CLEAN DEVELOPMENT MECHANISM

**CDM-MP78-A07**

# Draft Small-scale Methodology

# AMS-III.xx.: Efficient operation of public transportation

Version 03.0

Sectoral scope(s): 07



United Nations
Framework Convention on
Climate Change

# COVER NOTE

## 1. Procedural background

1. The Executive Board of the clean development mechanism (CDM) (hereinafter referred to as the Board), at its 101st meeting (EB 101 report, paragraph 38), while considering the draft new methodology "AMS.III.xx: Efficient Operation of Public Transportation", decided to further revise the methodology to include simplified methods to reflect the secondary effects on the baseline during the crediting period, taking into account the suitability and adequacy of related parameters that are monitored (e.g. whether total vehicle-kilometres travelled by buses in year *y* is an appropriate indicator or an alternative, less onerous parameter could be proposed).

## 2. Purpose

2. The purpose is to address the concerns expressed by the Board at EB 101, as outlined above.

## 3. Key issues and proposed solutions

3. In the methodology draft considered at EB 101, baseline emissions were adjusted by a Baseline Adjustment Factor parameter ($BAF_y$), representing changes observed during the crediting period not related to the project and that would affect the baseline (such as replacing the fleet of buses by more efficient vehicles, introducing new electric buses, increased congestion along the route).

4. To address issues highlighted in paragraph 1 above, the Methodology Panel (MP) revised the calculation of emission reductions based on an Emission Reduction Factor ($ERF_k$) that represents a likely relative fuel consumption saving from the measure(s) that is(are) implemented under the project activity. This parameter can be either determined by comparing the energy consumed per passenger-kilometer in the baseline ($SEC_{PKM,k-BL}$) with that in the project route ($SEC_{PKM,k}$) or sourced from published literature, official reports or statistics published by independent third parties or studies carried out by project proponents (including transportation modelling) and validated by designated operational entities:

   (a) $SEC_{PKM,k-BL}$ may be determined either using historical data, or through a baseline campaign where it can be demonstrated that one full year of historical data is not available;

   (b) $SEC_{PKM,k}$ may be determined either using data monitored during the first year of the crediting period[1] , or using data measured through a project campaign if one

[1] A one year period is sufficient to absorb the increase in the passenger demand that resulted from the implementation of the project activity.

full year of data is not available because of concomitant replacement of the existing bus fleet with more efficient or higher capacity vehicles. This requirement prevents that other measures not included by the methodology affect the calculation of emission reductions[2].

## 4. Impacts

5. The proposed new methodology will broaden the portfolio of methodological standards in the area of passenger transportation.

## 5. Subsequent work and timelines

6. The methodology is recommended by the MP for consideration by the Board at its 102nd meeting. No further work is envisaged.

## 6. Recommendations to the Board

7. The MP recommends that the Board adopt this draft methodology, to be made effective at the time of the Board's approval.

[2] The replacement of fleet by more efficient or higher capacity vehicles reduces the value of $SEC_{PKM,k}$, which results in an increase in the emission reduction factor ($ERF_k$). Consequently, the final emission reductions calculation will also increase.

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# 1. Introduction

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

**Table 1. Methodology key elements**

| | |
|---|---|
| **Typical projects** | Implementation of measures to improve the operation of buses used for public transportation such as ITS (Intelligent Transportation Systems) and changes/improvements in bus routes, without reducing the level of service |
| **Type of GHG emissions mitigation action** | Energy efficiency:<br>Reduction in the consumption of fossil fuels per passenger transported |

# 2. Scope, applicability, and entry into force

## 2.1. Scope

2. This methodology applies to project activities that implement measures that improve the efficiency of operation of public transportation by buses, such as use of Intelligent Transportation System (ITS) measures and/or improve bus routes (e.g., re-design of routes, implementation of priority bus lanes that are not part of a Bus Rapid Transit (BRT) system, use of high quality pavement, construction of viaducts/tunnels, express service connecting only high demand stops during peak hours). The project activity results in emission reductions due to more efficient operation of the buses which may also improve the ridership of buses.



## 2.2. Applicability

3. The methodology is applicable forto ~~project activities that improve the operation of public transportation by buses by~~ implementing one or more of the following measures (stand-alone or in combination) to one or more existing bus routes:

   (a) Implementation of ITS measures to improve the operation of buses;

   (b) Changes/improvements in bus routes that allow for a more efficient journey between the origin and final destination. The interventions can be:

      (i) Re-design of bus routes;

      (ii) Construction of viaducts, tunnels or other improvements for the purpose of improving the infra-structure of dedicated bus lanes that are not part of a BRT system, eliminating traffic lights or roundabouts and improving the traffic flow of buses;

      (iii) Implementation of priority bus lanes that are not part of a BRT system;

      (iv) Implementation of an express service connecting high demand stops by reducing the number of intermediate stops during peak hours;

(v) Implementation of a bus queue jump lane;

(vi) Rehabilitation of the pavement of the existing dedicated bus routes/lanes with high-quality pavement.

4. The project activity shall not reduce the number of passengers travelling on the affected bus route(s), as compared to the baseline. The number of passengers that are travelling during the crediting period are monitored and used for the purpose.

