percentage of biofuel) as commonly used by conventional comparable² urban buses in the country i.e. the methodology is not applicable if project buses use higher or lower blends of biofuels than those used by conventional buses. In addition, the project buses shall not use a significantly higher biofuel blend than cars and taxis;
 - (g) The methodology is not applicable for the implementation of air- and water-based transport systems;
 - (h) The methodology is applicable for urban or suburban trips. It is not applicable for inter-urban transport.
5. In addition, the applicability conditions included in the tools referred to **above below** apply.
6. The methodology is applicable if the most plausible baseline scenario is the continuation of the use of current modes of transport.

2.3. Entry into force

7. Not applicable (call for public input).

3. Normative references

8. This consolidated baseline and monitoring methodology is based on the following proposed new methodologies:
- (a) “NM0258: Methodology for Bus Lanes” developed by Grütter Consulting AG, Switzerland;
 - (b) “NM0266: Methodology for Rail Based Urban Mass Rapid Transit Systems (MRTS)” developed by Grütter Consulting AG, Switzerland.

¹ No provisions to calculate upstream emissions from the production of the fuels are provided in order to keep the methodology simple. Therefore, in order to ensure that the calculated emission reductions are conservative, this applicability condition aims to limit the use of the methodology to cases where the upstream emissions under the project activity are likely to be equal or lower than in the baseline scenario. Note that other methodologies involving fuel switch situations usually require the consideration of upstream emissions.

² Comparable means of the same fuel type e.g. project buses using diesel are compared with conventional buses using diesel etc. The comparison is made for each year of monitoring based on official fuels sold. The term commonly used refers to the majority of units.

9. This methodology also refers to the latest approved version of the following tools:
- (a) “Tool for the demonstration and assessment of additionality”;
 - (b) “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”;
 - (c) “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”;
 - (d) “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period”.
10. For more information regarding the proposed new methodologies and the tools as well as their consideration by the CDM Executive Board of the clean development mechanism (CDM) (hereinafter referred to as the Board) please refer to <<http://cdm.unfccc.int/goto/MPappmeth>>.

3.1. Selected approach from paragraph 48 of the CDM modalities and procedures

11. Existing actual or historical emissions, as applicable.

4. Definitions

12. The definitions contained in the Glossary of CDM terms shall apply.
13. For the purpose of this methodology, the following definitions apply:
- (a) **Mass Rapid Transit Systems (MRTS)** - are collective urban or suburban passenger services operating at high levels of performance, especially with regard to travel times and passenger carrying capacity. They can be based on elevated, surface level or underground roads or rail systems. MRTS can be rail-based systems such as subways/metros, Light Rail Transit (LRTs) systems, including trams, or suburban heavy duty rail systems or road-based bus systems. For the purpose of this methodology road-based MRTS are bus systems using bus-lanes (see below the definition of a bus lane), which can also be called Bus Rapid Transit (BRT) systems;
 - (b) **Larger urban zone (LUZ)** - of a city covers the whole functional zone around the city (including the core city) i.e. it corresponds to the commuting field around the city;
 - (c) **Bus lane** (or trunk route) - refers to a segregated lane, where only buses are allowed to operate. Private vehicles are not allowed to use the bus lane. Exceptions such as emergency vehicles can apply. Bus lanes need not necessarily be physically separated from other traffic lanes. If no physical separation is realized then it must be ensured that enforcement takes place to prevent the usage of the bus lane by other vehicles. It is not a requirement that 100 per cent of the route is a bus-only lane as buses might share part of the lanes with other modes of transport e.g. at traffic crossings, bridges, tunnels, in narrow parts or on roads with limited traffic e.g. in suburban parts of the city. However to qualify for this methodology more than half of the included bus route must be a bus-only lane;

- (d) **Extensions of bus lanes** - are those where the same bus operates the entire route i.e. passengers need not change from one bus to another bus when using the bus lane. The entire bus lane is thus composed of an existing or “old lane” and a “lane extension” (latter is the project activity);

Figure 1. Extension of bus lanes



- (e) **New bus lanes** - are routes operated by different buses. Additional bus routes might share certain stations with an existing lane but passengers will have to switch buses if their trip involves stations on the “old” and the “new” lane;

Figure 2. New bus lanes



- (f) **Feeder routes** - refer to bus routes which have intersections with trunk routes and which “feed” passengers on the trunk routes. Feeder routes are those with less passenger demand and operate under mixed traffic conditions;
- (g) **Extension of rail infrastructure** - is defined as adding additional kilometres along an existing rail-route;
- (h) **Rebound effect (or take-back effect)** - is the term used to describe the effect that the MRTS has on changing ‘consumer behaviour’ leading to additional trips. The rebound effect is an extension of the “Law of Demand”, a basic principle of economics, which states that if prices decline, consumption usually increases. If the MRTS project reduces traffic congestion, therefore reducing opportunity costs, it tends to increase total vehicle mileage. Generated Traffic is the additional vehicle travel that occurs when reduced congestion increases traffic speeds and reduces travel time;
- (i) **Affected roads** - are the roads influenced by the establishment of the MRTS. Affected roads are those inside a radius of minimum 1 kilometer running parallel to the MRTS line (roads on both sides of the MRTS line are included). Only roads with large traffic volumes are included;
- (j) **City** - is an area of continuous urban development and includes the historical core area and the adjacent suburbs defined by its administrative boundaries;

- (k) **Commercial entity** - is a company, excluding banks, where more than 20 per cent of equity capital is privately owned.

5. Baseline methodology

5.1. Project boundary

14. The spatial extent of the project boundary encompasses the larger urban zone of the city in which the project takes place. It is based on the origins and destinations of passengers using the project system. As the project cannot control the trip origins or destinations of passengers the spatial area of the project is the entire larger urban zone of the city in which the project operates.
15. The project only includes emission reductions from the MRTS lanes. The location of the MRTS lanes should be transparently outlined in the **project design document** (CDM-PDD). If any MRTS lane would in a later stage be extended (prolonged) beyond the originally planned route detailed in the CDM-PDD, then the project proponents shall follow the latest approved version of the "Procedures for notifying and requesting approval of changes from the project activity as described in the registered project design document" in order to claim emission reductions from these additional lanes.
16. In case of using electricity from an interconnected grid or captive power plant for the propulsion of the transport system, the project boundary also includes the power plants connected physically to the electricity system that supply power to the project, and/or the captive power plant. Please refer to the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
17. The greenhouse gases included in or excluded from the project boundary are shown in Table 2.

Table 2. Emission sources included in or excluded from the project boundary

Source		Gas	Included	Justification/Explanation
Baseline	Mobile source emissions of different modes of transport due to the trips made by the passengers using the MRTS	CO ₂	Yes	Major emission source
		CH ₄	Yes	Included only if gaseous fuels are used and excluded for liquid fuels. CH ₄ emissions are a minor emission source of the total CO ₂ e emissions in diesel/gasoline vehicles Neglecting these emissions in baseline as well as project emissions is conservative as fuel consumption and thus also CH ₄ emissions are reduced through the project
		N ₂ O	No	N ₂ O emissions are a minor source of the total CO ₂ e emissions. Neglecting these emissions in baseline as well as project emissions is conservative as fuel consumption and thus also N ₂ O emissions are reduced through the project
Project activity	Mobile source emissions of the project transport system (MRTS) due to the trips made by the passengers using it	CO ₂	Yes	Major emission source
		CH ₄	Yes	Included only if gaseous fuels are used. See argument above
		N ₂ O	No	See argument above
	Mobile source emissions of different modes of transport due to the trips made by the passengers using the MRTS, from their trip origin to the MRTS and from the MRTS to their trip destination	CO ₂	Yes	Major emission source
		CH ₄	Yes	Included only if gaseous fuels are used. See argument above
		N ₂ O	No	See argument above
Leakage	Emissions due to changes in the load factors of taxis and conventional buses; and due to congestion change (incl. change in vehicle speed and induced traffic (rebound effect))	CO ₂	Yes	Major emission source
		CH ₄	Yes	Included only if gaseous fuels are used. See argument above
		N ₂ O	No	See argument above

5.2. Procedure for the identification of the most plausible baseline scenario and demonstration of additionality

18. MRTS projects implemented in least developed countries (LDC) are deemed to be automatically additional.
19. If MRTS projects are implemented in non-LDCs and face the first-if-its-kind barrier, the latest **approved** version of the **EB** “Guidelines on additionality of first-of-its-kind project activities” shall be followed to demonstrate the additionality of these project activities.
20. For MRTS projects, which are implemented in non-LDCs and which are not first-of-its-kind, the following procedure illustrated in Figure **4.3** and described below shall be applied.
21. When validating the application of the additionality demonstration, designated operational entities (DOEs) shall carefully assess and verify the reliability and credibility of all data, rationales, assumptions, justifications and documentation provided by project participants to support the demonstration of additionality. The elements and data checked during this assessment and the conclusions shall be documented transparently in the validation report.

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Figure 3. — Additionality

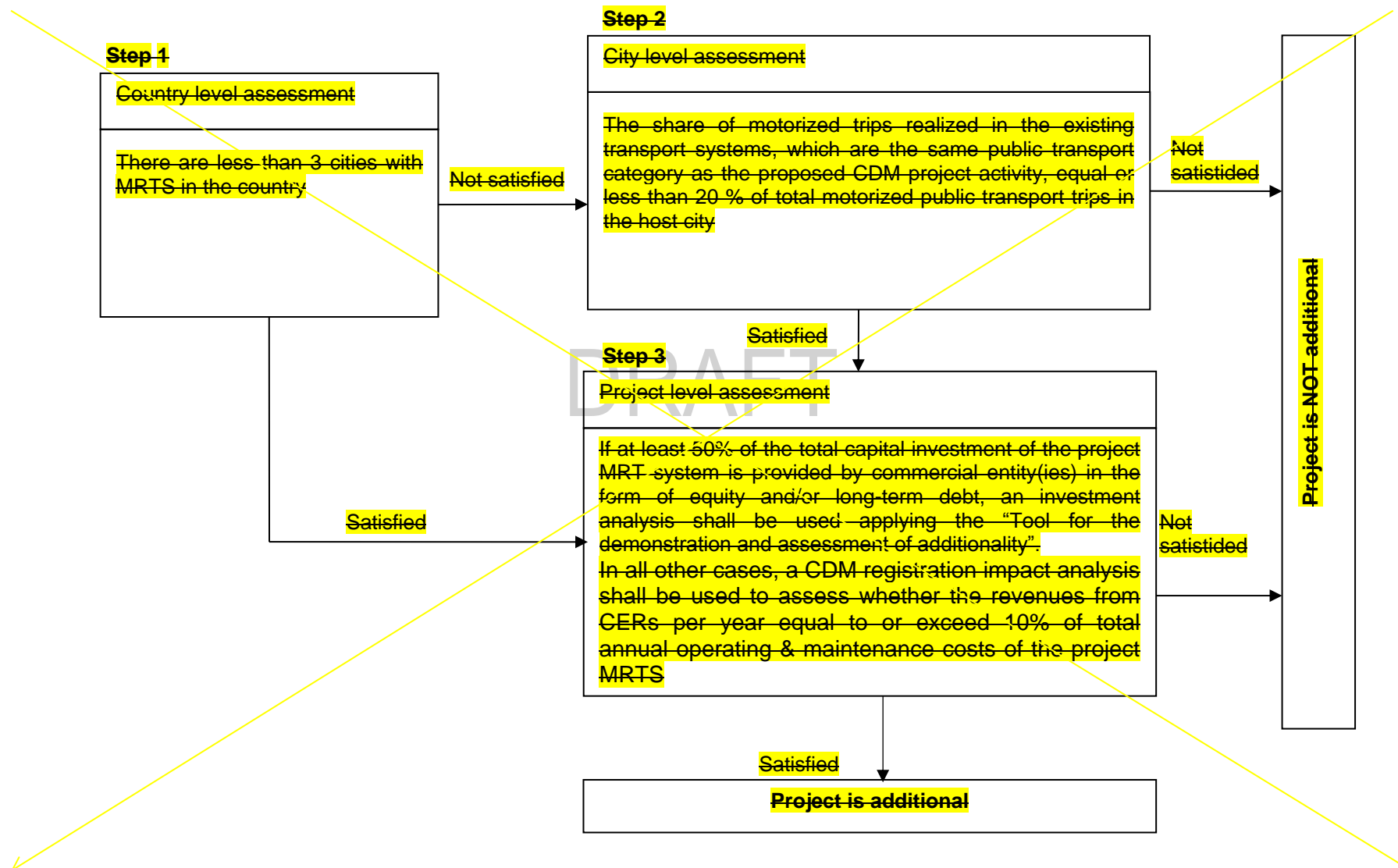
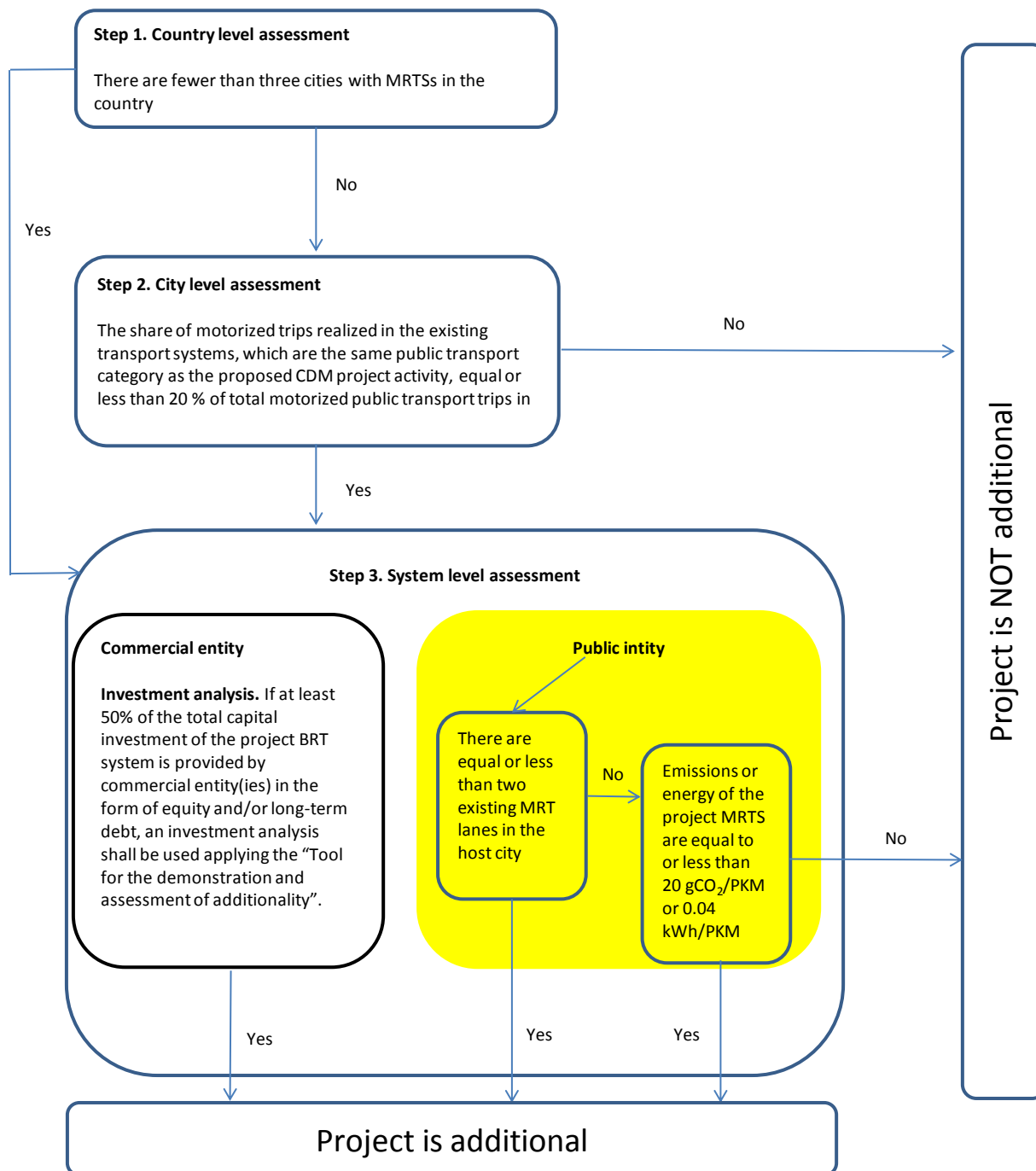


Figure 4.3 Additionality demonstration



5.2.1. Step 1: Country level assessment

22. This step aims to determine whether the proposed CDM project activity is common practice in the host country where the project is proposed to be implemented. For this purpose, project participants shall assess whether there are less than three cities with MRT systems that started commercial operation in the host country of the proposed CDM project activity prior to the start of the CDM project activity.
23. The project participants shall:
- (a) Identify all cities with MRTS that have started commercial operation in the host country prior to the start of the CDM project activity. Project participants shall include a brief description of each system in the CDM-PDD;
 - (b) Identify which MRT systems were developed as CDM project activities in the host country (registered project activities and project activities which have been published on the UNFCCC website for global stakeholder consultation as part of the validation process) and exclude all³ MRT systems developed as CDM project activities from the assessment of common practice in this step.
24. ***If the number of cities with MRTS (excluding systems developed as CDM project activities) is equal to or exceeds three cities, then projects participants should proceed to Step 2, otherwise project participants should proceed to Step 3 (see Figure 4-3).***

5.2.2. Step 2: City level assessment

25. This step aims to determine whether the proposed project activity is common practice in the host city where the proposed CDM project activity is intended to be implemented. For this purpose, project participants shall assess whether the share of trips realized on the existing public transport system(s) in the host city, which belong to the same public transport category as the proposed CDM project activity, is equal or less than 20 per cent of total public transport trips in the host city.
26. The project participants shall :
- (a) Provide a breakdown of the total public transport trips realized in the host city by the shares of trips realized on different public transport categories, distinguishing between the following public transport categories:
 - (i) Metro;
 - (ii) Sub-urban rail;
 - (iii) Light rail transit including trams;
 - (iv) Conventional bus system;
 - (v) BRTs;

³ This is subject to further decisions by the Board.

