T-VER-P-METH-04-02

Replacement of Internal Combustion Engine Buses with Electric Buses for Public Passenger Transportation

Version 01

Scope: 07 - Transportation

Entry into force on 22 June 2024

1. Methodology	Replacement of Internal Combustion Engine Buses with Electric Buses for Public Passenger Transportation
2. Project Type	Use of electric vehicle
3. Scope	07 - Transportation
4. Project Outline	Project activity is aimed to provide battery electric vehicle (BEV) for passenger transport service (excluding rail transport systems) replacing the use of buses with internal combustion engines. The BEV electric buses for passenger transport must comply with the laws of the Department of Land Transport (Land Transport Act).
5. Applicability	Project activity is the use of BEV electric buses in the form of the purchase or hire purchase or leasing for passenger transportation. It includes the modification of internal combustion engine buses (ICE buses). The BEV electric buses must operate under the original service route, including the original route that has been revised to be suitable for the use of electric buses.
6. Project Conditions	1) The BEV electric buses are used for passenger transportation only. The BEV electric buses are public buses in accordance with the laws of the Department of Land Transport and carry out transportation activities according to the definition of the Department of Land Transport. 2) ICE Buses (baseline) and BEV electric buses (project activity) must be the same type and have a maximum load capacity or engine power (horsepower) that is not more than 10 percent difference compared to ICE buses. In the case of baseline buses equipped with air conditioners. The BEV buses must be equipped with air conditioners as well. 3) Conditions for service routes are as follows: 3.1) In the case of the original service route, the project owner or project developer must present documentary evidence of permission from the Department of Land Transport. 3.2) In the case of the revised service route, it must be approved by the Department of Land Transport. The project owner or project developer must provide evidence of permission from the Department of Land Transport before starting the project. In this regard, the project developer must have a valid operating license on the service route for BEV electric buses that covers the crediting period of the project.

	4) In case of project activity, the daily service distance per vehicle or the total daily service distance must be different with no more than 10 percent compared to the baseline route. 5) The BEV electric buses must be monitored the electricity consumption for charging and the travel distance. 6) The charging stations for BEV electric bus powered by renewable energy can be carried out. The electricity produced from renewable energy must not be supplied to other equipment. 7) Project owners or project developers must demonstrate the management guidelines for damaged or end-of-life batteries equipped to BEV electric buses. 8) ICE Buses (baseline) must not be used for other activities. The project owner or project developer must present evidence of cancellation of the baseline bus use to the Department of Land Transport and show documents confirming the management for the baseline bus wreck in accordance with relevant regulations. It excepts in the case of ICE buses that are converted to electric buses (EV Conversion).
7. Project Starting Date	The date of project owner date (Buyer/renter) and seller or lessor has jointly signed a contract for the purchase or hire purchase or leasing of battery electric vehicles for project activity that will be developed to T-VER project.
8. Definition	**Battery Electric Vehicle (BEV)** means a bus that uses only an electric motor to drive using energy from an electric battery. **Service route** means a bus service route for bus passenger transport that has been permitted by the Department of Land Transport. **Bus operating license** means the duration of the concession to provide bus passenger transport services on routes approved by the Department of Land Transport. **Renewable energy** means a type of renewable energy. It is an energy source that can be unlimited and replenished such as sunlight, wind, water, and biomass, etc. **Bus** means a vehicle for passenger transport in accordance with the Land Transport Act B.E. 2522 of the Department of Land Transport.
9. Note:	

Details of T-VER Methodology for
Replacement of Internal Combustion Engine Buses with Electric Buses for Public Passenger Transportation

1. Greenhouse gas emission reduction activities used in the calculations

Table 1. Sources and types of greenhouse gases

Greenhouse gas emission	Source	Types of greenhouse gas	Details of activities that emit greenhouse gas emissions
Baseline Emission	Using of fossil fuels	CO_2	The use of fossil fuels from ICE buses
Project Emission	Using electricity	CO_2	Using electricity from BEV electric buses
Leakage	Not relevant	-	-

2. Applicability and Scope of Project

Project activities must have the objective of providing BEV electric bus service for bus passenger transportation (excluding rail transport systems) to replace the use of buses that use internal combustion engines

3. Additionality

The project activity must be proven the additionality using “Guidelines to Additionality Demonstration under the Thailand Voluntary Emission Reduction Program: T-VER” published by the TGO. In addition, project owners or project developers applying BEV electric buses gaining subsidies of electric vehicle promotion from government agencies must create guidelines to prove additional financial operations including amount of all direct and indirect support, such as direct subsidies and various tax deductions, etc.