5. Under this methodology the Emission Reduction Factor for the route *k* ($ERF_k$) is a key parameter that needs to be estimated as per equation 2. This methodology is applicable, where the data can be collected for the same cohort of buses from which $ERF_k$ was calculated, to determine the specific energy consumed per passenger-kilometer in the baseline route *k-BL* ($SEC_{PKM,k-BL}$) and the specific energy consumed per passenger-kilometer in the project route *k* ($SEC_{PKM,k}$).

6. Under this methodology, measures which impact the occupancy of buses that are different from the measures included in the project activity shall not be implemented before the parameter $SEC_{PMK,k}$ is determined.

7. During the crediting period, buses may be replaced by more efficient buses or by buses with a higher capacity, and the methodology assumes that this change would also happen in the baseline scenario.

8. The methodology is not applicable to project activities implementing a new BRT or expanding an existing BRT by creating new lanes.



~~9. The project activity shall not reduce the number of passengers travelling on the affected bus route(s), as compared to the baseline. The number of passengers that are travelling during the crediting period are monitored and used for the purpose.~~

10. The applicability conditions included in the tools referred to below shall also apply.

11. The methodology is not applicable to buses operating on BRTs.

12. Measures are limited to those that result in emission reductions of less than or equal to 60 kt $CO_2$ annually.

## 2.1. Entry into force

13. The date of entry into force is the date of the publication of the EB XX meeting report on DD Month YYYY.

### 2.2. Applicability of sectoral scopes

14. For validation and verification of CDM projects and programme of activities by a designated operational entity (DOE) using this methodology, application of sectoral scope 07 is mandatory.

## 3. Normative references

15. The methodology also refers to the latest approved version of the following methodological tools, standards and guidelines:

    (a) "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation";

    (b) "TOOL07: Tool to calculate the emission factor for an electricity system";

    (c) "TOOL11: Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period";

    (d) "TOOL21: Demonstration of additionality of small-scale project activities";

    (e) "Standard: Sampling and surveys for CDM project activities and programme of activities";

    (f) "Guideline: Sampling and surveys for CDM project activities and programmes of activities".



16. For more information regarding the approved methodologies and the tools as well as their consideration by the Executive Board (hereinafter referred to as the Board) of the clean development mechanism (CDM) please refer to <http://cdm.unfccc.int/goto/MPappmeth>.

## 4. Definitions

17. The definitions contained in the Glossary of CDM terms shall apply.

18. For the purpose of this methodology the following definitions apply:

    (a) **Baseline route -** the route driven by buses before the implementation of the project. For project activities that involve the re-design of bus routes, the baseline route is the former bus route that was replaced by the project route. For project activities that implement other measures, the baseline route is the project route itself before the implementation of the measures;

    (b) **Bus rapid transit (BRT) system -** is a bus-based urban or sub-urban passenger transit service system that uses dedicated bus lanes as trunk routes with busways and stations- often aligned to the center of the road-, off-board fare collection, and operates at high levels of performance, especially with regard to travel times and passenger carrying capacity;

    (c) **High-quality pavement -** a pavement with a minimum thirty-year life span that can be of asphalt, jointed plain concrete pavement (JPCP) or continuously reinforced concrete pavement (CRCP);

(d) **Intelligent Transportation System (ITS) -** ITS is an operational system of technologies that, when combined and managed, improve the operating capabilities of the overall system (e.g. sensors installed in buses and in roads that detect buses approaching a crossroad and gives a traffic light priority for the buses);

(e) **Priority lane for buses -** lanes implemented on roads for the dedicated use of buses. These lanes can operate through the day or during peak-hours only. Differently from a BRT, these lanes do not serve as trunk routes;

(f) **Project route -** the route driven by buses after the implementation of the project. Depending on the type of measure implemented, the project route may be longer than, equal to or shorter than the baseline route;

(g) **Queue jump lane -** reserved bus lanes located at intersections with a dedicated traffic light that allow buses to move before other vehicles, avoiding long queues;

(h) **Viaduct** – a bridge that carries a road over another road or railway, in order to reduce disturbances to vehicle flow.

# 5. Baseline methodology

## 5.1. Project boundary

19. The project boundary includes the routes in which measures are implemented.

20. $CO_2$ emissions from the buses (fossil fuel and/or electric) that operate in the baseline and project routes are included. $N_2O$ and $CH_4$ emissions are excluded from the project boundary as the amount of these emissions is considered not significant.



## 5.2. Baseline scenario

21. The baseline scenario is assumed to be the continued operation of the buses in the baseline route(s) without the implementation of the project activity.

## 5.3. Demonstration of additionality

22. The project activity is additional if it is demonstrated, through the application of "TOOL21: Demonstration of additionality of small-scale project activities", that at least one barrier would prevent the implementation of the project.

