METHODOLOGY FOR IMPROVED EFFICIENCY OF FLEET VEHICLES AND COMBUSTION ENGINES

Revision of CDM Methodology AMS-III.BC.

Prepared by dynaCERT

Title	Methodology for Improved Efficiency of Fleet Vehicles and Combustion Engines
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Relationship to Approved or Pending Methodologies

Approved and pending methodologies under the VCS Program and approved GHG programs that fall under the same combination of sectoral scopes, were reviewed to determine whether an existing methodology could be reasonably revised to meet the objective of this proposed methodology. 13 methodologies were identified and are set out in Table 1.

Table 1: Similar methodologies

Methodology	Title	GHG Program	Comments
AM0031	Baseline Methodology for Bus Rapid Transit Projects	CDM	The methodology is for public transit activities including mode switch and thus not compatible with proposed new methodology. Thus, the procedure for baseline determination is completely different.
ACM0016	Baseline Methodology for Mass Rapid Transit Projects	CDM	The methodology is for public transit activities including mode switch and thus not compatible with proposed new methodology. Thus, the procedure for baseline determination is completely different.
AM0090	Emission reductions by electric and hybrid vehicles	CDM	The methodology is for switching from fossil to electric or hybrid vehicles and not for efficiency gains. Thus, the procedure for baseline determination is completely different.
AMS-III.S	Introduction of low emission vehicles/technologies to commercial vehicle fleets	CDM	The methodology is for fixed route vehicles, only for small scale projects and not for machinery. The procedure for the determination of the baseline and projected emissions is thus different from the proposed baseline scenario.
AMS-III.T	Plant oil production and use for transport applications	CDM	The methodology is for the production of biofuel and thus different.
AMS-III.U	Cable Cars for Mass Rapid Transit Systems (MRTS)	CDM	The methodology is for the establishment of cable car-based mass transit systems and thus a different area than the proposed methodology. Thus, the procedure for baseline determination is completely different
AMS-III.AA	Transportation energy efficiency activities using retrofit technologies	CDM	The methodology is for passenger vehicles and single type measures. The determination of the baseline procedure and emissions calculations are different.

AMS-III.AP	Transport energy efficiency activities using post-fit idling stop device	CDM	The methodology is for use in one type of device and for passenger transport.
AMS-III.AQ	Introduction of Bio-CNG in transportation applications	CDM	The methodology is for the introduction of Bio-CNG in transportation applications and thus a different area from this methodology.
AMS-III.BC	Emissions reductions through improved efficiency of vehicle fleets	CDM	This methodology is the basis of the current methodology but does not include the revision to include technology improvements that improve combustion efficiency in engines with out improving efficiency of engines and does not include mobile machinery.
AMS-III.AT	Transport energy efficiency activities installing digital tachograph systems to commercial freight transport fleets	CDM	The methodology is applicable to one type of device only. The baseline determination is different.
VM0019	Fuel switch from gasoline to ethanol in flex-fuel vehicles.	VCS	This methodology calculates the GHG emissions reductions from substituting ethanol in place of gasoline or gasoline blends in commercial fleets of flex-fuel vehicles. The proposed methodology does not include ethanol fuel switch.
VMR0004	Revision to AMS-III.BC to include Mobile Machinery v1.03	VCS	The methodology is for project activities that improve the efficiency of vehicle fleets resulting in reduced fuel usage and greenhouse gas emissions. This revision is to include mobile machinery but does not incorporate revisions proposed in the proposed methodology.

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1 SOURCES

This methodology is based on AMS-III.BC.: Emission reductions through improved efficiency of vehicle fleets (version 2.0) and VMR0004 Revision to AMS-III.BC to include Mobile Machinery (version 1.03).

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

Additionality and Crediting Method	
Additionality	Project Method
Crediting Baseline	Project Method

This methodology applies to project activities that improve efficiency of vehicle fleets and mobile machinery (e.g. fleets of trucks, buses, cars, taxis or motorized tricycles, excavators, cranes), resulting in reduced fuel usage and GHG emissions. This methodology is globally applicable. It is not applicable to fuel switch activities and measures that improve the system efficiency of the fleet such as changes of operational procedures.

The methodology is based on the CDM methodology *AMS-III.BC. Emission reductions through improved efficiency of vehicle fleets* and approved VCS Methodology Revision VMR0004 that included mobile machinery.

This methodology includes these further revisions:

- Inclusion of activities that improve combustion efficiency; and
- Inclusion of a telematics system for monitoring fuel usage, odometer distance and operational time of the engine, to record changes in engine performance in real time.

3 DEFINITIONS

Activity level
The index used to determine the output level of the vehicle/machinery (e.g., machine hour or gross ton-hour of the machine).

Gross vehicle weight (GVW)
Equals vehicle weight plus freight weight, measured in tons.

Heavy duty vehicles
Vehicles with gross vehicle weight more than or equal to 3.5 t are classified as heavy-duty vehicles.

Light duty vehicles
Vehicles with gross vehicle weight less than 3.5 t are classified as light duty vehicles.

Mobile machinery
Equipment which is not fixed at a specific site but can be moved around either under its own power or with assistance when engineering specifications or logistics dictate (e.g., moving a loader using a lo-bed rather than driving the loader to the destination). Mobile machinery must be self-propelled, except where a self-propelled unit has had its drive carriage removed to secure the unit to a structure during operation and may include but not be limited to: excavators, log harvesting bunchers, log loaders, cranes, timber processors, fork-lifters, road-building machines and/or bulldozers. Generators used for power generation do not qualify as mobile machinery under this methodology.

