Draft revision to the approved consolidated baseline and monitoring methodology ACM0016

~~Baseline and Monitoring Methodology for~~ "Mass Rapid Transit Projects"

I.   SOURCE, DEFINITIONS AND APPLICABILITY

Sources

This consolidated baseline and monitoring methodology is based on the following proposed new methodologies:

- NM0258 "Methodology for Bus Lanes" developed by Grütter Consulting AG, Switzerland;

- NM0266 "Methodology for Rail Based Urban Mass Rapid Transit Systems (MRTS)" developed by Grütter Consulting AG, Switzerland.

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

- "Tool for the demonstration and assessment of additionality";

- "Tool to calculate baseline, project and/or leakage emissions from electricity consumption";

- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".

For more information regarding the proposed new methodologies and the tools as well as their consideration by the CDM Executive Board (the Board) please refer to <http://cdm.unfccc.int/goto/MPappmeth>.

Selected Approach from Paragraph 48 of the CDM Modalities and Procedures

Existing actual or historical emissions, as applicable.

Definitions

For the purpose of this methodology, the following definitions apply:

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 ~~Transit~~ Rail Transit (L~~T~~RTs) systems, including trams, or suburban heavy duty rail systems or ~~. MRTS can also be~~ 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.

~~The l~~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.

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 ~~and taxis~~ 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 ~~through~~ by other vehicles. It is not a requirement that 100% 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 ~~the included bus route must be in general a bus-only lane~~ more than half of the included bus route must be a bus-only lane.

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).

Old lane	Lane extension

~~Additional~~ 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.

~~Additional~~ new lane

Old lane
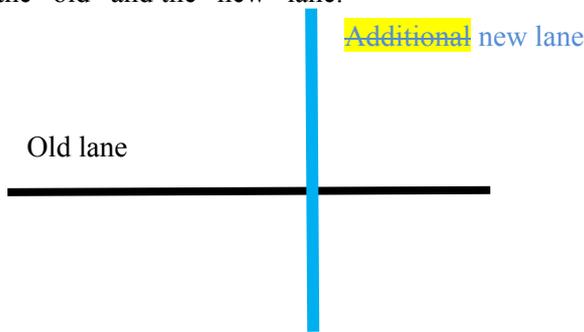
Feeder routes refer to bus routes which have intersections with trunk routes and which "feed" passengers on the trunk routes. Feeder routes are those with less passenger demand and operate under mixed traffic conditions.

Extension of rail infrastructure is defined as adding additional kilometres along an existing rail-route.

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.

Affected roads are the roads influenced by the establishment of the MRTS. Affected roads are those inside a radius of minimum 1 kilometre running parallel to the MRTS line (roads on both sides of the MRTS line are included). Only roads with large traffic volumes are included.

City is an area of continuous urban development and includes the historical core area and the adjacent suburbs defined by its administrative boundaries.

Commercial entity is a company, excluding banks, where more than 20% of equity capital is privately owned.

Applicability

This methodology applies to project activities that establish and operate a~~n rail-based or bus-based~~ MRTS ~~or segregated bus lanes~~ in urban or suburban regions, ~~including BRTs~~.

For BRTs with feeder plus trunk routes the methodology AM0031 is more suitable ~~recommended~~. ~~as~~ 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:

- The project constructs a new rail-based infrastructure or segregated bus lanes.

  o ~~In the case of~~ For rail systems, the project needs to involve the construction of ~~provide~~ a new infrastructure (new rail lines);

  o ~~In the case of~~ For ~~bus lanes~~ BRTs, the project can be based on existing road infrastructure, but which separates physically bus lanes from mixed traffic.

- The segregated BRT bus lanes or the rail-based MRTS replace~~s~~ existing bus routes (e.g. through scrapping units or through closing or re-scheduling existing bus routes) operating under mixed traffic conditions;

- 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;

- 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;

- The methodology is applicable for passenger transport only;

- Any fuels including (liquified) gaseous fuels or biofuel blends, as well as electricity can be used in the baseline or project case. The following condition~~s~~[1] apply:

  ~~o In the case of gaseous fossil fuels, the methodology is applicable if equal or more gaseous fossil fuels are used in the baseline scenario than in the project activity. The methodology is not applicable in its current form if more gaseous fossil fuel is used in the project activity compared to the baseline scenario;[2]~~

  o ~~In the case of~~ For biofuels, project buses must use the same biofuel blend (same percentage of biofuel) as commonly used by conventional comparable[3] urban buses in the country i.e. the

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[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] ~~Project proponents wishing to consider a higher consumption of gaseous fuels in the project activity than in the baseline may propose a revision of this methodology by adding the relevant upstream emission terms that a fuel switch towards gaseous fuels entails, taken e.g. from the approved methodology ACM0009 "Consolidated baseline and monitoring methodology for fuel switching from coal or petroleum fuel to natural gas". Similarly, Pp~~roject proponents wishing to consider project buses with a higher biofuel blend may propose a revision of this methodology based on future EB guidance on biofuels use.

[3] 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.

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.[2]

- The methodology is not applicable for the implementation of air- and water-based transport systems;

- The project system partially replaces a traditional public transport system in a given city. The methodology cannot be used in areas where currently no public transport is available;

- The methodology is applicable for urban or suburban trips. It is not applicable for inter-urban transport.

In addition, the applicability conditions included in the tools referred to above apply.

The methodology is applicable if the most plausible baseline scenario is the continuation of the use of current modes of transport.

Finally, this methodology is only applicable if the application of the procedure to identify the baseline scenario results in that a continuation of the current public transport system use of current modes of transport is as the most plausible baseline scenario.

II. BASELINE METHODOLOGY

Project Boundary

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.

The project only includes emission reductions from the MRTS lanes. as The location of the MRTS lanes should be transparently outlined in the 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 emission reductions can only be claimed for the original lane included in the PDD 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.

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".

The greenhouse gases included in or excluded from the project boundary are shown in **Table 1**.

Table 1: Emissions sources included in or excluded from the project boundary

	Source	Gas	Included?	Justification
Baseline Scenario	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~~.~~ ~~Vehicle tailpipe CH$_4$ emissions are~~ and excluded for liquid fuels ~~Combined CH$_4$ and N$_2$O emissions make less than 2% of total CO$_2$e emissions in diesel/gasoline vehicles.~~ CH_4 emissions are a minor emission source of the total CO_2e emissions in diesel/gasoline vehicles ~~Its omittance~~ 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_2O	No	~~Combined CH4 and N2O emissions make less than 2% of total CO2eq~~ N_2O emissions are a minor source of the total CO_2e emissions ~~in diesel/gasoline vehicles. Its omittance~~ Neglecting these emissions in baseline as well as project emissions is conservative as fuel consumption and thus also N_2O emissions are reduced through the project
Project Activity	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_2O	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_2O	No	See argument above
Leakage	Emissions due to changes ~~of~~ in the load factors of taxis and conventional buses; and due to congestion change (incl. change ~~of~~ 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_2O	No	See argument above

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

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

Apply Step 1 of the latest approved version of the "Tool for the demonstration and assessment of additionality". In applying Step 1a of the tool, the following alternative scenarios should, *inter alia*, be considered:

- The proposed project activity not being registered as a CDM project activity;

- The proposed project activity being implemented at a later date in the future, without being registered as a CDM project activity;

since it is a cross-cutting issue, the small group decided to discuss this issue in plenary to decide whether to keep it or delete it.

- The continuation of the current public and individual transport systems, including (future) investments in road based infrastructure if applicable;

- Transport systems which are different to the proposed project activity, e.g. if a bus lane is the project activity then alternatives might be a metro and reverse.

The alternative scenarios assessed can include combinations of public transport systems and individual modes of transportation, such as passenger cars, taxis, motorcycles and non-motorized transport. The alternatives should be assessed in a dynamic framework for the entire crediting period, taking into account the evolutions foreseen during this period (e.g. the growth of the larger urban zone of the city and the related increase of demand for transport services).

Step 2: Investment analysis

Apply Step 2 of the latest approved version of the "Tool for the demonstration and assessment of additionality". Conduct an investment comparison analysis for all alternatives that are remaining after Step 1. Use the NPV as indicator.

The investment analysis should be undertaken from the perspective of the operator of the public transportation system of the city or urban area, reflecting the costs and revenues from the perspective of the operator. If the project is subsidized through public authorities (e.g. the central government), e.g. through grants which do not need to be repaid, the financial assessment is made including as investment the total system costs minus any such public subsidies. If the project operator is owned by the municipality or city authority, then any subsidies or investments of the latter should be included in the calculations, i.e. subsidies 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.

In applying the investment comparison analysis, cost overruns of former investments in MRTS or reduced revenues of former MRTS investments compared to original projections, which make new investments less viable and riskier, 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 at the time of project start. 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.

- *If the sensitivity analysis is not conclusive, then the alternative to the project activity with least emissions among the alternative scenarios is considered as baseline scenario. If the sensitivity analysis confirms the result of the investment comparison analysis, then the most economically or financially attractive alternative scenario is considered as baseline scenario;*

- *If the alternative considered as baseline scenario is the "proposed project activity undertaken without being registered as a CDM project activity", then the project activity is not additional. Otherwise, proceed to Step 3.*

Step 3: Common practice analysis

The investment analysis shall be complemented with an analysis of the extent to which the proposed project type has already diffused in host country. This test is a credibility check to complement the investment analysis (Step 2). For the purpose of the common practice analysis, a set of cities for comparison with the city of the project activity is defined as follows:

- If the larger urban zone (LUZ) of the city of the project activity contains more than one million inhabitants, then the set of cities for comparison includes all cities (including the city of the project activity) in the host country with a LUZ that contains more than 1 million inhabitants;

- If the LUZ of the city of the project activity contains less than 1 million inhabitants, then the set of cities for comparison includes all cities (including the city of the project activity) in the host country with a LUZ that contains between a half and one million inhabitants. If there are no cities in the host country with a LUZ between a half and one million inhabitants, then the geographical area must be expanded and the cities outside the host country with a LUZ counting between a half and one million inhabitants that are closest to the project location (using beeline) are also included in the set, until the set for comparison comprises of three cities.

Collect information on which cities in the considered set of cities for comparison have already implemented a MRTS. The proposed project activity is regarded as common practice if MRTS have already been implemented in 50% of the cities in the set of cities for comparison as defined above without using the CDM.