- (b) Describe in the CDM-PDD the existing public transport systems and identify to which of the public transport categories they belong. Identify also to which public transport category the proposed project activity belongs. Determine and document in the CDM-PDD the shares of trips realized on each relevant public transport system and on each public transport category, expressed in percentages of the total public transport trips realized on all public transport systems in the host city.

27. *If the share of motorized trips realized on the existing systems which belong to the same public transport category as the proposed project activity exceeds 20 per cent of total motorized public transport trips in the host city, then the proposed CDM project activity is not additional. If the share of trips is equal or below 20 per cent, then project participants should proceed to Step 3.*

5.2.3. Step 3: Project System level assessment

28. Two procedures are provided to demonstrate the additionality of the proposed project activity, depending on whether a commercial entity(ies) covers at least 50 per cent of total capital investment in the project MRT system.

- (a) If at least 50 per cent of the total capital investment in the project MRT system is provided by commercial entity(ies) in the form of equity and/or long-term debt, an investment analysis shall be conducted, following the procedure A for commercial entities below;
- (b) In all other cases, ~~an impact assessment of CDM project registration a penetration rate or a benchmark analysis~~ shall be conducted, following procedure B for public entities below.

5.2.3.1. Commercial entity: Procedure A: Investment analysis

29. The aim of this analysis is to determine whether the proposed project activity is not economically or financially feasible using “Option III. Benchmark analysis”, including the sensitivity analysis, provided in the “Tool for the demonstration and assessment of additionality”.

30. The investment analysis should be undertaken from the perspective of the private sector operator/investor of the public transportation system of the city or urban area, reflecting the costs and revenues from the perspective of the operator/investor. If the project is subsidized through public authorities and institutions (e.g. local or central government, international donor organizations), e.g. through grants which do not need to be repaid, soft loans or contributions to operating and maintenance costs, or deficit guarantees, the financial assessment is made, taking into account these subsidies, including as investment the total system costs minus any such public subsidies. Any capital that needs to be repaid should be included in the calculations, e.g. loans by the municipality or city authority should be considered as a capital investment by the project operator and not be subtracted from the total system costs.

31. In applying the investment analysis, cost overruns of former investments in MRTS or reduced revenues of former MRTS investments compared to original projections, which make new investments less viable and riskier, can be considered in the investment analysis. In this case, project participants should evaluate the cost overruns or reduced

revenues of former MRTS that were implemented in the same host country in the last 20 years. Information on originally projected and actually observed costs/revenues should be based on official and public data. As a conservative approach, the lower end of the range of cost-overruns or reduced revenues observed over this period should be assumed for the project MRTS.

32. *If the sensitivity analysis is not conclusive, then the project activity is not additional. If the sensitivity analysis confirms the proposed project activity is not economically attractive, then the proposed project activity is additional.*

5.2.3.2. Public entity Procedure B: Analysis of the impact of CDM registration Penetration rate or a benchmark analysis

33. The aim of this step is to determine whether the number of lanes (or lines) of the project system is below the penetration rate or emissions and energy consumption are below the benchmark. For public entities developing MRTS two alternatives to demonstrate additionality are available. The first alternative enables project proponents to demonstrate that there are equal to or less than two existing lanes (or lines) of the MRT system, which belongs to the same public transport category as the proposed CDM project activity, in the host city. If the penetration rate in the host city is equal to or less than two existing lanes (or lines) then the project system is additional. If there are more than two lanes (or lines) operate in the host city, project proponents shall demonstrate that the annual revenues from CERs constitute a significant proportion of the total annual operating and maintenance costs for road-based systems, forecasted emissions of from the project MRTS per passenger-kilometre are equal to or below the emissions benchmark and, for rail-based systems, forecasted energy consumption per passenger-kilometre of the project MRTS are equal to or below the energy consumption benchmark. For this purpose of the benchmark analysis, the project participants shall assess whether the annual revenues from CERs are equal to or exceed 10% of the total annual operating and maintenance costs emissions of from the project MRTS per passenger-kilometre are equal to or less than 20 gCO₂/PKM for road-based systems and 0.04 kWh/PKM for rail-based systems. For the purpose of this analysis, project participants should use the amount of operating and maintenance costs and the amount of CERs annual amount of emissions from the project MRT system for road-based systems and annual amount of electricity consumption by the project MRT system for rail-based systems, annual number of passengers expected to travel in the project system and an average distance that these passengers are expected to travel in the project MRT be reached when the project MRT system will reach its planned capacity.. This analysis shall be conducted one time ex ante for the additionality demonstration purpose only. All assumptions used in calculations need to be documented and substantiated in the CDM-PDD. The input values and data used to conduct the analysis of the impact of CDM registration shall comply with the same requirements as the input values and data used to conduct the investment analysis specified in the "Tool for the demonstration and assessment of additionality".

34. The project participants shall:
- (a) Provide an ex ante assessment of the revenues from CERs estimate of total annual emissions or annual electricity consumption per passenger-kilometre year expected to be generated reached by the proposed project activity. For this assessment, operating and maintenance costs annual emissions from or annual electricity consumed by the project MRT as well as expected passenger demand

and distance expected to be travelled by the passengers in the project MRT shall be estimated for the year when the BRT system is expected to reach its planned stable operation. The price of CERs should be taken as the average secondary CER price for the full year prior to the submission of the CDM-PDD for validation. In case the project participants signed an emission reduction purchase agreement with a buyer, the CER price from this purchase agreement can be used for the calculations;

- (b) Document, and describe transparently and justify relevant assumption used in the projections of annual emissions or annual electricity consumption by the project system, passenger demand and an average distance expected to be travelled by the passengers in the project MRT; the operational and maintenance cost components that are taken into account and provide an estimate of the total expected operating and maintenance costs of the proposed project activity per year, justifying relevant assumptions.

An indicative list of operational and maintenance cost categories that project proponents should include in the analysis is presented in Table 32 and Table 43 below for bus-based and rail-based MRTS, respectively. Depending on the specific circumstances of the proposed project activity, operational and maintenance cost components of a particular MRTS may differ from those listed in Table 2 and Table 3, which are provided as examples.

Table. Operational and maintenance cost components of BRTs

Item	Unit of accounting in cost calculations
Fixed operating costs	
Driver salaries	Employees/vehicle
Salaries of mechanics	Employees/vehicle
Salaries of administrative personnel and supervisors	Employees/vehicle
Other administrative expenses	% of variable costs + maintenance + personnel
Fleet issuance	% of value of vehicle/year
Variable operating costs	
Fuel	Liters/ 100 km m ³ of natural gas/100 km
Tires	
(a) New tires	Units/ 100,000 km
(b) Retreading	Units/ 100,000 km
Lubricants	
(a) Motor	Liters /10,000 km
(b) Transmission	Liters /10,000 km
(c) Differential	Liters /10,000 km
(d) Grease	Kilograms/10,000 km
Maintenance	% value of vehicle/year

Source: GTZ 2005. Mass transit options.

Table. Operational and maintenance cost components of rail systems (metro, light rail and trams)

Item	Unit of accounting in cost calculations
Fixed operating costs	
Driver salaries	Employees/train
Salaries of mechanics	Employees/train
Salaries of administrative personnel and supervisors	Employees/train
Other administrative expenses	% of variable costs + maintenance + personnel
Rolling stock issuance	% of value of car/year
Variable operating costs	
Fuel	Liters/ 100 km kWh/ 100 km
Rails	Units/ 100,000 km
Maintenance	% value of car/year

35. If the annual revenues from CERs are equal to or exceed 10% of the total annual operating and maintenance costs of If there are equal to or less than two existing lanes (or lines) of the MRT system, which belongs to the same public transport category as the proposed CDM project activity, in the host city then the MRTS proposed as a CDM project activity is additional.
36. If there are more than two existing lanes (or lines) of the existing MRT system and annual emissions per passenger-kilometre of the project MRT are equal to or less than 20 g CO₂/PKM for road-based systems or electricity consumption is equal to or less than 0.04 kWh/PKM for rail-based systems in the year when the MRT system reaches its planned capacity, then the proposed CDM project activity is additional. Otherwise, the proposed CDM project activity is not deemed additional.
37. If the project activity is deemed to be additional, then the baseline scenario is assumed to be the continuation of the use of current modes of transport provided that the project participants can provide an explanation showing that the existing transport system would be sufficient to meet the transportation demand that will be met by the project system.

5.3. Baseline emissions

38. Baseline emissions include the emissions that would have happened due to the transportation of the passengers who use the project activity, had the project activity not been implemented. This is differentiated according to the modes of transport (relevant vehicle categories) that the passengers would have used in the absence of the project.

39. Baseline emissions are calculated using the tool “Baseline emissions for modal shift measures in urban passenger transport” per passenger surveyed. For each passenger surveyed the individual baseline emissions are calculated and multiplied with the individual expansion factor thus getting the baseline emissions of all passengers of the specific week surveyed. These are multiplied with the total of the passengers of the period to arrive at baseline emissions. The following steps should be followed:
- Step 1:** Conduct a survey, following the procedures presented in **Annex Appendix 4**, in which for each surveyed passenger, the trip distance per transport mode that would have taken place in the baseline is determined;
 - Step 2:** Calculate the individual baseline emissions for each surveyed passenger (equation (2) below);
 - Step 3:** Apply an individual expansion factor to each surveyed passenger in accordance with the survey sample design (as defined in **Annex Appendix 4**), and summarize these to get the total baseline emissions of the period (week) surveyed. To get the annual (or monitoring period) baseline emissions the baseline emissions of the surveyed period (week) are calculated per passenger of the period (week) and multiplied with the total passengers transported per year (or monitoring period), as per equation (1) below;
 - Step 4:** Take the lower limit of the 95 per cent confidence interval as total baseline emissions (see **Annex Appendix 4**).
40. Baseline emissions are calculated as follows:

$$BE_y = \frac{P_y}{P_{SPER}} \sum_p (BE_{p,y} \times FEX_{p,y}) \quad \text{Equation (1)}$$

Where:

- BE_y = Baseline emissions in year y (t CO₂)
 $BE_{p,y}$ = Baseline emissions per surveyed passenger p in year y (t CO₂)
 $FEX_{p,y}$ = Expansion factor for each surveyed passenger p surveyed in year y (each surveyed passenger has a different expansion factor)
 P_y = Total number of passengers in year y
 P_{SPER} = Number of passengers in the time period of the survey (1 week)
 p = Surveyed passenger (each individual)
 y = Year of the crediting period

41. The baseline emissions per surveyed passenger p are calculated based on the mode used, the trip distance per mode and the emission factor per mode:

$$BE_{p,y} = \sum_i BTD_{p,i,y} \times EF_{PKM,i,y} \times 10^{-6} \quad \text{Equation (2)}$$

Where:

$BE_{p,y}$	=	Baseline emissions per surveyed passenger p in year y (t CO ₂)
$EF_{PKM,i,y}$	=	Emission factor per passenger-kilometre of mode i in year y (g CO ₂ /PKM)
$BTD_{p,i,y}$	=	Baseline trip distance per surveyed passenger p using mode i in year y (PKM)
p	=	Surveyed passenger (each individual)
i	=	Relevant vehicle category
y	=	Year of the crediting period

5.3.1. Identification of the relevant vehicle categories (modes of transport)

42. The relevant vehicle categories i referred to in equation (2) above may include inter alia:

- (a) Buses, differentiating between the sub-categories of large, medium and small buses, if appropriate. This includes also buses from bus lanes or BRTs which exist prior to the project activity. For the latter, emissions are determined separately for buses from a conventional bus system and buses from a BRT;
- (b) Passenger cars;
- (c) Taxis;
- (d) Motorcycles;
- (e) Tricycles or motorcycles with more than two wheels used for transporting passengers;
- (f) Existing metro, rail, LRT (Light Rail Transit) including tram;⁴
- (g) NMT (Non-Motorized Transport);
- (h) Other vehicle categories.

43. Criteria for identifying the categories are as follows:

- (a) At a minimum, public transport, non-motorised transport and induced traffic have to be included;
- (b) Conditions to include categories with reliable data on fuel consumption and load factors;
- (c) Only include categories that are relevant for the BRT project. If the project will only generate credits from public transport without modal shift, then passenger cars, taxis and motorcycles need not be included;
- (d) Differentiate relevant fuel types for each category. Diesel, gasoline and gas (CNG or LPG) are listed separately if a minimum of 10 per cent of vehicles of the

⁴ If the project activity is a bus lane or BRT then existing rail-based systems must not be included as their baseline emissions are taken as 0 (conservative approach).

respective category use such a fuel, while the threshold for zero-GHG-emission⁵ fuels is minimum 1 per cent. The 10 per cent threshold is justified, as greenhouse gas (GHG) emission differentials between diesel, gasoline and gaseous fuels are less than 20 per cent;

(e) In case of a system extension, the currently operating system is not included as a vehicle category.

44. The relevant vehicle categories should be clearly identified in the CDM-PDD.
45. If some vehicle categories are not explicitly identified or do not fit into one of the categories above, they should be subsumed in the survey as “others”. Baseline emissions of this category are counted as 0-emissions.⁶ The index *i* is used to identify each relevant vehicle category (mode of transport) included in the analysis.

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

46. Passenger-kilometre (PKM) is defined as the average passenger trip distance multiplied by the number of passengers. The emission factors per PKM are determined ex ante for each vehicle category. Any change in the occupancy rate of taxis and buses influencing the corresponding emission factors is monitored as leakage.
47. The emission factors per PKM are calculated as follows:

5.3.2.1. Case 1: Emission factor per PKM for electricity-based transport systems (e.g. urban rail-based systems)

48. For electricity-based vehicle categories, the following equation should be used:

$$EF_{PKM,i,y} = \frac{TE_{EL,i,y}}{P_{EL,i,y} \times TD_{EL,i}} \times 10^6 \quad \text{Equation (3)}$$

Where:

- $EF_{PKM,i,y}$ = Emission factor per passenger-kilometre for electricity-based vehicle category *i* for year *y* (g CO₂/PKM)
- $TE_{EL,i,y}$ = Total emissions from the electricity-based vehicle category *i* for year *y* (t CO₂)
- $P_{EL,i,y}$ = Total passengers transported per year by the electricity-based vehicle category *i* for year *y* (passengers)
- $TD_{EL,i}$ = Average trip distance travelled by passengers using the electricity-based vehicle category *i* prior to project start (km)

49. The total emissions from the electricity-based vehicle category *i*, $TE_{EL,i,y}$, should be calculated, for each vehicle category *i*, using the “Tool to calculate baseline, project

⁵ Zero-emission in the context of operating emissions and not well-to-wheel or life-cycle emissions; this includes hydrogen.

⁶ In indirect project emissions the highest emission factor of all categories is taken if the survey respondent chooses the item “others”.

and/or leakage emissions from electricity consumption". When applying the tool, the parameter $EC_{BL,k,y}$ in the tool should be taken as the amount of electricity used by the electricity-based vehicle category i for year y , consistent with the transportation of $P_{EL,i,y}$ passengers along the average distance $TD_{EL,i}$.⁷

5.3.2.2. Case 2: Emission factors per PKM for fuel-based transport systems (e.g. road-based vehicles)

50. For fuel-based vehicle categories, the emission factor per PKM should be calculated as:

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

Where:

$EF_{PKM,i,y}$ = Emission factor per passenger-kilometre of vehicle category i in year y (g CO₂/PKM)

$EF_{KM,i,y}$ = Emission factor per kilometre of vehicle category i in year y (g CO₂/km)

OC_i = Average occupation rate of vehicle category i prior to the project start (passengers)

i = Relevant vehicle category

y = Year of the crediting period

5.3.2.2.1. Determination of the average occupation rate (OC_i)

51. The average occupation rate of vehicle category i is determined based on visual occupation studies for all vehicle categories i . For buses, besides the visual occupation studies, the occupation rate can also be based on boarding-alighting studies or electronic smart tickets, with expansion factors for routes served to determine the average occupation rate along the entire route. For taxis, the driver should not be included.
52. The detailed procedures concerning visual occupation studies and boarding-alighting studies are presented in Annexes Appendices 1, 2 and 3. The detailed procedures concerning expansion factors are presented in Annex Appendix 4.
53. For buses, as an alternative, the occupation rate can be based on an average trip distance of bus passengers, total passengers and total distance driven by buses, using the following equation:

$$OC_B = \frac{PBL_B \times TDBL_{P,B}}{DD_B} \quad \text{Equation (5)}$$

⁷ The trip distance is only monitored prior to the project start. The electricity consumed and the passengers transported are monitored annually to track technological improvements in the rail-based system leading to changes in the emission factor per passenger transported.

Where:

- OC_B = Average occupation rate of buses prior to the project start (passengers)
- PBL_B = Passengers transported by baseline buses prior to the project start (passengers)
- $TDBL_{P,B}$ = Average trip distance travelled by passengers using baseline buses prior to the project start (kilometre)
- DD_B = Total distance driven by all buses prior to the project start (kilometre)

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

54. Relevant fuel types, for each vehicle category, have to be identified. The emission factor per kilometre is re-calculated annually based on the recorded (last available official records) share of fuels per category. In case biofuel blends are used, the biofuel share of the blend should be accounted for with zero emission factor ($EF_{CO2,x,y}$).
55. If various sub-categories of buses exist (e.g. small, medium, large units) the emission factor is calculated for each bus sub-category, and after aggregated as explained further below. If bus lanes exist, the category “bus from bus lane” shall be included.
56. The emission factor per kilometre is not constant, but annually updated. Two options can be used to calculate $EF_{KM,i,y}$. For each vehicle category the project can choose which option to take. During the crediting period the project cannot change between one and the other option, i.e. the decision is fixed for the crediting period. Rail-based vehicles must monitor annually their electricity consumption plus passengers transported (see equation (3)).

