Joint Crediting Mechanism Approved Methodology ID_AM026
"Introduction of CNG-Diesel Hybrid Equipment to Public Buses"

A. Title of the methodology

Introduction of CNG-Diesel Hybrid Equipment to Public Buses, Version 01.0

B. Terms and definitions

Terms	Definitions
CNG-diesel hybrid equipment	Equipment (i.e. CNG fuel tank, fuel pressure regulator, fuel injector) which enables diesel engines to combust diesel fuel and CNG at the same time

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	Introduction of CNG-diesel hybrid equipment to public buses with diesel engines enables to replace diesel fuel with CNG, and also enables to improve fuel efficiency of buses, which lead to GHG emission reductions.
Calculation of reference emissions	Reference emissions are emissions from buses without CNG-diesel hybrid equipment which consume diesel fuel only. They are calculated with CNG and diesel fuel consumption by project buses, net calorific value of CNG and diesel fuel, CO_2 emission factor of diesel fuel, and fuel efficiency of project bus and reference bus.
Calculation of project emissions	Project emissions are emissions from buses with CNG-diesel hybrid equipment which consume both CNG and diesel fuel. They are calculated with CNG and diesel fuel consumption by project buses, net calorific value of CNG and diesel fuel, and CO_2 emission factor of CNG and diesel fuel. Project emissions from fuel consumption by project fuel trucks to carry CNG from the supplier of CNG to the CNG stations

	are excluded from project emissions since the emissions from fuel trucks to carry diesel fuel in reference scenario are considered to be the same as the ones for CNG in project scenario.
Monitoring parameters	・ CNG consumption by project buses ・ Diesel fuel consumption by project buses ・ Drive distance of project buses

D. Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

Criterion 1	CNG-diesel hybrid equipment is newly installed to the public transport buses which have already been in operation or are newly procured.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Diesel fuel consumption by reference buses	CO_2
Project emissions	
Emission sources	GHG types
Diesel fuel consumption by project buses	CO_2
CNG consumption by project buses	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

Reference emissions are calculated with CNG consumption and diesel fuel consumption by project buses, net calorific value of CNG and diesel fuel, CO_2 emission factor of diesel fuel, and fuel efficiency of project bus and reference bus.

Fuel efficiency of project bus is determined *ex-post* based on monitored data, which reflect actual fuel efficiency. On the other hand, fuel efficiency of reference bus is determined *ex-ante* from the following three options in a conservative manner to ensure net emission reductions:

[Option 1]
Daily data sets of drive distance and diesel fuel consumption of bus *i* are collected prior to installation of CNG-diesel hybrid equipment. The highest value (the most efficient value) from the measured data sets for at least 60 days is selected and determined as fuel efficiency of reference bus *i*.

[Option 2]
A catalogue value of fuel efficiency of bus *i* which is converted from mono diesel fuel combustion to CNG-diesel hybrid combustion in the project is determined as fuel efficiency of reference bus *i*.
A catalogue value usually shows better fuel efficiency than the one which is calculated for the bus being operated. Therefore, setting a default value of fuel efficiency of reference bus based on the catalogue values is conservative.

[Option 3]
The default value set in this methodology is applied as fuel efficiency of reference bus *i*.
The default values are determined from the most recent catalogue values of public buses manufactured by Japanese manufacturers, which usually show better fuel efficiency than the ones which are calculated for the bus being operated, hence conservative.

F.2. Calculation of reference emissions

$$RE_p = \sum_i \left\{ \left[\left(FC_{PJ,CNG,i,p} \times NCV_{CNG} \right) + \left(FC_{PJ,diesel,i,p} \times NCV_{diesel} \right) \right] \times \frac{\eta_{PJ,i,p}}{\eta_{RE,i}} \right\} \times EF_{diesel}$$

Where

RE_p	Reference emissions during the period *p* [tCO_2/p]
$FC_{PJ,CNG,i,p}$	CNG consumption by project bus *i* during the period *p* [t/p]*
NCV_{CNG}	Net calorific value of CNG [GJ/t]
$FC_{PJ,diesel,i,p}$	Diesel fuel consumption by project bus *i* during the period *p* [kl/p]
NCV_{diesel}	Net calorific value of diesel fuel [GJ/kl]
$\eta_{PJ,i,p}$	Fuel efficiency of project bus *i* during the period *p* [km/l]
$\eta_{RE,i}$	Fuel efficiency of reference bus *i* [km/l]
EF_{diesel}	CO_2 emission factor of diesel fuel [tCO_2/GJ]
i	Identification number of project buses

*When CNG consumption by project bus is monitored in units of LSP (Litter Setara Premium), the value is converted in units of tonne [t] with the equation below.
CNG consumption [t] = CNG consumption [LSP] × 0.7218 × 10^{-3}
[Source] Ministry of Energy and Mineral Resources

Fuel efficiency of project bus *i* during the period *p* ($\eta_{PJ,i,p}$) is calculated with the following equation.