MRTS projects implemented in least developed countries (LDC) are deemed to be automatically additional.

If MRTS projects are implemented in non-LDCs and face the first-if-its-kind barrier, the latest 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.

For MRTS projects, which are implemented in non-LDCs and which are not first-of-its-kind, the following procedure illustrated in Figure 1 and described below shall be applied.

When validating the application of the additionality demonstration, Designated Operation 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.
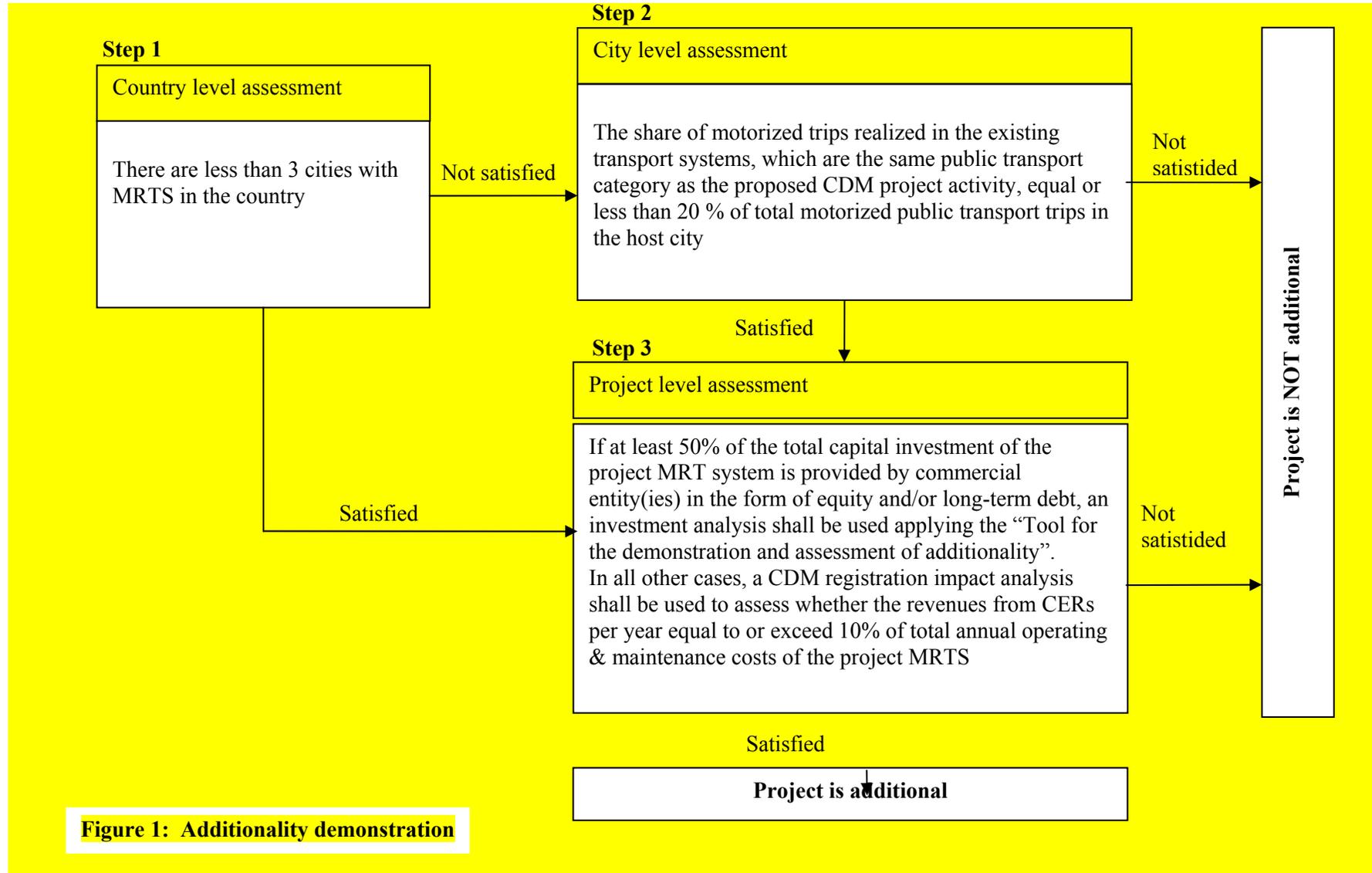
Step 1

Country level assessment

There are less than 3 cities with MRTS in the country

Not satisfied →

Step 2

City level assessment

The share of motorized trips realized in the existing transport systems, which are the same public transport category as the proposed CDM project activity, equal or less than 20 % of total motorized public transport trips in the host city

Not satistided →

Satisfied ↓

Step 3

Project level assessment

If at least 50% of the total capital investment of 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 used applying the "Tool for the demonstration and assessment of additionality".
In all other cases, a CDM registration impact analysis shall be used to assess whether the revenues from CERs per year equal to or exceed 10% of total annual operating & maintenance costs of the project MRTS

Satisfied ←

Not satistided →

Satisfied ↓

Project is additional

Project is NOT additional

Figure 1: Additionality demonstration

Step 1:   Country level assessment

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.

The project participants shall:

- 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;

- 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 all[4] MRT systems developed as CDM project activities from the assessment of common practice in this step.

If the number of cities with MRTS (excluding systems developed as CDM project activities) is equal to or exceeds 3 cities, then projects participants should proceed to Step 2, otherwise project participants should proceed to Step 3 (see Figure 1***).***

Step 2:   City level assessment

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% of total public transport trips in the host city.

The project participants shall :

- 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:

    o   Metro;

    o   Sub-urban rail;

    o   Light rail transit including trams;

    o   Conventional bus system;

    o   BRTs.

- 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.

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[4] This is subject to further decisions by the Executive Board.

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% of total motorized public transport trips in the host city, then <u>the proposed CDM project activity is not additional.</u> If the share of trips is equal or below 20%, then project participants should proceed to Step 3.

Step 3:   Project level assessment

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

- If at least 50% 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 procedure A below;

- In all other cases, an impact assessment of CDM project registration shall be conducted, following procedure B below.

Procedure A: Investment analysis

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".

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.

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.

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.

Procedure B: Analysis of the impact of CDM registration

The aim of this step is to determine whether the annual revenues from CERs constitute a significant proportion of the total annual operating and maintenance costs of the project MRTS. For this purpose, 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 of the project MRTS. For the purpose of this analysis, project participants should use the amount of operating and maintenance costs and the amount of CERs that are expected to 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"

The project participants shall:

- Provide an *ex-ante* assessment of the revenues from CERs per year expected to be generated by the proposed project activity. For this assessment, operating and maintenance costs as well as passenger demand shall be estimated for the year when the MRT 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;

- Document and describe transparently 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 2 and Table 3 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 2: 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 • New tires • Retreading	Units/ 100,000 km Units/ 100,000 km

Item	Unit of accounting in cost calculations
Lubricants	
• Motor	Liters /10,000 km
• Transmission	Liters /10,000 km
• Differential	Liters /10,000 km
• Grease	Kilograms/10,000 km
Maintenance	% value of vehicle/year

Source: GTZ 2005. Mass transit options.

**Table 3: 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

If the annual revenues from CERs are equal to or exceed 10% of the total annual operating and maintenance costs of the MRTS proposed as CDM project activity, then the proposed CDM project activity is additional. Otherwise, the proposed CDM project activity is not deemed additional.

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.

Baseline Emissions

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.

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

Step 1: Conduct a survey, following the procedures presented in Annex 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 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% confidence interval as total baseline emissions (see Annex 4).

Baseline emissions are calculated as follows:

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

Where:

BE_y	=	Baseline emissions in the year y (gtCO$_2$)
$BE_{p,y}$	=	Baseline emissions per surveyed passenger p in the year y (gtCO$_2$)
$FEX_{p,y}$	=	Expansion factor for each surveyed passenger p surveyed in the year y (each surveyed passenger has a different expansion factor)
P_y	=	Total number of passengers in the year y
P_{SPER}	=	Number of passengers in the time period of the survey (1 week)
p	=	Surveyed passenger (each individual)
y	=	Year of the crediting period

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

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

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

Where:

$BE_{p,y}$	=	Baseline emissions per surveyed passenger p in the year y (tgCO$_2$)
$EF_{PKM,i,y}$	=	Emission factor per passenger-kilometre of mode i in the year y (tgCO$_2$/PKM)
$BTD_{p,i,y}$	=	Baseline trip distance per surveyed passenger p using mode i in the year y (PKM)
p	=	Surveyed passenger (each individual)
i	=	Relevant vehicle category
y	=	Year of the crediting period

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

The relevant vehicle categories i referred to in equation 2 above may include *inter alia*:

- 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 (i.e. normal for buses from a conventional bus system and buses from bus lane a BRT);

- Passenger cars;

- Taxis;

- Motorcycles;

- Tricycles or motorcycles with more than 2 wheels used for transporting passengers;

- Existing metro, rail, ~~LTR~~ LRT (Light ~~Transit~~ Rail Transit) ~~or~~ including tram;[5]

- NMT (Non-Motorized Transport);

- Other vehicle categories.

The relevant vehicle categories should be clearly identified in the CDM-PDD.

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.

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

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

The emission factors per PKM are calculated as follows:

(2.1)   Case 1: Emission factor per PKM for electricity-based transport systems (e.g. urban rail-based systems)
For electricity-based vehicle categories, the following equation should be used:

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

$$EF_{PKM,i,y} = \frac{TE_{EL,i,y}}{P_{EL,i,y} \cdot TD_{EL,i}} \times 10^6 \qquad \textbf{(3)}$$

Where:
$EF_{PKM,i,y}$ =   Emission factor per passenger-kilometre for electricity-based vehicle category i for year y (gCO$_2$/PKM)
$TE_{EL,i,y}$ =   Total emissions from the electricity-based vehicle category i for year y (tCO$_2$)
$P_{EL,i,y}$ =   Total passengers transported per year by the electricity-based vehicle category i for year y (passengers)
$TD_{EL,i}$ =   Average trip distance ~~of~~ travelled by passengers using the electricity-based vehicle category i prior to project start (km)

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 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

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[5]   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).

