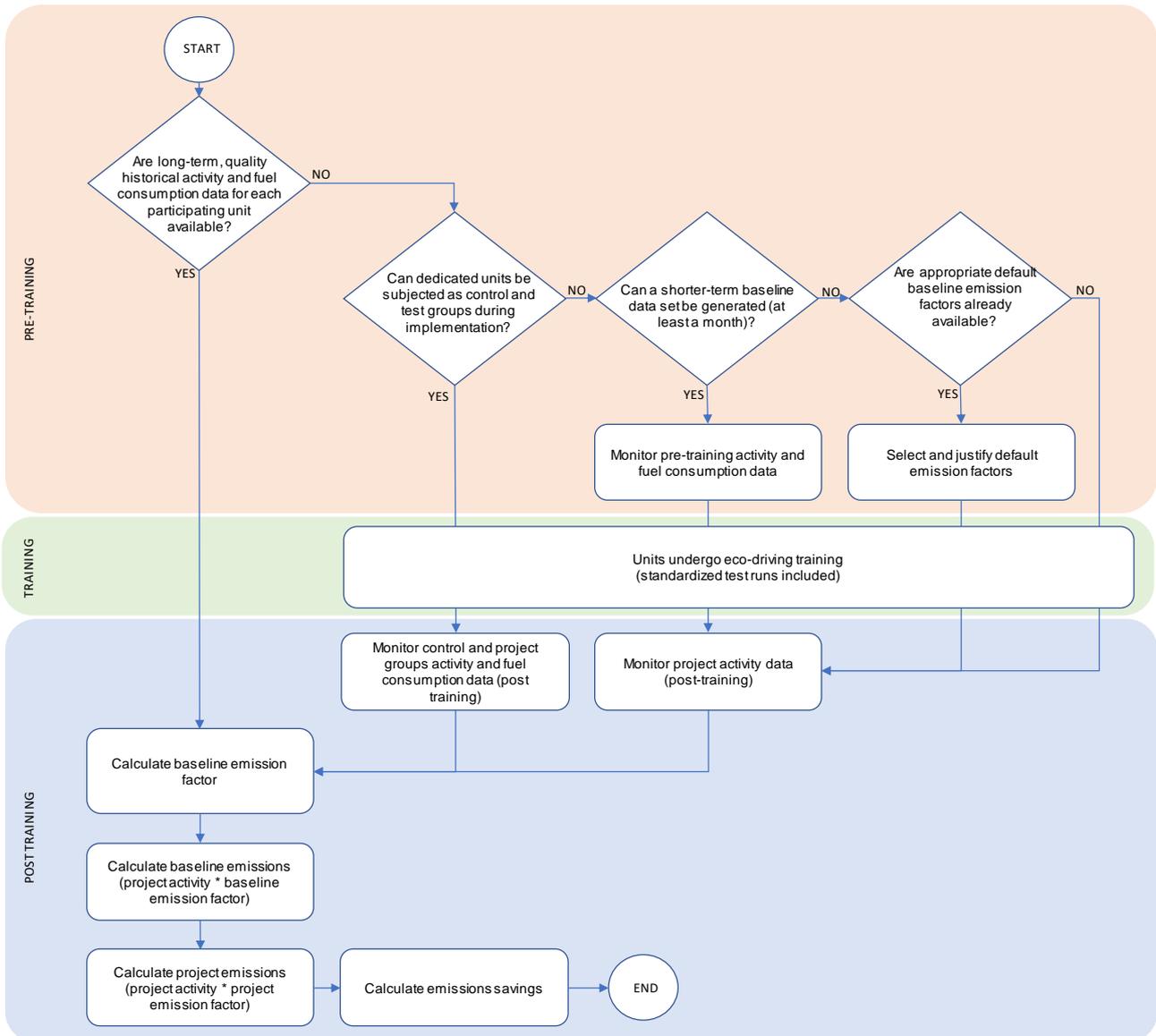


## Annex C: Impact Assessment method for fuel consumption monitoring

### PRE-TRAINING PERIOD



**Figure 1. Emissions Impact Calculation Flowchart**

1. The method for establishment of the baseline scenario emission factor to be used in the assessment is a critical step before any entity participates in the eco-driving trainings to be conducted. The baseline scenario essentially depicts a scenario wherein the eco-driving training would not exist, and that the efficiencies of the vehicle-driver units would have stayed the same due to non-intervention.
2. Given that the intended program would target approximately five hundred (500) small and medium sized enterprises (SMEs), and about five hundred to thousand drivers, some level of flexibility in terms of establishing the baseline emission factors should be given. Moreover, many of these participating SMEs would have limited capacities in terms of keeping long-term, quality data records of their units' activity and fuel consumption, or in dedicating randomized control tests, or a simpler control vs test group testing.
3. As depicted in Figure 1, the participating entities (SMEs) need to ask themselves whether they have quality long-term historical data (6 months or more) for each of the unit that they would subject to the project. A unit in this case would ideally refer to a single vehicle-driver combination. In cases where a

one-to-one correspondence is not available, the sets of vehicles and drivers to be subjected to the assessment need to be the same, and the group would eventually be assessed as a whole.

