CLEAN DEVELOPMENT MECHANISM

AM0101

Large-scale Methodology

High speed passenger rail systems

Version 02.0

Sectoral scope(s): 07

United Nations
Framework Convention on
Climate Change

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1. Introduction

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

Table 1. Methodology key elements

Typical project(s)	Establishment and operation of a new high speed rail system. Extension of an existing high speed rail system. Replacement or upgrading of a conventional rail system to the high speed rail system
Type of GHG emissions mitigation action	Energy efficiency Displacement of more GHG-intensive transport modes (airplanes, buses, conventional rail, motorcycles and personal cars) by less-GHG intensive one (high speed rail)

2. Scope, applicability, and entry into force

2.1. Scope

2. The methodology includes the establishment and operation of a high speed rail (HSR) passenger transport system between urban areas.

2.2. Applicability

3. The average design speed between the origin and the destination point of the new HSR shall be at least 200 km/h.

4. The new rail infrastructure can be the extension of an existing HSR. It can also be the replacement or upgrading of an existing conventional rail system to HSR. In the case of the extension, replacement or upgrading, only the section extended/replaced/upgraded is eligible for crediting;

5. The methodology is only applicable for passenger transport. If the project HSR system also transports freight goods, no baseline emissions can be claimed for transporting freight goods, while all emissions associated with the HSR are accounted for as project emissions;

6. The entire project HSR system (origin, destination and urban areas serviced by the project HSR) shall be located in the same host country;

7. Only electricity shall be used for the propulsion of the project HSR system;

8. The average distance between two consecutive stations served by the HSR system is at least 20 km.

9. The methodology is only applicable if the procedure to select the baseline scenario leads to the result that a continuation of the use of current modes of transport is the baseline scenario.

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

2.3. Entry into force

11. The date of entry into force is the date of the publication of the EB 85 meeting report on 24 July 2015.

3. Normative references

12. This baseline and monitoring methodology is based on elements from the following proposed new methodology:

    (a) "NM0351: High Speed Passenger Rail Systems" prepared by Grütter Consulting AG.

13. This methodology also refers to the latest approved versions of the following documents:

    (a) "Tool for the demonstration and assessment of additionality";

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

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

    (d) Additionality of first-of-its-kind project activities;

    (e) International Civil Aviation Organization (ICAO). ICAO Carbon Emissions Calculator. Version 2, 5.2009.

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

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

15. "Existing actual or historical emissions, as applicable".

4. Definitions

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

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

    (a) **Extension of an existing HSR** - refers to providing new infrastructure in order to increase the length of an existing high-speed rail line;

    (b) **High speed rail (HSR)** - is a system of rail infrastructure, rolling stock and its operations. The HSR infrastructure includes specially built high-speed rail lines equipped for speeds equal to or greater than 250 km/h and specially up-graded high-speed rail lines equipped for speeds of at least 200 km/h. The HSR rolling stock may consist of a fixed formation of train sets indivisible in service or of individual vehicles having a maximum speed of at least 250 km/h;

(c) **HSR entry station** - refers to the station where a surveyed passenger enters into the new, upgraded or extended HSR system established under the project activity;

(d) **HSR exit station** - refers to the station where a surveyed passenger leaves the new, upgraded or extended HSR system established under the project activity;

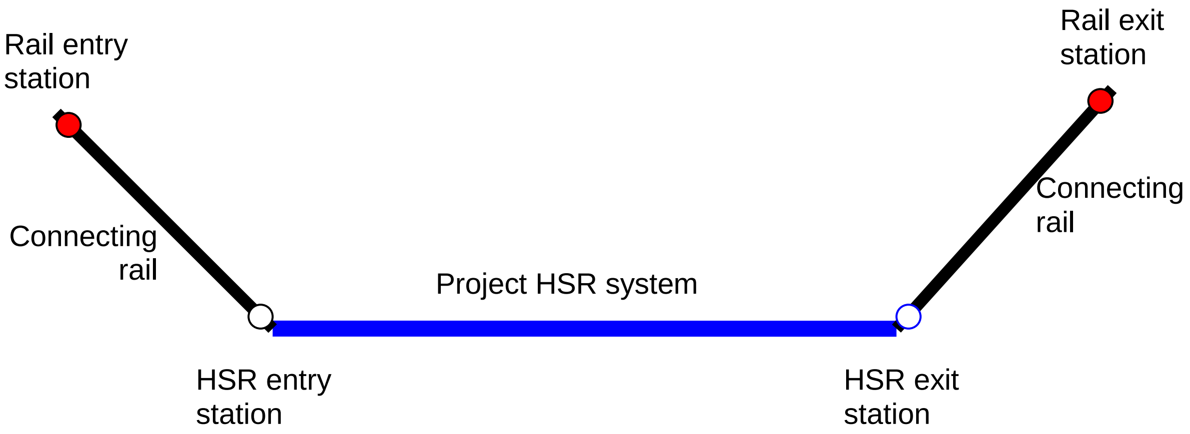
(e) **Rail entry station** - refers to the rail station where a surveyed passenger starts their trip on a rail based system. This includes non-project rail system that connects to the project HSR and may be high-speed or conventional rail line. If the passenger starts the trip on a station of the project HSR system, then the rail entry station corresponds to the HSR entry station;

(f) **Rail exit station** - refers to the rail station where a surveyed passenger ends their trip on a rail based system. This includes non-project rail system that connects to the project HSR and may be high-speed or conventional rail line. If the passenger ends the trip on a station of the project HSR system, then the rail exit station corresponds to the HSR exit station;

(g) **Replacement or upgrading of a conventional rail system to HSR -** refers to making a change to an existing rail-network to allow for HSR with a speed of at least 200 km/h. The maximum permissible speed of the rail network before the upgrade shall have been below 150 km/h;

18. The definitions of the HSR entry and exit station and the rail entry and exit station are illustrated in the following schematic figure:

Figure 1. Project HSR system



5. Baseline methodology

5.1. Project boundary

19. The spatial extent of the project boundary encompasses the transport infrastructure between the urban areas serviced by the project HSR system including its extensions and connection lines, limited to domestic travel. The project boundary also includes the

power plant(s) connected physically to the electricity system that supplies power to the project.

20. The greenhouse gases included in or excluded from the project boundary are shown in Table 2.

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

Source		Gas	Included	Justification/Explanation
Baseline	Emissions from baseline modes of transport	CO_2	Yes	Major emission source
		CH_4	Yes	Included only if gaseous fuels are used and excluded for liquid fuels as CH_4 emissions are a minor source of the total CO_2e emissions from liquid fuels.
		N_2O	No	N_2O emissions are a minor source of total CO_2e emissions.
Project activity	Emissions from project HSR and connecting rail system	CO_2	Yes	Major emission source.
		CH_4	No	See explanation above
		N_2O	No	See explanation above