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

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]

<u>(2.2)   Case 2: Emission factors per PKM for fuel-based transport systems (e.g. road-based vehicles)</u>

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

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

Where:
$EF_{PKM,i,y}$ = Emission factor per passenger-kilometre of vehicle category i in ~~the~~ year y (gCO$_2$/PKM)
$EF_{KM,i,y}$ = Emission factor per kilometre of vehicle category i in ~~the~~ year y (gCO$_2$/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

<u>(2.2.1)   Determination of the average occupation rate (OC_i)</u>

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. ~~In the case of~~ For taxis, the driver should not be included.

The detailed procedures concerning visual occupation studies and boarding-alighting studies are presented in Annexes 1, 2 and 3. The detailed procedures concerning expansion factors are presented in Annex 4.

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 ~~of~~ by buses, using the following equation:

$$OC_B = \frac{PBL_B \cdot TDBL_{P,B}}{DD_B} \qquad\qquad \textbf{(5)}$$

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)
~~Average trip distance of passengers using a baseline bus~~
DD_B = Total ~~D~~distance driven by all ~~baseline~~ buses prior to the project start (kilometre)

<u>(2.2.2)   Determination of the emission factors per kilometre ($EF_{KM,i,y}$)</u>

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.

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[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.

In case biofuel blends are used, the biofuel share of the blend should be accounted for with zero emission factor ($EF_{CO2,x,y}$).

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" ~~is~~ shall be included.

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 ~~the~~ electricity consumption plus passengers transported (see equation 3).

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

$$EF_{KM,i,y} = \frac{\sum_x \left(SFC_{i,x,y} \cdot NCV_{x,y} \cdot EF_{CO2,x,y} \cdot N_{x,i} \right)}{N_i} \tag{6}$$

Where:

$EF_{KM,i,y}$	=	Emission factor per kilometre of vehicle category *i* in ~~the~~ year *y* (gCO$_2$/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* (gCO$_2$/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

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

$$EF_{KM,i,y} = \left(IR_i \right)^{t+y} \cdot \frac{\sum_x \left(SFC_{i,x} \cdot NCV_{x,y} \cdot EF_{CO2,x,y} \cdot N_{x,i} \right)}{N_i} \tag{7}$$

Where:

$EF_{KM,i,y}$	=	Emission factor per kilometre of vehicle category *i* in ~~the~~ year *y* (g CO$_2$/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)
$EF_{CO2,x,y}$	=	Carbon emission factor for fuel type *x* in year *y* (g CO$_2$/J)
N_i	=	Number of vehicles of category *i* prior to the project start (units)
IR_i	=	Technology improvement factor for ~~the~~ vehicle ~~of~~ 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

~~The~~ ~~t~~Technology improvement factor~~s~~ ~~as~~ are listed in the following table:

Table 4 2: 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

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:

$$\tag{8}$$

Where:

$EF_{KM,B,y}$ = Emission factor per kilometre ~~of~~ for buses (gCO_2/km)

$EF_{KM,L/M/S,y}$ = Emission factor per kilometre ~~of~~ for buses of sub-category L (large buses), M (medium sized buses) and S (small buses) (gCO_2/km)

$DD_{L/M/S}$ = Total distance driven ~~of~~ 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

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 $EF_{km,BBL}$.

The distance driven ~~of~~ 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 ~~of~~ by units.

Baseline emissions cover the entire emissions which would have been caused by the project passenger in absence of the project from his trip origin to his trip destination:

- The origin and destination of the trip ~~is~~ 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;

- The trip distance and the modes used between O (origin) and D (destination) are however different in the baseline than in the project case;

- The trip distance may vary as some passengers using the project MRTS may be willing ~~e.g.~~ to make detours due to the higher speed of the MRTS versus conventional bus transport.

To fully capture all potential changes the methodology ~~thus~~ compares emissions per O-D trip of the baseline with emissions per O-D trip of the project. The data to determine O-D mode(s) and distances per mode are derived from a representative survey of project passengers realized annually. Total baseline

emissions are calculated thereafter annually based on these parameters, the emissions per PKM and the amount of passengers transported by the project.

Project Emissions

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 2.
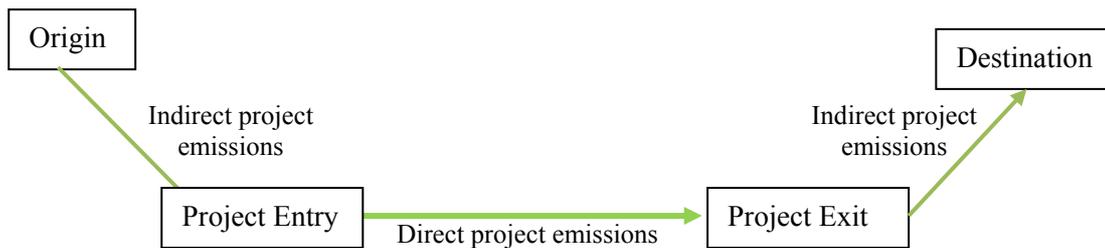
Figure 2: Direct and Indirect Project Emissions

Project emissions are calculated as follows:

$$\tag{9}$$

Where:

PE_y	=	Project emissions in ~~the~~ year y (tCO$_2$)
DPE_y	=	Direct project emissions in ~~the~~ year y (tCO$_2$)
IPE_y	=	Indirect project emissions in ~~the~~ year y (tCO$_2$)

Determination of direct project emissions (DPE$_y$)

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

If the project transport system uses fossil fuels, the ~~following equation applies:~~ latest version of the "Tool to calculate project or leakage CO$_2$ emissions from fossil fuel combustion" shall be used. The following guidance is given for applying the tool:

- The parameter $PE_{FC,i,y}$ in the tool corresponds to the direct project emissions from the project transport system that uses fossil fuels in year y (DPE_y); and

- Element process j corresponds to the combustion of fuel type x in the project vehicles;

$$DPE_y = \sum_x \left(TC_{PJ,x,y} \cdot NCV_{x,y} \cdot EF_{CO2,x,y} \right)$$

~~Where:~~
~~DPE_y~~	~~=~~	~~Direct project emissions in year y (tCO$_2$)~~
~~$TC_{PJ,x,y}$~~	~~=~~	~~Total fuel consumed of fuel type x in the year y (mass or volume units of fuel)~~
~~$NCV_{x,y}$~~	~~=~~	~~Net calorific value of fuel x in year y (J/mass or volume units of fuel)~~
~~$EF_{CO2,x,y}$~~	~~=~~	~~Carbon CO$_2$emission factor for fuel type x in year y (gCO$_2$/J)~~

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 units 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% confidence level. This means that with 95% ~~security~~ confidence ~~we can~~ it is possible to state that the actual project fuel consumption is equal to or lower than the value used by the project.

If the total fuel consumed is determined based on sample measurements, the following equation is used:

$$\text{~~TC~~FC}_{PJ,x,y} = SFC_{i,x,y} \cdot DD_{PJ,x,y} \tag{10}$$

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

Where:

~~TC~~$FC_{PJ,x,y}$ = Total fuel consumed ~~of~~ by project transport units using fuel type x in ~~the~~ year y ~~(tons)~~ (mass or volume units of fuel)

$SFC_{i,x,y}$ = Specific fuel consumption of vehicle category i using fuel x in ~~the~~ year y (mass or volume units of fuel per km)

$DD_{PJ,x,y}$ = Distance driven ~~of~~ by transport units consuming fuel x in ~~the~~ year y (km)

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

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.

Determination of indirect project emissions (IPE_y)

Indirect project emissions are those caused by passengers from their trip origin up to the project activity entry station, and from the project activity exit station up to the trip final destination.

- The survey realized identifies the origin, ~~the~~ project entry station, ~~the~~ project exit station and ~~the~~ final destination of the passenger plus the modes used between the different points, e.g. bike from origin to project entry station and taxi from project exit station to final destination;

- The distances between origin and entry and between exit and destination are calculated based, e.g. on public transit routes, electronic maps and GPS (identical to baseline trip determination);

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

The ~~following~~ next steps should be followed to determine indirect project emissions:

Step 1: Conduct a survey, following the procedures presented in Annex 4, in which for each surveyed passenger the trip distance per transport mode used to/from the MRTS is determined.

Step 2: Calculate indirect project emissions for each surveyed passenger, as per equation 13 below.

Step 3: Apply to each surveyed passenger an individual expansion factor in accordance with the survey sample design (as defined in Annex 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 12 below.

Step 4: Apply the upper 95% confidence interval to the total indirect project emissions (see Annex 4).

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

$$IPE_y = \frac{P_y}{P_{SPER}} \sum_p \left(IPE_{p,y} \cdot FEX_{p,y} \right) \times 10^{-6} \tag{11}$$

Where:

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

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

$$IPE_{p,y} = \sum_i IPTD_{p,i,y} \times EF_{PKM,i,y} \tag{12}$$

Where:

$IPE_{p,y}$	=	Indirect project emissions of ~~the~~ surveyed passenger p in ~~the~~ year y (gCO_2)
$EF_{PKM,i,y}$	=	Emission factor per passenger-kilometre of mode i in ~~the~~ year y (gCO_2/PKM)
$IPTD_{p,i,y}$	=	Indirect project trip distance of ~~the~~ surveyed passenger p using mode i in ~~the~~ year y (km)

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

Leakage

Leakage emissions include the following sources:

- Emissions due to changes of the load factor of taxis and buses of the baseline transport system due to the project ($LE_{LFB,y}$ and $LE_{LFT,y}$), and

- Emissions due to reduced congestion on affected roads, provoking higher average vehicle speed, plus a rebound effect. ($LE_{CON,y}$), and

- Upstream Emissions of Gaseous Fuels ($LE_{UP,y}$).

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

Leakage emissions are calculated as follows:

$$LE_y = LE_{LFB,y} + LE_{LFT,y} + LE_{CON,y} \tag{13}$$

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

Where:

LE_y = Leakage emissions in ~~the~~ year y (tCO$_2$)
$LE_{LFB,y}$ = Leakage emissions due to change of load factor of buses in ~~the~~ year y (tCO$_2$)
$LE_{LFT,y}$ = Leakage emissions due to change of load factor of taxis in ~~the~~ year y (tCO$_2$)
$LE_{CON,y}$ = Leakage emissions due to change in congestion in ~~the~~ year y (tCO$_2$)
$LE_{UP,y}$ = Leakage emissions due to upstream emissions of gaseous fuels in ~~the~~ year y (tCO$_2$)

~~If for a certain year LEy < 0, then leakage should not be included in the calculation of emissions reductions. If LEy > 0, then it should be included.~~

~~If for a certain year LE$_{LFB,y}$ < 0, then this leakage should not be included in the calculation of emissions reductions. If LE$_{LFB,y}$ > 0, then it should be included.~~

~~If for a certain year LE$_{LFT,y}$ < 0, then this leakage should not be included in the calculation of emissions reductions. If LE$_{LFT,y}$ > 0, then it should be included.~~

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.