## 5.4. ~~Baseline~~ Emission~~s~~ Reductions

~~23. Baseline emissions are calculated as the amount of CO2 emitted per passenger-kilometre transported in the absence of the measures (tCO2/pkm) in each baseline route k-BL included in the project boundary, following the equation below:~~

$$BE_y = \sum_k BAF_{k,y} \times P_{k,y} \times AVD_{k,y} \times EF_{CO2,PKM,k-BL}$$

~~Equation (1)~~

Where:

| | | |
|---|---|---|
| $BE_y$ | = | Baseline emissions in year *y* ($tCO_2$) |
| $BAF_{k,y}$ | = | Baseline adjustment factor for route *k* in year y (fraction) |
| $P_{k,y}$ | = | Total passengers transported by the buses in the project route *k* in year *y* (passengers) |
| $AVD_{k,y}$ | = | Average distance travelled by the passengers in the project route *k* in year *y* (km). If the project route *k* is longer than the baseline route, this parameter is capped as the length of the baseline route |
| $EF_{CO2,PKM,k-BL}$ | = | $CO_2$ emission factor per passenger-kilometre from the baseline route *k-BL* ($tCO_2$/pkm) |

$$BAF_{k,y} = \frac{EF_{CO2,VKM,k,y}}{EF_{CO2,VKM,k,1}}$$ Equation (2)

Where:

| | | |
|---|---|---|
| $EF_{CO2,VKM,k,y}$ | = | $CO_2$ emission factor per vehicle-kilometre in project route *k* in year *y* of the crediting period ($tCO_2$/vkm), calculated using equation 6 |
| $EF_{CO2,VKM,k,1}$ | = | $CO_2$ emission factor per vehicle-kilometre in project route *k* observed for year 1 of the crediting period ($tCO_2$/vkm), calculated using equation 6 |

24. The parameter $EF_{CO2,PKM,k-BL}$ can be determined either using historical data or through a baseline campaign. In both options, if fuel switching takes place during the crediting period, the baseline emission factor shall be adjusted based on the fuel used in the project situation.



25. Emission reductions are determined by summing the emission reductions in each project route *k* included in the project boundary, calculated by multiplying the number of passengers- travelling in the project route *k*, the average distance travelled by passengers in the project route *k*, a $CO_2$ emission factor in the project scenario and an emission reduction factor from the specific measure(s) that is(are) implemented under the project activity, as indicated in the equation below.

$$ER_y = \sum_k P_{k,y} \times AVD_{k,y} \times EF_{CO2,PKM,k,y} \times ERF_k$$ Equation (1)

Where:

| | | |
|---|---|---|
| $ER_y$ | = | Emission reductions in year *y* ($tCO_2$) |
| $P_{k,y}$ | = | Total passengers transported by the buses in the project route *k* in year *y* (passengers) |
| $AVD_{k,y}$ | = | Average distance travelled by the passengers in the project route *k* in year *y* (km) |
| $EF_{CO2,PKM,k,y}$ | = | $CO_2$ emission factor per passenger-kilometre of the project route *k* ($tCO_2$/pkm) |
| $ERF_k$ | = | Emission reduction factor of the project route *k* (fraction) |

### 5.4.1. Determination of $ERF_k$

26. $ERF_k$ captures the savings in the fuel consumed in each route *k* as a result of the specific measure(s) that is(are) implemented under the project activity relative to the baseline. It is determined by comparing the energy consumed per passenger-kilometer, in the baseline route *k-BL* ($SEC_{PKM,k-BL}$) with that in the project route *k* ($SEC_{PKM,k}$), as indicated in the equation below[3]:

$$ERF_k = \frac{SEC_{PKM,k-BL}}{SEC_{PKM,k}} - 1 \quad \text{Equation (2)}$$

Where:

| | | |
|---|---|---|
| $SEC_{PKM,k-BL}$ | = | Specific energy consumed per passenger-kilometre from the baseline route *k-BL* that is replaced by the project route *k* (GJ/pkm), determined as per section 5.4.2 below. |
| $SEC_{PKM,k}$ | = | Specific energy consumed per passenger-kilometre from the project route *k* (GJ/pkm), determined as per section 5.4.3 below. |

27. An alternative option to calculate the parameter $ERF_k$ is based on the relative fuel consumption savings sourced from published literature, official reports or statistics published by independent third party or studies carried out by project proponents and validated by designated operational entities (including transportation modelling). Under this alternative, the parameter $ERF_k$ is determined based on the equation below:



$$ERF_k = \frac{F_k}{1 - F_k} \quad \text{Equation (3)}$$

| | | |
|---|---|---|
| $F_k$ | = | Relative fuel consumption savings (fraction) of the route *k* between the baseline and the specific measure that is implemented under the project activity |

### 5.4.2. Determination of $SEC_{PKM,k-BL}$

28. The parameter $SEC_{PKM,k-BL}$ may be determined either using historical data or through a baseline campaign using the options as described below:~~.~~

#### 5.4.2.1. Option 1: Historical Data

29. Under this option, the ~~emission factor~~ specific energy consumption is calculated using the most recent three years of historical data[4] based on the number of passenger-kilometres transported on each baseline route *k-BL*, type and quantity of fossil fuels consumed by the buses travelling in each baseline route *k-BL,* and quantity of electricity consumed by the buses travelling on the baseline route *k*-BL ~~and CO2 emission factor of the electric grid~~.

[3] The methodology conservatively assumes that new passengers would have travelled by bus in the baseline scenario.