Telematics System
Telematics is a method of monitoring cars, trucks, equipment and other assets by using GPS technology and on-board diagnostics (OBD) to plot the asset's movements on a computerized map. By connecting to the on-board diagnostics, telematics devices retrieve data generated by the vehicle, like GPS position, speed, fuel usage, engine light information and faults.

Tons (t)
Metric tons

4 APPLICABILITY CONDITIONS

This methodology applies to project activities that improve efficiency of vehicle fleets and mobile machinery (e.g. fleets of trucks, buses, cars, taxis or motorized tricycles, excavators, cranes), resulting in reduced fuel usage and GHG emissions.

This methodology is applicable under the following conditions:

1) This methodology applies to project activities that implement one or more of the following measures:

a) Idling stop device,[1]

b) Eco-drive systems;[2]

c) Tire-rolling resistance improvements;[3]

d) Air-conditioning system improvements;[4]

e) Use of low viscosity oils;[5]

f) Aerodynamic drag reduction measures;[6]

g) Transmission improvements;[7]

h) Retrofits that improve engine and combustion efficiency.[8]

i) Other energy efficiency improvement measures identified by the project description. Such other measures must have been described in independent third-party studies as leading to fuel savings.

2) More than one energy efficiency measure covered by the methodology may be implemented in the project vehicle fleet(s) and the measures implemented may vary across vehicles in the fleet(s).

3) Where the project proponent is not the owner of the vehicle fleets (eg, the project proponent is a fleet manager with many clients, each client being the owner of its

[1] Refers to the action of turning off the vehicle engine and thus preventing idling (as specifically defined above) and the associated fuel consumption that would otherwise have occurred while idling, in absence of the project activity. Anti-idling devices can also include techniques to avoid use of the base engine during extended idle by substituting alternative sources of HVAC (heating, ventilation or air conditioning) and electricity during rest stops.

[2] Eco-drive systems include equipment that monitors vehicle and driver performance and provides real- time feedback to drivers on efficient driving behavior.

[3] Rolling resistance can be reduced by avoiding under-inflation of existing tyres e.g., through automatic tire inflation (ATI), usage of special low rolling resistance tyres, or substituting one wide tyre for a pair of dual tyres on trucks.

[4] Enhanced air conditioning systems can decrease base engine load requirements from mobile air conditioning systems by replacing fixed displacement compressors (FDCs) with externally controlled variable displacement compressors (VDCs), using improved control systems, condensers and evaporators.

[5] Low-viscosity engine lubricants are made from synthetic or mineral oil blends for the purpose of reducing internal engine friction. Low viscosity oils based on SAE-Viscosity classes are 0W30 and 5W30.

[6] Aerodynamic drag of trucks can be significantly reduced by installing add-on devices to improve the vehicle profile (truck tractor aerodynamic drag reduction options include cab top deflector, sloping hood, and cab side flares; truck side and underside aerodynamic drag reduction options include closing and covering the gap between a tractor and trailer (or van), aerodynamic bumper, underside air baffles, and wheel well covers), pneumatic blowing systems (this type of system blows air from slots at the rear of the trailers of heavy-duty vehicles in order to smooth air flow over the trailer surfaces and reduce aerodynamic drag, and boat tail plates rectangular plates mounted to the end of a trailer in an attempt to reduce the wake of trucks), or by improving vehicle load profile.

[7] Improving transmission systems by using high-efficiency transmission technologies i.e., continuously variable transmission (CVT) and/or low-viscosity transmission lubricants.

[8] Retrofits involves direct installation of technologies onto the vehicle/engine that improve the efficiency of engine operation and fuel combustion by, for example, tapping into spare unused kinetic energy, solar energy or thermo- electric generation and/or generating hydrogen on board though an electrolysis technology, e.g., electro-catalytic efficiency technologies.

respective vehicle fleets), there must exist a contract between the project proponent and each fleet owner to establish clear ownership of the emission reductions.[9]

4) The project proponent must provide ex-ante estimation of the percentage of baseline emissions avoided per each energy efficiency measure. The ex-ante estimations must be based on published literature, official reports or statistics published by an independent third party or studies carried out by the project proponent, and validated by the validation/verification body. This is applied for any measure identified in the project description. The ex-ante estimations will also serve as a cap on the specific emission reductions (using the specific emission reduction percentage per activity unit as the metric[10]). In other words, the reduction in the project emission factor compared to the baseline emission factor may not exceed the ex-ante estimation.

5) This methodology is not applicable under the following conditions:

   a) Measures that improve the system efficiency of the fleet, for example a change of operational procedures to improve the occupancy rate of vehicles and modal shift in transportation.

   b) A switch from fossil fuels to biofuels in transportation applications. The usage of a fixed biofuel blend is, however, admissible if project vehicles use the same blend of biofuel as used by baseline vehicles. In the case of using biofuel blends, the biofuel share is accounted for as zero emitting.

   c) A fuel-switch, for example from liquid to gaseous fuels.