4. Baseline Scenario

Referring to the guidelines for determining the baseline scenario with the concept of Below Business as Usual or Below BAU, the baseline emissions from the use of natural gas in ICE buses replaced by electricity from the national grid of BEV electric buses has been considered. Therefore, the baseline data is the greenhouse gas emissions from the use of natural gas combustion in ICE buses.

5. Baseline Emissions

Baseline emissions consider only carbon dioxide (CO_2) emissions from the use of natural gas as fuel for buses using internal combustion engines, calculated from passenger transport volume or distance traveled by BEV electric buses.

Baseline emissions can be calculated in 2 methods:

5.1 Method 1: Baseline emissions from distance from bus service

Baseline emissions from distance from bus service can be calculated as follows:

$$BE_y = \sum_i \left(EF_{KM,BL,i,y} \times \sum_k TD_{k.i,y}\right) \quad \textbf{Equation (1)}$$

Where:

BE_y	=	Baseline emissions in year y (tCO_2e/year)
$EF_{KM,BL,i,y}$	=	Emission factor from baseline buses on route i in year y (tCO_2/km)
$TD_{k.i,y}$	=	Distance from service of the original route or the original route that has been permitted to be improved from the project implementation of baseline buses k on route i in year y (km)
i	=	Service route
k	=	The vehicle of the bus

5.1.1 Emission factor from baseline buses

Emission factor from baseline buses is calculated as follows:

$$EF_{KM,BL,i,y} = SFC_{BL,i,y} \times NCV_{BL,i} \times EF_{CO2,NG} \times IR^t \quad \textbf{Equation (2)}$$

Where:

$EF_{KM,BL,i,y}$	=	Emission factor from baseline buses on route i in year y (tCO_2/km)

$SFC_{BL,i,y}$ = Specific fuel consumption of baseline bus of route i in year y (unit/km)

$NCV_{BL,i}$ = Net calorific value of baseline fuel type i

$EF_{CO2,NG}$ = CO_2 emission factor from the combustion of natural gas equal to 56,100 tCO_2/GJ

IR^t = Technology improvement factor for baseline vehicle in year t.

t = Constant value for annual performance improvement. Starting from the day the project was started.

5.1.2 Specific fuel consumption of baseline bus

The specific fuel consumption of baseline bus has two options as follows:

Option 1 : In the case of continuous activities and specific bus operating data measurement such as buses that use the same route and have comparable operating conditions, etc. The $SFC_{BL,i,y}$ values used are the lowest values obtained from the following two calculation methods.

(1) Average bus operation data for at least 1 year.

(2) Fuel efficiency from the manufacturer is conservative.

Option 2 : The specific bus operating conditions cannot be determined or there is no operational information. The used data from a group of buses that have comparable operating conditions and are statistically significant such as age of buses, traffic conditions, number of passengers and installing air conditioners, etc., or from searching for information from relevant agencies. You can arrange the importance of the data sets as follows.

(1) The route of the same company operating simultaneously with the project implementation

(2) Routes of other companies that have comparable operations and are operating simultaneously with the project

(3) Country statistics

(4) Values given by IPCC or data from foreign countries

However, in the case where project activities change the service route after project registration by more than 10 percent, the project developer must consider according to the criteria for changes in operations after registration (Revalidation) specified in the guidelines for developing voluntary greenhouse gas reduction projects according to Premium T-VER. The latest edition of the TGO and the new SFC value must be considered.

5.2 Method 2: Baseline emissions from passenger volume.

Baseline emissions from passenger volume are calculated as follows:

$$BE_y = \sum_i \sum_k BEF_{BL,k,i} \left(\sum_j (P_{j,k,i,y} \times dp_{j,k,i,y}) + PKM_{k,i,y} \right) \quad \text{Equation (3)}$$

Where:

BE_y = Baseline Emissions in year y (tCO_2/year)

$P_{j,k,i,y}$ = Total passenger volume for service distance j in buses k on route i from the project implementation in year y (passengers)

$BEF_{BL,k,i}$ = Baseline emission factor per passenger-kilometre for the baseline bus k on route i (tCO_2/passenger-km)

$dp_{j,k.i,y}$ = Average distance from service j in bus k on route i from project implementation in year y

$PKM_{k,i,y}$ = Passenger-kilometer volume obtained from data collected from direct passenger on and off bus-stops records of bus k on route i from the project activity in year y.