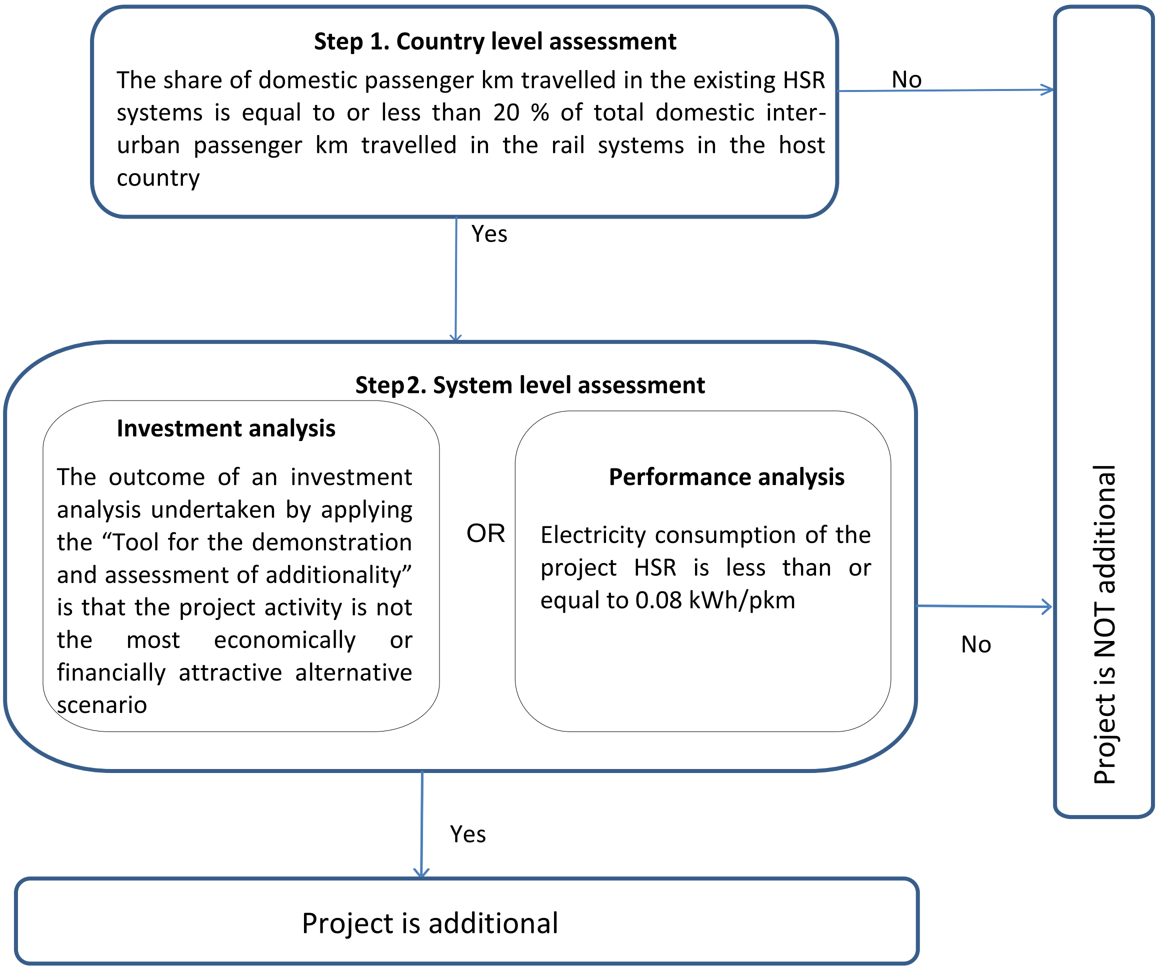
5.2. Additionality demonstration

21. If the host country is a least developed country (LDC) at the point of time of publication of the project design document (CDM-PDD) by the designated operational entity (DOE) for stakeholder consultation, the project activity is deemed to be automatically additional.

22. If the host country is not an LDC at the point of time of publication of the CDM-PDD by the DOE for stakeholder consultation, but faces the barrier of first-if-its-kind, then the latest approved version of the "Additionality of first-of-its-kind project activities" shall be followed to demonstrate the additionality of these project activities.

23. In all other situations, the procedure illustrated in Figure 2 and described below shall be applied.

Figure 2. Additionality demonstration



5.2.1. Step 1: Country level assessment

24. 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. This analysis shall be limited to domestic inter-urban rail-based transport and shall not include urban and sub-urban rail-based transit systems. For this purpose, project participants shall assess whether the share of domestic passenger km travelled in all HSR systems, which existed at the point of submission of the CDM-PDD for validation to the DOE or prior to the implementation of the project activity (whatever is earlier) in the host country, is equal to or less than 20 per cent of the total domestic inter-urban passenger km travelled in the rail systems in the host country in the most recent three calendar years.

25. The project participants shall:

    (a) Describe in the CDM-PDD the existing domestic inter-urban rail transport systems in the host country and identify which of these inter-urban rail lines are HSR lines. Rail lines providing sub-urban and urban transport service shall be excluded from this analysis;

    (b) Determine, based on the most recently available data, the share of domestic passenger km travelled in the HSR systems in the host country in the most recent three calendar years prior to the submission of the CDM-PDD for validation to the DOE or prior to the implementation of the project activity, whatever is earlier.

26. If the share of domestic passenger km travelled in the existing HSR systems exceeds 20 per cent, then the proposed CDM project activity is not additional. If the share of domestic passenger km is less than or equal to 20 per cent, then project participants should proceed to Step 2.

5.2.2. Step 2: System level assessment

27. Two options are provided for the system level assessment of the proposed project activity.

    (a) Conduct an investment analysis, following the procedure under section 5.2.2.1 below;

    (b) Conduct a performance analysis, following the procedure under section 5.2.2.2 below.

5.2.2.1. Procedure for Investment analysis

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

29. The investment analysis should be undertaken from the perspective of the operator/investor of the HSR system, reflecting the costs and revenues from the perspective of the operator/investor. If the project is subsidized through public authorities and institutions (e.g. national government or any other public authority, 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 national government or any other public authority should be considered as a capital investment by the project operator and not be subtracted from the total system costs.

30. In applying the investment analysis, cost overruns of former investments in existing HSR systems or reduced revenues of former HSR 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 HSRs 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 HSR.

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

5.2.2.2. Procedure for a performance analysis

32. The HSR project shall demonstrate that the forecasted electricity consumption of the project HSR per passenger-kilometer is less than or equal to 0.08 kWh/pkm[1] to demonstrate that project is additional.

33. For this purpose the annual amount of electricity consumed by the project HSR system shall be calculated based on annual number of passengers expected to travel in the project system and an average distance that these passengers are expected to travel in the project HSR when the project HSR system will reach its planned capacity. A four-step model, or equivalent, of the transportation system of the project city as mentioned under section 5.7 below shall be used as the basis for forecasting the number of passengers and distance of travel on the system. This analysis shall be conducted one time ex ante for the purpose of additionality demonstration. All assumptions used in calculations need to be documented and substantiated in the CDM-PDD.

5.3. Baseline emissions

34. 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 transit from the origins to destinations of passengers using the project HSR system 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.

35. The current modes of passenger transport in the baseline scenario may include, when applicable, road-based modes (e.g. cars, buses, and motorcycles), conventional and existing high-speed rail, water-based transport modes and domestic air travel.

[1] Refer section 3 of "Performance benchmarks in draft revision of AM0031, AM0101 and ACM0016" available as annex 3 to 67th meeting report of Meth Panel.

36. The CDM-PDD shall describe all existing transport modes used for domestic inter-urban travel in the project boundary prior to the implementation of the proposed project activity and include a map with the core domestic inter-urban travel routes per medium (such as road, rail, air and water). The distribution of passengers per baseline mode is assessed during the project implementation through passenger surveys, i.e. the actual baseline modes and therefore baseline emissions are determined in a dynamic manner. The survey includes also as mode “others” which represents all modes not calculated ex ante by the project due to estimating its incidence as being marginal (e.g. motorcycles).

37. Baseline emissions are those that would have occurred due to the transportation of the passengers who use the project HSR system, had the project activity not been implemented. Baseline emissions are calculated for the modes of domestic inter-urban transport that the passengers would have used in the absence of the project activity.

38. Baseline emissions are based on ex ante determined emission factors per passenger-kilometer and per mode of transport, multiplied with the total trip distance travelled by passengers per baseline mode of transport, as follows:

$$BE_y = \left(EF_{BL,pkm,R} \times D_{P,R,y} + EF_{BL,F,y} \times D_{P,F,y} + \sum_i EF_{BL,pkm,i,y} \times D_{P,i,y} \right) \times 10^{-6} \quad \text{Equation (1)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2e)
$EF_{BL,pkm,R}$	=	Baseline emission factor per passenger-kilometer for the existing rail system (gCO_2e/pkm)
$D_{P,R,y}$	=	Total trip distance travelled by passengers who would have used the existing rail system in the absence of the project activity in year *y* (pkm)
$EF_{BL,pkm,i,y}$	=	Baseline emission factor per passenger-kilometer for road-based vehicle category *i* in year *y* (gCO_2e/pkm)
$D_{P,i,y}$	=	Total trip distance travelled by passengers who would have used road-based vehicle category *i* in the absence of the project activity in year *y* (pkm)
$EF_{BL,F,y}$	=	Baseline emission factor per passenger-kilometer for flights in year *y* (gCO_2e/pkm)
$D_{P,F,y}$	=	Total trip distance travelled by passengers who would have travelled by airplanes in the absence of the project activity in year *y* (pkm)
i	=	Road-based vehicle categories: passenger cars (C), buses (B) and motorcycles (M)

5.3.1. Step 1: Identification of the modes of transport in the baseline

39. Identify the relevant modes of transport in the baseline. The relevant modes of transport are those that a passenger could use for the same trip prior to the start of commercial operation of the project HSR as offered by the project HSR system after the start of its commercial operation.

40. Modes of transport are separated in:

(a) Rail-based mode of transport (existing rail system) (*R*). This is relevant if prior to the implementation of the project activity a rail based system was already in place which passengers could use instead of the HSR system;

(b) Flight based mode of transport (*F*). This mode is relevant if flights serve the same destinations as the project HSR system, including connections with the project HSR system;

(c) Road based modes of transport with different vehicle categories *i*:

(i) Passenger Cars (*C*);

(ii) Buses (*B*);

(iii) Motorcycles (*M*).