6) Project fleets may use various fuel types. The composition of the fleet with regard to fuel types used may also change over time. The introduction of hybrid vehicles is allowed. Hybrid fuel vehicles are classified according to their fossil fuel engine type and compared with the same baseline fossil fuel type (e.g., compressed natural gas, diesel, gasoline hybrids are compared with diesel, gasoline or compressed natural gas engines).

7) Only vehicles in which at least one of the ex-ante identified project activity measures has been implemented shall be included in the project fleet.

8) Each fleet included in the project activity shall include only one vehicle category. In each vehicle category, vehicles are classified according to the fuel types used. Baseline and project emissions are calculated for each fuel type of each vehicle category. A project

[9] This applicability condition is not a substitute for the VCS requirements with respect to Right of Use. The project description must be accompanied by documentary evidence establishing Right of Use, in accordance with the VCS rules.

[10] In other words, it is the percentage of emission reductions that is relevant for consideration. Therefore, the cap is defined based on the specific emission reductions arising from each energy efficiency measure. For example, assume idling stop and eco-drive were estimated to reduce CO_2 emissions by 10% per machine hour. Also, ex ante 5,000 machine hours were projected for the vehicle type, with specific emissions per machine hour of 2 tCO_2 per hour. The specific cap on emission reductions would therefore be 0.2 tCO_2 per machine hour (i.e,, 10% of 2 tCO_2). This is independent of the activity level. The absolute cap will thereafter be the specific cap multiplied with the activity level. If in year y, for example, there were 6,000 machine hours of operation (as opposed to 5,000), the cap would be 6,000 x 0.2 = 1,200 tCO_2. See applicability condition 5 of CDM methodology AMS-III.BC which states that the cap is based on the specific emission reduction (per tkm or per km) and not based on absolute figures.

activity may, however, encompass various fleets. Vehicle categories in the context of this methodology are

a) Trucks with a gross vehicle weight[11] (GVW) >3.5 t;

b) Trucks with a GVW <3.5 t;

c) Buses with a GVW >3.5 t;

d) Taxis: in the case of significantly different taxi types such as conventional cars, minibuses, jeepneys, etc., these shall also be considered as separate vehicle categories;

e) Passenger cars (e.g., company cars, rental cars);

f) Motorized tricycles (e.g., used as taxis or for deliveries); and

g) Mobile machinery.

5 PROJECT BOUNDARY

The project boundary is the physical, geographical location of the vehicles that are part of the project activity. The spatial extent of the project boundary encompasses the geographical area of the trips of these project vehicles.

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

Table 2: GHG Sources included in or excluded from the project boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Fleet vehicle exhaust gas	CO_2	Yes	Major source of GHG emissions in the exhaust gas
		CH_4	No	Negligible in the exhaust gas
		N_2O	No	Negligible in the exhaust gas
		Other	No	Negligible in the exhaust gas
Project	Fleet vehicle exhaust gas	CO_2	Yes	Major source of GHG emissions in the exhaust gas
		CH_4	No	Negligible in the exhaust gas
		N_2O	No	Negligible in the exhaust gas
		Other	No	Negligible in the exhaust gas

[11] The gross vehicle weight (GVW) is the maximum allowable total weight of a vehicle when loaded. This weight includes the vehicle as well as fuel, passengers and cargo. This is a fixed weight that is set and specified by the vehicle manufacturer.

6 BASELINE SCENARIO

The baseline scenario is the operation of a group of vehicles of the same fleet or mobile machinery without energy efficiency measures and for similar transportation services as the project vehicles.

7 ADDITIONALITY

Step 1: Regulatory Surplus

The project shall not be mandated by any law, statute or other regulatory framework, or for UNFCCC non-Annex I countries, any systematically enforced law, statute or other regulatory framework. For UNFCCC non-Annex I countries, laws, statutes, regulatory frameworks or policies implemented[12] since 11 November 2001 that give comparative advantage to less emissions-intensive technologies or activities relative to more emissions-intensive technologies or activities need not be taken into account. For all countries, laws, statutes, regulatory frameworks or policies implemented since 11 December 1997 that give comparative advantage to more emissions-intensive technologies or activities relative to less emissions-intensive technologies or activities shall not be taken into account.

Step 2: Implementation barriers

Additionality may be demonstrated based on typical barriers faced by energy efficiency projects, including:

(a) Commercial/legal barriers: the "owner/tenant" contractual issue typical of energy efficiency projects may be a legitimate barrier. This is typical for example in the case of the fleets of car rental companies where the car renter buys the fuel and the owner makes the vehicle investment. Many taxi fleets especially in developing countries are also managed in this manner, with taxi drivers paying a fixed daily rent per vehicle. The same is true in the case of leased vehicles typical in the trucking business.

(b) Aggregation barriers: in order to make implementation of efficiency projects feasible, they may require an aggregation mechanism. Aggregation mechanisms, in the case of promoting efficiency in transport fleets, have been successful for example in Switzerland, Canada and the United States. Aggregation parties are generally business associations, efficiency-driven institutions, or providers of technology solutions for efficiency improvements. The cost of establishing and maintaining such an aggregation mechanism can, however, be a major barrier that can be offset with carbon revenues.

[12] Implemented in the context of this paragraph means enacted or introduced, consistent with use of the term under the CDM rules on so-called Type E+ and Type E- policies.

(c) Other barriers: in case other barriers exist, these may be assessed based on the most recent version of the CDM additionality tool.