5.3.2.2.3. Option 1: Annual monitoring of the specific fuel consumption (SFC) of the respective vehicle category i

$$EF_{KM,i,y} = \frac{\sum_x (SFC_{i,x,y} \times NCV_{x,y} \times EF_{CO2,x,y} \times N_{x,i})}{N_i} \quad \text{Equation (6)}$$

Where:

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

5.3.2.2.4. Option 2: Use of a fixed technology improvement factor (*IR*) for the respective vehicle category *i*

$$EF_{KM,i,y} = (IR_i)^{t+y} \cdot \frac{\sum_x (SFC_{i,x} \cdot NCV_{x,y} \cdot EF_{CO_2,x,y} \cdot N_{x,i})}{N_i} \quad \text{Equation (7)}$$

Where:

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

57. Technology improvement factors are listed in the following table:

Table 3. Default technology improvement factors (per annum)

Vehicle category	Technology improvement factor (IR)
Buses	0.99
Passenger cars	0.99
Taxis	0.99
Motorcycles (incl. tricycles)	0.99

58. For both Options 1 and 2 above, if various sub-categories of buses exist (e.g. small, medium, large units), after the emission factor for each sub-category ($EF_{KM,L,y}$, $EF_{KM,M,y}$, $EF_{KM,S,y}$) is calculated using the equation for $EF_{KM,i,y}$ presented above, the following aggregated emission factor has to be calculated and used:

$$EF_{KM,B,y} = \frac{EF_{KM,L,y} \times DD_L + EF_{KM,M,y} \times DD_M + EF_{KM,S,y} \times DD_S}{DD_L + DD_M + DD_S} \quad \text{Equation (8)}$$

Where:

$EF_{KM,B,y}$ = Emission factor per kilometre for buses (g CO₂/km)

$EF_{KM,L/M/S,y}$ = Emission factor per kilometre for buses of sub-category *L* (large buses), *M* (medium sized buses) and *S* (small buses) (g CO₂/km)

$DD_{L/M/S}$ = Total distance driven by buses sub-category *L* (large buses), *M* (medium sized buses) and *S* (small buses) prior to the project start (kilometre)

y = Year of the crediting period

59. If bus lanes already exist in the baseline the relevant emission factor per kilometre is calculated as average of all bus lanes existing within the category $EF_{km,BBL}$.
60. The distance driven by buses can be based on the average annual distance and the number of units. In other cases, however, companies might have reliable records on total distance driven by units.
61. Baseline emissions cover the entire emissions which would have been caused by the project passenger in absence of the project from his trip origin to his trip destination:
 - (a) The origin and destination of the trip are assumed to be equal for the baseline as for the project case with an exception of induced traffic included only as project but not as baseline trips;
 - (b) The trip distance and the modes used between O (origin) and D (destination) are however different in the baseline than in the project case;
 - (c) The trip distance may vary as some passengers using the project MRTS may be willing to make detours due to the higher speed of the MRTS versus conventional bus transport.
62. To fully capture all potential changes the methodology compares emissions per O-D trip of the baseline with emissions per O-D trip of the project. The data to determine O-D mode(s) and distances per mode are derived from a representative survey of project passengers realized annually. Total baseline emissions are calculated thereafter annually based on these parameters, the emissions per PKM and the amount of passengers transported by the project.

5.4. Project emissions

63. Project emissions are based on the fuel and/or electricity consumed by the MRTS (direct project emissions) plus emissions caused by project passengers from their trip origin to the entry station of the project and from the exit station of the project to their final destination (indirect project emissions), as illustrated in Figure 24.

Figure. 24 Direct and indirect project emissions



64. Project emissions are calculated as follows:

$$PE_y = DPE_y + IPE_y \quad \text{Equation (9)}$$

Where:

- PE_y = Project emissions in year y (t CO₂)
 DPE_y = Direct project emissions in year y (t CO₂)
 IPE_y = Indirect project emissions in year y (t CO₂)

5.4.1. Determination of direct project emissions (DPE_y)

5.4.1.1. Case 1: Use of fossil fuels in the project activity transport system

65. If the project transport system uses fossil fuels, the latest version of the “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion” shall be used. The following guidance is given for applying the tool:
- (a) The parameter $PE_{FC,j,y}$ in the tool corresponds to the direct project emissions from the project transport system that uses fossil fuels in year y (DPE_y);
 - (b) Element process j corresponds to the combustion of fuel type xn in the project vehicles.
66. If the project has no reliable records on total fuel consumed, the specific fuel consumption of a representative sample of comparable transport units (comparable technology, vintage and size) together with the total distance driven can be taken to calculate the parameter $FC_{PJ,x,y}$ in the tool. Transport units of the sample must be project units running on project routes. The sample criteria are based on technology (e.g. Euro standard), age, and unit size. To be conservative, project fuel consumptions based on sample data shall be based on the upper limit of the uncertainty band at a 95 per cent confidence level. This means that with 95 per cent confidence it is possible to state that the actual project fuel consumption is equal to or lower than the value used by the project.
67. If the total fuel consumed is determined based on sample measurements, the following equation is used:

$$FC_{PJ,x,y} = SFC_{i,x,y} \times DD_{PJ,x,y}$$

$$FC_{PJ,n,y} = SFC_{i,n,y} \times DD_{PJ,n,y} \quad \text{Equation (10)}$$

Where:

- $FC_{PJ,xn,y}$ = Total fuel consumed by project transport units using fuel type xn in year y (mass or volume units of fuel)
- $SFC_{i,xn,y}$ = Specific fuel consumption of vehicle category i using fuel xn in year y (mass or volume units of fuel per km)
- $DD_{PJ,xn,y}$ = Distance driven by transport units consuming fuel xn in year y (km)

5.4.1.2. Case 2: Use of electricity in the project activity transport system

68. If the project activity involves electricity-based transport systems (e.g. electrical railway systems), the emissions from electricity consumption are based on the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”. The parameter $PE_{EC,y}$ in the tool corresponds to the direct project emissions from the project transport system in year y (DPE_y). Only electricity consumed for train propulsion should be included in rail-based MRTS.

5.4.2. Determination of indirect project emissions (IPE_y)

69. Indirect project emissions are those caused by passengers from their trip origin up to the project activity entry station, and from the project activity exit station up to the trip final destination:
- (a) The survey realized identifies the origin, project entry station, project exit station and final destination of the passenger plus the modes used between the different points, e.g. bike from origin to project entry station and taxi from project exit station to final destination;
 - (b) The distances between origin and entry and between exit and destination are calculated based, e.g. on public transit routes, electronic maps and GPS (identical to baseline trip determination);
 - (c) The emission factors per passenger-kilometre used for indirect project emissions are identical to the baseline passenger-kilometre factors ($EF_{PKM,i,y}$).
70. The next steps should be followed to determine indirect project emissions:
- (a) **Step 1:** Conduct a survey, following the procedures presented in Appendix 4, in which for each surveyed passenger the trip distance per transport mode used to/from the MRTS is determined;
 - (b) **Step 2:** Calculate indirect project emissions for each surveyed passenger, as per equation 43 12 below;
 - (c) **Step 3:** Apply to each surveyed passenger an individual expansion factor in accordance with the survey sample design (as defined in Appendix 4), and summarize these to get the total indirect project emissions for the survey period (week). To get the annual (or monitoring period) indirect project emissions the indirect project emissions of the surveyed period (week) are calculated per passenger of the survey period (week) and multiplied with the total passengers transported per year (or period), as per equation 42 11 below.

- (d) **Step 4:** Apply the upper 95 per cent confidence interval to the total indirect project emissions (see Appendix 4).

$$IPE_y = \frac{P_y}{P_{SPER}} \sum_p (IPE_{p,y} \times FEX_{p,y}) \times 10^{-6} \quad \text{Equation (11)}$$

Where:

- IPE_y = Indirect project emissions in year y (t CO₂)
 $IPE_{p,y}$ = Indirect project emissions per surveyed passenger p in year y (g CO₂)
 $FEX_{p,y}$ = Expansion factor for each surveyed passenger p in year y
 P_y = Total number of passengers in year y
 P_{SPER} = Number of passengers in the time period of the survey (one week)
 p = Surveyed passenger (each individual)
 y = Year of the crediting period

71. The indirect project emissions per surveyed passenger are calculated based on the transport mode used, trip distance per mode and emission factor per mode.

$$IPE_{p,y} = \sum_i IPTD_{p,i,y} \times EF_{PKM,i,y} \quad \text{Equation (12)}$$

Where:

- $IPE_{p,y}$ = Indirect project emissions of surveyed passenger p in year y (g CO₂)
 $EF_{PKM,i,y}$ = Emission factor per passenger-kilometre of mode i in year y (g CO₂/PKM)
 $IPTD_{p,i,y}$ = Indirect project trip distance of surveyed passenger p using mode i in year y (km)

72. Based on the surveyed passenger and the survey design, the corresponding expansion factors are applied to calculate total indirect project emissions. Total indirect project emissions are determined based on the upper limit of the 95 per cent confidence interval as results are based on a sample/survey.

5.5. Leakage

73. Leakage emissions include the following sources:

- (a) Emissions due to changes of the load factor of taxis and buses of the baseline transport system due to the project ($LE_{LFB,y}$ and $LE_{LFT,y}$);
(b) Emissions due to reduced congestion on affected roads, provoking higher average vehicle speed, plus a rebound effect ($LE_{CON,y}$);
(c) Upstream Emissions of Gaseous Fuels ($LE_{UP,y}$).

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

$$LE_y = LE_{LFB,y} + LE_{LFT,y} + LE_{Con,y} + LE_{UP,y} \quad \text{Equation (13)}$$

Where:

- LE_y = Leakage emissions in year y (t CO₂)
- $LE_{LFB,y}$ = Leakage emissions due to change of load factor of buses in year y (t CO₂)
- $LE_{LFT,y}$ = Leakage emissions due to change of load factor of taxis in year y (t CO₂)
- $LE_{CON,y}$ = Leakage emissions due to change in congestion in year y (t CO₂)
- $LE_{UP,y}$ = Leakage emissions due to upstream emissions of gaseous fuels in year y (t CO₂)

76. As a conservative approach, it is assumed that for each components $LE_{LFB,y}$, $LE_{LFT,y}$, $LE_{CON,y}$, and $LE_{UP,y}$, only the positive value (leading to net emissions) is considered.

5.5.1. Determination of emissions due to a change in load factor of buses ($LE_{LFB,y}$)

77. The project could have a negative impact on the load factor of the conventional bus fleet. Load factor changes are monitored for the entire larger urban zone of the city as the potential impact is not necessarily in the proximity of the project MRTS (buses can be used in other parts of the larger urban zone of the city). The load factor of buses is monitored in the years 1 and 4 and of the crediting period. Leakage from load factor change of buses is only included if the load factor of buses has decreased by more than 10 percentage points comparing the monitored value with the baseline value, and are calculated as:

$$LE_{LFB,y} = \max \left\{ \frac{1}{10^6} \times N_{B,y} \times AD_B \times EF_{KM,B,y} \times \left(1 - \frac{OC_{B,y}}{OC_B} \right); 0 \right\} \quad \text{Equation (14)}$$

Where:

- $LE_{LFB,y}$ = Leakage emissions due to a change in load factor of buses in year y (t CO₂)
- $N_{B,y}$ = Number of baseline buses in year y (buses)
- AD_B = Average annual distance driven by baseline buses (km/bus)
- $EF_{KM,B,y}$ = Emission factor per kilometre for baseline buses in year y (g CO₂/km)
- $OC_{B,y}$ = Average occupancy rate of baseline buses in year y (passengers)
- OC_B = Average occupancy rate of baseline buses prior to the project start (passengers)

78. The occupancy rate of buses is monitored through boarding-alighting or through visual occupancy studies or by other means to be described in the CDM-PDD. The same monitoring method should be used for monitoring the baseline load factor before the project start and the load factor during the project execution. The detailed procedures concerning visual occupancy studies and boarding-alighting studies are presented in appendices 1, 2 and 3.

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

79. The project could have a negative impact on the load factor of taxis. Taxis can include cars as well as motorized rickshaws providing taxi services. If both types of services exist, the load factor change is monitored separately for these two taxi categories. Load factor changes are monitored for the entire larger urban zone of the city as taxis operate all over the larger urban zone of the city and are not confined to deliver their services in certain areas. The load factor of taxis is monitored in the years 1 and 4 of the crediting period. This leakage is calculated as follows:

$$LE_{LFT,y} = \max \left\{ N_{T,y} \times AD_T \times EF_{KM,T,y} \times \left(1 - \frac{OC_{T,y}}{OC_T} \right) \times \frac{1}{10^6}; 0 \right\} \quad \text{Equation (15)}$$

Where:

- $LE_{LFT,y}$ = Leakage emissions due to a change in load factor of taxis in year y (tCO₂)
 $N_{T,y}$ = Number of baseline taxis in year y (taxis)
 AD_T = Average annual distance driven by baseline taxis (km/taxi)
 $EF_{KM,T,y}$ = Emission factor per kilometre for baseline taxis in year y (g CO₂/km)
 $OC_{T,y}$ = Average occupancy rate of baseline taxis in year y (passengers)
 OC_T = Average occupancy rate of baseline taxis prior to the project start (passengers)

80. The maximum change in load factor attributed to taxis is the emission reductions due to passengers switching from taxis to the project (calculated by the emission factor per passenger-kilometre for taxis, trip distance and number of passengers transported by the project, which would have used taxis in absence of the project). This maximum condition is established as load factors might worsen citywide also due to factors external to the project and leakage from a change in load factor of taxis due to the project can at maximum be according to the number of passengers transported by the project which who in absence of the latter would have taken a taxi.
81. The occupancy rate of taxis is monitored through visual occupation studies counting the number of passengers. The detailed procedures concerning visual occupancy studies for taxis are presented in Appendix 3.
82. The parameter emission factor per kilometre for baseline taxis in year y ($EF_{KM,T,y}$) is calculated using the equation for $EF_{KM,i,y}$ presented in the baseline emissions section, substituting i for T (taxis).

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

83. The project activity may reduce the number of remaining buses and potentially other vehicles on roads used by mixed traffic and, thus, also reduce congestion. On the other hand, MRTS project activities may also reduce the road space available for conventional buses and individual transport modes. Therefore, two effects resulting from reduced congestion are considered:
- (a) Induced traffic effect (or rebound effect), i.e. more trips of passenger cars on the “affected roads”;
 - (b) Changes in vehicle speed effect, i.e. change of emissions due to a reduced or increased speed of cars on “affected roads”.
84. 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.⁸ This change in road capacity available for individual motorised transport modes may result from the reduction of road space due to the implementation of MRTS and/or a potential reduction of traffic flow due to the withdrawal of conventional public transport units as a result of the project activity.
85. To determine whether road capacity is reduced the following procedure shall be applied:

5.5.3.1. ~~Step a):~~ Determination of the additional road capacity available to motorised transport modes

86. The following equation determines the additional road capacity, available to the transport modes remaining in operation, as a result of the implementation of project activity in the year when the project MRT system is intended to reach its planned capacity:

$$ARS_y = \sum_y \frac{BSCR_y}{N_B} \times SRS - \frac{RS_{BL} - RS_{PJ}}{RS_{BL}} \quad \text{Equation (16)}$$

Where:

ARS_y	=	Additional road capacity available to individual motorised transport modes in year y when the project MRT system is intended to reach its planned capacity (in percentage)
$BSCR_y$	=	Bus units retired as a result of the project in year y
N_B	=	Number of buses in use in the baseline year x (units)
SRS	=	Share of road space used by public transport in the baseline year x (in percentage)
RS_{BL}	=	Total road space available in the baseline year x (lane-kilometers)

⁸ Emission reductions due to the speed increase of the traffic flow generally overweighs the increase in emissions resulting from the traffic induction of passenger cars as a result of reduced congestion.

RS_{PJ} = Total available road space in the project (=RSB minus kilometre of lanes that where reduced due to dedicating bus lanes to the project activity) (lane-kilometers)

x = Most recent calendar year for which data is available. Data not older than three years

87. The following equation shall be used to determine SRS if no recent and good quality study is available which has calculated this parameter:

$$SRS = \frac{TD_B \times 2.5}{TD_B \times 2.5 + TD_T + TD_C} \quad \text{Equation (17)}$$

Where:

SRS = Share of road space used by public transport in the baseline year x (in percentage)

TD_B = Total distance driven by public transport buses in the baseline year x (kilometers)

TD_T = Total distance driven in kilometers by taxis in the baseline year x (kilometers)

TD_C = Total distance driven in by passenger cars in the baseline year x (kilometers)

x = Most recent calendar year for which data is available. Data not older than three years

88. It is assumed that one bus occupies 2.5 times more road space than a personal car or a taxi.
89. For all distance variables the same vintage of data, the same spatial scope and the same time-span (e.g. one month or one year) is required.
90. If AR_{Sy} is negative, leakage emissions due to increased congestion as a result of the reduced road capacity due to the project activity shall be quantified as per section 5.5.3.2. Step b) below. If AR_{Sy} is positive, $LE_{CON,y}$ is assumed to be zero.