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

The project could have a negative impact on the load factor of the conventional bus fleet. Load factor changes are monitored for the entire 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 ~~7~~ of the crediting period ~~and the year 10 of the crediting period, if a 10-year period is taken~~. 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:

$$\cancel{LE_{LFB,y} = \frac{1}{10^6} \cdot N_{B,y} \cdot AD_B \cdot EF_{KM,B,y} \cdot \left(1 - \frac{OC_{B,y}}{OC_B}\right)} \tag{14}$$

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

Where:

$LE_{LFB,y}$ = Leakage emissions due to ~~a~~ change ~~of~~ in load factor of buses in ~~the~~ year y (tCO$_2$)
$N_{B,y}$ = Number of baseline buses in ~~the~~ year y (buses)
AD_B = Average annual distance driven by baseline buses (km/bus)
$EF_{KM,B,y}$ = Emission factor per kilometre ~~of~~ for baseline buses in ~~the~~ year y (gCO$_2$/km)
$OC_{B,y}$ = Average occupancy rate of baseline buses in ~~the~~ year y (passengers)
OC_B = Average occupancy rate of baseline buses prior to the project start (passengers)

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

Determination of emissions due to a change in load factor of taxis (LE_LFT,y)

The project could have a negative impact on the load factor of taxis. Taxis can include cars as well as motorized rickshaws ~~realizing~~ 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 ~~and 7~~ of the crediting period ~~and the year 10 of the crediting period, if a 10-year period is taken~~. This leakage is calculated as follows:

$$LE_{LFT,y} = N_{T,y} \cdot AD_T \cdot EF_{KM,T,y} \left(1 - \frac{OC_{T,y}}{OC_T}\right) \cdot \frac{1}{10^6} \tag{15}$$

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

Where:

$LE_{LFT,y}$	=	Leakage emissions due to a change in load factor of taxis in ~~the~~ year y (tCO$_2$)
$N_{T,y}$	=	Number of baseline taxis in ~~the~~ year y (taxis)
AD_T	=	Average annual distance driven ~~of~~ by baseline taxis (km/taxi)
$EF_{KM,T,y}$	=	Emission factor per kilometre ~~of~~ for baseline taxis in ~~the~~ year y (gCO$_2$/km)
$OC_{T,y}$	=	Average occupancy rate of baseline taxis in ~~the~~ year y (passengers)
OC_T	=	Average occupancy rate of baseline taxis prior to the project start (passengers)

The maximum change in load factor ~~change~~ attributed to taxis is the emission reductions due to passengers switching from taxis to the project (calculated by the emission factor per passenger-kilometre for taxis, ~~the~~ trip distance and ~~the~~ number of passengers transported by the project, which would have used taxis in absence of the project). This maximum condition is established as load factors might worsen citywide also due to factors external to the project and leakage from a change in load factor ~~change~~ of taxis due to the project can at maximum be according to the number of passengers transported by the project which in absence of the latter would have taken a taxi.

The occupancy rate of taxis is monitored through visual occupation studies counting the number of passengers. The detailed procedures concerning visual occupation studies for taxis are presented in Annex 3.

The parameter emission factor per kilometre ~~of~~ for baseline taxis in ~~the~~ year y ($EF_{KM,T,y}$) is calculated using the equation for $EF_{KM,i,y}$ presented in the baseline emissions section, substituting i for T (taxis).

Determination of emissions due reduced congestion (LE_CON,y)

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. ~~It is not possible however to determine ex ante if effect will result in positive leakage emisins (i.e., emission increase) or neganitve leakage emissions (i.e., emissions reductions).~~ On the other hand, MRTS project activities may also reduce the road space available for conventional buses and individual transport modes. Therefore, ~~T~~two effects resulting from reduced congestion are considered:

- Induced traffic effect (or rebound effect), i.e. more trips of passenger cars on the "affected roads";

- Changes in vehicle speed effect, i.e. change of emissions due to a reduced or increased speed of cars on "affected roads".

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.

To determine whether road capacity is reduced the following procedure shall be applied:

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

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:

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

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 (units)
SRS	=	Share of road space used by public transport in the baseline (in percentage)
RS_{BL}	=	Total road space available in the baseline (lane-kilometers)
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)

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

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

Where:

SRS	=	Share of road space used by public transport in the baseline (in percentage)
TD_B	=	Total distance driven by public transport buses in the baseline (kilometers)
TD_T	=	Total distance driven in kilometers by taxis in the baseline (kilometers)
TD_C	=	Total distance driven in by passenger cars in the baseline (kilometers)

It is assumed that one bus occupies 2.5 times more road space than a personal car or a taxi.

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

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.

If ARS_y 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 Step b) below. If ARSy is positive, LE$_{CON,y}$ is assumed to be zero.

Step b): Calculation of LE$_{CON,y}$

The corresponding emissions LE$_{CON,y}$ are calculated as follows:

$$LE_{CON,y} = LE_{REB,y} + LE_{SP,y}$$

$$LE_{CON,y} = \max(LE_{REB,y} + LE_{SP,y}, 0) \qquad\qquad \textbf{(18)}$$

Where:

LE$_{REB,y}$	=	Leakage emissions due to induced traffic / rebound effect in ~~the~~ year y (tCO$_2$)
LE$_{SP,y}$	=	Leakage emissions due to change in vehicle speed in ~~the~~ year y (tCO$_2$)

~~If for a certain year LE$_{REB,y}$ < 0, then leakage should not be included in the calculation of LE$_{CON,y}$. If LE$_{REB,y}$ > 0, then it should be included.~~

~~b)~~ ***Step c): Determination of emissions due to induced traffic/rebound effect (LE$_{REB,y}$)***

The concept to capture emissions from induced traffic (or rebound effect) includes the following assumptions (induced traffic is measured for passenger cars and taxis):

- The distance driven on the affected roads ~~of~~ 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;

- 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.

The monitoring is realized through measurements of traffic flows and distance driven ~~of~~ by passenger cars and taxis on the affected roads. Monitoring is realized ~~annually~~ in the years 1 and 4 of the crediting period.

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".

A negative rebound effect based on additional congestion is ~~not~~ expected ~~as MRTS reduce congestion compared to the baseline~~ in this situation. ~~Also, not taking this into consideration is conservative as a negative rebound effect would lead to emission reductions~~. 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.

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.

The rebound effect for the affected roads is calculated as follows:

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

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

Where:

$LE_{REB,y}$	=	Leakage emissions due to rebound effect in the year y (tCO$_2$)
$TDIZ_{i,y}$	=	Average trip distance made by cars/taxis on the affected roads in the year y (km)
$EF_{KM,i,y}$	=	Emission factor per kilometre of for cars and taxis in the year y (gCO$_2$/km)
$NIZ_{i,y}$	=	Number of cars/taxis per annum using the affected roads in the year y (cars, taxis)
$NIZ_{i,BL}$	=	Number of cars/taxis per annum using the affected roads in the baseline (cars, taxis)
$NIZ_{i,MS,y}$	=	Number of cars/taxis per annum not used anymore due to mode shift to the MRTS in the year y (cars, taxis)
i	=	Cars, taxis

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

$$NIZ_{i,MS,y} = \frac{MS_{i,s} \cdot P_y}{OC_i} \tag{20}$$

Where:

$NIZ_{i,MS,y}$	=	Number of cars/taxis per annum not used anymore due to mode shift to the MRTS in the year y (cars, taxis)
$MS_{i,y}$	=	Net share of passengers using the MRTS which would have used mode i in the year y (%)
P_y	=	Passengers transported by the project in the year y (passengers)
OC_i	=	Average occupation rate of vehicle category i prior to the project start (passengers)
i	=	Cars, taxis

The net share of passengers with mode switch 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).

b Step d): Determination of emissions due to changes in vehicle speed (LE$_{SP,y}$)

Leakage emissions due to changes in vehicle speed are determined only for cars and taxis, as presented below. The non-inclusion of other vehicles such as buses or trucks is conservative as a reduced congestion also leads to reduced emissions of remaining buses plus trucks on affected roads due to the speed effect. If speed measurements for cars/taxis show that the EF for cars/taxis for the year y is lower than the baseline emission factor (thus leading to negative leakage) the project proponent can choose not to include this factor and thus avoid measurements of numbers of cars/taxis and trip distance of cars/taxis.

$$LE_{SP,y} = \frac{1}{10^6} \cdot \sum_i \left(NIZ_{i,y} \cdot TDIZ_{i,y} \cdot \left(EF_{KM,VP,i,y} - EF_{KM,VB,i} \right) \right) \tag{21}$$

Where:

$LE_{SP,y}$	=	Leakage emissions due to changes in vehicle speed of cars and taxis in year y (tCO$_2$)
$NIZ_{i,y}$	=	Number of cars/taxis using the affected roads in the year y (cars, taxis)
$TDIZ_{i,y}$	=	Average trip distance made by cars/taxis on the affected roads in the year y (km)
$EF_{KM,VP,i,y}$	=	Emission factor per kilometre of for cars/taxis at the project speed in the year y (gCO$_2$/km)
$EF_{KM,VB,i}$	=	Emission factor per kilometre of for cars/taxis at the baseline speed (gCO$_2$/km)
i	=	Cars, taxis

The project speed on the determined routes affected roads is monitored annually in the years 1 and 4 of the crediting period on the affected roads. Vehicle speed is monitored under moving conditions. The same method should be used for determining the baseline and project speed determination.

The number of cars and taxis on the affected roads are monitored through visual or electronic counting.