[4] A minimum of one year of data may be used if three years of operational data are not available.

$$SEC_{PKM,k-BL} = \frac{\sum_i \left(FC_{i,k-BL} \times NCV_i \times EF_{CO2,t}\right) + \frac{EC_{k-BL} \times EF_{grid,CO2} \times 3.6}{\left(1 - TDL_{grid,BL}\right)}}{PKM_{k-BL}}$$ Equation (4)

Where:

| | | |
|---|---|---|
| $EF_{CO2,PKM,k-BL}$ | = | $CO_2$ emission factor per passenger-kilometre from the baseline route *k-BL* that is replaced by the project route *k* ($tCO_2$/pkm) |
| $SEC_{PKM,k-BL}$ | = | Specific energy consumed per passenger-kilometer from the baseline route *k*-BL that is replaced by the project route k (GJ/pkm) |
| $FC_{i,k-BL}$ | = | Total amount of fossil fuel type *i* consumed by the buses driving in the baseline route *k-BL* in the three years4 prior to the start date of the project activity (mass or volume units) |
| $NCV_i$ | = | Net calorific value of the fuel type *i* (GJ/mass or volume units) |
| $EF_{CO2,t}$ | = | $CO_2$ emission factor of the fuel type *i* ($tCO_2$/GJ) |
| $PKM_{k-BL}$ | = | Total passenger-kilometres transported in the baseline route *k-BL* by both electric and fossil-fuel buses in the three years 4 prior to the start date of the project activity (passenger-kilometres) |
| $EC_{k-BL}$ | = | Total electricity consumed by electric buses driving on the baseline route *k-BL* in the three years4 prior to the start date of the project activity (MWh) |
| $EF_{grid,CO2}$ | = | $CO_2$ emission factor of the electric grid that supplies electricity to the electric bus *m* ($tCO_2$/MWh) |
| $TDL_{grid,BL}$ | = | Average technical transmission and distribution losses for providing electricity to grid in the baseline (%) |



### 5.4.2.2. Option 2: Baseline Campaign

30. This option shall be used only where it can be demonstrated that one full year of historical data is not available.

31. Under this option, the specific energy consumed~~CO2 emission factor~~ per passenger-kilometre for the baseline route *k-BL* is calculated using Equation 4 ~~2~~ above, where the parameters $PKM_{k-BL}$, $FC_{i,k-BL}$ and $EC_{m,k-BL}$ are determined through a sampling~~survey~~ following the latest version of the "Standard: Sampling and surveys for CDM project activities and programme of activities" and the "Guideline: Sampling and surveys for CDM project activities and programmes of activities".

32. The baseline campaign shall be conducted through an entire week that corresponds neither to a public holiday nor school vacations, and shall be representative of the typical demand for transport services, and the fuel consumption of the baseline route *k-BL* in the considered year[5].

[5] E.g., by taking into account road and weather conditions, traffic, as well as variations in occupancy and trip distances etc. related to e.g. school year, vacation period, weekends.

## 5.5. Project Emissions

33. Project emissions are the sum of the emissions from each project route k included in the project activity,and the emissions in each route *k* is calculated based on the amount of fuel and electricity consumed by the buses travelling in the route, as indicated in the equation below:

$$PE_y = \sum_k PE_{k,y}$$ Equation (0)

Where:

$PE_y$ = Project emissions in year *y* ($tCO_2$)

$PE_{k,y}$ = Project emissions in project route *k* in year *y* ($tCO_2$)

34. The emissions in each project route k is determined based on the equation below:

$$PE_{k,y} = \sum_i \left(FC_{i,k,y} \times NCV_i \times EF_{CO2,i}\right) + \frac{EC_{k,y} \times EF_{grid,CO2}}{1 - TDL_{grid,y}}$$ Equation (0)

Where:

$FC_{i,k,y}$ = Total amount of fossil fuel type *i* consumed by the buses driving in project route *k* in year *y* (mass or volume units/year)

$NCV_i$ = Net calorific value of fuel type *i* (GJ/mass or volume units)

$EF_{CO2,i}$ = $CO_2$ emission factor of fuel type *i* ($tCO_2$/GJ)

$EC_{m,k,y}$ = Total electricity consumed by all electric buses driving on project route *k* in year *y* (MWh/year)

$EF_{grid,CO2}$ = $CO_2$ emission factor of the electric grid that supplies electricity to electric buses ($tCO_2$/MWh)

$TDL_{grid,y}$ = Average technical transmission and distribution losses for providing electricity to grid in year *y* (%)

35. Parameter $EF_{CO2,VKM,k,1}$ required to determine the baseline adjustment factor in equation 2, is calculated for each project route, k every year, by applying the equation below.

$$EF_{CO2,VKM,k,y} = \frac{PE_{k,y}}{VKM_{k,y}}$$ Equation (0)

Where:

$PE_{k,y}$ = Project emissions in the project route *k* in year *y* ($tCO_2e$), determined based on equation 5

$EF_{CO2,VKM,k,y}$ = $CO_2$ emission factor per vehicle-kilometre in project route *k* in year *y* ($tCO_2$/vkm)

$VKM_{k,y}$ = Total vehicle-kilometres travelled by buses in project route *k* in year *y* (vkm)

~~36. Parameter $EF_{CO2,VKM,k,1}$, required to determine the baseline adjustment factor in equation 2, is determined by applying equation 6 for year 1 only.~~