5.5.3.2. **Step b): Calculation of $LE_{CON,y}$**

91. The corresponding emissions $LE_{CON,y}$ are calculated as follows:

$$LE_{CON,y} = \max(LE_{REB,y} + LE_{SP,y}, 0) \quad \text{Equation (18)}$$

Where:

$LE_{REB,y}$ = Leakage emissions due to induced traffic / rebound effect in year y (t CO₂)

$LE_{SP,y}$ = Leakage emissions due to change in vehicle speed in year y (t CO₂)

5.5.3.3. **Step c): Determination of emissions due to induced traffic/rebound effect ($LE_{REB,y}$)**

92. The concept to capture emissions from induced traffic (or rebound effect) includes the following assumptions (induced traffic is measured for passenger cars and taxis):
 - (a) The distance driven on the affected roads by all additional cars/taxis is considered as additional trip distance, i.e. it is assumed that formerly used alternative routes are shorter, which is a conservative assumption;
 - (b) All additional cars/taxis on the affected roads are considered to be induced by the project and not by external effects such as general traffic growth, which again is a conservative assumption.
93. The monitoring is realized through measurements of traffic flows and distance driven by passenger cars and taxis on the affected roads. Monitoring is realized in the years 1 and 4 of the crediting period.
94. As a first step the “affected roads” are identified and clearly listed in the PDD including a map. The procedure to identify the “affected roads” is described in the definition section of the methodology under the term “affected roads”.
95. A negative rebound effect based on additional congestion is expected in this situation. As prior condition to measuring the negative rebound effect thus for each affected road the average speed of cars/taxis is monitored and compared with the baseline one.
96. Vehicle speed refers to the average speed, i.e. total distance divided by total time, on the affected road. Taxis and passenger cars are treated identical. This condition should be monitored for each affected road.
97. The rebound effect for the affected roads is calculated as follows:

$$LE_{REB,y} = \frac{1}{10^6} \times \sum_i \left(TDIZ_{i,y} \times EF_{KM,i,y} \times (NIZ_{i,y} - NIZ_{i,BL} + NIZ_{i,MS,y}) \right) \quad \text{Equation (19)}$$

Where:

- $LE_{REB,y}$ = Leakage emissions due to rebound effect in year y (t CO₂)
- $TDIZ_{i,y}$ = Average trip distance made by cars/taxis on the affected roads in year y (km)
- $EF_{KM,i,y}$ = Emission factor per kilometre for cars and taxis in year y (g CO₂/km)
- $NIZ_{i,y}$ = Number of cars/taxis per annum using the affected roads in year y (cars, taxis)
- $NIZ_{i,BL}$ = Number of cars/taxis per annum using the affected roads in **the baseline year x** (cars, taxis)

$NIZ_{i,MS,y}$ = Number of cars/taxis per annum not used anymore due to mode shift to the MRTS in year y (cars, taxis)
 i = Cars, taxis
 x = Most recent calendar year for which data is available. Data not older than three years

98. The number of cars and taxis per annum not used anymore due to mode shift to the MRTS in year y is calculated as:

$$NIZ_{i,MS,y} = \frac{MS_{i,y} \times P_y}{OC_i} \quad \text{Equation (20)}$$

Where:

$NIZ_{i,MS,y}$ = Number of cars/taxis per annum not used anymore due to mode shift to the MRTS in year y (cars, taxis)
 $MS_{i,y}$ = Net share of passengers using the MRTS which would have used mode i in year y (%)
 P_y = Passengers transported by the project in year y (passengers)
 OC_i = Average occupancy rate of vehicle category i prior to the project start year x (passengers)
 i = Cars, taxis
 x = Most recent calendar year for which data is available. Data not older than three years

99. The net share of passengers that shifted from car/taxi to the MRTS is based on the percentage of passengers which would have used in the baseline cars/taxis at least partially for their trip minus the share of passengers of the MRTS which use cars/taxis partially for their trip (to and/or from the MRTS).

5.5.3.4. ~~Step d)~~ **Determination of emissions due to changes in vehicle speed ($LE_{SP,y}$)**

100. Leakage emissions due to changes in vehicle speed are determined only for cars and taxis, as presented below.

$$LE_{SP,y} = \frac{1}{10^6} \times \sum_i (NIZ_{i,y} \times TDIZ_{i,y}) \quad \text{Equation (21)}$$

$$LE_{SP,y} = \frac{1}{10^6} \times \sum_i (NIZ_{i,y} \times TDIZ_{i,y} \times (EF_{KM,VP,i,y} - EF_{KM,VB,i})) \quad \text{E}$$

Where:

- $LE_{SP,y}$ = Leakage emissions due to changes in vehicle speed of cars and taxis in year y (t CO₂)
- $NIZ_{i,y}$ = Number of cars/taxis using the affected roads in year y (cars, taxis)
- $TDIZ_{i,y}$ = Average trip distance made by cars/taxis on the affected roads in year y (km)
- $EF_{KM,VP,i,y}$ = Emission factor per kilometre for cars/taxis at the project speed in year y (g CO₂/km)
- $EF_{KM,VB,i}$ = Emission factor per kilometre for cars/taxis at the baseline speed (g CO₂/km)
- i = Cars, taxis

101. The project speed on the affected roads is monitored in the years 1 and 4 of the crediting period. Vehicle speed is monitored under moving conditions. The same method should be used for determining the baseline and project speed.
102. The number of cars and taxis on the affected roads are monitored through visual or electronic counting.
103. To determine the emission factor per kilometre of cars/taxis at the project speed and baseline speed, project proponents can either use a speed dependency factor developed with an officially recognized methodology for the project region with the corresponding documentation to ensure good quality (this is the preferred option) or use as a default relationship between the speed dependency factor and emissions for passenger cars developed by CORINAIR. The same vehicle speed is used for passenger cars and taxis.

$$\frac{EF_{KM,VP,i,y}}{EF_{KM,VB,i}} = \left(\frac{V_{P,y}}{V_B} \right)^{-0.7} \quad \text{Equation (3)}$$

Where:

- $EF_{KM,VB,i}$ = Emission factor per kilometre for cars/taxis at the baseline speed (gCO₂/km)
- $EF_{KM,VP,i,y}$ = Emission factor per kilometre for cars/taxis at the project speed in year y (gCO₂/km)
- V_B = Average speed of cars/taxis prior to the project start (km/h)
- $V_{P,y}$ = Average speed of cars/taxis in year y (km/h)

104. V_B and V_P in this case refer to moving speed, i.e. the speed of the vehicle under moving conditions.

5.5.3.4.1. Upstream emissions from Gaseous Fuels ($LE_{UP,y}$)

105. Upstream leakage of gaseous fuels shall be only included if the project vehicles consume more gaseous fuels than baseline vehicles. In this case, and in order to simplify the calculations, the calculation of upstream leakage emissions is based only on the gaseous fuels used under the project activity. The following leakage emission sources shall be considered:

- (a) Fugitive CH_4 emissions associated with fuel extraction, processing, liquefaction, transportation, re-gasification and distribution of natural gas used in the project plant and fossil fuels used in the grid in the absence of the project activity;
- (b) In the case more LNG is used under the project activity: CO_2 emissions from fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression into a natural gas transmission or distribution system.

106. Thus, leakage emissions are calculated as follows:

$$LE_{UP,y} = LE_{CH_4,y} + LE_{LNG,CO_2,y} \quad \text{Equation (22)}$$

Where:

- $LE_{UP,y}$ = Leakage upstream emissions of gaseous fuels during the year y in t CO_2e
- $LE_{CH_4,y}$ = Leakage emissions due to fugitive upstream CH_4 emissions in the year y in t CO_2e
- $LE_{LNG,CO_2,y}$ = Leakage emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year y in t CO_2e

5.5.3.4.2. Emissions due to fugitive upstream CH_4 emissions

$$LE_{CH_4,y} = FC_{PJ,NG,y} \times NCV_{NG,y} \times EF_{NG,upstream,CH_4} \times GWP_{CH_4} \quad \text{Equation (23)}$$

Where:

- $L_{CH_4,y}$ = Leakage emissions due to upstream fugitive CH_4 emissions in the year y in t CO_2e
- $FC_{PJ,NG,y}$ = Quantity of natural gas used by project units in the year y in m^3
- $NCV_{NG,y}$ = Net calorific value of the natural gas used by the project during the year y in GJ/m^3
- $EF_{NG,upstream,CH_4}$ = Emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas in t CH_4/GJ
- GWP_{CH_4} = Global warming potential of methane valid for the relevant commitment period

107. Where reliable and accurate national data on fugitive CH₄ emissions associated with the production, transportation and distribution of NG is available, project participants should use this data. Where such data is not available, project participants may use the default values provided by IPCC (latest version). The NCV is based on local, regional or national data or on IPCC default values.

5.5.3.4.3. CO₂ emissions from LNG

108. Where applicable, CO₂ emissions from fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system ($LE_{LNG,CO_2,y}$) should be estimated by multiplying the quantity of natural gas combusted in the project system with an appropriate emission factor, as follows:

$$LE_{LNG,CO_2,y} = FC_{PJ,NG,y} \times EF_{CO_2,upstream,LNG} \quad \text{Equation (24)}$$

Where:

$LE_{LNG,CO_2,y}$	=	Leakage emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year y in t CO ₂ e
$FC_{PJ,NG,y}$	=	Quantity of natural gas used by project units during the year y in TJ
$EF_{CO_2,upstream,LNG}$	=	Emission factor for upstream CO ₂ emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system in t CO ₂ /TJ

109. Where reliable and accurate national data on fugitive CH₄ emissions associated with the production, transportation and distribution of LNG is available, project participants should use this data. Where such data is not available, project participants may use the default values provided by IPCC (latest version).

5.6. Emission reductions

110. Emissions reductions are calculated as:

$$ER_y = BE_y - PE_y + LE_y \quad \text{Equation (25)}$$

Where:

ER_y	=	Emissions reductions in year y (t CO ₂)
BE_y	=	Baseline emissions in year y (t CO ₂)
PE_y	=	Project emissions in year y (t CO ₂)
LE_y	=	Leakage emissions in year y (t CO ₂)

5.7. Crediting period

The implementation of the methodology is limited to a 10-year crediting period.

111. When a renewable crediting period is chosen, project participants shall use a four-step model, or equivalent, of the transportation system of the project city for the purpose of modelling the modal split, share of passengers who shifted from electricity-based or road-based vehicle category i , S_i or share of passenger-kilometres who shifted from electricity-based or road-based vehicle category i , SD_i , and an average trip distances travelled by passengers who shifted from electricity-based or road-based vehicle category D_i for the second and third crediting periods. The model should be tested and calibrated with the results of origin-destination surveys. For the determination of the baseline emissions, the most conservative value shall be used between estimates of baseline emissions based on the modelled parameters and the parameters determined via passenger surveys.
112. Percentage or share of vehicle-kilometers or vehicles in vehicle category i using fuel type n in year y of the second or third crediting period, $N_{i,n,y}/N_{i,y}$, or parameters used to estimate this share $N_{i,y}$ and $N_{i,n,y}$, which are the number of vehicle-kilometers or vehicles in vehicle category i , and the number of vehicle-kilometers or vehicles in vehicle category i using fuel type n in year y , can be based on data from municipal transit authorities on vehicle registration statistics from the respective city or data from vehicle control stations (technical and emission control stations). If no city/municipal data is available, regional data (canton, state) or, as a last option, national data can be used.
113. Furthermore, project participants shall apply the latest approved version of the tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period".

5.8. Data and parameters not monitored

114. In addition to the parameters listed in the tables below, the procedures contained in the tools referred to in this methodology also apply.

Data / Parameter table 1.

Data / Parameter:	$OC_i/OC_B/OC_T/OC_C/OC_{MR}$
Data unit:	Passengers
Description:	Average occupation rate of vehicle category i prior to the project start. In particular, B stands for buses, T for taxis, C for passenger cars and MR for motorized rickshaws
Source of data:	Municipal transit authorities or specific studies done by the project proponent or a third party. Vintage maximum three years

Measurement procedures (if any):	<p>Based on visual occupancy studies for all vehicle categories.</p> <p>For buses the occupancy rate is based on boarding-alighting studies, electronic smart tickets or on visual occupancy studies with expansion factors for routes served to determine the average occupancy rate along the entire route. As an alternative for buses, the occupancy rate can be based on average trip distance of bus passengers, total passengers and total distance driven by buses.</p> <p>For taxis (including motorized rickshaws), the driver should not be counted.</p> <p>The detailed procedures concerning visual occupancy and boarding-alighting studies are presented in Annexes Appendices 1, 2 and 3</p>
Any comment:	-

Data / Parameter table 2.

Data / Parameter:	PBL_B
Data unit:	Passengers
Description:	Passengers transported by baseline buses prior to the project start (per day or year)
Source of data:	Municipal transit authorities or bus operators Vintage maximum three years. Use the same vintage as for the parameter <i>TDBL_{P,B}</i>
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 3.

Data / Parameter:	TDBL_{P,B}
Data unit:	Kilometres
Description:	Average trip distance travelled by passengers using baseline buses prior to the project start
Source of data:	Municipal transit authorities or specific studies done by the project proponent or a third party
Measurement procedures (if any):	In general, based on a survey asking passengers entry and exit stations and calculating the trip distance on the bus. Vintage maximum three years. Use the same vintage as for the parameter PBL _B
Any comment:	Used to determine the average occupation rate of buses together with the total number of buses and the total distance driven by buses

Data / Parameter table 4.

Data / Parameter:	DD_B/DD_L/DD_M/DD_S
Data unit:	Kilometres
Description:	Total distance driven by buses from various sub-categories prior to the project start. B stands for all buses, L for large buses, M for medium buses and S for small buses

Source of data:	Data from bus companies (company records), municipal transit authorities or specific studies done by the project proponent or a third party. Vintage maximum three years
Measurement procedures (if any):	Distance driven by buses is often recorded by bus companies based on odometer reading. Preferable is GPS or other electronic means, however this is not yet common in bus companies. Data can also be based on sample measurements based, in general, on daily distance driven (measured by odometer or GPS) plus the average number of operation days of a bus (based on bus operator information). The total distance driven by all buses is the multiplication of the average annual distance driven per bus and the number of registered buses operating in the larger urban zone of the city
Any comment:	-

Data / Parameter table 5.

Data / Parameter:	AD_B
Data unit:	Kilometres/bus
Description:	Average annual distance driven by baseline buses
Source of data:	Data from bus companies (company records), municipal transit authorities or specific studies done by the project proponent or a third party. Vintage maximum three years
Measurement procedures (if any):	Distance driven by buses is often recorded by bus companies based on odometer reading. Preferable is GPS or other electronic means, however this is not yet common in bus companies. Data can also be based on sample measurements based, in general, on daily distance driven (measured by odometer or GPS) plus the average number of operation days of a bus (based on bus operator information). Calculated as the division of the total distance driven by all registered buses operating in the larger urban zone of the city, by the number of registered buses
Any comment:	-

Data / Parameter table 6.

Data / Parameter:	SFC_{i,x}
Data unit:	grams of fuel/km
Description:	Specific fuel consumption of vehicle category <i>i</i> using fuel type <i>x</i> prior to the project start
Source of data:	In decreasing order of preference: Local measured data not older than 3 years (studies e.g. performed by universities or ordered by project proponent); National or international data from studies not older than three years; IPCC default values for the respective vehicle categories (latest year)

Measurement procedures (if any):	<p>The following alternatives are proposed to determine specific fuel consumption (in order of preference):</p> <p>Alternative 1: Measurement of fuel consumption data using total data (if available e.g. from bus or taxi companies) or a representative sample for the respective category and fuel type. Sampling per category and fuel should include, if data is available, as core characteristics, vehicle age and motorization to ensure that the sample is as close as possible to the actual vehicle composition of the larger urban zone of the city. Vehicle age and technology (related often to emission standards such as Euro standards) are factors which influence, to a significant extent, the fuel consumption. This is recognized e.g. by IPCC default factors which are characterized according to age and technology. To be conservative, specific fuel consumptions based on samples shall be based on the lower limit of the uncertainty band at a 95% confidence level, i.e. with 95% confidence the actual average fuel consumption is equal to or higher than the value used by the project</p> <p>Alternative 2: Use of fixed values based on the national or international literature. The literature data can either be based on measurements of similar vehicles in comparable surroundings (e.g. from comparable cities of other countries) or may include identifying the vehicle age and technology of average vehicles circulating in the project region and then matching this with the most appropriate IPCC default values. The most important proxy to identify vehicle technologies is the average age of vehicles used in the zone of influence of the project. To determine if either US, Japanese or European default factors apply or local vehicle manufacturer information can be used (in the case of having a substantial domestic vehicle motor industry) or source of origin of vehicle imports).</p> <p>Alternative 3: Latest IPCC default values reported matching the respective vehicle category, age, vehicle origin and technology</p>
Any comment:	-

Data / Parameter table 7.

Data / Parameter:	N_i
Data unit:	Vehicles
Description:	Number of vehicles of category <i>i</i> prior to the project start
Source of data:	Municipal transit authorities based on vehicle registration statistics from the respective city or data from vehicle control stations (technical and emission control stations). If no city/municipal data is available, regional data (canton, state) or, as a last option, national data can be used. Vintage maximum three years
Measurement procedures (if any):	-

Any comment:	Used for all vehicle categories included in the project. For passenger cars and taxis this data is monitored annually. For all other categories no annual monitoring is required. For buses as well as for taxis informal or illegal units may operate. While estimates on the number of informal units may be available these are due to their nature not trustworthy. For both categories it is thus recommended to only include formally registered units. As the methodology is based on emissions per PKM absolute numbers are not relevant for determining this parameter. It is however important that transported passengers are also based on the official records thus not including passenger trips of informal units
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Data / Parameter table 8.

Data / Parameter:	$N_{x,i}$
Data unit:	Dimensionless
Description:	Number of vehicles in vehicle category i using fuel type x prior to the project start
Source of data:	Municipal transit authorities based on vehicle registration statistics from the respective city or data from vehicle control stations (technical and emission control stations). If no city/municipal data is available, regional data (canton, state) or, as a last option, national data can be used. Vintage maximum three years
Measurement procedures (if any):	-
Any comment:	Used for all vehicle categories included in the project. For passenger cars and taxis this data is monitored annually. For all other categories no annual monitoring is required. For buses as well as for taxis informal or illegal units may operate. While estimates on the number of informal units may be available these are due to their nature not trustworthy. For both categories it is thus recommended to only include formally registered units. As the methodology is based on emissions per PKM absolute numbers are not relevant for determining this parameter. It is however important that transported passengers are also based on the official records thus not including passenger trips of informal units

Data / Parameter table 9.