41. If some vehicle categories are not explicitly identified or do not fit into one of the categories above, they should be subsumed as “others”. The project participants can also decide not to include any of the above vehicle categories in the baseline emission calculations. This is conservative as any non-included mode of transit is subsumed under “others”. Baseline emissions of the category “others” are counted for as zero emissions.

5.3.2. Step 2: Determination of the baseline emission factor per passenger-kilometer for rail

42. The baseline emission factor per passenger-kilometer for the existing rail system ($EF_{BL,pkm,R}$) is determined ex ante and fixed for the crediting period. The baseline emission factor for the existing rail system shall be determined for the rail line, which serves the same destinations as the project HSR line, i.e. the rail line which is intended to be substituted, at least partially, by the project HSR. The data used to determine the baseline emission factor for the existing rail-line system shall be for the most recent calendar year prior to the start of commercial operation of the project HSR system or prior to the submission of the CDM-PDD for validation, whatever is earlier. If information specifically on that rail system is not available then the baseline emissions from that rail system are counted as zero baseline emissions.

43. The baseline emission factor per passenger-kilometer for the existing rail system can be determined according to the following options:

5.3.2.1. Option A: Using reported passenger-km data

44. If passenger-kilometers of the existing rail line systems are reported by the rail lines operator(s), then this data shall be used to calculate the baseline emission factor per passenger-kilometer ($EF_{BL,pkm,R}$) according to the equation below:

$$EF_{BL,pkm,R} = \frac{TE_{R,x}}{pkm_{R,x}} \times 10^6 \qquad \text{Equation (2)}$$

Where:

$EF_{BL,pkm,R}$	=	Baseline emission factor per passenger-kilometer for the existing rail system (g CO_2e/pkm)
$TE_{R,x}$	=	Total emissions from the existing rail system in year x (t CO_2)
$pkm_{R,x}$	=	Passenger-kilometers travelled in the existing rail system in year x (pkm)
x	=	Most recent calendar year prior to the start of commercial operation of the project HSR system or prior to the submission of the CDM-PDD for validation, whatever is earlier

5.3.2.2. Option B: Using the number of passengers and an average trip distance

45. If data on passenger-kilometers of the existing rail system are not reported by the rail operator, but data on the number of passengers and the average trip distance is available, then the baseline emission factor per passenger-kilometer ($EF_{BL,pkm,R}$) can be determined based on the number of passengers transported by the existing rail system and the average trip distance according to the equation below.

$$EF_{BL,pkm,R,x} = \frac{TE_{R,x}}{P_{R,x} \times D_{R,x}} \times 10^6 \qquad \text{Equation (3)}$$

Where:

$EF_{BL,pkm,R,x}$	=	Baseline emission factor per passenger-kilometer for the existing rail system (g CO_2e/pkm)
$TE_{R,x}$	=	Total emissions from the existing rail system in year x (t CO_2)
$P_{R,x}$	=	Total passengers transported by the existing rail system in year x (passengers)
$D_{R,x}$	=	Average trip distance travelled by passengers using the existing rail system in year x (km)
x	=	Most recent calendar year prior to the start of commercial operation of the project HSR system or prior to the submission of the CDM-PDD for validation, whatever is earlier

46. The total emissions from the existing rail system are calculated using equation (4) for trains running on fossil fuels or using the latest version of the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” for trains running on electricity, where the amount of electricity consumed by the existing rail system for traction corresponds to parameter $EC_{BL,k,y}$ in the tool. The option of using equation (4) and the tool can also be combined, if necessary.

$$TE_{R,x} = \sum_n FC_{R,n,x} \times NCV_{n,x} \times EF_{CO2,n,y} \qquad \text{Equation (4)}$$

Where:

$TE_{R,x}$	=	Total emissions from the existing rail system in year x (t CO_2e)
$FC_{R,n,x}$	=	Amount of fossil fuel type n consumed by the existing rail system in year x (mass or volume unit)
$NCV_{n,x}$	=	Net calorific value of fossil fuel type n used in year x (MJ/mass or volume unit)
$EF_{CO2,n,y}$	=	Carbon dioxide emission factor for fossil fuel type n used in year y (t CO_2e/MJ)
n	=	Fossil fuel types used for trains in the existing rail system
x	=	Most recent calendar year prior to the start of commercial operation of the project HSR system or prior to the submission of the CDM-PDD for validation, whatever is earlier

5.3.3. Step 3: Determination of the baseline emission factor per passenger-kilometer for road-based vehicle categories

47. The emission factor per pkm for road-based vehicle categories ($EF_{BL,pkm,i,y}$) is determined ex ante for each year y of the crediting period, based on an annual technology improvement factor.

48. For road-based vehicle categories, the emission factor per pkm should be calculated as:

$$EF_{BL,pkm,i,y} = \frac{EF_{km,i,y}}{OC_{i,x}} \qquad \text{Equation (5)}$$

Where:

$EF_{BL,pkm,i,y}$	=	Baseline emission factor per passenger-kilometer for road-based vehicle category i in year y (g CO_2e/pkm)
$EF_{km,i,y}$	=	Baseline emission factor per kilometer of vehicle category i in year y (g CO_2e/km)
$OC_{i,x}$	=	Average occupancy rate of vehicle category i in year x (passengers)
x	=	Most recent calendar year prior to the start of commercial operation of the project HSR system or prior to the submission of the CDM-PDD for validation, whatever is earlier
i	=	Road-based vehicle categories: passenger cars (C), buses (B) and motorcycles (M)

5.3.4. Determination of the average occupancy rate ($OC_{i,x}$)

49. Project participants may choose among the following options to determine the average occupancy rate:

5.3.4.1. Option A: Visual occupation studies

50. Determine the average occupancy rate based on visual occupation studies. The detailed procedures concerning visual occupation studies for cars/motorcycles are presented in Appendix 1.

5.3.4.2. Option B: Use of reported passenger-kilometer data

51. This option is applicable to buses in situations where bus operator(s) or 3rd parties report data on passenger-kilometer of inter-urban buses. In this case, the average occupancy rate of these buses prior to the start of commercial operation of the project HSR system can be determined using the following equation:

$$OC_{B,x} = \frac{pkm_{B,x}}{D_{B,x}} \quad \text{Equation (6)}$$

Where:

$OC_{B,x}$	=	Average occupancy rate of buses in year x (passengers)
$pkm_{B,x}$	=	Passenger-kilometers of buses in year x (pkm)
$D_{B,x}$	=	Distance driven by buses in year x (kilometers)
x	=	Most recent calendar year prior to the start of commercial operation of the project HSR system or prior to the submission of the CDM-PDD for validation, whatever is earlier

5.3.4.3. Option C. Use the average trip distance, total number of passengers and total distance driven

52. This option is applicable to buses. Determine the average occupancy rate of the buses prior to the start of commercial operation of the project HSR system based on the average trip distance of bus passengers, the total number of passengers and the total distance driven by buses, using the following equation:

$$OC_{B,x} = \frac{P_{BL,B,x} \times D_{B,AVG,x}}{D_{B,x}} \quad \text{Equation (7)}$$

Where:

$OC_{B,x}$	=	Average occupancy rate of buses in year x (passengers)
$P_{BL,B,x}$	=	Number of passengers transported by buses in year x (passengers)
$D_{B,AVG,x}$	=	Average trip distance travelled by passengers of buses in year x (kilometer)
$D_{B,x}$	=	Distance driven by buses in year x (kilometers)
x	=	Most recent calendar year prior to the start of commercial operation of the project HSR system or prior to the submission of the CDM-PDD for validation, whatever is earlier

5.3.4.4. Option D. Use of default values

53. This option is applicable to all transport modes. A default value of three passengers for cars, 1.5 passengers for motorcycles and 80 per cent of the average seating capacity of average inter-urban buses can be used.

5.3.5. Determination of the baseline emission factors per kilometer

54. The baseline emission factor per kilometer for road vehicles ($EF_{km,i,y}$) is determined, as the 1[st] preference, for the routes serving the same destinations as the project HSR system. If information specifically for these routes is not available then, as the 2[nd] preference, the emission factor for road vehicles can be determined for the entire host country based on a highway driving mode.

55. For each vehicle category, the relevant fuel types *n* shall be identified. In case biofuels or bio-fuel blends are used, the bio-fuel share of the blend should be accounted for with an emission factor ($EF_{CO2,n,y}$) of zero.