### ~~5.5.1. Leakage~~

~~37. No leakage needs to be accounted.~~

### 5.5.2. Determination of $SEC_{PKM,k}$

38. The parameter $SEC_{PKM,k}$ may be determined either using data measured through a project campaign or data monitored during the first year of the crediting period[6] using the options as described below:

#### 5.5.2.1. Option 1: Data monitored during the first year of the crediting period

39. Under this option, the parameter $SEC_{PKM,k}$ is determined using monitored data during the first year of the crediting period, covering the number of passenger transported on project route *k*, the average distance travelled by passengers in the project route *k*, type and quantity of fossil fuels consumed by the buses travelling in project route *k* and quantity of electricity consumed by buses travelling on the route *k*.

$$SEC_{PKM,k} = \frac{\sum_i \left(FC_{i,k,1} \times NCV_i\right) + \frac{EC_{k,1} \times 3.6}{\left(1 - TDL_{grid,1}\right)}}{P_{k,1} \times AVD_{k,1}} \qquad \text{Equation (5)}$$



Where:

| | | |
|---|---|---|
| $FC_{i,k,1}$ | = | Total amount of fossil fuel type *i* consumed by the buses driving in the project route *k* during the first year of the crediting period (mass or volume units) |
| $NCV_i$ | = | Net calorific value of the fuel type *i* (GJ/mass or volume units) |
| $P_{k,1}$ | = | Total passenger transported in the project route *k* by both electric and fossil-fuel buses during the first year of the crediting period (passenger) |
| $AVD_{k,1}$ | = | Average distance travelled by passengers in project route-*k* during the first year of the crediting period (km) |
| $EC_{k,1}$ | = | Total electricity consumed by electric buses driving on the project route *k* during the first year of the crediting period (MWh) |
| $TDL_{grid,1}$ | = | Average technical transmission and distribution losses for providing electricity to grid ~~in the baseline~~ during the first year of the crediting period (%) |

[6] A one year period is sufficient to absorb the increase in the passenger demand resulted from the implementation of the project activity.

#### 5.5.2.2. Option 2: Project Campaign

40. This option shall be used only if one full year of relevant project data is not available because of concomitant replacement of the existing bus fleet with more efficient or higher capacity vehicles[7].

41. Under this option, the specific energy consumed per passenger-kilometre for the baseline route *k* is calculated using Equation 5 above, where the parameters $P_{k,1}$, $AVD_{k,1}$, $FC_{i,k,1}$ and $EC_{m,k,1}$ are determined through a project campaign that shall be conducted through an entire week that corresponds neither to a public holiday nor school vacations, and shall be representative of the typical demand for transport services, and the fuel consumption of the project route *k* during the first year of the crediting period[5].

### 5.5.3. Determination of $EF_{CO2,PKM,k,y}$

42. The parameter $EF_{CO2,PKM,k,y}$ is determined for every year of the crediting period, using monitored data of the number of passengers transported on each project route *k*, type and quantity of fossil fuels consumed by the buses travelling in each project route *k,* and quantity of electricity consumed by the buses travelling on the project route *k*, and survey results of average distance travelled by passengers (conducted in years 1 and 4 of the crediting period).

$$EF_{CO2,PKM,k,y} = \frac{\sum_i \left(FC_{i,k,y} \times NCV_i \times EF_{CO2,i}\right) + \frac{EC_{k,y} \times EF_{grid,CO2}}{\left(1 - TDL_{grid,y}\right)}}{P_{k,y} \times AVD_{k,y}}$$ Equation (6)

Where:

| | | |
|---|---|---|
| $FC_{i,k,y}$ | = | Total amount of fossil fuel type *i* consumed by the buses driving in the project route *k* in year *y* (mass or volume units) |
| $NCV_i$ | = | Net calorific value of the fuel type *i* (GJ/mass or volume units) |
| $P_{k,y}$ | = | Total passenger transported in the project route *k* by both electric and fossil-fuel buses in year *y* (passenger) |
| $AVD_{k,y}$ | = | Average distance travelled by the passengers in the project route *k* in year *y* (km). Determined through surveys conducted in years 1 and 4 of the crediting period |
| $EC_{k,y}$ | = | Total electricity consumed by electric buses driving on the project route *k* in year *y* (MWh) |
| $TDL_{grid,y}$ | = | Average technical transmission and distribution losses for providing electricity to grid in the baseline in year y (%) |

[7] This requirement prevents that other measures not included by the methodology affect the calculation of emission reductions (e.g. the replacement of fleet by more efficient or higher capacity vehicles reduces the value of $SEC_{PKM,k}$, which results in an increase in the $ERF_k$ and, consequently, in an increase in the final calculation of emission reductions).

$ER_y = BE_y - PE_y$ Equation (7)

Where:

$ER_y$ = Emission reductions in year *y* ($tCO_2$)

## 5.6. Changes required for methodology implementation in 2nd and 3rd crediting periods

43. Project participants shall apply the latest approved version of "TOOL11: Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period".