Data / Parameter:	N_B
Data unit:	Dimensionless
Description:	Number of buses in use in the baseline
Source of data:	Municipal transit authorities based on vehicle registration statistics from the respective city or data from vehicle control stations (technical and emission control stations). If no city/municipal data is available, regional data (canton, state) or, as a last option, national data can be used. Vintage maximum three years
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 10.

Data / Parameter:	RS_{BL}, RS_{PJ}
Data unit:	km
Description:	Road space in the baseline and project
Source of data:	Official statistics or studies conducted by the project proponent or a third party
Measurement procedures (if any):	-
Any comment:	Road space baseline based on official information. Reduced road space based on construction plans (reduced road space is lanes which were eliminated due to dedicating bus lanes to the project system). Road space project = road space baseline – eliminated lanes

Data / Parameter table 11.

Data / Parameter:	AD_T
Data unit:	Kilometres/taxi
Description:	Average annual distance driven by taxis
Source of data:	Municipal transit authorities or taxi operators. Vintage maximum three years
Measurement procedures (if any):	Based on records of taxi companies or on surveys. A simple method can be odometer reading of a sample of taxis and dividing total distance driven by the vehicle age
Any comment:	-

Data / Parameter table 12.

Data / Parameter:	$NIZ_{i,BL}/NIZ_{C,BL}/NIZ_{T,BL}$
Data unit:	Number of vehicles
Description:	Number of vehicles of vehicle category i using the affected roads per annum in the baseline. In particular, C stands for cars, and T for taxis
Source of data:	Municipal transit authorities or studies ordered by project proponent. Vintage maximum three years
Measurement procedures (if any):	Visual counting on the identified roads. Counting should be based on various parts of the road, if major roads depart from the observed road to ensure average numbers
Any comment:	The same method should be applied to determine number of cars and taxis in the project situation to ensure a consistent approach

Data / Parameter table 13.

Data / Parameter:	V_B
Data unit:	km/h
Description:	Average total speed and average speed under circulation is measured

Source of data:	Municipal transit authorities or studies ordered by project proponent. Vintage maximum three years, if no major infrastructure or policy (e.g. licence plate scheme or new traffic signalling) changes have occurred since the last major change
Measurement procedures (if any):	On-board measurements determining the average speed when circulating and average total speed on the road based e.g. on GPS
Any comment:	<p>Average speed required for calculation of the rebound effect refers to total distance divided by total time on the affected road.</p> <p>Average moving speed required for the calculation of the speed effect refers to the speed under moving conditions i.e. total distance divided by time under movement (total time minus standstill time of vehicle), on the affected road.</p> <p>Only passenger cars and 4-wheel taxis are monitored. The same speed data is taken for both vehicle types.</p> <p>The same method should be applied to determine vehicle project speed thereafter to ensure a consistent approach.</p> <p>Required for monitoring of the rebound effect and the speed effect on affected roads</p>

Data / Parameter table 14.

Data / Parameter:	TD_B, TD_T, TD_C
Data unit:	km
Description:	Total distance driven by buses (B), taxis (T) and personal cars (C) in the baseline
Source of data:	Official statistics (vehicle registration data; transportation statistics)
Measurement procedures (if any):	-
Any comment:	Data can be either with or without informal transport as long as the above mentioned parameters are from the same data source. In general, data including only formal transport is of a better data quality and should thus be taken

Data / Parameter table 15.

Data / Parameter:	$EF_{CO2,upstream,CH4}$
Data unit:	t CH ₄ /GJ
Description:	Emission factor for upstream fugitive methane emissions of natural gas from production, transportation, distribution, and, in the case of LNG, liquefaction, transportation, re-gasification and compression into a transmission or distribution system

Source of data:	<p>Where reliable and accurate national data on fugitive CH₄ emissions associated with the production, and in case of natural gas, the transportation and distribution of the fuels is available, project participants should use this data to determine average emission factors by dividing the total quantity of CH₄ emissions by the quantity of fuel produced or supplied respectively. Where such data is not available, project participants may use the default values provided in the table below. Note that the emission factor for fugitive upstream emissions for natural gas should include fugitive emissions from production, processing, transport and distribution of natural gas, as indicated in the table below. Where default values from this table are used, the natural gas emission factors for the location of the project activity should be used. The US/Canada values may be used in cases where it can be shown that the relevant system element (gas production and/or processing/transmission/ distribution) is predominantly of recent vintage and built and operated to international standards</p> <table><tr><th>Activity</th><th>Unit</th><th>Default emission factor</th><th>Reference for the underlying emission factor range in Volume 3 of the 1996 Revised IPCC Guidelines</th></tr><tr><td colspan="4">USA and Canada</td></tr><tr><td>Production</td><td>t CH₄ / PJ</td><td>72</td><td>Table 1-60, p. 1.129</td></tr><tr><td>Processing, transport and distribution</td><td>t CH₄ / PJ</td><td>88</td><td>Table 1-60, p. 1.129</td></tr><tr><td>Total</td><td>t CH₄ / PJ</td><td>160</td><td></td></tr><tr><td colspan="4">Eastern Europe and former USSR</td></tr><tr><td>Production</td><td>t CH₄ / PJ</td><td>393</td><td>Table 1-61, p. 1.129</td></tr><tr><td>Processing, transport and distribution</td><td>t CH₄ / PJ</td><td>528</td><td>Table 1-61, p. 1.129</td></tr><tr><td>Total</td><td>t CH₄ / PJ</td><td>921</td><td></td></tr><tr><td colspan="4">Western Europe</td></tr><tr><td>Production</td><td>t CH₄ / PJ</td><td>21</td><td>Table 1-62, p. 1.130</td></tr><tr><td>Processing, transport and distribution</td><td>t CH₄ / PJ</td><td>85</td><td>Table 1-62, p. 1.130</td></tr><tr><td>Total</td><td>t CH₄ / PJ</td><td>105</td><td></td></tr><tr><td colspan="4">Other oil exporting countries / Rest of world</td></tr><tr><td>Production</td><td>t CH₄ / PJ</td><td>68</td><td>Table 1-63 and 1-64, p. 1.130 and 1.131</td></tr><tr><td>Processing, transport and distribution</td><td>t CH₄ / PJ</td><td>228</td><td>Table 1-63 and 1-64, p. 1.130 and 1.131</td></tr><tr><td>Total</td><td>t CH₄ / PJ</td><td>296</td><td></td></tr></table> <p>Note: The emission factors in this table have been derived from IPCC default Tier 1 emission factors provided in Volume 3 of the 1996 Revised IPCC Guidelines, by calculating the average of the provided default emission factor range.</p>	Activity	Unit	Default emission factor	Reference for the underlying emission factor range in Volume 3 of the 1996 Revised IPCC Guidelines	USA and Canada				Production	t CH ₄ / PJ	72	Table 1-60, p. 1.129	Processing, transport and distribution	t CH ₄ / PJ	88	Table 1-60, p. 1.129	Total	t CH ₄ / PJ	160		Eastern Europe and former USSR				Production	t CH ₄ / PJ	393	Table 1-61, p. 1.129	Processing, transport and distribution	t CH ₄ / PJ	528	Table 1-61, p. 1.129	Total	t CH ₄ / PJ	921		Western Europe				Production	t CH ₄ / PJ	21	Table 1-62, p. 1.130	Processing, transport and distribution	t CH ₄ / PJ	85	Table 1-62, p. 1.130	Total	t CH ₄ / PJ	105		Other oil exporting countries / Rest of world				Production	t CH ₄ / PJ	68	Table 1-63 and 1-64, p. 1.130 and 1.131	Processing, transport and distribution	t CH ₄ / PJ	228	Table 1-63 and 1-64, p. 1.130 and 1.131	Total	t CH ₄ / PJ	296	
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Measurement procedures (if any):	-																																																																				
Any comment:	-																																																																				

Data / Parameter table 16.

Data / Parameter:	EF _{CO₂,upstream,LNG}
Data unit:	t CO ₂ e/TJ
Description:	Emission factor for upstream CO ₂ emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system

Source of data:	Where reliable and accurate data on upstream CO ₂ emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system is available, project participants should use this data to determine an average emission factor. Where such data is not available, project participants may use the default value of 6 t CO ₂ e/TJ
Measurement procedures (if any):	-
Any comment:	-

6. Monitoring methodology

6.1. Data and parameters monitored

115. All data collected as part of monitoring should be archived electronically and be kept at least for two years after the end of the last crediting period. 100% One hundred per cent of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards.
116. In addition to the parameters listed in the tables below, the procedures contained in the tools referred to in this methodology also apply.

Data / Parameter table 17.

Data / Parameter:	FC _{PJ,xn,y}
Data unit:	Mass or volume units of fuel
Description:	Total fuel of type xn consumed by the project transport units
Source of data:	MRTS operator(s)
Measurement procedures (if any):	Based on fuelling station reports
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	Control with fuel invoices
Any comment:	Used for MRTS with buses or rail-based systems not using electricity

Data / Parameter table 18.

Data / Parameter:	NCV _{x:n,y}
Data unit:	J/mass or volume units of fuel in year y
Description:	Net calorific value of fuel type xn

Source of data:	The following data sources may be used if the relevant conditions apply:	
	Data source	Conditions for using the data source
	(a) Values provided by the fuel supplier in invoices taken from a sample of fuel stations in the larger urban zone of the city	This is the preferred source if the carbon fraction of the fuel is not provided
	(b) Measurements by the project participants taken from a sample of fuel stations in the larger urban zone of the city	If (a) is not available
	(c) Regional or national default values	If (a) is not available This source can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)
	(d) IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	
Measurement procedures (if any):	For (a) and (b): measurements should be undertaken in line with national or international fuel standards	
Monitoring frequency:	For (a) and (b): the NCV should be obtained for each fuel delivery, from which weighted average annual values should be calculated. For (c): review the appropriateness of the values annually. For (d): any future revision of the IPCC Guidelines should be taken into account	
QA/QC procedures:	Verify if the values under (a), (b) and (c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range, collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in (a), (b) or (c) should have ISO17025 accreditation or justify that they can comply with similar quality standards	
Any comment:	The parameter is used for baseline as well as project emissions and vehicle owners or operators can buy fuel from a variety of sources (fuel stations). In practice therefore it is considered to be simpler to determine the parameter using options (c) or (d)	

Data / Parameter table 19.

Data / Parameter:	EF_{CO₂,x,y}
Data unit:	g CO ₂ /J
Description:	CO ₂ emission factor for fuel type x in year y

Source of data:	The following data sources may be used, if the relevant conditions apply:	
	Data source	Conditions for using the data source
	(a) Values provided by the fuel supplier in invoices taken from a sample of fuel stations in the larger urban zone of the city	This is the preferred source
	(b) Measurements by the project participants taken from a sample of fuel stations in the larger urban zone of the city	If (a) is not available
	(c) Regional or national default values	If (a) is not available. This source can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)
	(d) IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	
Measurement procedures (if any):	<p>For (a) and (b): measurements should be undertaken in line with national or international fuel standards.</p> <p>For (a): if fuel suppliers provide the NCV value and the CO₂ emission factor on the invoices and these two values are based on measurements for this specific fuel, this CO₂ factor should be used. If another source for the CO₂ emission factor is used or no CO₂ emission factor is provided, options (b), (c) or (d) should be used</p>	
Monitoring frequency:	<p>For (a) and (b): the CO₂ emission factor should be obtained for each fuel delivery, from which weighted average annual values should be calculated.</p> <p>For (c): review the appropriateness of the values annually.</p> <p>For (d): any future revision of the IPCC Guidelines should be taken into account</p>	
QA/QC procedures:	-	
Any comment:	The parameter is used for baseline as well as project emissions and vehicle owners or operators can buy fuel from a variety of sources (fuel stations). In practice therefore it is considered to be simpler to determine the parameter using options (c) or (d)	

Data / Parameter table 20.

Data / Parameter:	SFC_{i,xn,y}
Data unit:	Mass or volume units of fuel/km
Description:	Specific fuel consumption of vehicle category <i>i</i> using fuel type <i>xn</i> in year <i>y</i>
Source of data:	MRTS operator(s) or project owner
Measurement procedures (if any):	<p>Based on specific studies or calculated based on total fuel consumed and total distance driven per bus size sub-category.</p> <p>If based on studies, the specific fuel consumption is taken of a representative sample of comparable project units in terms of technology, vintage and size. Buses of the sample must be project units running on project bus lanes. The sample criteria are based on technology (Euro standard), age, and bus size. The sample must be representative of the route(s) serviced by the project as well as the operation frequencies during the day to account for differences of fuel consumption related to time.</p> <p>Measurement procedures must include distance driven (preferably recorded by GPS or other electronic means with a maximum error level of 5 per cent) and the fuel consumed monitored either through appropriate equipment installed in the units or through standard measurement procedures at a calibrated fuel station</p>
Monitoring frequency:	Annually
QA/QC procedures:	To be conservative project fuel consumptions based on specific fuel consumption values of samples shall be based on the upper limit of the uncertainty band at a 95 per cent confidence level i.e. with 95 per cent confidence the actual average fuel consumption is equal to or lower than the value used by the project
Any comment:	<p>This data is only required if total fuel consumption (TC) is not available.</p> <p>This data is only collected if the MRTS operates with buses</p>

Data / Parameter table 21.

Data / Parameter:	DD_{PJ,xn,y}
Data unit:	Kilometres
Description:	Distance driven by project units using fuel type <i>xn</i> in year <i>y</i>
Source of data:	MRTS operator(s) or system manager
Measurement procedures (if any):	Based on GPS (preferred), other electronic means, odometer or number of units per route and turnover per route
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	In many systems operators are paid according to distance driven. Payment of operators can thus be used to check the distance driven
Any comment:	Used only for QA/QC in case of bus operated MRTS to control the specific fuel consumption (fuel per distance)

Data / Parameter table 22.

Data / Parameter:	$OC_{i,y}/OC_{B,y}/OC_{T,y}$
Data unit:	Passengers
Description:	Average occupation rate of vehicle category <i>i</i> in year <i>y</i> . In particular, B stands for buses, and T for taxis
Source of data:	Municipal transit authorities or specific studies done by the project proponent or a third party
Measurement procedures (if any):	Based on visual occupation studies for all vehicle categories. For buses the occupation rate is based on boarding-alighting studies, electronic smart tickets or on visual occupation studies with expansion factors for routes served to determine the average occupation rate along the entire route. As an alternative for buses, the occupation rate can be based on average trip distance of bus passengers, total passengers and total distance driven of buses. For taxis, the driver should not be counted. The detailed procedures concerning visual occupation and boarding alighting studies are presented in Annexes appendices 1, 2 and 3
Monitoring frequency:	Studies conducted in years 1 and 4 of the crediting period
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 23.

Data / Parameter:	$TDIZ_{i,y}$
Data unit:	Kilometres
Description:	Average distance driven by taxis and cars on affected roads in year <i>y</i>
Source of data:	Municipal transit authorities or project owner
Measurement procedures (if any):	Electronic or visual tracking of samples of vehicles entering/exiting the affected roads registering the entry and the exit point and measuring the distance by GPS or other means
Monitoring frequency:	Once in the years 1 and 4 of the crediting period
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 24.

Data / Parameter:	$NIZ_{i,y}/NIZ_{C,y}/NIZ_{T,y}$
Data unit:	Number of vehicles
Description:	Number of vehicles of vehicle category <i>i</i> using affected roads. In particular, C stands for cars, and T for taxis
Source of data:	Municipal transit authorities or project owner
Measurement procedures (if any):	Visual counting. Counting should be based on various parts of the road if major roads depart from the lane to ensure average numbers
Monitoring frequency:	Once in the years 1 and 4 of the crediting period
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 25.

Data / Parameter:	P_y
Data unit:	Passengers
Description:	Total passengers transported by the project activity transport system
Source of data:	MRTS operator(s) or system control manager
Measurement procedures (if any):	Based on electronic (e.g. electronic smart cards) or mechanical control means (e.g. turnpikes at stations or in trains)
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	Control with ticket sales
Any comment:	For passenger numbers controls must be based on counting physically passengers e.g. through electronic smart cards or mechanical entry control units. Systems operating only with tickets valid for 1 ride can also use ticket sales. Systems operating however without multiple ticket entry (e.g. monthly card allowing the user indiscriminate usage of the system) must have entry control units to count the number of passengers. In case of such systems ticket sales only offer an approximation of passengers using the system, appropriate for QA/QC

Data / Parameter table 26.

Data / Parameter:	$MS_{i,y}$
Data unit:	Percentage
Description:	Net share of passengers using the MRTS which would have used mode i in the year y
Source of data:	Survey realized by an external survey company
Measurement procedures (if any):	Survey. The relevant question numbers are 2 and 3
Monitoring frequency:	The survey is realized in the years 1 and 4 of the crediting period
QA/QC procedures:	See Appendix 4 for the survey design
Any comment:	Only used for leakage calculation of rebound effect (reduced amount of cars and taxis) if required (see condition for rebound effect calculation)

Data / Parameter table 27.

Data / Parameter:	$N_{i,y} / N_{B,y} / N_{T,y}$
Data unit:	Number of vehicles
Description:	Number of vehicles of vehicle category i circulating in the larger urban zone of the city. In particular B stands for buses, and T for taxis
Source of data:	Municipal transit authorities based on vehicle registration statistics from the respective city or data from vehicle control stations (technical and emission control stations)
Measurement procedures (if any):	For buses as well as for taxis informal or illegal units may operate. While estimates on the number of informal units may be available these are due to their nature not trustworthy. For both categories it is thus recommended to only include formally registered units

Monitoring frequency:	Studies conducted in years 1 and 4 of the crediting period
QA/QC procedures:	-
Any comment:	See also the table for N_i

Data / Parameter table 28.