All barriers shall be assessed based on the *CDM Guidelines for objective demonstration and assessment of barriers*.

Step 3: Common practice

Fleet owners are often skeptical of such practices and resistant to adopt them. A project activity is considered to be additional if the market penetration rate of each of the planned project measures is less than 5 per cent for the types of vehicles included in the fleets.[13] Sources of data for the market penetration rates may include independent studies, information from business associations, analysis of publicly available information demonstrating the "penetration rate" of the measures proposed by the project within the host country, sample surveys of comparable fleets that ask fleet managers to identify vehicles in which the identified efficiency measures have been implemented in the absence of the VCS or any other approved GHG programs, or random sample surveys of the same vehicle categories, carried out, for example, at bus/truck/taxi depots in major cities.

8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

8.1 Baseline Emissions

The baseline scenario is the operation of a group of vehicles of the same fleet without energy efficiency measures and for similar transportation services as the project vehicles. Baseline emissions are calculated based on a baseline emission factor for each vehicle category i and fuel type x ($BEF_{km,l,x,y}$) derived from:

- The vehicles own data prior to the project measure's implementation, for all vehicle types equipped with a telematics system capable of tracking fuel consumption; or,
- The monitored specific fuel consumption of a control group of vehicles and the monitored project activity level, for all vehicle types not equipped with a telematics system capable of tracking fuel consumption.

[13] Penetration rates are assessed for the specific categories of vehicles in which the measures are implemented, and not for the fleet as a whole, because a project may implement specific measures only on some vehicles and not the entire fleet. To assess the penetration rate for the fleet, a weighting based on the number of each type of vehicle is made. Each planned measure must fulfil the threshold value of 5 per cent individually if this barrier is used.

8.1.1 Baseline emissions utilizing telematics systems

Baseline emissions for all vehicle categories utilizing telematics systems must be determined following the procedure below. For all vehicle categories where telematics cannot be utilized, baseline emissions must be determined following the procedure provided in Section 8.1.2. All mobile machinery should follow the Control Group procedure for non-telematics monitoring.

For all vehicle types equipped with a telematics system capable of tracking fuel consumption, the baseline emissions shall be calculated using the vehicles own data prior to the project measure's implementation. The project vehicle shall allow for a minimum of 5,000 km of vehicle operation to obtain baseline emissions. The project vehicle's usage must be similar or less than the regular usage during the baseline period.

The emission factor is monitored within the control group of vehicles and multiplied by the activity level of the project:

$$BE_y = \sum_{i,x} BEF_{i,x,y} \times AL_{i,x,y} \times 10^{-6} \quad (1)$$

Where:

BE_y = Baseline emissions in the year *y* (tCO_2)

$BEF_{i,x,y}$ = Baseline emission factor per activity level metric of project group vehicles *i* during using fuel type *x* in the year *y* (gCO_2/activity level metric)

$AL_{i,x,y}$ = Activity level of project per activity level metric of project group vehicles *i* using fuel type *x* in the year *y* (activity level metric)

$$BEF_{i,x,y} = SFC_{BL,i,x,y} \times NCV_{x,y} \times EF_{CO2,x,y} \quad (2)$$

Where:

$SFC_{BL,i,x,y}$ = Specific baseline fuel consumption of control group vehicle category *i* using fuel type *x* in year *y* (fuel metric/activity level metric)

$NCV_{x,y}$ = Net calorific value of fuel type *x* in year *y* (MJ/fuel metric)

$EF_{CO2,x,y}$ = CO_2 emission factor for fuel type *x* in year *y* (gCO_2/MJ).

The activity level metric AL (eg, hours) is defined by the project description. See Section 9.2 for definitions and calculation method of AL.

For electric or hybrid vehicles, BEF is determined using equation 10 below. The parameters SEC, EF_{elec} and TDL are determined in accordance with the latest version of CDM methodology AMS-III.C.

$$BEF_{i,elec,y} = \sum_{i} \frac{SEC_{i,y} \times EF_{elec,y}}{(1 - TDL_y) \times 10^{-3}} \quad (3)$$

Where:

$BEF_{i,elec,y}$ = Baseline emission factor per activity level metric of control group mobile machinery *i* using electricity in year *y* (gCO_2/activity level metric)

$SEC_{i,y}$ = Specific electricity consumption by control group mobile machinery *i* per activity level in year *y* (kWh/activity level metric)

$EF_{elec,y}$ = CO_2 emission factor of electricity in year *y* (gCO_2/kWh)

TDL_y = Average technical transmission and distribution losses for providing electricity in the year *y* (no unit)

If mobile machinery uses both electricity and fossil fuels, then the emissions from both sources must be summed using equation 3.

8.1.2 Baseline emissions not utilizing telematics systems (control group method)

$BEF_{km,l,x,y}$ is monitored annually. The metric used for the baseline emissions is:

- Emissions per tonne-km (tkm) for heavy duty vehicles; or
- Emissions per km for all other vehicle categories.