$$\eta_{PJ,i,p} = \frac{TD_{PJ,i,p}}{HFC_{PJ,diesel,i,p} \times 10^3}$$

$$HFC_{PJ,diesel,i,p} = \sum_i FC_{PJ,CNG,i,p} \times NCV_{CNG} \div NCV_{diesel} + \sum_i FC_{PJ,diesel,i,p}$$

Where

$\eta_{PJ,i,p}$	Fuel efficiency of project bus *i* during the period *p* [km/l]
$TD_{PJ,i,p}$	Total drive distance of project bus *i* during the period *p* [km/p]
$HFC_{PJ,diesel,i,p}$	Hypothetical total diesel fuel consumption by project bus *i* during the period *p* [kl/p]
$FC_{PJ,CNG,i,p}$	CNG consumption by project bus *i* during the period *p* [t/p]
NCV_{CNG}	Net calorific value of CNG [GJ/t]
NCV_{diesel}	Net calorific value of diesel fuel [GJ/kl]
$FC_{PJ,diesel,i,p}$	Diesel fuel consumption by project bus *i* during the period *p* [kl/p]
i	Identification number of project buses

G. Calculation of project emissions

$$PE_p = PE_{CNG,p} + PE_{diesel,p}$$

$$PE_{CNG,p} = \sum_i \left(FC_{PJ,CNG,i,p} \times NCV_{CNG} \times EF_{CNG}\right)$$

$$PE_{diesel,p} = \sum_i \left(FC_{PJ,diesel,i,p} \times NCV_{diesel} \times EF_{diesel}\right)$$

Where

PE_p	Project emissions during the period *p* [tCO_2/p]
$PE_{CNG,p}$	Project emissions from CNG consumption by project buses during the period *p* [tCO_2/p]

$PE_{diesel,p}$	Project emissions from diesel fuel consumption by project buses during the period p [tCO_2/p]
$FC_{PJ,CNG,i,p}$	CNG consumption by project bus i during the period p [t/p]
NCV_{CNG}	Net calorific value of CNG [GJ/t]
EF_{CNG}	CO_2 emission factor of CNG [tCO_2/GJ]
$FC_{PJ,diesel,i,p}$	Diesel fuel consumption by project bus i during the period p [kl/p]
NCV_{diesel}	Net calorific value of diesel fuel [GJ/kl]
EF_{diesel}	CO_2 emission factor of diesel fuel [tCO_2/GJ]
i	Identification number of project buses

H. Calculation of emissions reductions

$$ER_p = RE_p - PE_p$$

Where

ER_p	Emission reductions during the period p [tCO_2/p]
RE_p	Reference emissions during the period p [tCO_2/p]
PE_p	Project emissions during the period p [tCO_2/p]

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
NCV_{CNG}	Net calorific value of CNG [GJ/t]	In the order of preference: a) value provided by fuel supplier; b) value measured by the project participants; c) regional or national default value; or d) IPCC default value provided in table 1.2 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Lower value is applied.

NCV_{diesel}	Net calorific value of diesel fuel [GJ/kl]	In the order of preference: a) value provided by fuel supplier; b) value measured by the project participants; c) regional or national default value; or d) IPCC default value provided in table 1.2 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Lower value is applied.
EF_{CNG}	CO_2 emission factor of CNG [tCO_2/GJ]	In the order of preference: a) value provided by fuel supplier; b) value measured by the project participants; c) regional or national default value; or d) IPCC default value provided in table 3.2.1 of Ch.3 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Higher value is applied.
EF_{diesel}	CO_2 emission factor of diesel fuel [tCO_2/GJ]	In the order of preference: a) value provided by fuel supplier; b) value measured by the project participants; c) regional or national default value; or d) IPCC default value provided in table 3.2.1 of Ch.3 Vol.2 of 2006 IPCC Guidelines on National GHG

		Inventories. Lower value is applied.
$\eta_{RE,i}$	Fuel efficiency of reference bus *i* [km/l] Fuel efficiency of reference bus is determined *ex-ante* in the following manner. [Option 1] Fuel efficiency of reference bus *i* is determined based on measured data of bus *i* prior to installation of CNG-diesel hybrid equipment. Daily data sets of drive distance and diesel fuel consumption of bus *i* are collected prior to installation of CNG-diesel hybrid equipment for at least 60 days. The highest value (the most efficient value) from the measured data sets is selected and determined as fuel efficiency of reference bus *i*. [Option 2] Catalogue value of fuel efficiency of bus *i* which is converted from mono diesel fuel combustion to CNG-diesel hybrid combustion in the project is determined as fuel efficiency of reference bus *i.* [Option 3] The default value in the following table in line with the total displacement is applied as fuel efficiency of reference bus *i*. ("x" in the table represents the total displacement of project bus *i*)	[Option 1] Measured data. [Option 2] Catalogue values of fuel efficiency provided by bus manufacturer. [Option 3] The catalogues of public buses manufactured by Japanese manufacturers. The default value is revised if deemed necessary by the JC.

	Total displacement	x < 5.2L (5,200cc)	5.2L (5,200cc) ≤ x	
	$\eta_{RE,i}$	6.5	4.7	

History of the document

Version	Date	Contents revised
01.0	23 December 2020	Electronic decision by the Joint Committee Initial approval.