j = Distance of service in each fare collection period

k = The vehicle of the bus

i = Service route

5.2.1 Baseline emission factor per passenger-kilometre for the baseline

$$BEF_{BL,k,i} = \frac{D_{BL,k,i} \times SFC_{BL,k,i} \times NCV_{BL,i} \times EF_{CO2,NG}}{P_{BL,k,i} \times dp_{BL,k,i}} \quad \text{Equation (4)}$$

Where:

$BEF_{BL,k,i}$ = Baseline emission factor per passenger-kilometre for the baseline bus k on route i (tCO_2/passenger-km)

$P_{BL,k,i}$ = Total passenger per year in baseline bus k on route i (passengers)

$dp_{BL,k,i}$ = Average annual distance of baseline bus k on route i (km)

$D_{BL,k,i}$ = Total distance per year of baseline bus k on route i (km)

$SFC_{BL,k,i}$ = Specific fuel consumption of baseline bus k on route i (unit/km)

$NCV_{BL,i}$ = Net calorific value of baseline fuel type i (GJ/unit)

$EF_{CO2,NG}$ = CO_2 emission factor from the combustion of natural gas equal to 56,100 tCO_2/GJ

Note: The selection of data for calculating $BEF_{BL,k,i}$ must be within the same period of not less than a year and no more than three years from the project starting date.

5.2.2 Calculation of specific fuel consumption of buses

Calculation of specific fuel consumption of buses is detailed in section 5.1.2.

6. Project Emission

Project emission considers carbon dioxide (CO_2) emission from the use of electricity supplied from the national grid for charging the BEV electric buses.

Project emissions are calculated as follows:

$$PE_y = \sum_i \sum_k EC_{PJ,k,i,y} \times EF_{Elec,y} \times 10^{-3} \qquad \textbf{Equation (5)}$$

Where:

PE_y = Project emissions in year y (tCO_2/year)

$EC_{PJ,k,i,y}$ = Net electricity consumption for charging BEV electric buses k on route i from project activity in year y (kWh/year)

$EF_{Elec,y}$ = Emission factor for electricity generation/consumption in year y (tCO_2/MWh)

i = Service route

k = The vehicle of the BEV electric bus

Note: If the project includes charging BEV electric buses produced from renewable energy, take the amount of electricity from the electrical network and subtract the amount of electricity from renewable energy. The amount of electricity from such renewable energy must be measurable.

7. Leakage Emissions

There are no operations involved.

8. Emission Reductions

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \text{Equation (6)}$$

Where:

ER_y = Emission reductions in year y (tCO_2e/year)

BE_y = Baseline Emissions in year y (tCO_2e/year)

PE_y = Project Emissions in year y (tCO_2e/year)

LE_y = Leakage emissions in year y (tCO_2e/year)

9. Monitoring Plan

9.1 Measurement Procedures

1) The project developer explains and specifies the steps for monitoring the project activity data (Activity data) or verifying all measurement results in the project proposal document. including the type of measuring instruments used Person responsible for monitoring results and verifying information Calibration of measuring instruments (if any) and procedures for warranty and quality control Where methods have different options, such as using default values or on-site measurements The project developer must specify which option to use. **In addition, the installation, maintenance, and calibration of measuring instruments should be carried out in accordance with the instructions of the equipment manufacturer and in accordance with national standards, or international standards such as IEC and ISO.**

2) All data collected as part of the greenhouse gas reduction monitoring. The data should be stored in electronic file format and the retention period is in accordance with the guidelines set by the Administrative Organization or the organization's quality system, but the period of time is not less than that specified by the TGO. Must follow the follow-up methods specified in the follow-up parameters specified in Table 9.3.

9.2 Data and parameters not monitored

Data / Parameter:	$NCV_{BL,i}$
Data unit:	GJ/unit
Description:	Net calorific value of baseline fuel type i
Source of data:	**Option 1** Net calorific value of fossil fuels specified in the invoice from the fuel supplier **Option 2** Direct measurement **Option 3** Report on Thailand's energy statistics such as Department of Alternative Energy Development and Energy Efficiency Ministry of Energy **Option 4** Reference values obtained from IPCC Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories

Data / Parameter:	$EF_{CO2,NG}$
Data unit:	tCO_2/GJ
Description:	CO_2 emission factor from the combustion of natural gas fuel
Source of data:	Use a value of 56,100 tCO_2/GJ (Refer to Table 1.4 2006 IPCC Guidelines for National GHG Inventories)

Data / Parameter:	IR^t
Data unit:	-
Description:	Technology improvement factor for baseline vehicle in year t.
Source of data:	The default value of the technology improvement factor for all baseline vehicle categories is 0.99