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 a 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.

$$EF_{KM,VB,i} = 135.44 - 2.314 \times V_B + 0.0144 \times V_B^2 \qquad (22)$$

and

$$EF_{KM,VP,i,y} = 135.44 - 2.314 \times V_{P,y} + 0.0144 \times V_{P,y}^2 \qquad (23)$$

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

Where:

$EF_{KM,VB,i}$	=	Emission factor per kilometre of for cars/taxis at the baseline speed (gCO$_2$/km)
$EF_{KM,VP,i,y}$	=	Emission factor per kilometre of for cars/taxis at the project speed in the year y (gCO$_2$/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)

V_B and V_P in this case refers to moving speed, i.e. the speed of the vehicle under moving conditions. The CORINAIR speed emission factor is only for relative speed changes. It cannot be used to calculate the absolute emission factor of a vehicle category. The equation above is applicable if the passenger cars and taxis in the project boundary are Euro 1 and onwards, the average circulating speed is between 13.1 and 130km/h and the average cylinder capacity is between 1.4 and 2.0 liters. In case these conditions do not apply, the formula appropriate for the city conditions can be found in table 8.6 of the Emission Inventory Guidebook CORINAIR as published by the European Environmental Agency 8-2002 or its latest update.

Upstream Emissions from Gaseous Fuels (LE$_{UP,y}$)

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:

- 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;

- 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.

Thus, leakage emissions are calculated as follows:

$$LE_{UP,y} = LE_{CH4,y} + LE_{LNG,CO2,y} \tag{24}$$

Where:

$LE_{UP,y}$ = Leakage upstream emissions of gaseous fuels during the year y in t CO_2e

$LE_{CH4,y}$ = Leakage emissions due to fugitive upstream CH_4 emissions in the year y in t CO_2e

$LE_{LNG,CO2,y}$ = 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

Emissions due to fugitive upstream CH_4 emissions

$$LE_{CH4,y} = FC_{PJ,NG,y} \times NCV_{NG,y} \times EF_{NG,upstream,\ddot{}CH4} \times GWP_{CH4} \tag{25}$$

Where:

$L_{CH4,y}$ = Leakage emissions due to upstream fugitive CH_4 emissions in the year y in tCO_2e

$FC_{PJ,NG,y}$ = Quantity of natural gas used by project units in the year y in m³

$NCV_{NG,y}$ = Net calorific value of the natural gas used by the project during the year y in GJ/m³

$EF_{NG,upstream,CH4}$ = Emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas in tCH_4/GJ

GWP_{CH4} = Global warming potential of methane valid for the relevant commitment period

Where reliable and accurate national data on fugitive CH_4 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.

CO_2 emissions from LNG

Where applicable, CO_2 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 ($LE_{LNG,CO2,y}$) should be estimated by multiplying the quantity of natural gas combusted in the project system with an appropriate emission factor, as follows:

$$LE_{LNG,CO2,y} = FC_{PJ,NG,y} \cdot EF_{CO2,upstream,LNG} \tag{26}$$

Where:

$LE_{LNG,CO2,y}$ = 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

$FC_{PJ,NG,y}$ = Quantity of natural gas used by project units during the year y in TJ

$EF_{CO2,upstream,LNG}$ = 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

Where reliable and accurate national data on fugitive CH_4 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).

Emission Reductions

Emissions reductions are calculated as:

$$ER_y = BE_y - PE_y - LE_y \tag{27}$$

Where:

ER$_y$ = Emissions reductions in year y (tCO2)
BE$_y$ = Baseline emissions in year y (tCO2)
PE$_y$ = Project emissions in year y (tCO2)
LE$_y$ = Leakage emissions in year y (tCO2)

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

In case the MRTS is extended (prolonged) beyond the length as included in the CDM-PDD, emissions reductions can only be claimed for the original length of the MRTS lanes as included in the PDD. For this purpose baseline emissions and indirect project emissions of the respective MRT lanes are calculated only for the number of passengers which entered the MRTS on stations of the MRTS included in the PDD. Direct project emissions are calculated either as a proportion of the distance of the MRTS included in the PDD relative to the total distance of the bus lane or as proportion of the passengers which entered the MRTS included in the PDD in relation to the total number of passengers transported on the total MRTS.

A sensitivity analysis is carried out for data and parameters, which are used to calculate baseline, project and leakage emissions. The sensitivity analysis is performed on all parameters except default and IPCC values listed as monitored values/parameters or values to be monitored. The sensitivity analysis is based on calculating the change of the data parameter that would be required to reduce emission reductions by 5%. This value gives an indication of the magnitude of change of the data parameter required to significantly change calculated emission reductions.

Steps to carry out the sensitivity analysis include:

- Carry out a sensitivity analysis on these parameters calculating the level of change of the parameter required to reduce emission reductions by 5% below that originally estimated;

- Assess the result in light of possible data uncertainty. As sensitive parameter/data are considered those where a change of less than 10% leads to a reduction of ERs of more than 5%. In these cases an explanation shall be given to ensure that the data value used is correct and conservative.

Changes Required for Methodology Implementation in 2nd and 3rd Crediting Periods

The revision at the end of the first crediting period in preparation for the next crediting period shall include an assessment of:

- The applicability conditions for the approved methodology shall still be valid at the time of the revision;

- Re-calculation of all relevant (see below) baseline parameters;

- Re-assessment if the baseline is still valid including an assessment of new regulations and policies on baseline emissions;

- Review if the project is not common practice. If the project can be considered common practice then the crediting period is not renewed.

Parameters such as specific fuel consumption and occupation rates of private vehicles, taxis and the remaining bus system are determined again for a new crediting period.

Crediting period

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

Data and Parameters not monitored

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:	$TD_{EL,i}$
Data Unit	Kilometres
Description	Average trip distance of travelled by passengers using the electricity-based vehicle category *i* prior to project start
Source of Data	Rail operator
Measurement Procedure	Based, in general, on electronic ticketing system or on surveys
Comments	Only rail trip distance, not total trip distance

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 3 years
Measurement Procedure	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 by buses.
	In the case of For taxis (including motorized rickshaws), the driver should not be counted.
	The detailed procedures concerning visual occupation and boarding-alighting studies are presented in Annexes 1, 2 and 3
Comments	-

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 3 years. Use the same vintage as for the parameter $TDBL_{P,B}$
Measurement Procedure	-
Comments	-

Data / Parameter:	$TDBL_{P,B}$
Data Unit	Kilometres
Description	Average trip distance of 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 Procedure	In general, based on a survey asking passengers entry and exit stations and calculating the trip distance on the bus. Vintage maximum 3 years. Use the same vintage as for the parameter PBL_B
Comments	Used to determine the average occupation rate of buses together with the total number of buses and the total distance driven of by buses

Data / Parameter:	$DD_B/DD_L/DD_M/DD_S$
Data Unit	Kilometres
Description	Total distance driven by buses ~~of~~ 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 3 years
Measurement Procedure	Distance driven ~~of~~ by buses is often recorded by bus companies based on odometer reading. Preferable is GPS or other electronic means, however this is not yet ~~frequent~~ 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 ~~of~~ 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
Comments	-

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 3 years
Measurement Procedure	Distance driven ~~of~~ by buses is often recorded by bus companies based on odometer reading. Preferable is GPS or other electronic means, however this is not yet ~~frequent~~ 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
Comments	-

Data / Parameter:	$SFC_{i,x}$
Data Unit	grams of fuel/km
Description	Specific fuel consumption of vehicle category i using fuel type x prior to the project start
Source of Data	In decreasing order of preference: 1. Local measured data not ~~elder~~ older than 3 years (studies e.g. performed by universities or ordered by project proponent); 2. National or international data from studies not ~~elder~~ older than 3 years; 3. IPCC default values for the respective vehicle categories (latest year)

Measurement Procedure	The following alternatives are proposed to determine specific fuel consumption (in order of preference): 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% ~~security~~ confidence the actual average fuel consumption is equal to or higher than the value used by the project 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 ~~either~~ 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). Alternative 3: Latest IPCC default values reported matching the respective vehicle category, age, vehicle origin and technology
Comments	-

Data / Parameter:	N_i
Data Unit	Vehicles
Description	Number of vehicles of category *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 3 years
Measurement Procedure	-
Comments	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:	$N_{x,i}$
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 3 years
Measurement Procedure	-
Comments	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:	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 3 years
Measurement Procedure	-
Comments	-

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 Procedure	-
Comments	Road space baseline based on official information. Reduced road space based on construction plans (reduced road space is lanes which where eliminated due to dedicating bus lanes to the project system). Road space project = road space baseline – eliminated lanes

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 3 years
Measurement Procedure	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 ~~with~~ by the vehicle age
Comments	-

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 3 years
Measurement Procedure	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
Comments	The same ~~monitoring methodology~~ method should be applied to ~~monitor~~ determine number of cars and taxis in the project situation to ensure a consistent approach

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 Procedure	On-board measurements determining the average speed when circulating and ~~in total~~ average total speed on the road based e.g. on GPS
Comments	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 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. Only passenger cars and 4-wheel taxis are monitored. The same speed data is taken for both vehicle types. The same ~~monitoring methodology~~ method should be applied to ~~monitor~~ determine vehicle project speed thereafter to ensure a consistent approach. Required for monitoring of the rebound effect and the speed effect on affected roads

Data / Parameter:	~~EF~~_{~~Grid~~}
~~Data Unit~~	~~kgCO₂/kWh~~
~~Description~~	~~Emission factor for the grid~~
~~Source of Data~~	~~Official data. Follow procedures as in the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"~~
~~Measurement Procedure~~	~~"Tool to calculate baseline, project and/or leakage emissions from electricity consumption" shall be applied~~
~~Comments~~	~~-~~

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 Procedure	
Comments	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:	$EF_{CO2,upstream,CH4}$
Data unit:	tCH_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:	Where reliable and accurate national data on fugitive CH_4 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 CH_4 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

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 CH4 / PJ	72	Table 1-60, p. 1.129
Processing, transport and distribution	t CH4 / PJ	88	Table 1-60, p. 1.129
Total	t CH4 / PJ	160	
Eastern Europe and former USSR			
Production	t CH4 / PJ	393	Table 1-61, p. 1.129
Processing, transport and distribution	t CH4 / PJ	528	Table 1-61, p. 1.129
Total	t CH4 / PJ	921	
Western Europe			
Production	t CH4 / PJ	21	Table 1-62, p. 1.130
Processing, transport and distribution	t CH4 / PJ	85	Table 1-62, p. 1.130
Total	t CH4 / PJ	105	
Other oil exporting countries / Rest of world			
Production	t CH4 / PJ	68	Table 1-63 and 1-64, p. 1.130 and 1.131
Processing, transport and distribution	t CH4 / PJ	228	Table 1-63 and 1-64, p. 1.130 and 1.131
Total	t CH4 / PJ	296	

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.