4. The calculation of the baseline emission factor requires activity (vehicle kilometres, load) and fuel consumption data. Ideally, this would be calculated based on trip-specific data based on detailed trip logs. The program can request the participating entities to submit such information which can later on be used to generate default emission factors considering characteristics such as vehicle types, weight, age, operating conditions, speed, among others.
5. In many cases, entities would not have unit-specific quality historical information. Another option would be to dedicate units that would comprise control and test groups that would be subjected to monitoring after the training is conducted. The control and test groups should be segmented into categories that would have similar vehicle characteristics, loads, and operating conditions. Trying to match such units would be difficult, but not impossible.
6. If this option is not possible, it is recommended that the participating SMEs dedicate a specific period to generate baseline data for their participating units. Standardized forms that are simple enough to accomplish in a consistent manner would be provided. At the very least, activity and fuel consumption data should be available for one month for each participating unit. If generating such data would not be possible for each unit, then data for representative samples for relevant categories need to be generated. The data quality should be checked regularly, as non-compliance to the monitoring procedures will lead to implementation delays.
7. In a case that an entity would like to participate in the training, and if there were issues with the baseline data, they can still participate in the program and utilize default baseline emission factors, if these are already available. This option maybe possible in later stages of the program implementation, once a project database of emission factors has been established based on the submissions of the entities. The entities that would opt for this option should justify why they are using such default emission factors, as well as the compatibility of such emission factors with their units. They must also commit towards monitoring, and submitting activity and fuel consumption data after their units are subjected to the program.

## **ECO-DRIVING TRAINING**

8. Eco-driving training events will be conducted. These trainings can be designed to include classroom lectures, interactive sessions, and practical tests. "Standardized test runs," which are aimed at generating evidence on the potential impacts of eco-driving, can be included as part of the training event. **These are normally conducted right before the training starts (pre-training), and right after the participants receive the training.**
9. Such standardized test runs are conducted in a pre-determined route (or track). A suitable route that mirrors the daily working route of the drivers can be chosen to carry out the trials. The test route can combine varying types of road gradients, road quality, but the conditions need to be the same during the pre, and post training test runs. The idea is to isolate the impacts of the applications of the learnings during the training, and realize that the application of the eco-driving rules can result in significant efficiency gains.
10. A minimum route length of 30 km is considered as a minimum to capture the driving behaviour. It is highly discouraged to do the test runs on public roads, particularly those which are susceptible to road traffic variations. If only a short route is available, the drivers can be asked to laps within the same route.
11. Depending on the composition of the participants, test vehicles can be varied based on what they normally use on a daily basis. However, as with the road/traffic conditions within the test route, the participants need to use the same vehicle during the pre, and post training test runs.

12. Fuel consumption monitors, and GPS can be utilized to accurately measure fuel flow and distances. If these are not available, manually the tank can be filled completely and refilled after each trip (automatic full tank-drive-automatic full tank method). If a fuel station is available within the test area, it is recommended that the starting and ending point of the test route be the station. The quantity of fuel used to refill is the quantity of fuel consumed for a trip.
13. Drivers can be classified based on the vehicle type they usually operate and trained as per the categorisation. If required, different routes can be fixed as per vehicle type, as long as the routes taken pre and post training are the same. Having a dedicated vehicle on a dedicated route during the entire course of the training helps eliminate variables and evaluate and compare driver performance at each stage. Most popular truck (make & model) which has the highest presence in the region should be chosen for training.
14. Considering 500-1000 drivers are to be trained, a minimum total sample of 100 drivers should be aimed for or ideally, all participants should undergo pre, and post training test runs. This can be achieved if the trainings are designed to accommodate small batches of drivers (e.g. by 20 or 30 per training activity), or if the training schedules, and test sites and vehicles are adjusted accordingly, if the participant pool per activity becomes larger. The comparison of before and after training obtained from the standardized test run provides a good magnitude of improvement.
15. If the quantitative approach is considered as difficult to execute due to several constraints, a qualitative approach could also be considered where the drivers are rated based on an eco-driving scores which includes parameters such as – speed, acceleration, braking, idling, and gear shift etc. However, this score will not provide impact in terms of fuel efficiency improvements and carbon emissions reduction.