Data / Parameter:	$SFC_{BL,i,y}$
Data unit:	unit/km
Description:	Specific fuel consumption of baseline bus of route i in year y
Source of data:	Fuel consumption report

Data / Parameter:	$SFC_{BL,k,i}$
Data unit:	unit/km
Description:	Specific fuel consumption of baseline vehicle k and route i
Source of data:	Fuel consumption report

Data / Parameter:	$D_{BL,k,i}$
Data unit:	km
Description:	Total distance per year of baseline bus k on route i
Source of data:	Document showing bus service routes

9.3 Data and parameters monitored

Data / Parameter:	$EC_{PJ,k,i,y}$
Data unit:	kWh/year
Description:	Net electricity consumption for charging BEV electric buses k on route i from project implementation in year y (Electricity from national grid minus electricity from renewable energy)
Source of data:	1) Values from electricity records from national grid 2) Values from electricity records from renewable energy
Measurement Procedures:	There are 3 methods for following up: 1) Method 1: Record data from the bus electricity recording system. 2) Method 2: Record data from the project owner's electrical charging system. 3) Method 3: Receipt from the public electric charging system. However, the electricity meter must be able to clearly indicate electricity usage for BEV electric buses under the project activity without sharing electricity with other electrical equipment and the meters must be calibrated according to standards as shown in section 9.1. In addition, recording data from evidence showing the amount of electricity used by BEV electric buses must be reported, monthly.
Monitoring frequency:	Continuous monitoring and monthly recording at least
Note:	For projects that include charging BEV electric buses produced from renewable energy and want to subtract the amount of electricity from renewable energy with the amount of electricity from national grid. The amount of electricity from renewable energy used for such deductions must be measurable.

Data / Parameter:	$EF_{Elec,y}$
Data unit:	tCO_2/MWh
Description:	Emission factor for electricity generation/consumption in year y
Source of data:	Report on greenhouse gas emissions (Emission Factor) from electricity production in national grid and from heat production for greenhouse gas reduction projects and activities announced by the TGO.
Measurement Procedures:	**For preparing project proposal documents** Use the latest $EF_{grid,y}$ value published by the TGO. **For carbon credit issuance** Use the $EF_{Elec,y}$ values announced by TGO according to the year of the carbon credit issuance. However, in the case that the year of the carbon credit issuance does not have $EF_{Elec,y}$ values published by TGO, use the latest $EF_{Elec,y}$ values published by TGO in that year instead.

Data / Parameter:	$TD_{k,i,y}$
Data unit:	km
Description:	Distance from service of the original route or the original route that has been permitted to be improved from the project implementation of baseline bus k on route i in year y.
Source of data:	Documents showing service routes of public passenger transport systems

Measurement Procedures:	Summary of annual travel distance information (round-trip) of service routes
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	$P_{BL,k,i}$
Data unit:	passengers
Description:	Total passenger per year in baseline bus k on route i
Source of data:	Passenger recording report which data set must be within the same period of not less than 1 year and not more than 3 years from the project start date.
Measurement Procedures:	Record information from ticket
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	$P_{j,k,i,y}$
Data unit:	passengers
Description:	Total passenger volume for service distance j in buses k on route i from the project activity in year y
Source of data:	Passenger volume recording report
Measurement Procedures:	Record information from ticket
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	$dp_{BL,k,i}$
Data unit:	km
Description:	Average annual distance of baseline bus k on route i
Source of data:	Document showing bus service routes
Measurement Procedures:	Summary of annual running distance information (round-trip) of service routes
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	$dp_{j,k,i,y}$
Data unit:	km
Description:	Average distance from service j in bus k on route i from project implementation in year y
Source of data:	Document showing service routes of public passenger transport systems
Measurement Procedures:	Summary of annual running distance information (round-trip) of service routes
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	$PKM_{k,i,y}$
Data unit:	km
Description:	Passenger-kilometer volume obtained from data collected from direct passenger on and off bus-stops records of bus k on route i from the project activity in year y.
Source of data:	Record the boarding and landing of passengers

Measurement Procedures:	Summary of annual passenger on and off bus-stops information
Monitoring frequency:	Continuous monitoring and monthly recording at least

10 Reference documents

Clean Development Mechanism (CDM)

1) AMS-III.S : Small-scale Methodology: Introduction of low-emission vehicles/technologies to commercial vehicle fleets Version 04.0
2) AMS-III.C : Small-scale Methodology: Emission reductions by electric and hybrid vehicles Version 15.0
3) AMS-III.AY : Small-scale Methodology : Introduction of LNG buses to existing and new bus routes

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01	-	22 June 2024	Initial adoption.