Data / Parameter:	$V_{P,y}$
Data unit:	km/h
Description:	Average speed of cars and taxis on affected roads in year y and total average speed and average moving speed
Source of data:	Municipal transit authorities or studies ordered by project proponent
Measurement procedures (if any):	On-board measurements determining the total average speed and the average moving speed (when circulating) on the affected road based, e.g. on GPS measuring. The same methodology as for determination of V_B should be used. Average speed required for calculation of the rebound effect refers to total distance divided by total time, on the affected road. Average moving speed required for calculation of the speed effect refers to speed under moving conditions i.e. total distance divided by time under movement (total time minus standstill time of vehicle), on the affected road. Taxis and passenger cars are treated identical. This condition should be monitored for each affected road
Monitoring frequency:	Once in the years 1 and 4 of the crediting period
QA/QC procedures:	-
Any comment:	Only passenger cars and 4-wheel taxis. See also table for V_B

Data / Parameter table 29.

Data / Parameter:	$P_{EL,i,y}$
Data unit:	Passengers
Description:	Total passengers transported by baseline rail-system in year y
Source of data:	Rail operator
Measurement procedures (if any):	Based in general on turnpike or electronic ticketing system; Cross check with ticket sales possible in some cases
Monitoring frequency:	Annually
QA/QC procedures:	-
Any comment:	Only required in case baseline rail systems operates

Data / Parameter table 30.

Data / Parameter:	$TE_{EL,i,y}$
Data unit:	t CO ₂
Description:	Total emissions from the electricity-based rail system in year y
Source of data:	Rail operator for electricity consumption and as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

Measurement procedures (if any):	As per the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”
Monitoring frequency:	Annually
QA/QC procedures:	-
Any comment:	<p>When applying the tool, the parameter $EC_{BL,k,y}$ in the tool should be taken as the amount of electricity used by the electricity-based rail system.</p> <p>All electricity emission factors used should be defined at the validation stage and fixed for the crediting period. Therefore if the grid emission factor is used, the ex ante approach should be used</p>

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Appendix 1. Guideline for the establishment of load factor studies for buses based on visual occupation

1. Load factor surveys based on visual occupation studies use the following procedures:
 - (a) Vehicle categories are defined according to the characteristics of the fleet and types of services (e.g. with or without standing passengers);
 - (b) Occupation categories are defined (usually five or six), for instance <50 per cent occupied, 50-100 per cent seats occupied, 100 per cent seats occupied, <50 per cent space for standing passengers occupied, 50-100 per cent of standing space occupied, overload (>100 per cent of legally permitted space occupied);
 - (c) Formats for field study are prepared;
 - (d) Field data collectors are trained;
 - (e) Locations, days and times for field study are defined. Points are strategically located to cover all the routes with the minimum of points. Atypical seasons (school or university vacations) should be avoided. The recommended time period for the study is the entire period of operation of the selected buses. Measurements should be realized for all weekdays proportional to the number of buses displaced on these days. The same days and time periods need to be chosen for the baseline as well as for the monitoring studies to ensure data comparability;
 - (f) Field data is collected. Coverage of the occupation counts should be higher than 95 per cent of the number of buses that cross the checkpoint. 100% coverage is desired. To control this outcome, a separate vehicle count is advised. Data can be adjusted with the actual count.

Appendix 2. Guideline for the establishment of load factor studies for buses based on boarding-alighting surveys

1. Load factor surveys based on boarding-alighting studies for buses use the following procedure:
 - (a) Routes for the survey must be selected, weighted upon the expected number of passengers per route. Only active routes are included;
 - (b) The load factor (occupation rate) is defined as the average percentage of capacity of the vehicle used by passengers. The average load factor of a route is based on the average of each load factor between each station of the specified route;
 - (c) The common operational procedure used is to ride on the unit and count at each station the number of passengers boarding and alighting. Instead of manual controls electronic or mechanical controls can be used;
 - (d) Locations, days and times for the survey are defined. Atypical seasons (school or university vacations) should be avoided. The recommended time period for the study is the entire period of operation of the selected buses. Measurements should be realized for all weekdays proportional to the number of buses displaced on these days. The same days and time periods need to be chosen for the baseline as well as for the monitoring studies to ensure data comparability;
 - (e) The survey must be conducted during the entire operation period of buses (not only peak or off-peak hours);
 - (f) The units selected are clearly identified including licence plate, day monitored, number of turn-arounds, route and route distance;
 - (g) Data are digitized and its quality is controlled. In case of mistakes in data collection, counts should be repeated.
2. Boarding and alighting information can also be obtained in some cases from electronic means such as electronic ticketing, digital camera passenger identification per bus, monitoring of average bus weight per station, etc.

Appendix 3. Guideline for the establishment of load factor studies for taxis/motorcycles or passenger cars

1. The actual number of passengers excluding the driver of taxis is counted in a given point within a given time period. The counting is based on visual occupation counting the number of passengers occupying the vehicle excluding the driver for taxis. The procedures to establish visual occupation are:
 - (a) 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 same days and time periods need to be chosen for the baseline as well as for the monitoring studies to ensure data comparability;
 - (b) 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. To control this outcome a separate vehicle count is advised. Data can be adjusted with the actual count;
 - (c) Occupation is the number of passengers using the vehicle. The driver is not counted for taxis. Taxis without passengers are counted as no (zero) occupation;
 - (d) 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;
 - (e) The study is realized in different locations of the larger urban zone of the city;
 - (f) The same methodology is used for the load study performed prior to the project start and during its monitoring. Locations of monitoring can, however, change as traffic flows in the larger urban zone of the cities change over time. Other parameters of the study (duration, sample size, counting method, etc.) however should remain constant to ensure consistency and comparability of studies.

Appendix 4. Methodological design of survey MRTS

1. The methodological design of the survey is presented in detail. The following points are discussed:
 - (a) Survey objective;
 - (b) Target population;
 - (c) Sample frame;
 - (d) Sample design;
 - (e) Relative error level;
 - (f) Geographical coverage;
 - (g) Sample frequency;
 - (h) Sample size;
 - (i) Size and result of the pilot test;
 - (j) Selection method of the sample;
 - (k) Methodology for information collection and estimation of the parameters;
 - (l) Data verification and validation including QA and QC;
 - (m) Survey realization;
 - (n) Calculation of a trip distance in the survey;
 - (o) Default questionnaire.
2. Whenever the MRTS is extended, a new survey distribution is realized and data of the new survey is used for calculating emissions reductions achieved from the moment of the MRTS extension.

Table 1. Technical summary data sheet of the survey - Strategy and sample design in the MRTS passenger survey

Parameter	<ol style="list-style-type: none"> 1. Main parameters: <ol style="list-style-type: none"> (a) Baseline emissions; (b) Indirect project emissions. 2. Secondary parameters and inputs: <ol style="list-style-type: none"> (a) Proportion of passengers using each mode of transport, with the project and in absence of the project; (b) The average distance travelled by these modes with the project and in absence of the project
Target population	Passengers over 12 years using the MRTS
Sample frame	Passenger flow in all the stations of the MRTS
Sample design	<ol style="list-style-type: none"> 1. Two staged probabilistic design: <ol style="list-style-type: none"> (a) First stage: stratified – simple random sampling (SRS); (b) Second stage: systematic sampling based on passengers flow per station. 2. Stratum: Stations. 3. Sub stratum: Days in a week and hours
Relative error level (CV)¹	For the survey a global desired level of precision (relative standard error or coefficient of variation – CV) between 5 per cent and 10 per cent for the parameters of interest, which also implies that having precision levels of 90/10, is required. Results obtained are based on a 95 per cent confidence level using the more conservative boundary
Coverage	Larger urban zone of the city where the MRTS operates
Size of Universe	Generally, in one day an MRTS mobilizes between 100,000 and 3,000,000 passengers, depending on the type of transport system
Sample size	The sample size ranges from 6,000 to 8,000 surveys in the measuring week with a re-test sample size of around 50 per cent of the original sample. ² The final sample size determination depends on the transport system characteristics regarding daily passenger flow and number of stations. The sample size indicated is an estimate and needs to be determined per project type (see corresponding chapter)
Sample frequency	Once in the years 1 and 4 of the crediting period during an entire week plus one re-test in the year 1 only

¹ 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.

² The re-test sample size is determined based on the variances encountered in the original sample.

Method of information collection	The information will be obtained through the face-to-face application of the established questionnaire on a random base
Consistency of the survey results	The internal consistency of the results of the survey must be carefully checked. The reliability will be measured using the Cronbach's alpha. A coefficient of over 0.7 has to be reached, values over 0.9 shall be re-checked to avoid redundancy of data. In case the survey does not demonstrate internal consistency in their results, it will be rejected and another survey could be arranged

1. Survey objective

3. The survey objective is to determine:

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

2. Target population

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

3. Sample frame

5. The sample frame is the passenger flow in all the stations of the MRTS. Data for the passenger frame is obtained from the system manager.

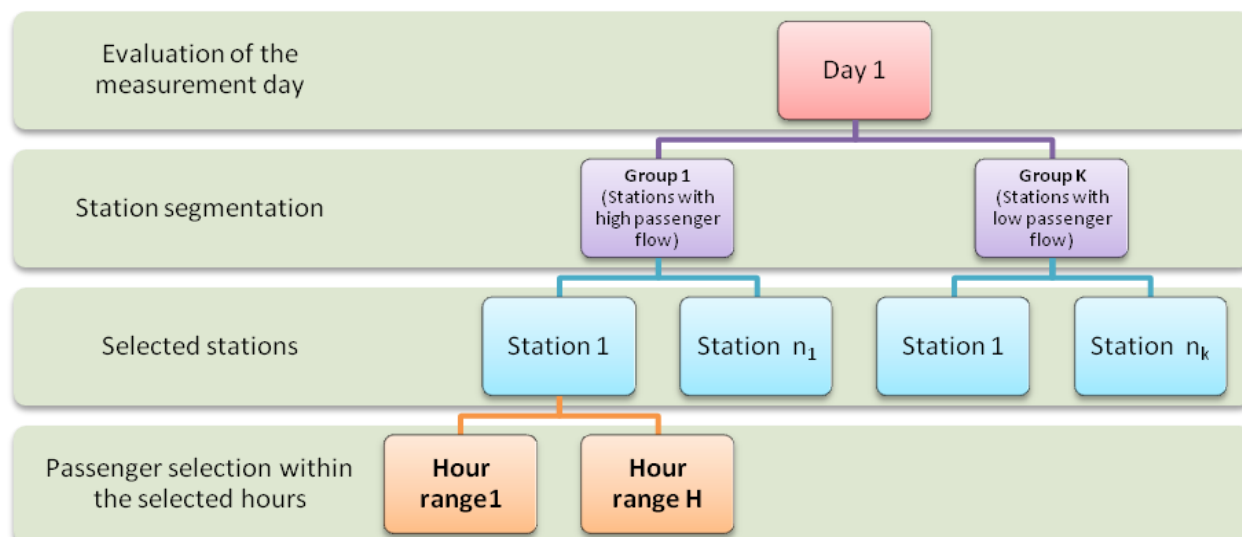
4. Sample design

6. A two staged probabilistic design is applied:

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

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

Figure 1. Stratification model used



8. **Main strata (Stations):** First a cluster analysis is performed that groups the stations depending on the passenger flow per station to provide information for busier stations and less frequented stations. In practical terms three groups of stations are created: stations with a high, medium and low passenger volume. In the case of large heterogeneity of passenger flows an additional group is included to control this variability.
9. **Sub strata:** Sub strata are built from the passenger flow information reported per day and hour. Sub strata are formed in such a manner that information is taken for the seven days of a week, and within each day, hours ranges are arranged according to the passenger flow.
10. In MRTS, there are generally predefined hourly passenger flow ranges (peak/off-peak hours) through which the fixed hours when passengers are surveyed during the seven week days are defined taking into account that peak hours have to be included i.e. in each of these hours information is collected and off-peak hours are partially included.
11. The sample is to be distributed in each day according to the average passenger flow per day and within the day, as per the users per day or hour range. Within each day, a random station selection process is to be carried out within the defined strata, in such a way that during the evaluation week the possibility for all stations to be visited is created. The station grouping is carried out according to a multi-variant cluster analysis, using as a classification variable the passenger flow reported daily by station.

5. Relative error level

12. For the survey, a global desired level of precision (relative standard error or coefficient of variation – CV) between 5 per cent and 10 per cent for the parameters of interest is required, which also implies having precision levels of 90/10.

13. It is considered that the result of an estimate is:
- (a) Statistically robust if its coefficient of variation is less than 5 per cent;
 - (b) Practically acceptable if its coefficient of variation is between 5 per cent and 10 per cent;
 - (c) Of low precision if its coefficient of variation is higher than 10 per cent and less than 15 per cent;
 - (d) It is not considered as robust if its coefficient of variation is higher than 15 per cent.
14. For the results obtained, a 95 per cent confidence level is calculated taking the (conservative) lower boundary for baseline emissions and the (conservative) upper boundary for indirect project emissions. The parameters determined in the survey are thus quantified at the 95 per cent confidence level following the Appendix 2 (EB 22 report, Annex 2, D, page 3): "Methodologies employing sampling to derive parameters in estimating emissions reductions shall quantify these parameter uncertainties at the 95 per cent confidence level".

6. Geographical coverage

15. The geographical coverage is the area where the MRTS operates (project boundary).

7. Sample frequency

16. The survey is realized minimum once during the year 1 and 4 of the crediting period plus a re-test survey realized in the year 1 only, thus achieving two samples in the year 1, and one sample in the year 4. The survey shall take place during an entire week. The selected week shall not correspond to a public holiday and shall be representative for the average demand for transport services in the considered year.
17. To guarantee that there is no seasonality, and if there was, the way in which it would be approached, the following steps are taken:
- (a) In the first year and while the system is stabilized, a single measurement is taken and a second measurement is carried out in a later period (test-retest method), with a sample size of less than half of the initial survey;
 - (b) With the passenger flows data of the first year, and with the comparison between the first survey and the test-retest, it is defined if there is any seasonality degree in the year. If there is evidence of the same, within each period where there are apparent differences, independent surveys are performed and at the end, the results are compared regarding the emissions difference and the parameters on the use of modes of transport and the average travel distance;
 - (c) If there are no significant differences between the analysis periods, the measurements of later years will be done only once a year, on the contrary, they will be carried out in the periods in which seasonality is identified;
 - (d) Independent from the result, at least one measurement in a whole week will always be performed in the years 4 and 7 of the crediting period, and the application of the test-retest method in the year 1. The two measurements in the

year 1 are done in different periods, one in the first semester of the year and the other in the second semester.

18. The criteria for identifying if there is any seasonality are the following one:
 - (a) A test of mean comparison is carried out between the data reported on the flow of passengers between months, and in the same way, within the weeks of each month;
 - (b) A further test consists in the application of a times series model SARIMA, where it is estimated if there is any seasonality degree in the passengers flows, either weekly or monthly. Through the functions of auto-correlation and partial auto-correlation, it is identified if there is any pattern in the data.

8. Sample size

19. For the calculation of the sample size, a global level of precision (relative standard error or coefficient of variation – CV) between 5 per cent and 10 per cent for the parameters of interest has to be met. This implies at the same time having precision levels of 90/10, i.e. a minimum confidence level of 90 per cent and a maximum precision level of 10 per cent.
20. In general, determining the sample size is done by simulation following the Särndal methodology (1992), in which a CV is fixed and the sample size is found by solving n of the formula of the estimator variance according to the design used in each case.

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

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Equation (1)

Where:

\hat{t}_y = Average for the parameter of interest y

$V(\hat{t}_y)$ = Variance of this estimate

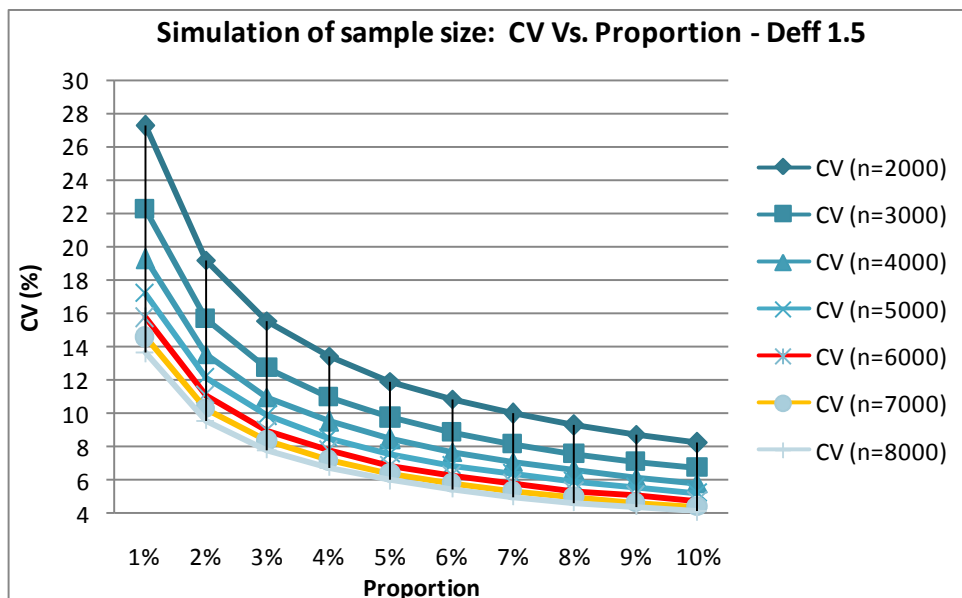
~~(a) Where \hat{t}_y is the estimate of the average for parameter of interest y and $V(\hat{t}_y)$ is the variance of this estimate.~~

21. The stratification structure complies with the principles of independence and invariance, reason for which in the formula for the CV in this study, the estimated variance of the estimator results from adding those obtained in each stratum (see [section 10](#) which provides formulas for the calculation of the variance in case of multi-stage designs).
22. The main parameter of interest is the distance per mode of transport for each passenger. The distance per mode is one parameter, i.e. D (i) indicating distance travelled by passengers using mode i .
23. However, an important parameter to determine the sample size is the percentage of passengers which use mode i . This is relevant as only few passengers of the new system would have used certain modes such as passenger cars (the large majority of

users come from conventional public transport). However, even if their share is low they could still have an impact on emission reduction calculations due to their high emission factor. For the survey to be reliable it needs a sufficient number of respondents also in modes used less frequently. The sample size determination is thus influenced strongly by the share of passengers per mode to have the desired precision level for this variable and therefore also for the main parameter of interest being the distance per mode. To determine the sample size ex ante therefore a pre-survey is conducted and/or data from other comparable-projects are taken.