Measurement procedures (if any):	-
Any comment:	-

Data / Parameter:	$EF_{CO2,upstream,LNG}$
Data unit:	tCO_2e/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 tCO2e/TJ
Measurement procedures (if any):	-
Any comment:	-

III. MONITORING METHODOLOGY

Data and Parameters Monitored

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% 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.

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:	~~TCFC~~$_{PJ,x,y}$
Data Unit	Mass or volume units of fuel
Description	Total fuel of type x consumed by the project transport units
Source of Data	MRTS operator(s)
Measurement Procedure	Based on fuelling station reports
Monitoring frequency	Continuously, aggregated at least annually
QA/QC procedures	Control with fuel invoices
Comments	Used for MRTS with buses or rail-based systems not using electricity

Data / Parameter:	$NCV_{x,y}$	
Data Unit	J/mass or volume units of fuel in year y	
Description	Net calorific value of fuel type x	
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 Procedure	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
Comments	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 as to be simpler to determine the parameter using options (c) or (d)

Data / Parameter:	$EF_{CO2,x,y}$
Data Unit	gCO_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 Procedure	For (a) and (b): measurements should be undertaken in line with national or international fuel standards.
	For (a): if fuel suppliers provide the NCV value and the CO_2 emission factor on the invoices and these two values are based on measurements for this specific fuel, this CO_2 factor should be used. If another source for the CO_2 emission factor is used or no CO_2 emission factor is provided, options (b), (c) or (d)
	Should be used

Monitoring frequency	For (a) and (b): the CO_2 emission factor 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	-
Comments	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 as to be simpler to determine the parameter using options (c) or (d)

Data / Parameter:	$SFC_{i,x,y}$
Data Unit	Mass or volume units of fuel/km
Description	Specific fuel consumption of vehicle category i using fuel x in the year y
Source of Data	MRTS operator(s) or project owner
Measurement Procedure	Based on specific studies or calculated based on total fuel consumed and total distance driven per bus size sub-category. 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. Measurement procedures must include distance driven (preferably recorded by GPS or other electronic means with a maximum error level of 5%) and the fuel consumed monitored either through appropriate equipment installed in the units or through standard measurement procedures at a calibrated fuel station
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% confidence level i.e. with 95% security confidence the actual average fuel consumption is equal to or lower than the value used by the project
Comments	This data is only required if total fuel consumption (TC) is not available. This data is only collected if the MRTS operates with buses

Data / Parameter:	$DD_{PJ,x,y}$
Data Unit	Kilometres
Description	Distance driven by project units using fuel type x in year y
Source of Data	MRTS operator(s) or system manager
Measurement Procedure	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
Comments	Used only for QA/QC in case of bus operated MRTS to control the specific fuel consumption (fuel per distance)

Data / Parameter:	$OC_{i,y}/OC_{B,y}/OC_{T,y}$
Data Unit	Passengers
Description	Average occupation rate of vehicle category i in year y. 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 Procedure	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. ~~In the case of~~ For taxis~~,~~ the driver should not be counted. The detailed procedures concerning visual occupation and boarding alighting studies are presented in Annexes 1, 2 and 3
Monitoring frequency	Studies conducted in years 1~~, and 4~~ and 4~~, 7 and, if applicable, 10~~ of the crediting period
QA/QC procedures	-
Comments	-

Data / Parameter:	$TDIZ_{i,y}$
Data Unit	Kilometres
Description	Average distance driven by taxis and cars on affected roads in year y
Source of Data	Municipal transit authorities or project owner
Measurement Procedure	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	~~Yearly~~ Once in the years 1 and 4 of the crediting period
QA/QC procedures	-
Comments	-

Data / Parameter:	$NIZ_{i,y}/NIZ_{C,y}/NIZ_{T,y}$
Data Unit	Number of vehicles
Description	Number of vehicles of vehicle category i using affected roads. In particular, C stands for cars, and T for taxis
Source of Data	Municipal transit authorities or project owner
Measurement Procedure	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	~~Yearly~~ Once in the years 1 and 4 of the crediting period
QA/QC procedures	-
Comments	-

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 Procedure	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
Comments	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:	$MS_{i,y}$
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 Procedure	Survey. The relevant question numbers are 2 and 3
Monitoring frequency	The survey is realized ~~annually~~ in the years 1 and 4 of the crediting period
QA/QC procedures	See Annex 4 for the survey design
Comments	Only used for leakage calculation of rebound effect (reduced amount of cars and taxis) if required (see condition for rebound effect calculation)

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 Procedure	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~~, 7 and, if applicable, 10~~ of the crediting period
QA/QC procedures	-
Comments	See also the table for N_i

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 Procedure	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	~~Yearly~~ Once in the years 1 and 4 of the crediting period
QA/QC procedures	-
Comments	Only passenger cars and 4-wheel taxis. See also table for V_B

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

Data / Parameter:	$TE_{EL,i,y}$
Data Unit	tCO_2
Description	Total emissions from the electricity-based rail system in ~~the~~ 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 Procedure	As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
Monitoring frequency	Annually
QA/QC procedures	-
Comments	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. 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

ANNEX 1

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

Load factor surveys based on visual occupation studies use the following procedures:

(1) Vehicle categories are defined according to the characteristics of the fleet and types of services (e.g. with or without standing passengers);

(2) Occupation categories are defined (usually five or six), for instance <50% occupied, 50-100% seats occupied, 100% seats occupied, <50% space for standing passengers occupied, 50-100% of standing space occupied, overload (>100% of legally permitted space occupied);

(3) Formats for field study are prepared;

(4) Field data collectors are trained;

(5) 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;

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

ANNEX 2

**Guideline for the establishment of load factor studies for buses based
on boarding-alighting surveys**

Load factor surveys based on boarding-alighting studies for buses use the following procedure:

(1) Routes for the survey must be selected, weighted upon the expected number of passengers per route. Only active routes are included;

(2) 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;

(3) 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;

(4) 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;

(5) The survey must be conducted during the entire operation period of buses (not only peak or off-peak hours);

(6) The units selected are clearly identified including licence plate, day monitored, number of turn-arounds, route and route distance;

(7) Data are digitized and its quality is controlled. In case of mistakes in data collection, counts should be repeated.

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.

ANNEX 3

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

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 ~~in the case of~~ for taxis. The procedures to establish visual occupation are:

(1) Locations, days and times for field study are defined, avoiding days immediately after or before a holiday. Atypical seasons (school or university vacations) should be avoided. The same days and time periods need to be chosen for the baseline as well as for the monitoring studies to ensure data comparability;

(2) 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;

(3) Occupation is the number of passengers using the vehicle. The driver is not counted ~~in the case of~~ for taxis. Taxis without passengers are counted as no (zero) occupation;

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

(5) The study is realized in different locations of the larger urban zone of the city;

(6) The same methodology is used for the load study performed prior to the project start ~~as~~ and during ~~the~~ 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.

ANNEX 4

Methodological design of survey MRTS

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

(1)   Survey objective;

(2)   Target population;

(3)   Sample frame;

(4)   Sample design;

(5)   Relative error level;

(6)   Geographical coverage;

(7)   Sample frequency;

(8)   Sample size;

(9)   Size and result of the pilot test;

(10)   Selection method of the sample;

(11)   Methodology for information collection and estimation of the parameters;

(12)   Data verification and validation including QA and QC;

(13)   Survey realization;

(14)   Calculation of a trip distance in the survey;

(15)   Default questionnaire.

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

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

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

Sample design	Two staged probabilistic design:
	• First stage: stratified – simple random sampling (SRS);
	• Second stage: systematic sampling based on passengers flow per station.
	Stratum: Stations.
	Sub stratum: Days in ~~the~~ a week and hours
Relative error level (CV)[9]	For the survey a global desired level of precision (relative standard error or coefficient of variation – CV) between 5% and 10% for the parameters of interest, which also implies ~~that~~ ~~at the same time~~ having precision levels of 90/10, is required. Results obtained are based on a 95% 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 ~~of~~ on the type of transport system ~~type~~
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% of the original sample[10]. 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 ~~annually~~ in the years 1 and 4 of the crediting period during an entire week plus one re-test ~~per annum~~ in the year 1 only
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*

The survey objective is to determine:

- 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;

- The indirect project emissions ~~of~~ 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*

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.

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[9] 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.

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

3.   Sample Frame

The siample 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

A two staged probabilistic design is applied:

- First stage: Stratified – Simple Random Sampling (SRS);

- Second stage: Systematic sampling based on passengers flow per station.

The stratification model used is represented by the following scheme, where the process for a specific day is shown, applies routinely for the seven measurement days.
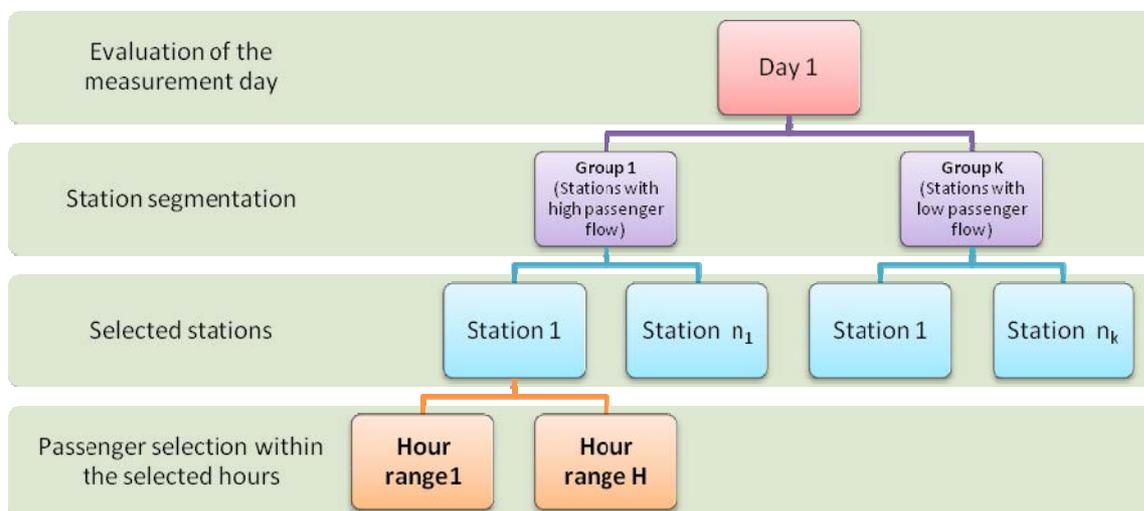
Main strata (Stations): First a cluster analysis is performed that groups the stations depending on the passenger flow per station to provide information for busier stations and less frequented stations. In practical terms three groups of stations are created: stations with a high, medium and low passenger volume. In the case of large heterogeneity of passenger flows an additional group is included to control this variability.

