

2.4 Maintenance

What is maintenance? And how it impacts LCA study?

Vehicle maintenance refers to the routine care of a vehicle to ensure its optimal performance, longevity, and safety by preventing issues from arising and preserving its overall condition. The maintenance phase of a vehicle's life cycle can have a none-negligible impact on its carbon footprint. Recent life cycle assessment studies estimate that the greenhouse gas emissions produced by vehicle maintenance during the use phase can range from 2%- 5% (citation required such as Ricardo study , OEM public reports, Green NCAP study etc.) of total vehicle carbon footprint, depending on the powertrain type and vehicle segment.

2.4.1 Scope

Different types of maintenance? And which types are in the scope of guideline?

Two types of maintenance are included in the guideline:

- *Consumables*: These are items that will need to be refilled periodically over the life of the vehicle to maintain optimal performance. This includes items such as engine oil, transmission fluid etc... For these items recycling is not required, and hence only carbon footprint related to material and production should be considered. Most of the time OEMs recommend a frequency of replacements of these consumables for a given region of usage.
- *Maintenance parts*: This refers to the replacement of parts due to normal wear and tear, including components that are not designed to last the entire lifespan of a vehicle, such as the brakes, clutch, tires, SLI battery etc... The range of parts that need to be replaced during maintenance varies between different cars, depending on factors such as the driver's behavior, road conditions and other variables (weather etc.). Hence, it is difficult for OEMs to recommend a frequency of exchange of these parts to the customer. The frequency of maintenance of such parts can only be estimated with acceptable probability through statistical analysis and a generic frequency of these parts should be used for the purpose of carbon footprint estimation. For these parts recycling aspects must be considered and are same as that of original production parts.

Other repair or maintenance activities not included in the guideline are:

Unexpected repairs (i.e., accident): Looking at the challenge of estimating the consequences of road accidents and premature fails (for components expected to last for service life), the guideline does not address such cases. Furthermore, impact of such cases is not very significant compared to overall carbon footprint of a car.

Cleaning operations: Effect of car wash may not be a significant factor in the calculation as it is a very small fraction of the overall carbon footprint of a car. Hence, the guideline does not address cleaning operations.

2.4.2 Carbon footprint estimation

How is carbon footprint estimated for maintenance?

Since the carbon footprint related to maintenance occurs after the vehicle is placed on the market, it can only be estimated based on statistical data.

There are two possibilities (considered in a hierarchical manner):

1. List of maintenance parts/consumable and associated frequency provided by the OEM.
2. List of maintenance parts/consumable not available

2.4.2.1 Maintenance data available

If list of maintenance parts/consumable and associated frequency is provided by the OEM then the following estimation should be used.

As this will reflect the effort from the OEM to reduce carbon footprint of maintenance, OEM should provide all the assumptions (list, frequency, carbon emission) used for carbon footprint estimation.

$$CO_{2eq.maintenance} = \sum_{i=1}^n CEF_i * f_{i.maintenance}$$

Where,

i : Consumable/ maintenance parts according to chapter 2.4.2.1.1

$f_{i.maintenance}$: Maintenance frequency of the consumable/ maintenance parts defined according to chapter 2.4.2.1.2

CEF_i : Carbon emission factor of the consumable/ maintenance parts as used for calculation of upstream emissions

2.4.2.1.1 Determination of list of consumables and parts

Following table provide a list of consumables and parts for guidance and should not be considered as exhaustive. The OEM should provide the list adapted to the powertrain and vehicle segment for which the carbon footprint is calculated.

Table 2.1 List of consumables and maintenance parts

	Gasoline	Diesel	CNG	NOVC-HEV	OVC-HEV	Pure EV	FCHV	OVC-FCHV	H ₂ -ICE	...
Consumables	Engine Coolant	✓	✓	✓	✓	✓	-	-	-	✓
	Engine Lubricant	✓	✓	✓	✓	✓	-	-	-	✓
	Screen Wash	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Break fluids	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Electric Drive Unit Fluid	-	-	-	✓	✓	✓	✓	✓	-
	Transmission fluid	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Refrigerant	✓	✓	✓	✓	✓	✓	✓	✓	✓
	AdBlue/Urea	-	✓	-	-	-	-	-	-	-
Maintenance parts	Passenger Air Filter	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Engine Filter	✓	✓	✓	✓	✓	-	-	-	-
	Spark plug	✓	-	✓	✓	✓	-	-	-	-
	Windshield Wiper Blades	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Tires	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Brake linings	✓	✓	✓	✓	✓	✓	✓	✓	✓
	SLI Battery (12V)	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Aftertreatment	✓	✓	✓	✓	✓	-	-	-	-
Traction Battery	-	-	-	✓	✓	✓	✓	✓	-	
Fuel cell	-	-	-	-	-	-	✓	✓	✓	

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2.4.2.1.2 Determination of frequency

Frequency can be calculated by the following two approach:

Frequency by distance

$$Frequency_{distance} = \frac{Service\ life\ [km]}{Maintenance\ interval\ [km]}$$

Frequency by duration

$$Frequency_{duration} = \frac{Service\ life\ [years]}{Maintenance\ interval\ [years]}$$

In case OEM recommends frequency by both distance and duration, both calculations should be performed, and most conservative frequency should be considered for the carbon footprint estimation.

2.4.2.2 Maintenance data not available

The maintenance parts/consumable are already included in the upstream emission as they are part of the vehicle before placing the vehicle on the market. Hence, if list of maintenance parts/consumable not available then a fixed percentage of upstream emission can be attributed

to maintenance depending upon powertrain, service life, vehicle segment and region of use.
 (credit should be given to Green NCAP for this , check for reference Green NCAP document)

These factors can be defined by each region through statistical analysis. For all category 1 vehicle it can be assumed that there is no variation within segments.

$$CO_{2eq.maintenance} = f_{maintainence} * (CO_{2eq.Material} + CO_{2eq.Production} + CO_{2eq.Recycling})$$

Where,

$f_{maintainence}$: Maintenance frequency as defined in table 2.2

$CO_{2eq.Material}$: Carbon footprint of material acquisition phase

$CO_{2eq.Production}$: Carbon footprint of production phase

$CO_{2eq.Recycling}$: Carbon footprint of recycling phase for maintenance parts

Table 2.2 Default maintenance frequency as a function of powertrain

Powertrain	Gasoline	Diesel	CNG	NOVC-HEV	OVC-HEV	Pure EV	FCHV	OVC-FCHV	H ₂ -ICE	...
$f_{maintenance}$	YY %	ZZ%								

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