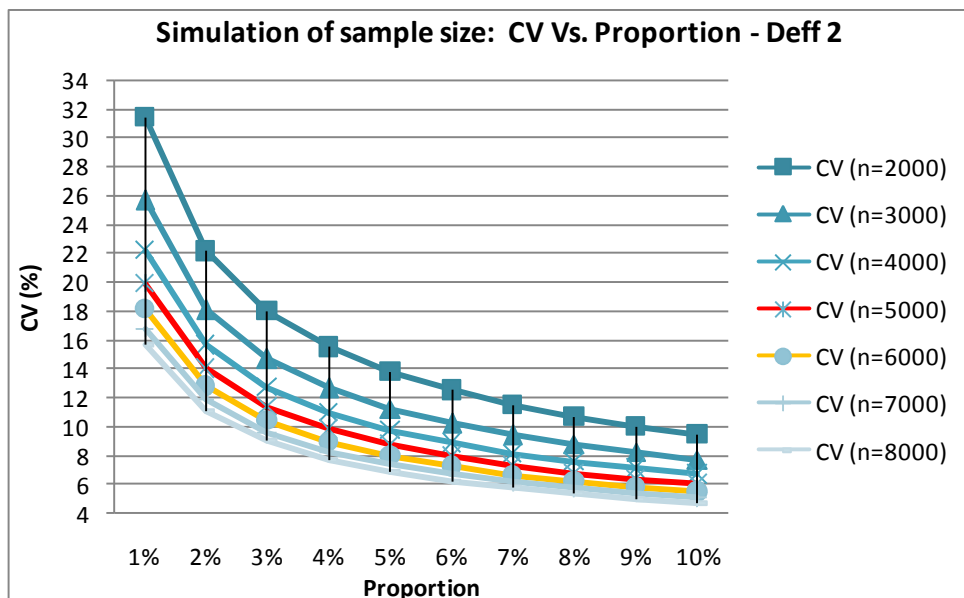
24. In practical terms, the procedure for determining the sample size is:
- (a) The results of the pilot test are taken as reference for the simulation (mean and standard deviation); This is especially important concerning share of modes for passengers as this determines the sample size to a considerable extent as some modes have a low frequency (e.g. passenger cars, potentially taxis and motorcycles);
 - (b) Simulation is subject to the modification of standard deviations larger than the one found in the pilot test, with the objective of obtaining an optimum sample size even under high variability conditions (limitation of the maximum variability level);
 - (c) The simulation process is first done using the results of the pilot survey under a SRS design (Simple Random Sampling), and under the multistage design (see the formulae described in [section 10](#)) and thereafter the design effect (Deff) is determined corresponding to the ratio between the variance of the multi-stage design, and the variance of a SRS design;
 - (d) Finally, based on the simulation and the presentation of different scenarios corresponding to different sampling sizes and various assumptions about the standard deviations of parameters of interest (for instance by using a deff factor between 2 and 3), the sample size that best adjusts to the expected error levels is taken.
25. The DOE shall verify that the procedures used to derive the sample size will lead to the level of precision for the parameters of interest stipulated above.
- 8.1. Design effect (Deff)**
26. The ratio between the variance of the particular design and the variance under a SRS design, is called the design effect (Deff). In this way, when Deff is less than 1 it implies that the selected design has more precision than the SRS one, and when it is larger than 1, the proposed design is less efficient than the SRS one. In the simulation case, the Deff value was assumed between 1 and 3.5, in such a way that the sample size is considered under the worst scenario i.e. when the variance associated to the multi-stage design was factor 2.5 fold the SRS. Sample size simulation were performed considering the variation coefficient (less than 10 per cent), the design effects (deff) (value between 1.5 and 3.5) and the lowest frequencies for the modal proportions (between 5 and 10 per cent) to be estimated.
27. The graphs below, provided for illustrative purposes only, present the result of such simulations. They show that a sample size of 6,000-8,000 would be sufficient even facing extreme scenarios such as with a deff of 3.5.

Figure 2. Simulation of sample size with Deff 1.5



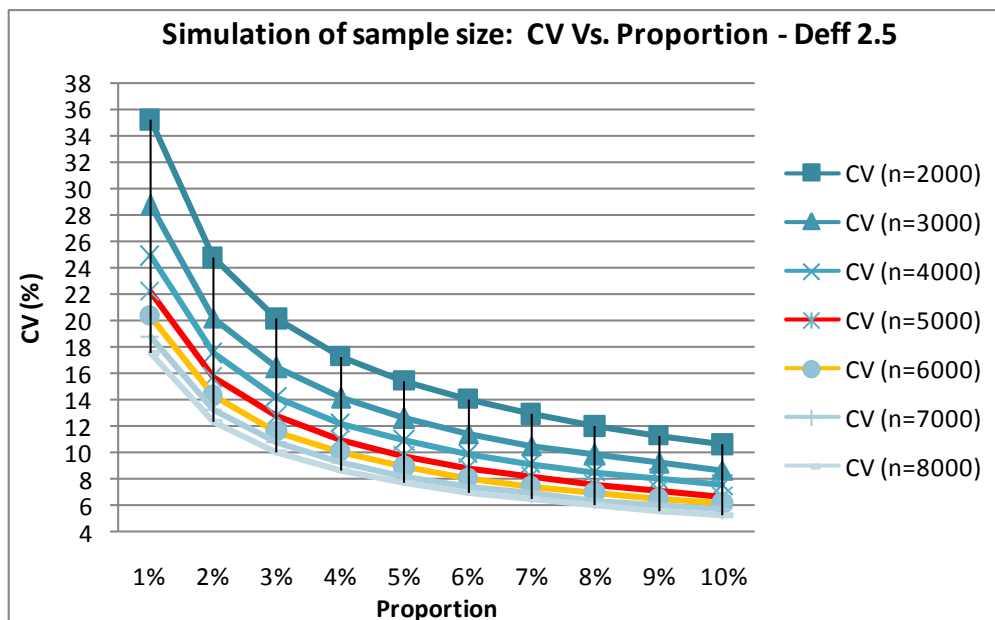
Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	27.2	22.2	19.3	17.2	15.7	14.5	13.6
2%	19.2	15.6	13.5	12.1	11.1	10.2	9.6
3%	15.6	12.7	11.0	9.8	9.0	8.3	7.8
4%	13.4	10.9	9.5	8.5	7.7	7.2	6.7
5%	11.9	9.7	8.4	7.5	6.9	6.4	6.0
6%	10.8	8.8	7.7	6.8	6.3	5.8	5.4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

Figure 3. Simulation of sample size with Deff 2.0



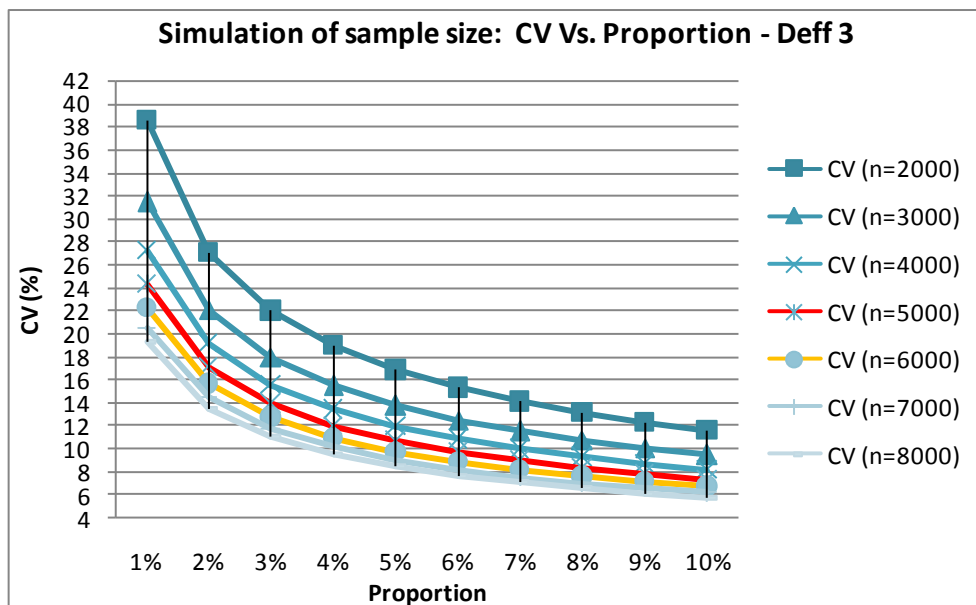
Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	31.5	25.7	22.2	19.9	18.1	16.8	15.7
2%	22.1	18.1	15.6	14.0	12.8	11.8	11.1
3%	18.0	14.7	12.7	11.4	10.4	9.6	9.0
4%	15.5	12.6	10.9	9.8	8.9	8.3	7.7
5%	13.8	11.2	9.7	8.7	8.0	7.4	6.9
6%	12.5	10.2	8.8	7.9	7.2	6.7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

Figure 4. Simulation of sample size with Deff 2.5



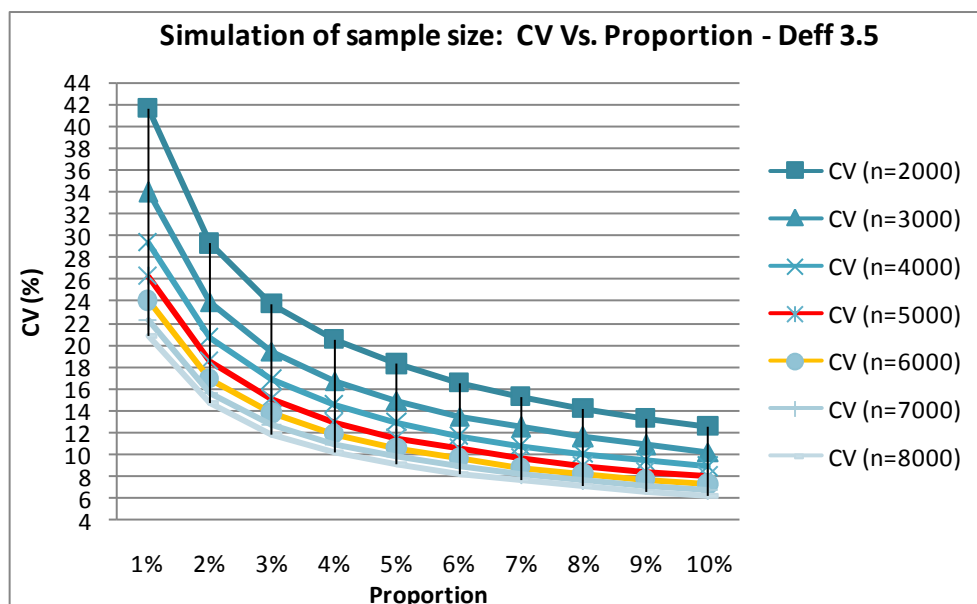
Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	35.2	28.7	24.9	22.2	20.3	18.8	17.6
2%	24.7	20.2	17.5	15.6	14.3	13.2	12.4
3%	20.1	16.4	14.2	12.7	11.6	10.7	10.0
4%	17.3	14.1	12.2	10.9	10.0	9.2	8.6
5%	15.4	12.6	10.9	9.7	8.9	8.2	7.7
6%	14.0	11.4	9.9	8.8	8.1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

Figure 5. Simulation of sample size with Deff 3.0



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

Figure 6. Simulation of sample size with Deff 3.5



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

9. Size and result of pilot test

28. The data obtained for a similar transport system will be used as a reference and pilot result. In case the MRTS is already operating, it is recommended to realize a pilot sample which can be of a smaller sample size and simplified concerning stratification etc. In cases where the MRTS is not operating, results from comparable surveys from comparable MRTS from other cities can be used as a reference.

10. Selection method of the sample

29. Stations, hours and passengers must be selected for the sample. The selection method has to demonstrate that it guarantees a random and non-biased selection process, which is especially important in face-to-face interviews. The random distribution allows that the sample mirrors the total population in any other non-observed variables such as age, gender, religion, personal preferences etc. A control is realized if the sample matches the total population in several of these parameters to ascertain that the sample reflects truly the population with all its characteristics.

10.1. Selection of stations and evaluation hours.

30. Given that there is a complete list of stations that are part of each established group (stratum), the selection of stations is carried out according to a SRS design, through the negative coordinated algorithm.
31. The same happens for the defined hour ranges: within each range a specific hour is selected under this method for the sample selection.

10.1.1. Algorithm of the negative coordinated method

32. N: Universe size.
33. n: Sample size to be selected.
34. A value $0 < \pi < 1$ is fixed and for each one of the universe elements random events ξ_1, \dots, ξ_N are carried out uniformly distributed (0,1). Which ones belong to the sample is decided as follows:
 - (a) If $\xi_k < \pi$ then k belongs to the sample;
 - (b) If $\xi_k \geq \pi$ then k does not belong to the sample.
35. In this way the probabilities of being part of the sample of the first and second order are: $\pi_k = \pi, \pi_{kl} = \pi^2$.
36. Since the expectation of the sample size is equal to $\sum_U \pi_k$ in the SRS design, it complies with $E(n_s) = \sum_U \pi_k = n$ therefore the departure point is from an expected sample size equal to n , further it is said that $\pi_k = \pi = n / N$ and from that value, the selection is carried out.

10.2. Selection of passengers

37. Given that there is no reference frame or list frame for the identification of MRTS users, the selection of the sample in the last stage will be performed according to the systematic sampling design, replicated identically for each stratum and considering the following steps:
 - (a) 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;
 - (b) Systematic selection of passengers: every n^{th} passenger entering the station, starting with the random number. In this way, if the random number is 20, the first passenger selected is the 20th that enters the station, the 2nd $n+20$ and thus successively every n^{th} passenger. The number n , called selection interval, will be determined based on the passenger flow per hour and the sample distribution of the specific measurement day.

11. Methodology for information collection and estimation of the parameter

11.1. General considerations on information collection

38. The information will be obtained through the face-to-face application of the established questionnaire.
39. According to the selected days and hour range, each survey interviewer will carry out the number of established surveys. Given that the selection of people is done randomly in a time range, the start point, that is, the person number from which the contact begins is random and is defined by the appointed pollster supervisor.
40. The random selection of individuals, as well as the sufficiency in the sample size, enables obtaining dispersion and representation of the study population through the sample. Further, it allows controlling factors that may affect the user type, in terms of use of modes of transport and distance in these travels. Some of these such as the social-economic level, the residence zone, owning a vehicle, among others, are represented within the selected sample.
41. It is recommended that additional to the surveyors other personnel systematically and in parallel to the information collection asks about and registers the system users on their social-economic level, gender (observable) and age, with the purpose that these data guarantee that people included in the sample correspond to the general demographic characteristics of the system users.
42. The age ranges recommended are: 1. From 12 to 17 years 2. From 18 to 25 years 3. From 26 to 35 years 4. From 36 to 45 years 5. From 46 to 55 years 6. From 56 to 65 years 7. More than 65 years old. If the person surveyed is not willing to answer the question, the interviewer will locate the person in the range according to his/her appearance.
43. For socio economic levels the ranges recommended are five different ranges of minimum salary. This needs to be adapted to the country circumstances so that a representative stratification is reached.
44. n measurements of later years, when any of the modes of transport to which the survey refers, are extinct at the moment of applying the survey or simply to clarify the issue or modes of transport to which the question refers to, photos or graphs with an amplified size can be used, to guarantee the correct interpretation of the question.

11.2. Method of estimation and expansion factors

45. In accordance with the sample strategy and with the sample design specified in **Section 4** there exist two stages in the method of estimation and selection of sampling observation units: (a) Selection of stations (SRS design); (b) Selection of passengers in accordance with the systematic design taking as auxiliary information the flow of passengers in the range of hours defined. Having in mind that the design used in each stratum is identical, the probabilities of inclusion will be calculated in an equivalent basis in each stratum:
 - (a) First stage:

$$\pi_{li} = \frac{n_{lisp}}{N_{lisp}},$$

- (i) π_{li} : Probability of inclusion in the sample in the first stage (1);
- (ii) n_{lisp} : Number of stations sp selected in the stratum h (3 stratus are created i.e. high, medium and low passenger flow);
- (iii) N_{lisp} : Total number of stations sp in the stratum h ;
- (iv) sp : stations of the system.

(b) Second stage:

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

- (i) $\pi_{k/i}$: Probability of inclusion of the individual passenger k in the sample in the second stage (i), given the selection of the first stage (I);
- (ii) n_{ihsp} : Number of passengers selected in the station sp , in stratum h ;
- (iii) N_{ihsp} : Total number of passengers in the station sp , in stratum h .

46. The general formula to calculate the expansion factor is:

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

47. Thus the expansion factors are:

(a) First stage:

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

- (i) Where n_{lisp} and N_{lisp} are as previously defined.

(b) Second stage:

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

- (i) Where n_{ihsp} and N_{ihsp} are established according to the total flow of passengers in the station sp during the day.

- (c) Estimator of the total for the variable of interest:³

$$\hat{t}_{\pi} = \sum_h \frac{N_{lhsp}}{n_{lhsp}} \sum_{s_l} \hat{t}_{i\pi}$$

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

- a. Where:

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

- i. Where “ s_i ” represents the sample of passengers in the second phase and “ k ” the information of the k^{th} individual selected.