## **POST-TRAINING PERIOD**

16. The activity and fuel consumption of all participating units must be monitored during the post-training period. Entities can utilize suitable tools, or technologies (GPS, or in-vehicle data recorders) to accurately generate such data. The entity must establish a database that should contain the following elements (other items can be added):

**Table 1. Suggested Database Tables and Fields**

Table	Fields	Remarks
Driver	Driver ID	Unique for each driver
	Name	
	Contact number	
	Vehicle ID	Unique for each vehicle
	Vehicle type	Standardized categories need to be set by the program
	Vehicle sub-type	Standardized sub-types need to be set by the program (can be combined with truck configuration details)
	Brand	
	Model	
	Production year	
	Fuel type	
	Fuel sub-type	
	Vehicle emission standard	If not known, this can be based on the national standards timeline (necessary if air pollutant emissions are to be estimated)
	Driver ID	
Vehicle ID		
Refuelling points	Refuelling point ID	Unique for each point when refuelling is done.
	Liters filled (full tank)	
	Odometer reading at filling	

	Date	
	Unique trip ID	
Trips	Odometer at start of trip	
	Odometer at end of trip	
	Start date	
	End date	
	Load	Weight of load (tons)
	Driver ID	
	Vehicle ID	
	Remarks	Extra-ordinary instances such as unusual traffic conditions, or crashes should be recorded

17. The driver and vehicle tables are basically profiles of the participating units for each entity. The monitoring of activity and fuel consumption data would be done regularly. Ideally, the drivers would be asked to jot down information for each trip (at the start, and end), and for each time they refuel. They would be given forms that would mimic the fields that are included in the table above. Drivers would be asked to jot down the information below each time they go for refuelling. Ideally, they would fill their tanks each and every time they refuel. Otherwise, it must be ensured that the monitoring periods end with a full tank to enable accurate assessments for the whole periods.
18. Simplified approaches that would include monitoring the values at the start date, and end date of each monitoring period (only applicable to vehicle kilometres, and total fuel consumption) can be used. However, the entities must ensure that total loads are monitored, and that the vehicles start out with filled tanks, and end up with filled tanks during the monitoring period. The good thing about implementing a detailed data monitoring system is that they can also use the data to look into specific insights that may further improve their operations.
19. It is extremely important to ensure that over the due course of the monitoring, data points obtained per truck should be relatively uniform i.e. larger standard deviations indicate imprecision and needs to be investigated for flaws in the measurement procedure or technical issues. The benchmark for identifying imprecision is the standard deviation during monitoring being significantly larger than the historic baseline. Standard outlier statistical tests can be conducted. <sup>1</sup>
20. Along with precision, completeness and comparability of the data is equally important. Data collected should be complete i.e. measure of the amount of valid data obtained from a measurement and comparable to the baseline i.e. measurements will be taken from sampling units over the same period and reported in a common metric. This methodology considers "comparable trucks driving in a comparable situation carrying comparable loads" as results can often be biased depending on the conditions of the vehicle and the environmental under which they were tested.
21. The program should decide on the length of the monitoring and reporting periods. It is suggested that the impacts be assessed every 6 months, if possible. Entities would then be required to submit their data and calculations for each of the monitoring period.
22. The emissions reduction from the implementation of eco-driving is computed as the difference between the baseline emissions and the project emissions.

$$ER_y = BE_y - PE_y$$

**Equation 1. Emissions Impact of the Program**

Where:

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<sup>1</sup> This can be done using Microsoft Excel functions which calculates the 1<sup>st</sup> and 3<sup>rd</sup> Quantiles for each of the data sets. The difference between these two values (referred to as Interquantile range or IQR) are used in setting the Upper and Lower Bounds. The Upper Bound is calculated as Quantile 3 minus (1.5 \* IQR). The Lower Bound is calculated as Quantile 1 minus (1.5 \* IQR). Any value outside these bounds were considered as outliers.