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

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.

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*

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

It is considered that the result of an estimate is:

- Statistically robust if its coefficient of variation is less than 5%;

- Practically acceptable if its coefficient of variation is between 5% and 10%;

- Of low precision if its coefficient of variation is higher than 10% and less than 15%;

- It is not considered as robust if its coefficient of variation is higher than 15%.

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

6. *Geographical Coverage*

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

7. *Sample Frequency*

The survey is realized minimum once annually during the year 1 and 4 of the crediting period plus an annual re-test survey realized in the year 1 only, thus achieving two samples per annum 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.

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.

The criteria for identifying if there is or not any seasonality is are the following one:

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

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

8. *Sample Size*

For the calculation of the sample size, a global level of precision (relative standard error or coefficient of variation – CV) between 5% and 10% 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% and a maximum precision level of 10%.

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

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

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

The stratification structure complies with the principles of independence and invariance, reason for which in the formula for the CV of 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).

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

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

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.

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.

Design Effect (Deff)

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

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

Simulation of Sample Size with Deff 1.5

Simulation of sample size: CV Vs. Proportion - Deff 1.5
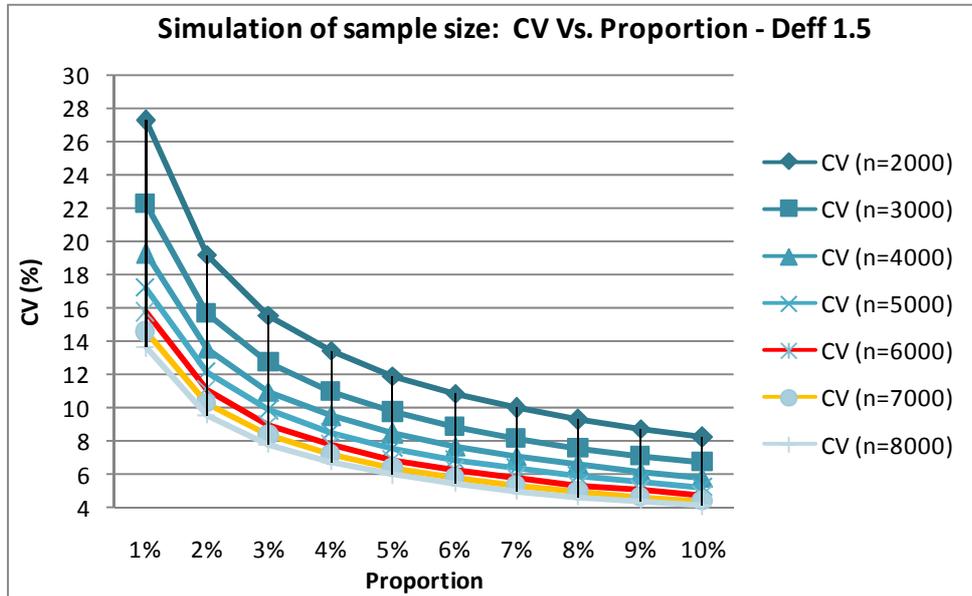
Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	27.2	22.2	19.3	17.2	15.7	14.5	13.6
2%	19.2	15.6	13.5	12.1	11.1	10.2	9.6
3%	15.6	12.7	11.0	9.8	9.0	8.3	7.8
4%	13.4	10.9	9.5	8.5	7.7	7.2	6.7
5%	11.9	9.7	8.4	7.5	6.9	6.4	6.0
6%	10.8	8.8	7.7	6.8	6.3	5.8	5.4
7%	10.0	8.1	7.1	6.3	5.8	5.3	5.0
8%	9.3	7.6	6.6	5.9	5.4	5.0	4.6
9%	8.7	7.1	6.2	5.5	5.0	4.6	4.3
10%	8.2	6.7	5.8	5.2	4.7	4.4	4.1

Simulation of Sample Size with Deff 2.0

Simulation of sample size: CV Vs. Proportion - Deff 2

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

Simulation of Sample Size with Deff 2.5

Simulation of sample size: CV Vs. Proportion - Deff 2.5
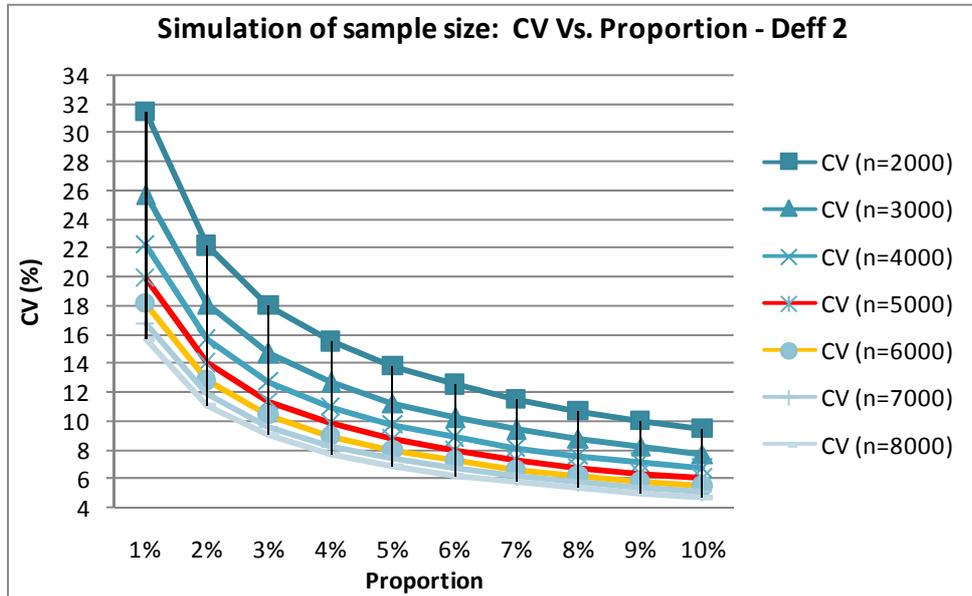
Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	35.2	28.7	24.9	22.2	20.3	18.8	17.6
2%	24.7	20.2	17.5	15.6	14.3	13.2	12.4
3%	20.1	16.4	14.2	12.7	11.6	10.7	10.0
4%	17.3	14.1	12.2	10.9	10.0	9.2	8.6
5%	15.4	12.6	10.9	9.7	8.9	8.2	7.7
6%	14.0	11.4	9.9	8.8	8.1	7.5	7.0
7%	12.9	10.5	9.1	8.1	7.4	6.9	6.4
8%	12.0	9.8	8.5	7.6	6.9	6.4	6.0
9%	11.2	9.2	7.9	7.1	6.5	6.0	5.6
10%	10.6	8.7	7.5	6.7	6.1	5.7	5.3

Simulation of Sample Size with Deff 3.0

Simulation of sample size: CV Vs. Proportion - Deff 3

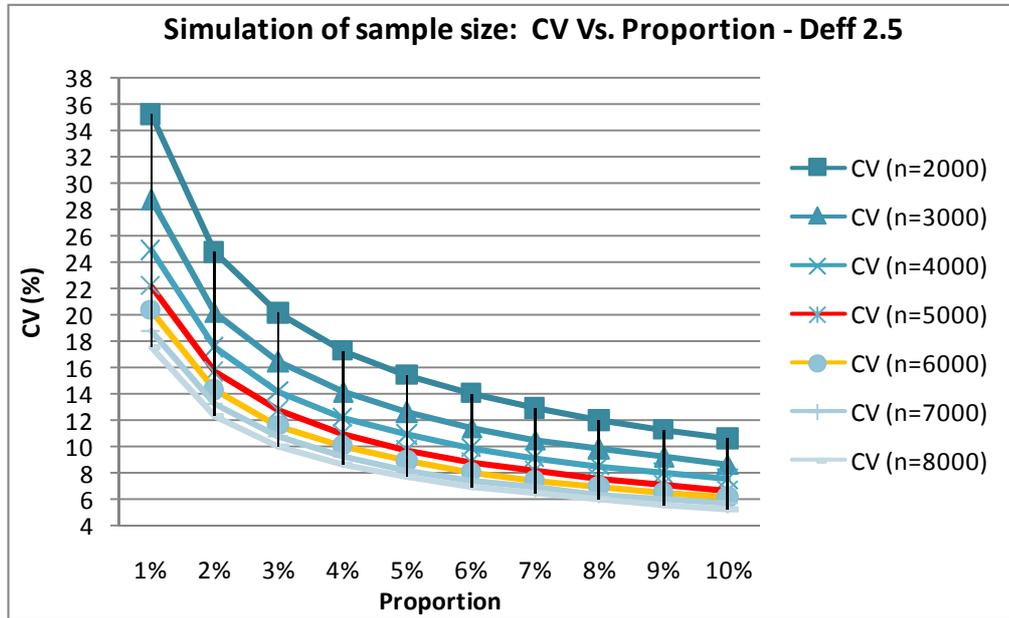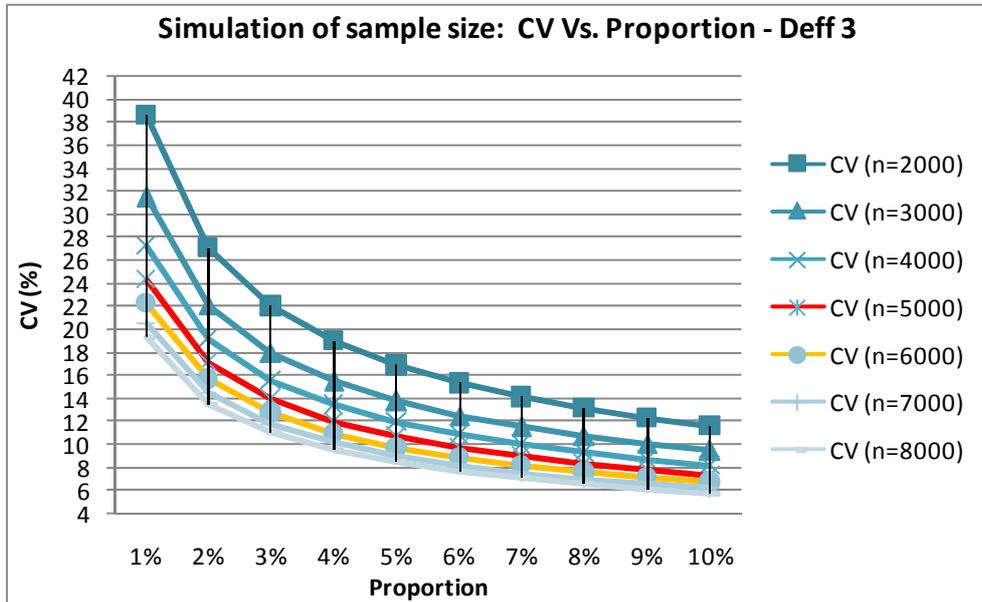| Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	38.5	31.4	27.2	24.4	22.2	20.6	19.2
2%	27.1	22.1	19.2	17.1	15.6	14.5	13.5
3%	22.0	18.0	15.6	13.9	12.7	11.8	11.0
4%	19.0	15.5	13.4	12.0	10.9	10.1	9.5
5%	16.9	13.8	11.9	10.7	**9.7**	9.0	8.4
6%	15.3	12.5	10.8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