To avoid crediting emission reductions to the project for external factors, the baseline emission factor shall be based on comparable vehicles driving in a comparable situation. This can be based either on a Randomized Control Trial (RCT) as described below or with a control group that complies with the following conditions to ensure that the control group is comparable to or more conservative than the project group:

- For buses, passenger cars, taxis and jeepneys, the following criteria shall be comparable for the control and the project group: average vehicle age, area of usage of the vehicle (e.g., urban or inter-urban routes), average passenger capacity and average share of vehicles with air conditioning:
    - The control group vehicles must have on an average, the same age or less than the project group vehicles.
    - The control group vehicles must be used on average in the same area of usage as the project vehicles.
    - The control group vehicles must have on an average the same or a lower passenger capacity than the project vehicles.
    - The share of vehicles with air conditioning in the control group must be the same or lower than that of the project group;
- For trucks the criteria are: average GVW, average annual distance driven and main area of usage of the vehicles (urban vs. inter-urban trips).
    - The average GVW of vehicles in the control group must be the same or greater than that of the vehicles in the project group.

- The average annual distance driven of the vehicles in the control group must be the same or greater than that of the vehicles in the project group.
- The share of inter-urban trips of vehicles in the control group must be on average equal to or higher than the share of the project vehicles.

- For mobile machinery the criteria are:

  - Mobile machinery in both groups must have a comparable power rating with variations of not more than ±20%;
  - Mobile machinery of the control group must have, on average, the same or lesser age than the project group mobile machinery;
  - The mobile machinery of the control group can be used to produce the same product or perform the same activity as the mobile machinery of the project group.

Control group vehicles shall be selected from the vehicle fleets of the project proponent or from third party fleets (preferred option). For the RCT, the population of interest is randomly assigned to either a project (where energy efficiency measures are implemented) or a control group. Each vehicle in the population of all eligible vehicles is randomly assigned to either the control or project group based on a random probability, as opposed to being assigned to one group or the other based on some characteristic of the vehicle (e.g. vehicle age or willingness of a driver to sign up for the project activity).

8.1.3 Baseline emission calculations for trucks and buses

Baseline emissions for trucks and buses are calculated based on the baseline emission factor per tkm per fuel type determined based on the monitoring of the control group vehicles. The baseline emission factor is multiplied by the actual tkm transported by the project activity per fuel type.

$$BE_y = \sum_{i,x} BEF_{tkm,i,x,y} \times AL_{tkm,i,x,y} \times 10^{-6} \quad (4)$$

Where:

BE_y = Baseline emissions in the year *y* (tCO_2)

$BEF_{tkm,i,x,y}$ = Baseline emission factor per tkm of vehicle category *i* using fuel type *x* in the year *y* (gCO_2/tkm)

$$BEF_{tkm,i,x,y} = \frac{SFC_{BL,i,x,y} \times NCV_{x,y} \times EF_{CO2,x,y}}{AW_{BL,i,x,y}} \quad (5)$$

Where:

$SFC_{BL,i,x,y}$ = Specific baseline fuel consumption of control group vehicle category *i* using fuel type *x* in year *y* (g/km)

$NCV_{x,y}$ = Net calorific value of fuel type *x* in year *y* (MJ/g)

$EF_{CO2,x,y}$ = CO2 emission factor for fuel type x in year y (gCO2/MJ). For electric or hybrid vehicles the emission factor is determined in accordance with the latest version of "AMS-II.C: Emissions reductions by electric and hybrid vehicles"

$AW_{BL,i,x,y}$ = Average GVW per vehicle unit of control group vehicle category *i* using fuel type *x* in the year *y* (tonnes). The gross vehicle weight as per vehicle registration or the maximum technical weight specified by the manufacturer of the vehicle should be used for the calculations

Vehicle categories are indicated in section 4. The project can include vehicle subcategories.

Baseline emissions for all other vehicle categories are calculated based on the baseline emission factor per km per fuel type determined for the control group vehicles. The baseline emission factor is multiplied by the actual distance travelled by the project activity fleet.

$$BE_y = \sum_{i,x} BEF_{km,i,x,y} \times AL_{km,i,x,y} \times 10^{-6} \quad (6)$$

Where:

$BEF_{km,i,x,y}$ = Baseline emission factor per km of vehicle category *i* using fuel type *x* in the year *y* (gCO_2/km)

$AL_{km,i,x,y}$ = Activity level of project in km of vehicle category *i* using fuel type *x* in the year *y* (tkm)

$$BEF_{km,i,x,y} = \left(SFC_{BL,i,x,y} \times NCV_{x,y} \times EF_{CO2,x,y}\right) \quad (7)$$

8.1.4 Baseline emissions for mobile machinery

Baseline emissions for mobile machinery are calculated based on the baseline emission factor per activity level for the control group vehicles. The activity level metric must be defined and justified in the project description and must fulfill the following criteria:

- Higher activity levels must lead to higher fuel consumption. The relationship between fuel consumption and the activity level metric must be described in the project description based on measurements or independent third-party studies.
- The activity level metric must be measurable with an acceptable level of certainty

(acceptable data accuracy is ±10%).

- Changes in the relationship between fuel usage and activity level must be related to efficiency or changes of fuel type used. In other words, such changes must not be random or due to external factors not under the influence of the project. To demonstrate this relationship, data from the sample to determine the baseline emission factor at the lower boundary of the 90% confidence interval must have a deviation of less than 20% from the average value. If this is not achieved, then more homogenous subgroups of mobile machinery must be made. At validation, the demonstration that changes in fuel consumption is directly related to efficiency or changes in fuel type are based on qualitative arguments or ex-ante data. At verification, this demonstration is based on the 20% deviation check of the 90% confidence interval described above.