56. The emission factor per kilometer is not constant, but annually updated by a technology improvement factor (IR_i). The emission factor is calculated as follows:

$$EF_{km,i,y} = \left[\sum_n SFC_{i,n,x} \times NCV_{n,y} \times \frac{N_{i,n,x}}{N_{i,x}} \times \left(EF_{CO2,n,y} + EF_{CH4,i,n,y} \times GWP_{CH4}\right)\right] \times IR_i^{t+y-1}$$

Equation (8)

Where:

$EF_{,km,i,y}$	=	Baseline emission factor per kilometer of vehicle category *i* in year *y* (gCO_2e/km)
$SFC_{i,n,x}$	=	Specific fuel consumption of vehicle category *i* using fuel type *n* in year *x* (mass or volume units of fuel/km)
$NCV_{n,y}$	=	Net calorific value of fuel type *n* in year *y* (MJ/mass or volume units of fuel)
$EF_{CO2,n,y}$	=	CO_2 emission factor for fuel type *n* in year *y* (g CO_2e/MJ)
$N_{i,n,x}$	=	Number of vehicles of category *i* using fuel type *n* in year *x* (units)
$N_{i,x}$	=	Number of vehicles of category *i* in year *x* (units)
$EF_{CH4,i,n,y}$	=	Methane emission factor for vehicle category *i* using fuel type *n* in year *y* (g CH_4/MJ)
GWP_{CH4}	=	Global Warming Potential of methane (g CO_2/g CH_4)

IR_i	=	Technology improvement factor per year[2] for vehicle category *i*
n	=	Fuel types used by vehicle category *i* in year *x*
i	=	Road-based vehicle categories: passenger car (C), buses (B) and motorcycles (M)
t	=	Time difference (in years) between the year for which data is available for vehicle category *i* and the first year of the crediting period
x	=	Most recent calendar year prior to the start of operation of the project HSR system or prior to the submission of the CDM-PDD for validation, whatever is earlier

57. Instead of the two parameters $N_{i,n,x}$ and $N_{i,x}$, it is possible to use one parameter $N_{i,n,x}/N_{i,x}$ which is the percentage of vehicles within vehicle category *i* that use the fuel type *n,* in the case that reliable data sources for this parameter exist (see the “Data and parameters not monitored” tables for further guidance on data requirements).

5.3.6. Step 4: Determination of the baseline emission factor per passenger-kilometer for flights

58. The baseline emission factor per passenger-kilometer for flights in year *y* ($EF_{BL,F,y}$) is determined based on the flight origin and destination reported by the survey respondents. It is assumed that the passengers would use a one-way direct domestic flight in the economy class between origin and destination airports reported in the survey. The baseline emission factor per passenger who would have flown in the absence of the project HSR is determined according to the equation below and based on the default emission factors provided in Data and parameters not monitored section, as follows:

$$EF_{BL,F,y} = \frac{\sum_{m=1}^{N_{P,F,y}} EF_{CO2,F,m}}{N_{P,F,y}}$$ Equation (9)

Where:

$EF_{BL,F,y}$	=	Baseline emission factor per passenger kilometer for flights in year *y* (g CO_2e/pkm)
$EF_{CO2,F,m}$	=	Default CO_2 emission factor for the flight which survey respondent *m* would have undertaken in the absence of the project activity (g CO_2e/pkm)
$N_{P,F,y}$	=	Number of surveyed passengers who would have used airplanes in the absence of the project activity in year *y*
m	=	Survey respondents

[2] For example, if the project started in the year 2011, the data vintage for specific fuel consumption and the number of vehicles in category *i* using fuel type *x* is 2009 and project proponents calculate the emission factor per km in the project year 2015, in this case *t* = 2011-2009 = 2 and *y* = 2015- 2011 = 4, so IR_i^{t+y-1} in the project year 2015 is $IR_i^{2+4-1} = 0.99^5$.

5.3.7. Step 5: Determination of passenger trip distances

59. The total trip distances travelled by passengers in the baseline are determined for each transport mode separately based on a survey. The average trip distances per transport mode are determined as the mean of the trip distances travelled by each surveyed passenger *m*. The average trip distances are then multiplied by the total amount of passengers using the baseline mode to determine the total trip distance travelled by passenger for each transport mode.

5.3.7.1. Total trip distance for flights

60. The total trip distance travelled by passengers using airplanes is determined by the average trip distance travelled per passenger multiplied with the amount of passengers who would have flown in the absence of the project activity:

$$D_{P,F,y} = D_{P,F,AVG,y} \times P_{F,y}$$ Equation (10)

Where:

$D_{P,F,y}$	=	Total trip distance travelled by passengers who would have travelled by airplanes in the absence of the project activity in year *y* (pkm)
$D_{P,F,AVG,y}$	=	Average trip distance travelled by passengers who would have used airplanes in the absence of the project activity in year *y* (km)
$P_{F,y}$	=	Number of passengers who would have used airplanes in the absence of the project activity in year *y* (passengers)

61. The average trip distance travelled by passengers who would have used airplanes in the absence of the project activity ($D_{P,F,AVG,y}$) is determined through a survey as the mean distance travelled by all passengers who would have used airplanes. For each surveyed passenger, the minimum distance is used between (a) the distance between the entry airport and exit airport which the surveyed passenger would have used in the absence of the project activity and (b) the beeline (shortest distance) between the entry and exit rail station which the passenger uses under the project activity, as follows:

$$D_{P,F,AVG,y} = \frac{\sum_{m=1}^{N_{P,F,y}} MIN(D_{P,F,OD,m,y}; D_{P,BEE,OD,m,y})}{N_{P,F,y}}$$ Equation (11)

Where:

$D_{P,F,AVG,y}$	=	Average trip distance travelled by passengers who would have used airplanes in the absence of the project activity in year *y* (km)
$D_{P,F,OD,m,y}$	=	Flight distance between the origin airport and the destination airport of surveyed passenger *m* who would have travelled by airplane in the absence of the project activity in year *y* (km)

$D_{P,BEE,OD,m,y}$	=	Beeline distance between the entry and exit rail stations of surveyed passenger *m* who would have travelled by airplane in the absence of the project activity in year *y* (km)
$N_{P,F,y}$	=	Number of surveyed passengers who would have used airplanes in the absence of the project activity in year *y*
m	=	Survey respondents

5.3.7.2. Total trip distance for rail

62. For passengers who would have travelled by rail, the trip distance travelled by each surveyed passenger $D_{P,R,OD,m,y}$ is determined as the distance between the rail entry stations and the rail exit station of the surveyed passenger.

63. The total trip distance travelled by passengers who would have used the existing rail system is determined as the average trip distance travelled per passenger multiplied with the number of passengers who would have used the existing rail system in the absence of the project activity:

$$D_{P,R,y} = \mathrm{D}_{\mathrm{P,R,AVG,y}} \times P_{R,y} \qquad \text{Equation (12)}$$

Where:

$D_{P,R,y}$	=	Total trip distance travelled by passengers who would have used the existing rail system in the absence of the project activity in year *y* (pkm)
$D_{P,R,AVG,y}$	=	Average trip distance travelled by passengers who would have used the existing rail system in the absence of the project activity in year *y* (km)
$P_{R,y}$	=	Number of passengers who would have used the existing rail system in the absence of the project activity in year *y* (passengers)

64. The average trip distance travelled by passengers who would have used the existing rail system ($D_{P,R,AVG,y}$) is determined as the mean distance travelled by the surveyed passengers by rail between their rail entry station and their rail exit station.

$$\mathrm{D}_{\mathrm{P,R,AVG,y}} = \frac{\sum_{m=1}^{N_{P,R,y}} \mathrm{D}_{\mathrm{P,R,OD,m,y}}}{\mathrm{N}_{\mathrm{P,R,y}}} \qquad \text{Equation (13)}$$

Where:

$D_{P,R,AVG,y}$	=	Average trip distance travelled by passengers who would have used the existing rail system in the absence of the project activity in year *y* (km)
$D_{P,R,OD,m,y}$	=	Rail line distance from the rail entry station to the rail exit station of surveyed passenger *m* who would have travelled by the existing rail system in the absence of the project activity in year *y* (km)
$N_{P,R,y}$	=	Number of surveyed passengers who would have used airplanes in the absence of the project activity in year *y*
m	=	Survey respondents