Simulation of Sample Size with Deff 3.5
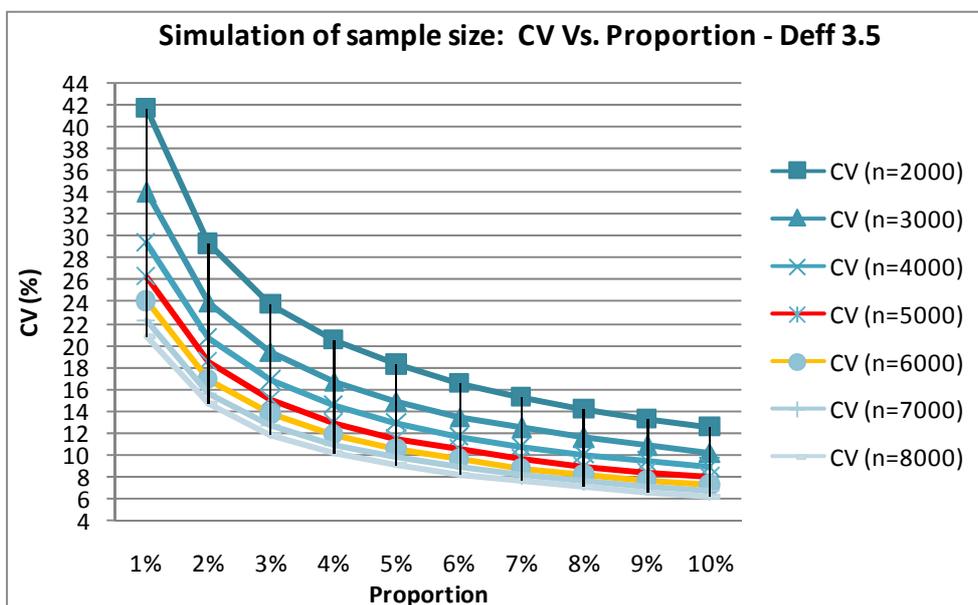
Proportion	CV (n=2000)	CV (n=3000)	CV (n=4000)	CV (n=5000)	CV (n=6000)	CV (n=7000)	CV (n=8000)
1%	41.6	34.0	29.4	26.3	24.0	22.2	20.8
2%	29.3	23.9	20.7	18.5	16.9	15.6	14.6
3%	23.8	19.4	16.8	15.0	13.7	12.7	11.9
4%	20.5	16.7	14.5	13.0	11.8	10.9	10.2
5%	18.2	14.9	12.9	11.5	10.5	**9.7**	9.1
6%	16.6	13.5	11.7	10.5	9.6	8.8	8.3
7%	15.2	12.4	10.8	9.6	8.8	8.1	7.6
8%	14.2	11.6	10.0	9.0	8.2	7.6	7.1
9%	13.3	10.9	9.4	8.4	7.7	7.1	6.6
10%	12.5	10.2	8.9	7.9	7.2	6.7	6.3

9. *Size and Result of Pilot Test*

The data obtained ~~of~~ 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*

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.

(a)   Selection of stations and evaluation hours

Given that there is a complete list of stations that are part of each established group (stratum), the selection of stations is carried out according to a SRS design, through the negative coordinated algorithm.

The same happens for the defined hour ranges: within each range a specific hour is selected under this method for the sample selection.

Algorithm of the Negative Coordinated Method

N: Universe size

n: Sample size to be selected.

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

- If $\xi_k < \pi$ then k belongs to the sample;

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

In this way the probabilities of being part of the sample of the first and second order are:

$$\pi_k = \pi, \pi_{kl} = \pi^2$$

Since the expectation of the 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.

(b)   Selection of Passengers

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

(i)   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;

(ii)   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*

(a)   General considerations on information collection

The information will be obtained through the face-to-face application of the established questionnaire.

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

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

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.

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.

For socio economic levels the ranges recommended are 5 different ranges of minimum salary. This needs to be adapted to the country circumstances so that a representative stratification is reached.

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.

(b)   Method of estimation and expansion factors

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:

(1)   Selection of stations (SRS design);

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

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

First stage:

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

π_{Ii}: Probability of inclusion in the sample in the first stage (1).

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

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

sp: stations of the system

Second stage:

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

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

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

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

The general formula to calculate the expansion factor is:

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

Thus the expansion factors are:

First stage:

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

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

Second stage:

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

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

Estimator of the total for the variable of interest[11]:

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

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

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[11] 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).

Where:

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

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

Estimator of the variance:

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

Where:

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

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.

Estimator for the variable of interest:

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

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

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

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

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 ty and tz represent the estimators associated to the total of the two variables.

Variance Estimator:

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

Where:

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

Thus it is established that:

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

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

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

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

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

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

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% confidence intervals.

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

- Number of stations;

- Passenger flow per station per hour, day and week;

- Selection rate of passengers surveyed per hour per station (i.e. each n passenger was selected for an interview).

  Based on this information the total baseline and the total indirect project emissions for the MRTS for the survey week can be calculated with a confidence interval of 95%. For the total baseline emissions the lower 95% boundary is taken and for the indirect project emissions the upper 95% boundary to have a

conservative calculation of emission reductions. For total annual or period baseline (indirect project) emissions the baseline (indirect project) emission per passenger of the survey week is calculated and thereafter multiplied with the total passengers transported by the MRTS per annum or period.

12. Data verification and validation including QA and QC

(a)   Criteria for evaluating data consistency

Considering that in each one of 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, the weekly measurement and the test-retest, through these the consistency on information collection is to be guaranteed.

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

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

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

(ii)   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;

(iii)   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.

    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.

    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 heteroegenity and inconsistency in information.

    With the goal of evaluating the possible correlation between BE and IPE a hypothesis test based on the Pearson or Spearman coefficient is 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.

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

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

    If the correlation is significant complex estimators and alternative methods of variance need to be used which do not guarantee however that the estimators are unbiased and

have a minimal variance. On the other hand if the correlation is non-significant the estimation of the two parameters BE and IPE separately leads to the same result as calculating them jointly.

Realizing the estimation of BE and IPE guarantees that even in the case of correlation 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).

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*

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:

- Non-responses should be recorded;

- Record and store all original surveys;

- 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.

(a)   Preparation phase

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

(1)   Drafting of the manual on information collection and basic concepts. The manual on information collection and basic concepts covers in general terms the profile of the field personnel, the questionnaire structure, the instructions and specifications for filling in the questionnaire, the definitions and basic concepts of the study and the instructions and formats used;

(2)   Selection and training of field personnel. The selection and training of the field personnel is performed on concepts of filling in of questionnaires, in order to select the most adequate survey interviewers for the development of the field work.

A pre-test is performed with the aim of familiarizing the supervisors with the instrument of information collection and establishing in general terms the acceptance degree of the population facing the instrument's application. The pre-test is also to assure that respondents understand what 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.

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.

(b)   Validation process of the information

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

14.   Calculation of trip distance in the survey

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

- For NMT, others and induced traffic this is not required as the applied EF is "0";

- For users of buses either:

    o   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

    o   Measuring the actual distance from the bus entry station to the bus exit station based on (electronic) route maps of the bus operators with official distances or measuring e.g. with GPS the distances between the involved stations.

- For users of passenger cars, taxis, motorcycles, motorized rickshaws and other modes of motorized transport except buses based on the shortest possible geographical distance based on electronic maps or measuring the distance between the two points with GPS or a comparable mean or through distance measurement on maps;

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

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

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

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

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SECTION C: Trip Data of Interviewed Person

Question 1

"Describe the trip you are currently realizing"

1.1. Your trip origin (starting trip point, e.g. my home):……………………………
1.2. Your entry (boarding) station MRTS lane (name or code of MRTS station):……………………
1.3. Your exit (deboarding) station MRTS lane (name or code of MRTS station):……………………
1.4. 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/Others[12] (……… …..) to point…………… by *……………….

From point………………to point ………………by *………………..

From point………………to point ………………by *………………..

From point…………….to home/office/others[13] (……………..) by *………………..

*can be

☐ 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

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[12] Origin of trip.
[13] Final destination.

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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History of the document

Version	Date	Nature of revision(s)
03.0.0	EB 65, Annex # 25 November 2011	- Introduces a new approach to additionality demonstration; - Reduces monitoring requirements set in the MRTS passenger survey from annual monitoring to monitoring in the years 1 and 4 of the crediting period; - Removes an applicability condition requiring demonstration that the project system partially replaces a traditional public transport system in the city hosting the proposed project activity. - Removes 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; - Reduces 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 - Removes the requirement to conduct a sensitivity analysis of data and parameters used to determine baseline, project and leakage emissions; - Introduces a reference to the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" to determine direct project emissions - Introduces the requirement to account for leakage due to upstream emissions in case project vehicles consume more gaseous fuels than baseline vehicles;

		• Improves language, readability and consistency.
02	EB 55, Annex 14 30 July 2010	• Introduces the definition of larger urban zone (LUZ) of a city; • Accommodates situations, for the common practice analysis, where the city has less than 1 million inhabitants in its LUZ.
01	EB 50, Annex 2 16 October 2009	Initial adoption.
Decision Class: Regulatory **Document Type**: Standard **Business Function**: Methodology		