Activity level metrics may be related to the mobile machinery itself, or to the production output (eg, amount of processed material). This is not a requirement, but rather an indication of how activity level metrics may be defined. The project proponent must demonstrate at validation that the activity level metric is appropriate to the project.

The emission factor is monitored within the control group of vehicles and multiplied by the activity level of the project.

$$BE_y = \sum_{i,x} BEF_{i,x,y} \times AL_{i,x,y} \times 10^{-6} \quad (8)$$

Where:

BE_y = Baseline emissions in the year *y* (tCO_2)

$BEF_{i,x,y}$ = Baseline emission factor per activity level metric of control group mobile machinery *i* using fuel type *x* in the year *y* (gCO_2/activity level metric)

$AL_{i,x,y}$ = Activity level of project per activity level metric of mobile machinery *i* using fuel type *x* in the year *y* (activity level metric)

$$BEF_{i,x,y} = SFC_{BL,i,x,y} \times NCV_{x,y} \times EF_{CO2,x,y} \quad (9)$$

Where:

$SFC_{BL,i,x,y}$ = Specific baseline fuel consumption of control group vehicle category *i* using fuel type *x* in year *y* (fuel metric/activity level metric)

$NCV_{x,y}$ = Net calorific value of fuel type *x* in year *y* (MJ/fuel metric)

$EF_{CO2,x,y}$ = CO_2 emissions factor foe fuel type *x* in year *y* (gCO_2/MJ)

The activity level metric *AL* (eg, hours) is defined by the project description. See Section 9.2 for definitions and calculation method of *AL*.

For electric or hybrid vehicles, *BEF* is determined using equation 10 below.

$$BEF_{i,elec,y} = \sum_{i} \frac{SEC_{i,y} \times EF_{elec,y}}{(1 - TDL_y) \times 10^{-3}} \quad (10)$$

Where:

$BEF_{i,elec,y}$ = Baseline emission factor per activity level metric of control group mobile machinery *i* using electricity in year *y* (gCO_2/activity level metric)

$SEC_{i,y}$ = Specific electricity consumption by control group mobile machinery *i* per activity level in year *y* (kWh/activity level metric)

$EF_{elec,y}$ = CO_2 emission factor of electricity in year *y* (gCO_2/kWh)

TDL_y = Average technical transmission and distribution losses for providing electricity in the year *y* (no unit)

If mobile machinery uses both electricity and fossil fuels, then the emissions from both sources must be summed using equation 8.

8.2 Project Emissions

8.2.1 Project emissions utilizing telematics systems

Project emissions for all vehicle categories utilizing telematics systems must be determined following the procedure below. For all vehicle categories where telematics cannot be utilized, project emissions must be determined following the procedure provided in the section "Project emissions not utilizing telematics systems" below.

$$PE_y = \sum_{i,x} PEF_{i,x,y} \times AL_{i,x,y} \times 10^{-6} \quad (11)$$

Where:

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

$PEF_{i,x,y}$ = Project emission factor per activity level metric of vehicle category *i* using fuel type *x* in year *y* (gCO_2/activity level metric)

$AL_{i,x,y}$ = Activity level of project per activity level metric of vehicle category *i* using fuel type *x* in the year *y* (activity level metric)

$$PEF_{i,x,y} = SFC_{PJ,i,x,y} \times NCV_{x,y} \times EF_{CO2,x,y} \quad (12)$$

Where:

$PEF_{i,x,y}$ = Project emission factor per activity level metric of vehicle category *i* using fuel type *x* in year *y* (gCO_2/activity level metric)

$SFC_{PJ,i,x,y}$ = Specific project fuel consumption of project group vehicle category *i* using fuel type *x* in the year y (fuel metric/activity level metric)

$NCV_{x,y}$ = Net calorific value of fuel type *x* in year *y* (MJ/fuel metric)

$EF_{CO2,x,y}$ = CO_2 emission factor for fuel type *x* in year *y* (gCO_2/MJ).

For electric or hybrid vehicles, PEF is determined in accordance with Equation 12 above, mutatis mutandis.

8.2.2 Project emissions not utilizing telematics systems

Project emission calculations for trucks and buses

$$PE_y = \sum_{i,x} PEF_{tkm,i,x,y} \times AL_{tkm,i,x,y} \times 10^{-6} \quad (13)$$

Where:

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

$PEF_{tkm,i,x,y}$ = Project emission factor per tkm of vehicle category *i* using fuel type *x* in year *y* (gCO_2/tkm)

$AL_{tkm,i,x,y}$ = Activity level of project in tkm of vehicle category *i* using fuel type *x* in the year *y* (tkm)

$$PEF_{tkm,i,x,y} = \frac{SFC_{PJ,i,x,y} \times NCV_{x,y} \times EF_{CO2,x,y}}{AW_{PJ,i,x,y}} \quad (14)$$

Where:

$SFC_{PJ,i,x,y}$ = Specific project fuel consumption of project group vehicle category *i* using f uel type *x* in the year *y* (g/km)

$AW_{PJ,i,x,y}$ = Average GVW per vehicle unit of project group vehicle category *i* using fuel type *x* in year *y* (tonnes). The gross vehicle weight as per vehicle registration or the maximum technical specified by the manufacturer of the vehicle should be used for the calculations.