5.3.7.3. Total trip distance for road

65. The total trip distance travelled by passengers who would have travelled by road-based modes is determined as the average trip distance per mode multiplied with the number of passengers who would have used this mode in the absence of the project activity:

$$D_{P,i,y} = D_{P,i,AVG,y} \times P_{i,y}$$ Equation (14)

Where:

$D_{P,i,y}$	=	Total trip distance travelled by passengers who would have used road-based vehicle category *i* in the absence of the project activity in year *y* (pkm)
$D_{P,i,AVG,y}$	=	Average trip distance travelled by passengers who would have used road-based vehicle category *i* in the absence of the project activity in year *y* (km)
$P_{i,y}$	=	Number of passengers who would have used road-based vehicle category *i* in the absence of the project activity in year *y* (passengers)

66. The average trip distance travelled by passengers who would have travelled by road-based modes is determined as the mean road distance travelled by the surveyed passengers between the rail entry station and the rail exist station:

$$D_{P,i,AVG,y} = \frac{\sum_{m=1}^{N_{P,i,y}} D_{P,i,OD,m,y}}{N_{P,i,y}}$$ Equation (15)

Where:

$D_{P,i,AVG,y}$	=	Average trip distance travelled by passengers who would have used road-based vehicle category *i* in the absence of the project activity in year *y* (km)
$D_{P,i,OD,m,y}$	=	Distance between the rail entry station to the rail exit station of surveyed passenger *m* who would have travelled by road-based vehicle category *i* in the absence of the project activity in year *y* (km)
$N_{P,i,y}$	=	Number of surveyed passengers who would have used road-based vehicle category *i* in the absence of the project activity in year *y*
i	=	Road-based vehicle category: passenger car (C), buses (B) and motorcycles (M)
m	=	Survey respondents

67. The trip distance travelled by each surveyed passenger $D_{P,i,OD,m,y}$ can be determined according to the following options:

(a) **Option A. Electronic mapping**. To determine the trip distance for each surveyed passenger who would have travelled by road-based vehicle categories *i*, the trip of the passenger between the rail entry station and the rail exit station (for details

see Passenger Survey, Section C: Trip data of interviewed person) is mapped using electronic maps or any other appropriate tools that allow estimating the shortest road distance between the rail entry and exit stations;

(b) **Option B. Beeline distance.** As a conservative option, the trip distance for each surveyed passenger who would have travelled by road-based vehicle categories *i* is determined using the beeline (the shortest distance) between the rail entry station and the rail exit station.

5.3.7.4. Ex ante estimation of total trip distances

68. For the ex ante calculation of emission reductions in the CDM-PDD, the total trip distances are estimated based on the average trip distance travelled in the existing rail line or system, assuming the same trip distance for road and rail-based users.

5.3.7.5. Determination of the number of passengers per mode

69. The number of passengers per mode is determined based on the total number of passengers transported by the project HSR and the share of survey respondents, who would have used the respective transit mode:

$$P_{F,y} = P_y \times S_{P,F,y} \quad \text{Equation (16)}$$

$$P_{R,y} = P_y \times S_{P,R,y} \quad \text{Equation (17)}$$

$$P_{i,y} = P_y \times S_{P,i,y} \quad \text{Equation (18)}$$

Where:

$P_{F,y}$	=	Number of passengers who would have travelled by airplanes in the absence of the project activity in year *y* (passengers)
$P_{R,y}$	=	Number of passengers who would have used the existing rail system in the absence of the project activity in year *y* (passengers)
$P_{i,y}$	=	Number of passengers who would have used road-based vehicle category *i* in the absence of the project activity in year *y* (passengers)
P_y	=	Total passengers transported by the project HSR system in year *y* (passengers)
$S_{P,F,y}$	=	Share of project passengers who would have travelled by airplanes in the absence of the project activity in year *y* (percentage)
$S_{P,R,y}$	=	Share of project passengers who would have travelled by the existing rail system in the absence of the project activity in year *y* (percentage)
$S_{P,i,y}$	=	Share of project passengers who would have travelled by road-based vehicle category *i* in the absence of the project activity in year *y* (percentage)

70. The shares of passengers are determined through surveys. The survey procedures are presented in Appendix 2.

71. For the ex ante calculation of emission reductions in the CDM-PDD, the shares are either determined based on a pilot survey of a comparable existing fast-train track or, if no such line exists, in the host country based on experience in other countries with HSR systems.

5.4. Project emissions

72. Project emissions are emissions associated with the transportation of the passengers travelling in the project HSR system from their rail entry station to their rail exit station. Therefore, project emissions include direct project emissions defined as emissions from the operation of the project HSR system plus indirect project emissions defined as rail-based emissions from the rail entry station to the HSR entry station and from the HSR exit station to the rail exit station.

$$\mathrm{PE_y = DPE_y + IPE_y} \tag{19}$$

Where:

PE_y	=	Project emissions in year y (t CO_2e)
DPE_y	=	Direct project emissions in year y (t CO_2e)
IPE_y	=	Indirect project emissions in year y (t CO_2e)

73. Direct project emissions (DPE_y) are calculated using the latest approved version of the 'Tool to calculate baseline, project and/or leakage emissions from electricity consumption', in which the amount of electricity consumed by the project HSR system for traction in year y corresponds to parameter $EC_{PJ,j,y}$ in the tool.

74. Indirect project emissions are determined using the same emission factor $EF_{BL,pkm,R}$ as for baseline emissions (see equation (2)), as follows:

$$IPE_y = \left(EF_{BL,pkm,R} \times D_{PJ,TOT,y}\right) \times 10^{-6} \tag{20}$$

Where:

IPE_y	=	Indirect project emissions in year y (t CO_2e)
$EF_{BL,pkm,R}$	=	Baseline emission factor per passenger-kilometer for the existing rail system (g CO_2e/pkm)
$D_{PJ,TOT,y}$	=	Total trip distance travelled by project HSR passengers on the non-project connecting rail system in year y (pkm)

75. The total distance of project HSR passengers on the non-project rail system is determined through the survey identifying the rail entry station, the HSR entry station, the HSR exit station, and the rail exit station of the passenger and the distances between the rail entry station and the HSR entry station and between the HSR exit station and the rail exit station.

$$D_{PJ,TOT,y} = D_{PJ,AVG,y} \times P_y$$ Equation (21)

Where:

$D_{PJ,TOT,y}$	=	Total trip distance travelled by project HSR passengers on the non-project connecting rail system in year *y* (pkm)
$D_{PJ,AVG,y}$	=	Average trip distance travelled by project HSR passengers on the non-project connecting rail system in year *y* (km)
P_y	=	Total number of passengers transported by the project HSR system in year *y* (passengers)

$$D_{PJ,AVG,y} = \frac{\sum_{m=1}^{N_{P,y}} D_{PJ,OD,m,y}}{N_{P,y}}$$ Equation (22)

Where:

$D_{PJ,AVG,y}$	=	Average trip distance travelled by project HSR passengers on the non-project connecting rail system in year *y* (km)
$D_{PJ,OD,m,y}$	=	Distance travelled by surveyed passenger *m* on the non-project connecting rail system from the rail entry station to the HSR entry station and from the HSR exit station to the rail exit station in year *y* (km)
$N_{P,y}$	=	Total number of surveyed passengers in year *y*
m	=	Survey respondents

5.5. Leakage emissions

76. No leakage emissions shall be accounted.

5.6. Emission reductions

77. Annual emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y$$ Equation (23)

Where:

ER_y	=	Emissions reductions in year *y* (t CO_2e)
BE_y	=	Baseline emissions in year *y* (t CO_2e)
PE_y	=	Project emissions in year *y* (t CO_2e)

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

78. When a renewable crediting period is chosen, project participants shall use a four-step model, or equivalent, of the transportation system of the project route(s) for the purpose of modelling the modal split, $S_{P,F,y}$, $S_{P,R,y}$ and $S_{P,i,y}$ for the second and third crediting periods. The model should be tested and calibrated with the results of origin-destination surveys. For the determination of the baseline emission, the most conservative value shall be applied between estimates of baseline emissions based on the modelled parameters and the parameters determined via passenger surveys.

79. Furthermore, project participants shall apply the latest approved version of the tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period".

5.8. Data and parameters not monitored

80. 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:	$D_{R,x}$
Data unit:	km
Description:	Average trip distance travelled by passengers using the existing rail system in year *x*
Source of data:	Rail operator
Measurement procedures (if any):	Vintage maximum three years Based in general on electronic ticketing system or on surveys
Any comment:	Only rail trip distance not total trip distance Same time period required for $P_{R,x}$, $D_{R,x}$, $FC_{R,n,x}$ and EC_R for consistency reason. All baseline rail data ($P_{R,x}$, $D_{R,x}$, $FC_{R,n,x}$ and EC_R) shall be based on the rail line, which serves destinations comparable to the project HSR system. This parameter is not required, if data is available on pkm_R from the rail operator

Data / Parameter table 2.