## 5.7. Data and parameters not monitored

44. In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

**Data / Parameter table 1.**

| **Data / Parameter:** | $F_k$ |
|---|---|
| Data unit: | Fraction |
| Description: | Relative fuel consumption savings (fraction) the route *k* between the baseline and the specific measure(s) that is(are) implemented under the project activity |
| Source of data: | Published literature, official reports or statistics published by independent third party or studies carried out by project proponents (including transportation modelling) and validated by designated operational entities |
| Measurement procedures (if any): | N/A |
| Any comment: | This factor shall remain fixed for the entire project lifetime. |

**Data / Parameter table 2.**

| **Data / Parameter:** | $FC_{i,k\text{-}BL}$ |
|---|---|
| Data unit: | Mass or volume units. |
| Description: | Total amount of fossil fuel type *i* consumed by the buses driving on the baseline route *k-BL* in the three years4 prior to the start date of the project activity. |
| Source of data: | If Option 1 - Historical Data is selected, the data shall be the total fuel consumed prior to the start date of the project activity (3 years or minimum of 1 year) and shall be sourced from official statistics or from the bus operator.<br>If Option 2 - Baseline Campaign is selected the data sourced shall be the total fuel consumed during the campaign. |

| | |
|---|---|
| Measurement procedures (if any): | If Option 2 - Baseline Campaign is selected, the latest version of the "Standard: Sampling and surveys for CDM project activities and programme of activities" and the "Guideline: Sampling and surveys for CDM project activities and programmes of activities" shall be followed. |
| Any comment: | The information shall be cross-checked against fuel purchase receipts. |

**Data / Parameter table 3.**

| **Data / Parameter:** | $EC_{k\text{-}BL}$ |
|---|---|
| Data unit: | MWh |
| Description: | Total electricity consumed by the electric buses driving in the baseline route *k-BL* in the three years4 prior to the start date of the project activity. |
| Source of data: | If Option 1 - Historical Data is selected, the data shall be the total electricity consumed prior to the start date of the project activity (3 years or minimum of 1 year) and shall be sourced from official statistics or from the bus operator.<br>If Option 2 – Baseline Campaign is selected the data sourced shall be the total electricity consumed during the campaign. |
| Measurement procedures (if any): | If Option 2 – Baseline Campaign is selected, the latest version of the "Standard: Sampling and surveys for CDM project activities and programme of activities" and the "Guideline: Sampling and surveys for CDM project activities and programmes of activities" shall be followed. |
| Any comment: | The data source are electric charging records of the electricity charging station.<br>The information shall be cross-checked against specific electricity consumption and distance travelled or against invoices from electricity charging station. |



**Data / Parameter table 4.**

| **Data / Parameter:** | $PKM_{k\text{-}BL}$ |
|---|---|
| Data unit: | Passenger-kilometres. |
| Description: | Total passenger-kilometres transported in the baseline route *k-BL* by both electric and fossil-fuel buses in in the three years4 prior to the start date of the project activity. |
| Source of data: | If Option 1 – Historical Data is selected, the data shall be the total number of passenger-kilometres travelling in the baseline route prior to the start date of the project activity (3 years or minimum of 1 year) and shall be sourced from official statistics or from the bus operator.<br>If Option 2 – Baseline Campaign is selected the data sourced shall be the total passengers-kilometres transported during the campaign. |
| Measurement procedures (if any): | If Option 2 – Baseline Campaign is selected, the latest version of the "Standard: Sampling and surveys for CDM project activities and programme of activities" and the "Guideline: Sampling and surveys for CDM project activities and programmes of activities" shall be followed. |

| | |
|---|---|
| Any comment: | The information shall be cross-checked against electronic ticketing system or other official record.<br><br>An alternative to determine this parameter based on historical data is by multiplying the number of passengers transported on both electric and fossil-fuel busses by the average distance travelled by each passenger. The passengers transported and the average distance travelled shall be determined based on electronic ticketing system or other official records or statistics. |

**Data / Parameter table 5.**

| **Data / Parameter:** | $TDL_{grid,BL}$ |
|---|---|
| Data unit: | % |
| Description: | Average technical transmission and distribution losses for providing electricity to grid in the baseline (%) |
| Source of data: | As per "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation".~~"~~ |
| Measurement procedures (if any): | As per "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation".~~"~~ |
| Any comment: | - |

# 6. Monitoring Methodology

45. In addition to the parameters listed in the tables below, the provisions on data and parameters monitored in the tools referred to in this methodology apply.



**Data / Parameter table 1.**

| **Data / Parameter:** | $P_{k,y}$ |
|---|---|
| Data unit: | Passengers |
| Description: | Total passengers transported in the project route *k* in year y. ~~*in year y.*~~ |
| Source of data: | Project system operator, based on electronic ticketing system or any other official records. |
| Measurement procedures (if any): | |
| Monitoring frequency: | Measured at the entry point of passengers on the buses travelling on the project route k. Data to be consolidated annually. |
| QA/QC procedures: | - |
| Any comment: | If this parameter is determined based on sampling, the latest version of the "Standard: Sampling and surveys for CDM project activities and programme of activities" and the "Guideline: Sampling and surveys for CDM project activities and programmes of activities" shall be followed.<br><br>~~This parameter needs to be compared with the passengers transported in the baseline route in order to check the compliance with the requirements of paragraph 4.~~ |