8.2.3 Project emissions for all other vehicle categories:

$$PE_y = \sum_{i,x} PEF_{km,i,x,y} \times AL_{km,i,x,y} \times 10^{-6} \quad (15)$$

Where:

$PEF_{km,i,x,y}$ = Project emission factor per kilometre of vehicle category *i* using fuel type *x* in year *y* (gCO_2/km)

$$PEF_{km,i,x,y} = SFC_{PJ,i,x,y} \times NCV_{x,y} \times EF_{CO2,x,y} \quad (16)$$

8.2.4 Project emissions for mobile machinery

Project emissions for mobile machinery must be determined following the procedure below.

$$PE_y = \sum_{i,x} PEF_{i,x,y} \times AL_{i,x,y} \times 10^{-6} \quad (17)$$

Where:

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

$PEF_{i,x,y}$ = Project emission factor per activity level metric of project group mobile machinery *i* using fuel type *x* in year *y* (gCO_2/activity level metric)

$AL_{i,x,y}$ = Activity level of project per activity level metric of mobile machinery *i* using fuel type *x* in the year *y* (activity level metric)

$$PEF_{i,x,y} = SFC_{PJ,i,x,y} \times NCV_{x,y} \times EF_{CO2,x,y} \quad (18)$$

Where:

$PEF_{i,x,y}$ = Project emission factor per activity level metric of project group mobile machinery *i* using fuel type *x* in year *y* (gCO_2/activity level metric)

$SFC_{PJ,i,x,y}$ = Specific project fuel consumption of project group mobile machinery *i* using fuel type *x* in the year y (fuel metric/activity level metric)

$NCV_{x,y}$ = Net calorific value of fuel type *x* in year *y* (MJ/fuel metric)

$EF_{CO2,x,y}$ = CO_2 emission factor for fuel type *x* in year *y* (gCO_2/MJ).

For electric or hybrid vehicles, PEF is determined in accordance with Equation 18 above, *mutatis mutandis*.

8.3 Leakage

Leakage is not considered for this activity.

8.4 Net GHG Emission Reductions and Removals

Net GHG emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad (19)$$

Where:

ER_Y = Net GHG emissions reductions and removals in year y (tCO_2e)
BE_Y = Baseline emissions in year *y* (tCO_2e)
PE_y = Project emissions in year *y* (tCO_2e)
LE_y = Leakage in year *y* (tCO_2e)

9 MONITORING

Project proponents must follow the monitoring procedures provided below.

9.1 Data and Parameters Available at Validation

No data or parameters are available at validation.

9.2 Data and Parameters Monitored

The following data and parameters must be monitored.

Data / Parameter:	$NCV_{x,y}$
Data unit:	MJ/g or MJ/L
Description:	Net calorific value of fuel type *x* in the year *y*
Equations	(5),(7),(9),(14),(16),(**18**)**Error! Reference source not found.**
Source of data:	National values or the latest version of IPCC Guidelines
Description of measurement methods and procedures to be applied:	-
Frequency of monitoring/recording:	Annual
QA/QC procedures to be applied:	-
Purpose of data:	-
Calculation method:	-

Comments:	The fuel measurement used (g, L) is determined based on available data. Should a telematics system be used to monitor the project, the fuel recording will likely occur as a L value.

Data / Parameter:	$EF_{CO2,x,y}$
Data unit:	gCO_2/MJ
Description:	CO_2 emission factor of fuel type *x* in the year *y*
Equations	(5),(7),(9),(14),(16),(18)**Error! Reference source not found.**
Source of data:	National values or the latest version of IPCC Guidelines
Description of measurement methods and procedures to be applied:	-
Frequency of monitoring/recording:	Annual
QA/QC procedures to be applied:	-
Purpose of data:	-
Calculation method:	-
Comments:	km

Data / Parameter:	$AL_{i,x,y}$
Data unit:	km, tkm, hours
Description:	Activity level of project vehicle category *i* using fuel type *x* in the trial period *z*
Equations	(4),(6),(8)**Error! Reference source not found.**,(13),(15),(17)**Error! Reference source**

	not found.
Source of data:	**Option 1:** Telematics system data recording, or control group data **Option 2**: Used for mobile machinery. The activity level metric is defined in the project description. For activity level metrics based on time (eg, operating hours for mobile machinery), time must be based on hour-monitoring devices installed at the mobile machinery and recorded by electronic or paper records. The metric for mobile machinery and its measurement must be detailed in the project description. Activity level metrics cannot be changed between baseline and project monitoring periods and must be measured in comparable manners.
Description of measurement methods and procedures to be applied:	For activity level metrics based on time and distance: **Option 1**: Monitoring for the methodology may be done via use of a vehicle telematic recording system capable of continuous tracking and securely recording accurate engine data including odometer, fuel consumption, and engine operational time, as provided by the vehicle's engine control module. The telematics system shall transmit the engine measurements over-the-air to the telematic service provider's protected database, where the data can be analyzed and reviewed to ensure compliance. **Option 2:** Electronic fuel consumption measurement devices or fuel records for fuel consumption. The specific fuel consumption is calculated (fuel usage / activity level). The activity level metric tkm should only be used for trucks and busses. The measurements may be undertaken using: **Option 1**: The use of a telematics system to record and monitor the GVW and odometer of the vehicle **Option 2**: Sample of vehicles randomly

	chosen in accordance with the latest version of the standard for "Sampling and surveys for CDM project activities and programme of activities".
Frequency of monitoring/recording:	If utilizing a telematics system, the data will be continuously monitored. If no telematics system is utilized, the data shall be monitored monthly or annually.
QA/QC procedures to be applied:	If using a telematics system, the telematics device must remain connected to, and plugged into, the OBD of the engine for the entire project length.
Purpose of data:	To determine the metric by which engine fuel consumption is monitored
Calculation method:	N/A
Comments:	