Data / Parameter:	$P_{R,x}$
Data unit:	Passengers
Description:	Total passengers transported by the existing rail system in year *x*
Source of data:	Rail operator
Measurement procedures (if any):	Vintage maximum three years Based in general on ticketing; same period (month/year) shall be used as used for $FC_{R,x}$

Any comment:	Same time period required for $P_{R,x}$, $D_{R,x}$, $FC_{R,n,x}$ and EC_R for consistency reason. All baseline rail data ($P_{R,x}$, $D_{R,x}$, $FC_{R,n,x}$ and EC_R) shall be based on the rail line, which serves destinations comparable to the project HSR system. This parameter is not required, if data is available on pkm_R from the rail operator

Data / Parameter table 3.

Data / Parameter:	$FC_{R,n,x}$
Data unit:	Mass or volume unit
Description:	Amount of fossil fuel type *n* consumed by the existing rail system in year *x*
Source of data:	Rail operator
Measurement procedures (if any):	Vintage maximum three years
Any comment:	Same time period required for P_R, D_R, $FC_{R,x}$ and $EC_{R,x}$ for consistency reason. All baseline rail data (P_R, D_R, $FC_{R,x}$ and $EC_{R,x}$) shall be based on the rail line, which serves destinations comparable to the project HSR system

Data / Parameter table 4.

Data / Parameter:	$OC_{B,x}/OC_{C,x}/OC_{M,x}$
Data unit:	Passengers
Description:	Average occupancy rate of buses (B), passenger cars (C) and motorcycles (M) in year *x*
Source of data:	Specific studies done by the project proponent or a third party
Measurement procedures (if any):	Vintage maximum three years. Based on visual occupation studies for cars and motorcycles and on visual occupation studies or on company records for buses. The detailed procedures concerning visual occupation studies are presented in Appendix 1
Any comment:	Options in order of preference: 1. On routes as served by the project HSR system; 2. National data; 3. Default values of 2 for cars, 1.5 for motorcycles and 80 per cent of average seating capacity of average inter-urban buses

Data / Parameter table 5.

Data / Parameter:	$P_{BL,B,x}$
Data unit:	Passengers (per time period)
Description:	Number of passengers transported by buses in year *x*
Source of data:	Bus operators or studies realized by 3rd parties
Measurement procedures (if any):	Vintage maximum three years

Any comment:	Used to calculate the occupancy rate. Options in order of preference: 1. On routes as served by project HSR system; 2. National data For consistency reason, the same time period, vintage and option (as listed above) is required for the parameters $pkm_{B,x}$, $P_{BL,B,x}$ and $D_{B,x}$

Data / Parameter table 6.

Data / Parameter:	$D_{B,AVG,x}$
Data unit:	km
Description:	Average trip distance travelled by passengers of buses in year *x*
Source of data:	Bus operator based e.g. on ticket sales or specific studies done by the project proponent or a third party
Measurement procedures (if any):	Vintage maximum three years
Any comment:	Used to calculate the occupancy rate. Options in order of preference: 1. On routes as served by project HSR system; 2. National data

Data / Parameter table 7.

Data / Parameter:	$D_{B,x}$
Data unit:	km
Description:	Distance driven by buses in year *x*
Source of data:	Data from bus companies (company records)
Measurement procedures (if any):	Vintage maximum three years. 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)
Any comment:	Used for occupation rate buses. For consistency reason the same time period, vintage and option (as listed above) is required for the parameters $pkm_{B,x}$, $PBL_{B,x}$ and $D_{B,x}$

Data / Parameter table 8.

Data / Parameter:	$pkm_{R,x/B,x}$
Data unit:	Passenger-kilometer (pkm)
Description:	Passenger-kilometers travelled in the existing rail system /buses (B) in year *x*
Source of data:	Data from rail/bus companies (company records)
Measurement procedures (if any):	Vintage maximum three years
Any comment:	Used for occupancy rate of buses or for emission factor per pkm rail. For consistency reason the same time period, vintage and option (as listed above) is required for the parameters $pkm_{B,x}$, $PBL_{B,x}$ and $D_{B,x}$

Data / Parameter table 9.

Data / Parameter:	$N_{i,n,x}$
Data unit:	Units
Description:	Number of vehicles of category *i* using fuel type *n* in year *x*
Source of data:	National transport statistics based on vehicle registration statistics, company data (for buses) or surveys
Measurement procedures (if any):	Vintage maximum three years. For buses it should be based on inter-urban units as urban buses often use a different fuel type than inter-urban units
Any comment:	Used for all vehicle categories included in the project boundary

Data / Parameter table 10.

Data / Parameter:	$N_{i,x}$
Data unit:	Units
Description:	Number of vehicles of category *i* in year *x*
Source of data:	National transport statistics based on vehicle registration statistics, company data (for buses) or surveys
Measurement procedures (if any):	Vintage maximum three years. For buses it should be based on inter-urban units as urban buses often use a different fuel type than inter-urban units
Any comment:	Used for all vehicle categories included in the project boundary

Data / Parameter table 11.

Data / Parameter:	$N_{i,n,x}/N_{i,x}$
Data unit:	Percentage
Description:	Percentage of vehicles of category *i* using fuel type *n* in year *x*
Source of data:	National transport statistics based on vehicle registration statistics, company data (for buses) or surveys
Measurement procedures (if any):	Vintage maximum three years. For buses it should be based on inter-urban units as urban buses often use a different fuel type than inter-urban units
Any comment:	Used for all vehicle categories included in the project boundary

Data / Parameter table 12.

Data / Parameter:	$SFC_{i,n,x}$
Data unit:	Mass or volume units of fuel/km
Description:	Specific fuel consumption of vehicle category *i* using fuel type *n* in year *x*
Source of data:	In decreasing order of preference: Local measured data not older than five years (studies e.g. performed by universities or ordered by project proponent); National or international data from studies not older than five years; Default values for the respective vehicle categories

Measurement procedures (if any):	The following alternatives are proposed to determine specific fuel consumption (in order of preference): Alternative 1: Measurement of fuel consumption data using total fuel consumption data (if available e.g. from bus companies) Alternative 2: Measurement of fuel consumption based on a representative sample for the respective category and fuel type. To be conservative, specific fuel consumptions based on samples shall be based on the lower limit of the uncertainty band at a 95 per cent confidence level, i.e. with 95 per cent confidence the actual average fuel consumption is equal to or higher than the value used by the project. The minimum sample size required is 30 units per vehicle category and per fuel type. If based on sampling for buses these shall be used basically on routes serving the same destinations as the project rail system plans to serve Alternative 3: Use of fixed values based on the national or international literature taking the most conservative values for the same vehicle category. The following default values may be used for cars and buses, if local data is not available: SFC of cars: 170 g CO_2e/km; SFC of buses: 870 g CO_2e/km
Any comment:	-

Data / Parameter table 13.

Data / Parameter:	$EF_{CH4,i,n,y}$
Data unit:	gCH_4/MJ
Description:	Methane emission factor for vehicle category *i* using fuel type *n* in year *y*
Source of data:	National values or IPCC latest version
Measurement procedures (if any):	-
Any comment:	Used for all vehicle categories powered by gaseous fuels. For vehicle categories powered by liquid fuels methane emissions shall not be accounted for and the methane emission factor per kilometer shall be taken as zero

Data / Parameter table 14.

Data / Parameter:	GWP_{CH4}
Data unit:	gCO_2/gCH_4
Description:	Global Warming Potential of methane
Source of data:	Project participants shall update GWPs according to any decisions by the CMP. For the first commitment period GWP = 25
Measurement procedures (if any):	-
Any comment:	Used for all vehicle categories which use gaseous fuels

Data / Parameter table 15.

Data / Parameter:	$EF_{CO2,n,y}$
Data unit:	t CO_2e/MJ
Description:	Carbon emission factor for fossil fuel type n in year *y*
Source of data:	The source of data should be the following, in order of preference: project specific data, country specific data or IPCC default values. As per guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain
Measurement procedures (if any):	Data vintage maximum three years
Any comment:	Lower 95 per cent confidence level of IPCC default values shall be used to be conservative as used primarily for baseline modes

Data / Parameter table 16.