$ER_y$  = CO2 Emission reductions in period y (tons CO2)  
 $BE_y$  = Baseline scenario CO2 emissions in period y (tons CO2)  
 $PE_y$  = Project scenario CO2 emissions in period y (tons CO2)

23. The emissions for the baseline scenario is basically the multiplication of the “project” activity and the baseline emission factor. The method used for calculating the baseline emission factor must be noted and reported by the entities.

$$BE_y = \sum \left( (Pton_{a,i,x,y} * Pvkm_{i,x,y}) * \left( \frac{(BFC_{i,x,z} * FD_x * NCV_x * CC_x * \frac{44}{12})}{(Bton_{i,x,z} * Bvkm_{i,x,z})} \right) \right) / 10^6$$

**Equation 2. Baseline Emissions**

Where:

$BE_y$  = baseline emissions for period y (tons CO2)  
 $PTon_{i,x}$  = tons carried by the vehicles under vehicle category i using fuel x driven by driver a in period y (tons)  
 $Pvkm_{i,x,y}$  = kilometers travelled by the project vehicle under vehicle category i using fuel x driven by driver a in period y (km)  
 $BFC_{i,x,z}$  = baseline consumption of fuel x of vehicle category i in period z (liter or kg)  
 $FD_x$  = density of fuel x (e.g. kg/liter for liquid fuels)  
 $NCV_x$  = net calorific value of fuel x (MJ/kg of fuel)  
 $CC_x$  = carbon content of fuel x (gram Carbon/MJ)  
 $44/12$  = conversion factor (Carbon to CO2)  
 $BTon_{i,x,z}$  = tons carried by the baseline vehicle under vehicle classification i using fuel x in period z (tons)  
 $Bvkm_{i,x,z}$  = kilometers travelled by the baseline vehicle under vehicle category i using fuel x in period z (km)  
 Period y = period encompassed by the project implementation  
 Period z = period when baseline values are established  
 Driver a = drivers who have been trained on eco-driving

24. The project emissions are computed using the actual monitored activity and fuel consumption data. the transport activity of the participating units during the post-training period will be accounted for and will be used in the determination of the CO2 emissions for the baseline scenarios.

$$PE_y = \left( (Pton_{i,x,y} * Pvkm_{i,x,y}) * \left( \frac{(PFC_{i,x,y} * FD_x * NCV_x * CC_x * \frac{44}{12})}{(Pton_{i,x,y} * Pvkm_{i,x,y})} \right) \right)$$

**Equation 3. Project Emissions**

$PE_y$  = project emissions for period y (grams CO2)  
 $PTon_{i,x,y}$  = tons carried by the project vehicle under vehicle category i using fuel x in period y (tons)  
 $Pvkm_{i,x,y}$  = kilometers travelled by the project vehicle under vehicle category i using fuel x in period y (km)  
 $PFC_{i,x,y}$  = consumption of fuel x of project vehicle under vehicle category i in period z (liter or kg)  
 $FD_x$  = density of fuel x (e.g. kg/liter for liquid fuels)  
 $NCV_x$  = net calorific value of fuel x (MJ/kg of fuel)  
 $CC_x$  = Carbon content of fuel x (gram Carbon/MJ)  
 $44/12$  = conversion factor (Carbon to CO2)  
 $PTon_{i,x,y}$  = tons carried by the project vehicle under vehicle classification i using fuel x in period z (tons)  
 $Pvkm_{i,x,y}$  = kilometers travelled by the project vehicle under vehicle category i using fuel x in period z (km)

Period y = period encompassed by the project implementation  
Period z = period when baseline values are established

## **IMPORTANT RELATED FACTORS**

25. The successful impact monitoring of the project is highly dependent on the commitment of the participating entities and driver. It is extremely important to select appropriate drivers and operators for the eco-driving study. Willingness to participate should not be the only criteria for participation in the eco-driving study. We recommend the following criteria for operator selection.
- Operate in GMS corridor
  - Ability to travel consistent, dedicated routes over long distances (higher the travel intensity, better would be the results of the demonstration and magnitude of impact)
  - Operator should be willing to offer trucks that are representative of the fleet/nation
  - Willingness to offer 'baseline' - control trucks or include fuel economy and truck operation data from a sampling of trucks travelling similar routes as the test vehicles, but which are not equipped with efficient technologies.
  - Ability to maintain and track fuel consumption in a consistent and reliable manner,
  - Ability to accommodate driver training for ecodriving and retain drivers during monitoring
  - Willingness to offer fuel consumption data from a sampling of trucks travelling similar routes as the test vehicles, but which are not driven by drivers with eco-driving training to provide an adequate baseline for comparison.
  - Willingness to provide other project data such as fuel logs, fuel receipts, truck/engine information, loading and characterization of operations
  - Having uniform loading patterns
26. Easy-to-use, standardized templates need to be produced and made available to the participating entities and drivers. Reporting instructions must be made clear, and standardized guidelines should be disseminated and explained thoroughly.
27. A system for incentivizing consistent and accurate reporting of data should be put in place, both for the entities, and for the drivers. Ultimately, the reliability of the calculations would be dependent on the quality (and consistency) of the data generated.

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