- (d) Estimator of the variance:

$$\hat{V}(\hat{t}_{\pi}) = \sum_h \left[\frac{N_{lhsp}}{n_{lhsp}} (n_{lhsp} - N_{lhsp}) S_{\hat{t}_{i\pi}}^2 + \frac{N_{lhsp}}{n_{lhsp}} \left(\sum_{s_l} \frac{N_{ihsp}}{n_{ihsp}} (n_{ihsp} - N_{ihsp}) S_{s_i}^2 \right) \right]$$

- (i) Where:

$$S_{\hat{t}_{i\pi}}^2 = \frac{1}{n_{lhsp} - 1} \sum_{s_l} \left[\hat{t}_{i\pi} - \left(\sum_{s_l} \hat{t}_{i\pi} / n_{lhsp} \right) \right]^2 \text{ and } S_{y_{s_i}}^2 = \frac{1}{n_{ihsp} - 1} \sum_{s_i} (y_{ksp} - \bar{y}_{ksp})^2$$

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

- (e) Estimator for the variable of interest:

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

³ The variables of interest used to calculate totals correspond to the trip distances per mode of passengers of the MRTS (the parameter is not distance alone it is trip distance per mode) both in the baseline situation (for BE) and in the project situation (for IPE).

(i) Where $\hat{t}_{y\pi}$ and $\hat{t}_{z\pi}$ are totals.

- a. R represents the relation between two variables, which in the particular case is a proportion, where $\hat{t}_{z\pi}$ estimates the universe of the study (N);
- b. The parameter (R) is not used to calculate directly BE or IPE or the distance per mode of transport which is the main parameter and the one required for calculating BE and IPE. It is however fundamental to determine the required simple size as proportions of passengers using various transport modes are required for the simple size determination as well as eventually for leakage calculations. (R) is also required for various other parameters where proportions are determined in the survey (e.g. income category). These other parameters are important information sources to assess if the survey has any bias or if other factors such as gender or income influence the outcome. The parameter (R) is therefore used for survey information gathered based on proportions.

Example: To calculate the proportion of users per mode of transport “X” a R ratio has to be calculated, taking into consideration as variable y : “Users can use the mode X” and as variable z “surveyed users”. Thereafter t_y and t_z represent the estimators associated to the total of the two variables.

(f) Variance estimator:

$$\hat{V}(\hat{R}) = \sum_h \left[\frac{N_{hsp}}{n_{hsp}} (n_{hsp} - N_{hsp}) S_{tus_i}^2 + \frac{N_{hsp}}{n_{hsp}} \left(\sum_{s_i} \frac{N_{ihsp}}{n_{ihsp}} (n_{ihsp} - N_{ihsp}) S_{u_{ki}}^2 \right) \right]$$

(i) Where:

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

a. Thus it is established that:

$$S_{tus_i}^2 = \frac{1}{n_{hsp} - 1} \sum_{s_i} \left[\hat{t}_{ui} - \left(\sum_{s_i} \hat{t}_{ui} / n_{hsp} \right) \right]^2$$

and

$$S_{u_k}^2 = \frac{1}{n_{ihsp} - 1} \sum_{s_i} (u_{ksp} - \bar{u}_{ksp})^2$$

(g) Other alternative methods to estimate the variance, especially helpful in multi-staged designs of complex samples can be used such as Jackknife or Bootstrap.

48. Based on the formerly described formulas and based upon if it is a total or a proportion the parameter \hat{t}_π and associated the variance $\hat{V}(\hat{t}_\pi)$ is determined.
49. To calculate the confidence interval a normal distribution is assumed (large sample size) using the formula for a 95 per cent confidence interval:

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

- (a) \hat{t}_π represents BE and IPE, both calculated separately. For BE the lower confidence interval is taken and for IPE the upper one;
 - (b) The DOE shall verify the validity of the statistical procedures used and the assumptions made to determine the total baseline and indirect project emissions including the determination of their respective 95 per cent confidence intervals.
 - (c) Summarized to calculate the expansion factor the following data is required next to the data resultant from the survey:
 - (i) Number of stations;
 - (ii) Passenger flow per station per hour, day and week;
 - (iii) Selection rate of passengers surveyed per hour per station (i.e. each n passenger was selected for an interview).
50. Based on this information the total baseline and the total indirect project emissions for the MRTS for the survey week can be calculated with a confidence interval of 95 per cent. For the total baseline emissions the lower 95 per cent boundary is taken and for the indirect project emissions the upper 95 per cent boundary to have a conservative calculation of emission reductions. For total annual or period baseline (indirect project) emissions the baseline (indirect project) emission per passenger of the survey week is calculated and thereafter multiplied with the total passengers transported by the MRTS per annum or period.

12. Data verification and validation including QA and QC

12.1. Criteria for evaluating data consistency

51. Considering that in the years 1 there will be at least two measurements (the weekly measurement and the test-retest) and in the year 4 of the crediting period at least one measurement, through these the consistency on information collection is to be guaranteed.
52. The assessment of consistency can be carried out by three supplementary statistical methods:
 - (a) A mean difference test is performed through a t – Student test, where the differences presented between both measurements are evaluated, for: 1. Proportion of users that use each type of modes of transport and 2. Average trip travel distance;

- (b) To perform the mean difference test, it is necessary to determine beforehand, if the two samples come from the same population. Thereafter a F test is carried out to determine the variability difference between one and the other. To assess that data used to estimate the study parameters follow the same distribution the Mann Whitney non-parametric U test and the Wilcoxon T test can be used.
- (c) To evaluate the users proportion per modes of transport, the Pearson's Chi Square can be used, where categories are defined for each mode of transport;
- (d) Globally and internally in each survey realized, consistency of data reported in the survey should be assessed through the Cronbach alpha coefficient. In practice a value higher than 0.7 in the coefficient has to be reached. Values over 0.9 shall be rechecked to avoid redundancy of data:
 - (i) For the internal consistency the Cronbach alpha coefficient is to be used whilst to test for consistency between different periods of measurement the first two options of testing are used;
 - (ii) The Cronbach alpha coefficient will be calculated for each stratum established as these a priori control the variations in the responses and therefore the control eliminates biases which could be generated due to heterogeneity and inconsistency in information;
- (e) With the goal of evaluating the possible correlation between BE and IPE a hypothesis test based on the Pearson or Spearman coefficient is to be made. The parameter to determine the existence of correlation is the p value. If the p value is less than 0.05 8 (significance value) it is concluded that the correlation is significant;
 - (i) 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:

$$\text{Var}(X-Y) = \text{Var}(X) + \text{Var}(Y) - 2 \text{Cov}(X,Y), \text{ where COV}(X,Y) \text{ is not } 0.$$
 - (ii) 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;
 - (iii) Realizing the estimation of BE and IPE guarantees that even in the case of correlation there is no problem with the bias in the variance of the estimators i.e. even in case of correlation the results are correct and no additional step needs to be taken. In the case of no correlation the difference between BE and IPE per passenger could also be determined directly reaching the same result (in the case of correlation it is necessary in all cases to make the estimation of BE and IPE separately);
 - (iv) Therefore it is preferable, as suggested in these procedures, to calculate the two parameters separately and to determine for each one an unbiased level of error. Additionally for each parameter separate confidence levels

can thus be constructed. If the two confidence intervals overlap there would be an indication of non-significant differences between BE and IPE.

13. Survey realization

53. The survey must be realized through a company with minimum 3 years of experience in comparable surveys in the respective country to ensure a professional survey execution. The following principles are to be followed in the survey realization:
- (a) Non-responses should be recorded;
 - (b) Record and store all original surveys;
 - (c) Surveys are conducted at MRTS stations when people wait for MRTS-boarding. It should be avoided to realize the survey with people de-boarding the MRTS as latter will not want to invest time in a survey thus potentially giving wrong answers.

13.1. Preparation phase

54. This phase is characterized by the development of all the activities previous to the execution of the field operation and it is divided in:
- (a) Drafting of the manual on information collection and basic concepts. The manual on information collection and basic concepts covers in general terms the profile of the field personnel, the questionnaire structure, the instructions and specifications for filling in the questionnaire, the definitions and basic concepts of the study and the instructions and formats used;
 - (b) Selection and training of field personnel. The selection and training of the field personnel is performed on concepts of filling in of questionnaires, in order to select the most adequate survey interviewers for the development of the field work:
 - (i) A pre-test is performed with the aim of familiarizing the supervisors with the instrument of information collection and establishing in general terms the acceptance degree of the population facing the instrument's application. The pre-test is also to assure that respondents understand what the MRTS is as they might not have taken a similar system before, to ensure that all the concepts are clearly defined and the questions are not ambiguously phrased and avoid interviewer errors. Interviewers may misread the question or twist the answers in their own words and thereby introduce bias. The pre-test has to detect and minimize this potential error;
 - (ii) The results of the pre-test will be documented and will be taken into consideration for the modification of the final instrument and for the preparation of the model of information collection.

13.2. Validation process of the information

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

14. Calculation of trip distance in the survey

56. Trip distances need to be determined for each surveyed passenger. The following procedures are applied:
- (a) For NMT, others and induced traffic this is not required as the applied EF is “0”;
 - (b) For users of buses either:
 - (i) The shortest possible geographical distance based on electronic maps or measuring the distance between the two points with GPS or a comparable mean or through distance measurement on maps; or
 - (ii) Measuring the actual distance from the bus entry station to the bus exit station based on (electronic) route maps of the bus operators with official distances or measuring e.g. with GPS the distances between the involved stations;
 - (c) For users of passenger cars, taxis, motorcycles, motorized rickshaws and other modes of motorized transport except buses based on the shortest possible geographical distance based on electronic maps or measuring the distance between the two points with GPS or a comparable mean or through distance measurement on maps;
 - (d) For non-project rail systems based on official or GPS distances between the entry and exit station of the rail-systems.
57. A default questionnaire to be used is included below. This questionnaire should be used by all projects except if valid arguments exist to change the questionnaire and to adapt it to local circumstances. The questionnaire must be realized in the local language. The questionnaire needs to be adapted to national or local circumstances, the wording needs to be checked locally and local test-runs should be performed to ensure that the questions are simple, easily understood, cannot be misinterpreted and lead to reliable results. The survey is reviewed in the language of users of the project, not translated directly from the CDM methodology.
58. References for survey design
- [1] Bautista, L. (1998). “*Diseños de Muestreo Estadístico*”. Publication of the Universidad Nacional de Colombia.
 - [2] Cochran, W.G. 1977, Sampling Techniques, 3d ed, Wiley, New York
 - [3] Särndal, C-E., Swensson, B., Wretman, J. (1992). “*Model Assisted Survey Sampling*”. Springer – Verlag, New York.

15. Default questionnaire

59. The questionnaire has to be adapted to local circumstances using local wording and language. The default questionnaire is basically the framework to follow.

SECTION A: Data concerning surveyor

Survey ID (correlative number):

Interviewer:

Date:

Time:

Place (station) where interview was performed:.....

Survey response/completeness:

☐ Survey was fully completed

☐ Survey was fully or partially not responded

Comments/Observations of surveyor:.....

SECTION B: General Data of Interviewed Person

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

Age of surveyed person:

☐ 12-17 years ☐ 18-25 years ☐ 26-35 years ☐ 36-45 years ☐ 46-55 years
☐ 56-65 years ☐ over 65 years

Gender of the surveyed person

☐ female ☐ male

Socio-economic level of the surveyed person

☐ < 1 minimum wage ☐ 1-2 minimum wages ☐ 2-4 minimum wages ☐ 4-6 minimum wages
☐ > 6 minimum wages

SECTION C: Trip Data of Interviewed Person

Question 1

“Describe the trip you are currently realizing”

Your trip origin (starting trip point, e.g. my home):.....

- 1.1. Your entry (boarding) station MRTS lane (name or code of MRTS station):.....

1.2. Your exit (deboarding) station MRTS lane (name or code of MRTS station):.....

1.3. Your final trip destination (final trip point, e.g. office):.....

Explanations for the interviewer:

- *The question refers to the current trip the passenger is making;*
- *The trip origin and the trip destination must be identified with a clear address. Use a map if it is unclear. If the person does not know or does not want to disclose this information then stop at this point. The questionnaire is deemed thereafter as non valid;*
- *The MRTS stations identified in 1.2 and 1.3 must be listed with their official names or codes;*
- *Only urban trips are considered. If the passenger has as trip origin or trip destination a point outside the boundaries of larger urban zone of the city then discontinue the interview. The questionnaire is deemed thereafter as non-valid.*

Question 2

“What mode of transport did you use from your trip start to the MRTS? Please refer to the mode on which you performed the longest stretch if you used various modes”

☐ Bus (conventional not bus lane) ☐ Existing bus lane/BRT (NOT the project) ☐ Rail (NOT the project) ☐ Taxi ☐ Passenger car ☐ Motorcycle ☐ Motorized taxi tri-cycle ☐ Bike or per foot ☐ Other

Explanations for the interviewer:

- *See graph 1 for explanation;*
- *Rail refers to non-project metro, urban rail, tram etc.;*
- *Only tick 1 answer (the mode used for the longest stretch of this trip segment).*

Question 3

“What mode of transport will you use from the point where you leave the MRTS lane until your final destination? Please refer to the mode on which you will perform the longest stretch if you intend to use various modes”

☐ Bus (conventional not bus lane) ☐ Existing bus lane/BRT (NOT the project) ☐ Rail (NOT the project) ☐ Taxi ☐ Passenger car ☐ Motorcycle ☐ Motorized taxi tri-cycle ☐ Bike or per foot ☐ Other

Explanations for the interviewer:

- *See graph for explanation;*
- *Rail refers to non-project metro, urban rail, tram etc.;*

- Only tick 1 answer (the mode used for the longest stretch of this trip segment).

Question 4

“Assuming that the MRTS you are currently using would not exist: Would you have made the trip you are currently doing anyway or would you have stayed at home/office/origin?”

☐ I would have made the trip” → Continue with question 5

☐ I would have stayed at home/office/origin → The questionnaire is terminated

For the interviewer:

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

Question 5

“Have you moved your home or workplace since the start of operations of the MRTS?”

☐ No → continue with question 6

☐ Yes: “Has the availability of the new MRTS been an important factor when choosing the location of your new home or new workplace?”

☐ No → continue with question 6

☐ Yes → “What was your original/former trip origin and trip destination?” (at the time before you moved your home or workplace)

Origin point:.....

Destination point:

Continue with question 6 (based on the origin and destination as identified)

Question 6

“Assuming that the MRTS you are currently using would not exist: How would you have made the same trip you are doing now?”

From Home/Office/Others⁴ (.....) to point..... by *.....

From point.....to pointby *.....

From point.....to pointby *.....

From point.....to home/office/others⁵ (.....) by *.....

*can be

⁴ Origin of trip.

⁵ Final destination.

- ☐ Bus (conventional not bus lane)
- ☐ Existing bus lane/BRT (NOT the project)
- ☐ Rail (NOT the project)
- ☐ Taxi → *continue with question 6A*
- ☐ Passenger car → *continue with question 6B*
- ☐ Motorcycle → *continue with question 6C*
- ☐ Motorized taxi tri-cycle → *continue with question 6D*
- ☐ Bike or per foot
- ☐ Other

Explanations for the interviewer:

- *Rail refers to non-project metro, urban rail, tram etc.;*
- *For each segment of the trip make a separate answer.*

Question 6A

“Have you used a taxi in the last 6 months?”

☐ Yes ☐ No

Question 6B

“Do you or your family own a car or do you have access to a car (e.g. car-sharing) or have you used a passenger car in the last 6 months?”

☐ Yes ☐ No

Question 6C

“Do you or your family own a motorcycle or do you have access to a motorcycle or have you used a motorcycle in the last 6 months?”

☐ Yes ☐ No

Question 6D

“Have you used a motorized taxi tri-cycle in the last 6 months?”

☐ Yes ☐ No

If interviewed persons respond in the questions 6A to 6D with NO they are not included in the final calculation i.e. this specific survey is not included as the response is deemed as non-consistent with the one given in question 6.

The project proponent must include the questionnaire as annex to the PDD. The questionnaire is to be reviewed by the DOE. The DOE assesses if the questionnaire is in accordance with the principles (core elements of survey) specified above.

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Document information

<i>Version</i>	<i>Date</i>	<i>Description</i>
Draft 04.0	3 November 2014	<p>MP 65, Annex 14</p> <p>A call for public input will be issued on this draft revised methodology.</p> <p>Revision to:</p> <ul style="list-style-type: none"> • Revise additionality demonstration; • Improve guidance on the renewal of the crediting period; • Improve the language, readability, clarity and consistency.
03.0	25 November 2011	<p>EB 65, Annex 18</p> <p>Revision to:</p> <ul style="list-style-type: none"> • Introduce a new approach to additionality demonstration; • Reduce monitoring requirements set in the MRTS passenger survey from annual monitoring to monitoring in the years 1 and 4 of the crediting period; • Remove an applicability condition requiring demonstration that the project system partially replaces a traditional public transport system in the city hosting the proposed project activity. • Remove an applicability condition restricting the use of the methodology in case more gaseous fossil fuels are used in the project activity compared to the baseline scenario; • Reduce monitoring requirements (from annual monitoring to monitoring in the years 1 and 4 of the crediting period) for leakage emissions from reduced congestion as a result of the project activity in case road capacity is reduced as a result of the project activity and requires no monitoring in case road capacity is not reduced as a result of the project activity. Provides additional guidance on assessing changes in road capacity due to the project activity • Remove the requirement to conduct a sensitivity analysis of data and parameters used to determine baseline, project and leakage emissions; • Introduce a reference to the “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion” to determine direct project emissions • Introduce the requirement to account for leakage due to upstream emissions in case project vehicles consume more gaseous fuels than baseline vehicles; • Improve language, readability and consistency; • Title modified from “Baseline and Monitoring Methodology for Mass Rapid Transit Projects” to “Mass Rapid Transit Projects”.

<i>Version</i>	<i>Date</i>	<i>Description</i>
02.0	30 July 2010	EB 55, Annex 14 Revision to: <ul style="list-style-type: none">• Introduce the definition of larger urban zone (LUZ) of a city;• Accommodate situations, for the common practice analysis, where the city has less than 1 million inhabitants in its LUZ.
01.0	16 October 2009	EB 50, Annex 2 Initial adoption.

Decision Class: Regulatory
Document Type: Standard
Business Function: Methodology
Keywords: transport, energy efficiency

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