Data / Parameter:	$SFC_{BL,i,x,y}/SFC_{PJ,i,x,y}$
Data unit:	g/activity level metric, or L/activity level metric
Description:	Specific project fuel (PJ)/baseline (BL) consumption of project /control group vehicle category *i* in the trial period *z* in the year *y*
Equations	(5),(7),(9),(14),(16),(18)**Error! Reference source not found.**
Source of data:	**Option 1:** Telematics system **Option 2:** Source of data can be mobile machinery statistics or sample measurements. If based on sample measurements, then sample vehicles must be randomly chosen in accordance with the latest version of the CDM *General guidelines for sampling and surveys for small-scale CDM project activities* using a 90% confidence interval and a ±10% error margin to determine the sample size. Further, the upper bound of the 90% confidence

	interval must be used as the Project Specific Fuel Consumption and the lower bound of the 90% confidence interval as the Baseline Specific Fuel Consumption. To determine the SFC, the fuel consumed by the respective group of mobile machinery must be divided with the activity level of that group during the same time period over which fuel consumption was monitored (eg, fuel consumed by a group of 5 mobile machinery during 2 days is divided by the activity level performed by these 5 mobile machinery during these 2 days).
Description of measurement methods and procedures to be applied:	**Option 1:** Monitoring for the methodology may be done via use of a vehicle telematic recording system capable of continuous tracking and securely recording accurate engine data including odometer, fuel consumption, and engine operational time, as provided by the vehicle's engine control module. The telematics system shall transmit the engine measurements over-the-air to the telematic service provider's protected database, where the data can be analyzed and reviewed to ensure compliance. **Option 2:** Electronic fuel consumption measurement devices or fuel records for fuel consumption. The specific fuel consumption is calculated (fuel usage / activity level).
Frequency of monitoring/recording:	**Option 1:** As required through the telematics system **Option 2:** Annual
QA/QC procedures to be applied:	**Option 1**: If using a telematics system, the telematics device must remain connected to, and plugged into, the OBD of the engine for the entire project length. **Option 2**: See CDM General guidelines for sampling and surveys for small-scale CDM project activities and Best Practices Examples Focusing on Sample Size And Reliability Calculations. If the width of the confidence interval exceeds 20% of the estimated value, then an appropriate confidence deduction must be VMR0004

	Sectoral Scope 7 Page 14 applied. The deduction must be based on the CDM Meth Panel guidance on addressing uncertainty in its Thirty Second Meeting Report, Annex 14, Table 4. The confidence deduction must always be in a conservative manner (ie, to lower baseline SFC and to increase project SFC).
Purpose of data:	Calculation of project/baseline emissions
Calculation method:	-
Comments:	Changes in the relationship between fuel usage and activity level must be related to efficiency or changes of fuel type used. In other words, such changes must not be random or due to external factors not under the influence of the project. To demonstrate this relationship, data from the sample to determine the baseline emission factor at the lower boundary of the 90% confidence interval must have a deviation of less than 20% from the average value. If this is not achieved, then more homogenous subgroups of mobile machinery must be made.

Data / Parameter:	$AW_{,PJ,I,x,y}$, $AW_{,BL,I,x,y}$
Data unit:	tonnes
Description:	Average gross weight per vehicle unit of vehicle category *i* using fuel type *x* in year *y*
Equations	(5),(14)
Source of data:	Control group data
Description of measurement methods and procedures to be applied:	The average GVW per vehicle unit is the average of the individual weight of vehicles of the project or baseline group fleet using fuel type *x*
Frequency of monitoring/recording:	Annual

QA/QC procedures to be applied:	To ensure data consistency SFC and AW must be based on the same group of vehicles
Purpose of data:	-
Calculation method:	-
Comments:	-

If any device installed in a project vehicle (e.g. for Ecodrive or engine retrofits, including fuel flow sensors or meters) is not operating correctly and or have not been disabled, no emissions reductions can be attributed to that vehicle for the period that the system has not been operating correctly.

Project activity under a programme of activities

The methodology is applicable for a programme of activities if the total emission reduction claims from all measures does not exceed 20 per cent, or, if the total emission reductions are greater than 20 per cent, the amount of reductions has been appropriately justified as being attributable to the project measures as documented in independent, relevant studies by the independent third parties (i.e. studies of the emissions reductions from the project devices).

9.3 Description of the Monitoring Plan

The data and parameters required by this methodology revision set out in Section 9.2 must be monitored by the project proponent and must be made available during verification. Project proponents must establish a comprehensive monitoring plan for ensuring the collection, measurement, recording and QA/QC procedures for these data and parameters and this must be documented in the project description.

All data collected as part of the monitoring plan must be archived electronically and be kept at least for 2 years after the end of the last project crediting period. Equipment used for measurements must comply with relevant industry standards (if existent) and must be calibrated according to such standards if relevant and applicable. Fuel consumption may be based specifically on tanking invoices/records.

10 REFERENCES

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