Data / Parameter:	$EF_{CO2,F,m}$
Data unit:	gCO_2e/pkm
Description:	Default CO_2 emission factor for the flight which survey respondent *m* would have undertaken in the absence of the project activity
Source of data:	See table below. Source: Estimated based on the International Civil Aviation Organization (ICAO) carbon emissions calculator 2009
Measurement procedures (if any):	-
Any comment:	-

Default emission factors for passengers travelled by air-plainsDistance range, km	Default CO_2 emission factor, gCO2e/km
0-500	140
501-1000	117
1001-2000	78
2001- +	71

Source: Estimated based on the International Civil Aviation Organization (ICAO) carbon emissions calculator 2009

Data / Parameter table 17.

Data / Parameter:	IR_i
Data unit:	-
Description:	Technology improvement factor per year for vehicle category *i*
Source of data:	-
Measurement procedures (if any):	-
Any comment:	The default technology improvement factor is 0.99 for all vehicle categories.

Data / Parameter table 18.

Data / Parameter:	$NCV_{n,x}$
Data unit:	MJ/mass or volume units of fuel
Description:	Net calorific value of fossil fuel type *n* used in year *x*
Source of data:	National or regional values (first preference) or IPCC
Measurement procedures (if any):	Data vintage maximum three years
Any comment:	Lower 95 per cent confidence level of IPCC default values shall be used to be conservative as used primarily for baseline modes Note that IPCC default values are provided in the unit of TJ/Gg. To convert from mass to volume unit, the density of the fuel should be determined in accordance with the options and relevant conditions provided in the latest approved version of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”

6. Monitoring methodology

81. 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. One hundred per cent of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards.

82. In addition, the monitoring provisions in the tools referred to in this methodology apply.

6.1. Data and parameters monitored

Data / Parameter table 19.

Data / Parameter:	$NCV_{n,y}$
Data unit:	MJ/mass or volume units of fuel
Description:	Net calorific value of fuel type n in year *y*
Source of data:	National or regional values (first preference) or IPCC
Measurement procedures (if any):	-
Monitoring frequency:	Annual if project system uses fossil fuel. Otherwise prior to validation and no monitoring required
QA/QC procedures:	Lower 95 per cent confidence level of IPCC default values to be conservative as used primarily by baseline vehicles
Any comment:	Note that IPCC default values are provided in the unit of TJ/Gg. To convert from mass to volume unit, the density of the fuel should be determined in accordance with the options and relevant conditions provided in the latest approved version of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”

Data / Parameter table 20.

Data / Parameter:	$EF_{CO2,n,y}$
Data unit:	gCO2e/MJ
Description:	CO_2 emission factor for fuel type n in year *y*
Source of data:	National or regional values (first preference) or IPCC
Measurement procedures (if any):	-
Monitoring frequency:	Annual if project system uses fossil fuel. Otherwise prior validation and no monitoring required
QA/QC procedures:	Lower 95 per cent confidence level of IPCC default values to be conservative as used primarily by baseline vehicles
Any comment:	

Data / Parameter table 21.

Data / Parameter:	P_y
Data unit:	Passengers
Description:	Total passengers transported by the project HSR system in year *y*
Source of data:	HSR rail operator
Measurement procedures (if any):	Based on ticket sales or passenger records maintained by HSR company
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 22.

Data / Parameter:	$EC_{PJ,y}$
Data unit:	MWh
Description:	Electricity consumption of the project HSR system for traction in year *y*
Source of data:	HSR operator
Measurement procedures (if any):	Based on electricity invoices or records
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 23.

Data / Parameter:	$S_{P,R,y/P,F,y//P,i,y}$
Data unit:	%
Description:	Share of project passengers who would have travelled by the existing rail system, air plane or road-based vehicle category *i* in the absence of the project activity in year *y*
Source of data:	Survey realized by a 3rd party

Measurement procedures (if any):	See Appendix 2 for survey procedures. The share of survey respondents per mode category is taken as idem to the share of total project passengers per mode category
Monitoring frequency:	Year 1 and 4 of the crediting period and re-test survey in the year 1 only
QA/QC procedures:	See Appendix 2
Any comment:	-

Data / Parameter table 24.

Data / Parameter:	$N_{P,y/ P,R,y /P,i,y/P,F,y}$
Data unit:	-
Description:	Total number of surveyed passengers total ($N_{P,y}$)/number of surveyed passengers who would have used the existing rail system in the absence of the project activity ($N_{P,R,y}$)/who would have used road-based vehicle category *i* ($N_{P,i,y}$)/who would have used airplanes ($N_{P,F,y}$) in the absence of the project activity in year *y*
Source of data:	Survey realized by 3rd party
Measurement procedures (if any):	See Appendix 2 for survey procedures
Monitoring frequency:	Year 1 and 4 of the crediting period and re-test survey in the year 1 only
QA/QC procedures:	See Appendix 2
Any comment:	Used to calculate the average distance driven on the baseline mode rail or road and the average distance driven on conventional rail in the project case for the trip origin to destination

Data / Parameter table 25.

Data / Parameter:	$D_{P,BEE,OD,m,y}$
Data unit:	km
Description:	Beeline distance between the entry and exit rail stations of surveyed passenger *m* who would have travelled by airplane in the absence of the project activity in year *y*
Source of data:	Survey realized by a 3rd party
Measurement procedures (if any):	See Appendix 2 for survey procedures
Monitoring frequency:	Year 1 and 4 of the crediting period and re-test survey in the year 1 only
QA/QC procedures:	See Appendix 2
Any comment:	Used to calculate the average trip distance travelled by passengers who would have used airplanes in the absence of the project activity

Data / Parameter table 26.

Data / Parameter:	$D_{P,F,OD,m,y}$
Data unit:	km

Description:	Flight distance between the origin airport and the destination airport of surveyed passenger *m* who would have travelled by airplane in the absence of the project activity in year *y*
Source of data:	Survey realized by a 3rd party
Measurement procedures (if any):	See Appendix 2 for survey procedures
Monitoring frequency:	Year 1 and 4 of the crediting period and re-test survey in the year 1 only
QA/QC procedures:	See Appendix 2
Any comment:	Used to calculate the average trip distance travelled by passengers who would have used airplanes in the absence of the project activity

Data / Parameter table 27.

Data / Parameter:	$D_{P,R,OD,m,y}$/$D_{P,i,m,y}$
Data unit:	km
Description:	Distance from the origin to destination of surveyed passenger *m* who would have travelled by the existing rail system/road-based vehicle category *i* (Pi) in the absence of the project activity in year *y*
Source of data:	Survey realized by a 3rd party
Measurement procedures (if any):	See Appendix 2 for survey procedures
Monitoring frequency:	Year 1 and 4 of the crediting period and re-test survey in the year 1 only
QA/QC procedures:	See Appendix 2
Any comment:	Used to calculate the average distance travelled on the rail or road baseline mode and the average distance driven on conventional rail in the project case for the trip origin to destination

Data / Parameter table 28.

Data / Parameter:	$D_{PJ,OD,m,y}$
Data unit:	km
Description:	Distance from the trip origin to project HSR system connection station (or project connection station to the trip destination station) of surveyed passenger *m* in year *y*
Source of data:	Survey realized by a 3rd party
Measurement procedures (if any):	See Appendix 2 for survey procedures. The distance is recorded for each surveyed respondent, who responded that he/she entered a station not part of the project HSR system or exited from a station not part of the project HSR system. The survey records the rail entry station (origin O) and the rail exit station (destination D). The distance is calculated based on the distance between the non-project rail station and the connection station of the project HSR system based on official rail data
Monitoring frequency:	Year 1 and 4 of the crediting period and re-test survey in the year 1 only
QA/QC procedures:	See Appendix 2

Any comment:	Used to calculate the average distance driven on non-project rail for the trip origin to destination

Appendix 1. Guideline for the establishment of load factor/occupancy rate studies for cars/motorcycles

1. The actual number of passengers 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. The procedures to establish visual occupation are:

   (a) Locations, days and times for field study are defined, avoiding days immediately after or before a holiday. A typical season (school or university vacations) should be avoided;

   (b) Field data is collected. Coverage of the occupancy counts should be higher than 95 per cent of the number of vehicles that cross the checkpoint. 100 per cent coverage is desired. To control this outcome a separate vehicle count is advised. Data can be adjusted with the actual count;

   (c) Occupation is the number of passengers using the vehicle;

   (d) The study is realized in different locations (minimum three) on the stretch between project origin and project destination. If various roads (e.g. highway plus “normal” road) can be used then locations should include different possible roads. Minimum four points need to be included;

   (e) The study should be realized at minimum during three different days including one weekend day. It is not required that each location is monitored during three days, i.e. locations can be spread over the minimum three different days;

   (f) The study should be realized from 7AM to 7PM at each location during at least 15 minutes per hour using during the entire time period the same time bracket e.g. always the first 15 minutes of each hour).