**Data / Parameter table 2.**

| **Data / Parameter:** | $P_{k,1}$ |
|---|---|
| Data unit: | Passengers |
| Description: | Total passengers transported in the project route *k* by both electric and fossil-fuel buses during the first of the crediting period |
| Source of data: | Project system operator, based on electronic ticketing system or any other official records. |
| Measurement procedures (if any): | |
| Monitoring frequency: | Measured at the entry point of passengers on the buses travelling on the project route k. Data to be consolidated annually. |
| QA/QC procedures: | - |
| Any comment: | If $SEC_{PKM,k}$ is determined based on item 5.4.3.2, $P_{k,1}$ shall represent the total passengers transported during the campaign. |

**Data / Parameter table 3.**

| **Data / Parameter:** | $AVD_{k,y}$ |
|---|---|
| Data unit: | km |
| Description: | Average distance travelled by passengers in the project route k in year y. |
| Source of data: | Survey. |
| Measurement procedures (if any): | Survey of the project passengers in year 1 and 4 of the first crediting period to determine the entry and exit bus stops on the project routes k through face-to-face interviews or by using other appropriate survey modes (e.g. using GPS data). |
| Monitoring frequency: | Year 1 and Year 4 of the crediting period. |
| QA/QC procedures: | - |
| Any comment: | |



**Data / Parameter table 4.**

| **Data / Parameter:** | $AVD_{k,1}$ |
|---|---|
| Data unit: | km |
| Description: | Average distance travelled by passengers in project route-*k* during the first year of the crediting period |
| Source of data: | Survey. |
| Measurement procedures (if any): | If $SEC_{PKM,k}$ is calculated based on item 5.4.3.1, $AVD_{k,1}$ is determined using survey of the project passengers in year 1 of the first crediting period to determine the entry and exit bus stops on the project routes k through face-to-face interviews or by using other appropriate survey modes (e.g. using GPS data).<br><br>If $SEC_{PKM,k}$ is calculated based on item 5.4.3.2, it is determined through a project campaign conducted through a representative sampling for an entire week. |
| Monitoring frequency: | Year 1. |

| | |
|---|---|
| QA/QC procedures: | - |
| Any comment: | |

**Data / Parameter table 5.**

| **Data / Parameter:** | $FC_{i,k,y}$ |
|---|---|
| Data unit: | Mass or volume units of fuel |
| Description: | Total amount of fossil fuel type *i* consumed by the buses driving in the project route *k* in year *y* |
| Source of data: | Operator of the bus |
| Measurement procedures (if any): | Based on fuelling station reports. |
| Monitoring frequency: | Measured when the buses are refuelling the tank. |
| QA/QC procedures: | The amount of fuel consumed shall be cross-checked against purchase receipts. |
| Any comment: | - |

**Data / Parameter table 6.**

| **Data / Parameter:** | $FC_{i,k,1}$ |
|---|---|
| Data unit: | Mass or volume units of fuel |
| Description: | Total amount of fossil fuel type *i* consumed by the buses driving in the project route *k* during the first year of the crediting period |
| Source of data: | Operator of the bus |
| Measurement procedures (if any): | Based on fuelling station reports. |
| Monitoring frequency: | Measured when the buses are refuelling the tank. |
| QA/QC procedures: | The amount of fuel consumed shall be cross-checked against purchase receipts. |
| Any comment: | If $SEC_{PKM,k}$ is determined based on item 5.4.3.2, $FC_{i,k,1}$ shall represent the total fuel consumed during the campaign. |

**Data / Parameter table 7.**

| **Data / Parameter:** | $NCV_i$ |
|---|---|
| Data unit: | GJ/mass or volume units |
| Description: | Net calorific value of the fuel type *i* |
| Source of data: | In order of preference:<br>(a) Provided in invoices from the fuel supplier;<br>(b) Measured using a sample of fuel stations, if (a) is not available;<br>(c) Regional or national default values, if (a) is not available and only applicable for liquid fuels;<br>(d) IPCC default values[8] |

[8] Use the lower bound of the 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories.

| | |
|---|---|
| Measurement procedures (if any): | For (a) and (b): measurements shall be undertaken in line with national or international fuel standards. |
| Monitoring frequency: | For (a) and (b): the NCV shall be obtained for each fuel delivery, from which weighted average annual values shall be calculated.<br>For (c): review the appropriateness of the values annually.<br>For (d): any future revision of the IPCC Guidelines shall 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.<br>If the values fall below this range, collect additional information from the testing laboratory to justify the outcome or conduct additional measurements.<br>The laboratories in (a), (b) or (c) shall have ISO17025 accreditation or justify that they can comply with similar quality standards. |
| Any comment: | - |

**Data / Parameter table 8.**

| **Data / Parameter:** | $EF_{CO2,i}$ |
|---|---|
| Data unit: | $tCO_2/GJ$ |
| Description: | $CO_2$ emission factor of the fuel type *i* |
| Source of data: | In order of preference:<br>(a) Provided in invoices from the fuel supplier;<br>(b) Measured using a sample of fuel stations, if (a) is not available;<br>(c) Regional or national default values, if (a) is not available and only applicable for liquid fuels;<br>(d) IPCC default values9 |
| Measurement procedures (if any): | For (a) and (b): measurements shall be undertaken in line with national or international fuel standards.<br>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 shall 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) shall be used. |
| Monitoring frequency: | For (a) and (b): the $CO_2$ emission factor shall be obtained for each fuel delivery, from which weighted average annual values shall be calculated.<br>For (c): review the appropriateness of the values annually.<br>For (d): any future revision of the IPCC Guidelines shall be taken into account. |
| QA/QC procedures: | - |



[9] Use the lower bound of the 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.

| | |
|---|---|
| Any comment: | - |

**Data / Parameter table 9.**

| **Data / Parameter:** | $EC_{k,y}$ |
|---|---|
| Data unit: | kWh |
| Description: | Total amount of electricity consumed by the electric buses driving in the project route *k* in year *y* |
| Source of data: | Electric charging records at the electricity charging station |
| Measurement procedures (if any): | As per the latest version of "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation".<br>When applying the tool, requirements for $EC_{PJ,grid,y}$ specified in the tool shall apply to electricity consumed form the grid. |
| Monitoring frequency: | Measured when the buses are recharged. |
| QA/QC procedures: | As per "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" |
| Any comment: | The data source are the electric charging records of the electricity charging station.<br>The information shall be cross-checked against specific electricity consumption and distance travelled or against invoices from electricity charging station. |



**Data / Parameter table 10.**

| **Data / Parameter:** | $EC_{k,1}$ |
|---|---|
| Data unit: | kWh |
| Description: | Total electricity consumed by electric buses driving on the project route *k* during the first year of the crediting period |
| Source of data: | Electric charging records at the electricity charging station |
| Measurement procedures (if any): | As per the latest version of "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation".<br>When applying the tool, requirements for $EC_{PJ,grid,y}$ specified in the tool shall apply to electricity consumed form the grid. |
| Monitoring frequency: | Measured when the buses are recharged. |
| QA/QC procedures: | As per "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" |
| Any comment: | The data source are the electric charging records of the electricity charging station.<br>The information shall be cross-checked against specific electricity consumption and distance travelled or against invoices from electricity charging station.<br>If $SEC_{PKM,k}$ is determined based on item 5.4.3.2, $EC_{k,1}$ shall represent the total electricity consumed during the campaign. |

**Data / Parameter table 11.**

| **Data / Parameter:** | $EF_{grid,CO2}$ |
|---|---|
| Data unit: | tCO2e/MWh |
| Description: | $CO_2$ emission factor of the electric grid that supplies electricity to the electric bus m |
| Source of data: | Determined following the steps from the "TOOL07: Tool to calculate the emission factor for an electricity system". |
| Measurement procedures (if any): | As per the "TOOL07: Tool to calculate the emission factor for an electricity system". |
| QA/QC procedures: | As per the "TOOL07: Tool to calculate the emission factor for an electricity system". |
| Any comment: | Applicable if the monitoring option selected is ex-post. |

**Data / Parameter table 12.**

| **Data / Parameter:** | $TDL_{grid,y}$, $TDL_{grid,1}$ |
|---|---|
| Data unit: | % |
| Description: | $TDL_{grid,y}$: Average technical transmission and distribution losses for providing electricity to the grid in year *y*.<br>$TDL_{grid,1}$: Average technical transmission and distribution losses for providing electricity to grid during the first year of the crediting period |
| Source of data: | As per "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation". |
| Measurement procedures (if any): | As per "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation". |
| Monitoring frequency: | As per "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation". |
| QA/QC procedures: | As per "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation". |
| Any comment: | - |

~~**Data / Parameter table 13.**~~

| ~~**Data / Parameter:**~~ | ~~$EF_{CO2,VKM,k,y}$~~ |
|---|---|
| ~~Data unit:~~ | ~~$tCO_2$/vkm~~ |
| ~~Description:~~ | ~~$CO_2$ emission factor per vehicle kilometre in project route *k* in year *y*~~ |
| ~~Source of data:~~ | ~~Calculated~~ |
| ~~Measurement procedures (if any):~~ | ~~-~~ |
| ~~Monitoring frequency:~~ | ~~-~~ |
| ~~QA/QC procedures:~~ | ~~-~~ |
| ~~Any comment:~~ | ~~-~~ |

**Data / Parameter table 14.**

| **Data / Parameter:** | $VKM_{k,y}$ |
|---|---|
| Data unit: | vkm |
| Description: | Total vehicle-kilometres travelled in project route *k* by both electric and fossil-fuel buses in year *y* |
| Source of data: | Bus operator, based on the odometer of the buses travelling in the project route *k*. |
| Measurement procedures (if any): | - |
| Monitoring frequency: | Distance travelled by each bus shall be measured continuously and recorded daily by the bus operator. |
| QA/QC procedures: | The odometer of each bus travelling in project route *k* shall be recorded at the start and at the end of each day for cross-checking. |
| Any comment: | The total distance travelled can be cross-checked by multiplying the number of trips that each bus travelled in project route *k* by the length of the route. |

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## Document information

| *Version* | *Date* | *Description* |
|---|---|---|
| 03.0 | 11 March 2019 | MP 78, Annex 7.<br>To be considered by the Board at EB 102<br>This version incorporates the input and guidance provided by the Board (EB 101) |
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