Appendix 2. Methodological design of survey

1. Technical summary data sheet of the survey

Table. Strategy and sample design in the High Speed Rail (HSR) passenger survey

Parameter	Main parameters: • Baseline emissions; • Indirect project emissions; Secondary parameters and inputs: • Proportion of passengers using each mode of transport in the absence of the project activity; • The average distance travelled by road and rail modes in the absence of the project activity; • The average distance from rail entry station to HSR connecting station and from HSR connecting station to rail exit station, if HSR is combined with other non-project rail system
Target population	Passengers over 12 years using High Speed Rail (HSR).
Sample frame	Passenger flow in all stations of HSR
Sample design	Two staged probabilistic design: • First stage: simple random sampling (SRS); • Second stage: systematic sampling based on passengers flow per station Sub stratum: Days in a week and hours
Relative error level (CV)[1]	For the survey, a global desired level of precision (relative standard error or coefficient of variation – CV) between 5% and 10% for the parameters of interest, which implies at the same time having precision levels of 90/10 is targeted. Results obtained are based on a 95% confidence level using the more conservative boundary
Coverage	Area where HSR operates
Size of Universe	Generally, in one working day HSR mobilizes around 50.000 passengers.
Sample size	The sample size is estimate at 4,000 surveys in the measuring week
Sample frequency	Once in the year 1 and 4 of the crediting period and re-test survey in the year 1 only for an entire week representative of the use of HSR around a year
Method of information collection	The information will be obtained through the face-to-face application of the established questionnaire on a random base

[1] Relative error level refers to the coefficient of variation (CV), which is calculated as the ratio between the standard deviation of the average and the population average.

2. Specific aspects of survey design

2.1. Target population

1. The target population is 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.

2.2. Sample frame

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

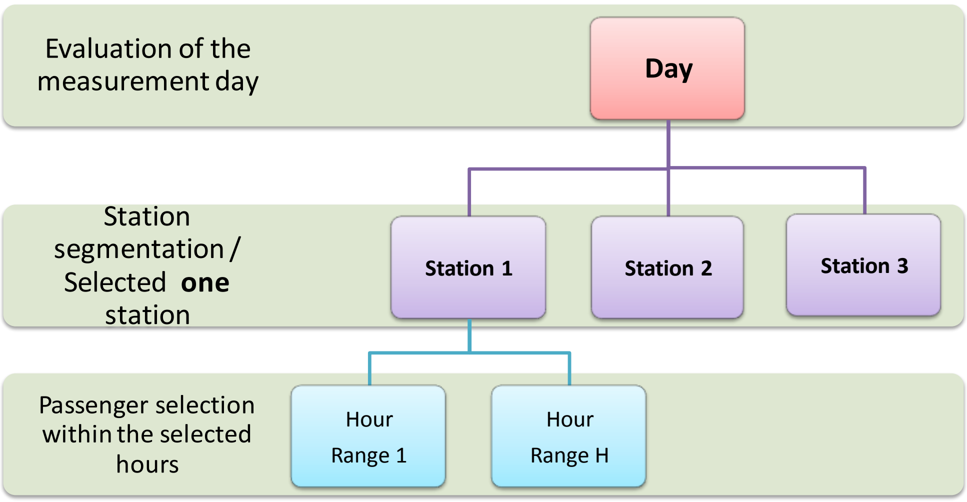
2.3. Sample design

3. A two staged probabilistic design is applied:

   (a) First stage: Simple Random Sampling (SRS);

   (b) Second stage: Systematic sampling based on average estimated number of passengers on the HSR train between each of the serviced stations.

Figure 3. Sample design



4. 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 the week, and within each day, hours ranges are arranged according to the passenger flow.

5. The sample is 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 carried out selecting a station per day guaranteeing that during the evaluation week the possibility for all stations to be visited is created.

2.4. Relative error level

6. 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 implies at the same time having precision levels of 90/10.

7. It is considered that the result of an estimate is:

   (a) Statistically robust if its coefficient of variation is less than 5%;

   (b) Practical acceptable if its coefficient of variation is between 5% and 10%;

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

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

8. For the results obtained a 95% confidence level is calculated taking the (conservative) lower boundary for baseline emissions. The parameters determined in the survey are thus quantified at the 95% confidence level.

2.5. Geographical coverage

9. The geographical coverage is the area in which the HSR operates (project boundary).

10. For the calculation of the sample size, a global desired level of precision (relative standard error or coefficient of variation – CV) between 5% and 10% for the parameters of interest, which 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% was determined.

11. 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 equation of the estimator variance according to the design used in each case.

$$CV = \left(\frac{\sqrt{V(\hat{t}_y)}}{\hat{t}_y} \right) \cdot 100 \qquad \text{Equation (1)}$$

12. 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.

13. The stratification structure complies with the principles of independence and invariance, reason for which in the equation for the CV of this study, the estimated variance of the estimator results from adding those obtained in each stratum.

2.6. Selection method of the sample

14. HSR train segments, hours and passengers shall be selected for the sample. The selection method guarantees a random and non-biased selection process especially important in face-to-face interviews. The random distribution allows that the sample mirrors the total population in any other non-observed variables such as age, gender, religion, personal preferences, etc.

2.7. Selection of passengers

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

(a) A random starting point is generated according to the statistics tables of uniform distribution between 1 and the average number of passengers in the evaluation hour and segment of the HSR train;

(b) Systematic selection of passengers: every n passenger on the HSR train, starting with the random number. In this way, if the random number is 20, the first passenger selected is the 20th passenger on the HSR train walking from the front to the rear of the train. 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.

2.8. Methodology for information collection and estimation of the parameter

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

17. 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.

18. 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.

2.9. Survey realization

19. The survey shall be realized through a company with minimum 3 years of experience in comparable surveys in the respective country to ensure a professional survey execution. Following principles are to be followed in the survey realization:

(a) Non-responses should be recorded;

(b) Record and store all original surveys;

(c) Surveys are conducted on the HSR train;

(d) 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.

20. 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 shall 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.

3. Passenger survey

SECTION A: Data concerning surveyor

Survey ID (correlative number): …………………………….

Interviewer:……………………………

Date:.………………………………….

Time:…………………………………….

Stretch where interview was performed: Between station: ………………and station: …………

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

SECTION C: Trip data of interviewed person

Question 1

On which rail station did you start your trip? …………………………….

Explanations for the interviewer:

- *The question refers to the current trip the passenger is making.*
- *The rail station where the person started his trip is not necessarily a station of HSR line as the passenger might first have used another train and then connected to HSR line.*

Question 2

On which rail station will you end your trip? ……………………………

Explanations for the interviewer:

- *The question refers to the current trip the passenger is making.*
- *The rail station where the person ends his trip is not necessarily a station of HSR line as the passenger might use another train after HSR line to reach his final destination.*

Question 3

What mode of transport would you have used in the absence of the HSR line?

Tick 1:

☐ Bus ☐ Normal Train (not HSR train) ☐ Car ☐ Plane ☐ Other

☐ Would not have made the trip, i.e. I would have stayed at home if there were no HSR line

3.1 If answer is plane, in which airport you would have started and ended your trip.

Origin airport:………………………….

Destination airport: ……………………….

Explanations for the interviewer:

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

Question 4

"Have you moved your home or workplace since the start of operations of the HSR?"

☐ No ➔ survey finished

☐ Yes: ➔ go to 4.1.

4.1 “Has the availability of the new HSR been an important factor when choosing the location of your new home or new workplace?”

☐ No ➔ survey finished

☐ Yes ➔ go to 4.2.

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

Origin point:…………………………

Destination point: ………………………

Mode used to travel between origin and destination:

☐ Bus ☐ Normal Train (not HSR) ☐ Car ☐ Plane ☐ Other

Remarks:

a. If 4 or 4.1 are responded with “no” then BE are calculated based on questions 1, 2 and 3.

b. If 4 and 4.1 are responded with “yes” then, as a conservative approach, baseline emissions from these passengers are accounted for as zero emissions.

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Document information

Version	*Date*	*Description*
02.0	24 July 2015	EB 85, Annex 9 Revision to: • Improve the approaches on additionality demonstration; • Improve the guidance on the renewal of the crediting period; • Improve the language, readability, clarity and consistency.
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