

Lubricants Life Cycle Assessment and Carbon Footprinting—Methodology and Best Practice

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Foreword

This document is classified as a Technical Report. API's *Procedures for Standards Development* define technical reports as documents that convey technical information on a specific subject or topic, are generally issued on a one time-basis, and are not standards.

This publication has been developed by industry subject matter experts established by the API Lubricants Standards Committee ("the Committee") with the original intention of producing a Standard. However, as development of this document proceeded, it was determined that the level of importance to industry of the accumulated information and references contained herein warranted early publication in the form of a Technical Report.

The Committee continues their effort to produce a Standard in a subsequent revision or replacement. Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, Suite 1100, Washington, DC 20001, standards@api.org.

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Lubricants Life Cycle Assessment and Carbon Footprinting—Methodology and Best Practice

1 Introduction and Scope

Life cycle assessment (LCA) and carbon footprints of products (CFP) are established methodologies used to quantify the environmental performance of products, processes, or services, and are increasingly being used as a basis for environmental decision-making along the supply chain. While LCA includes multiple impact categories, CFP focuses specifically on the impact category of “climate change”, which is associated with greenhouse gas (GHG) emissions/removals.

Both LCA ^[1, 2] and CFP ^[6] depend on functional methods for which there are international standards that set principles, requirements, and guidelines for carrying out such studies. Despite these standards, choices are still left with the practitioner performing the study, regarding, for example: setting the boundaries of the system; allocation of impacts between co-products or recycled products; selecting metrics used to estimate impacts; and choosing the sources of data. These choices can have significant impacts on the outcome of a performed assessment, and alignment on these choices is needed to allow for fair comparison of results from different studies.

This need for alignment is the motivation to create a common LCA and CFP framework for lubricant products within the API Lubricants Sustainability Group. This collaboration was formed through the cooperation of API members with the intention of providing guidance via this technical report (TR).

The purpose of this document is to define terminology and to identify and capture best practices for LCA and CFP of lubricants ¹ (see [Figure 1](#)). The overall aim is to promote harmonization and consistency in the application of LCA and CFP across the lubricants industry. While many concepts discussed in this technical report will be generally applicable to both LCA and CFP assessments, more detailed discussion in this version of the document is often focused on CFP assessments; this is driven by strong interest from the industry in the topic.

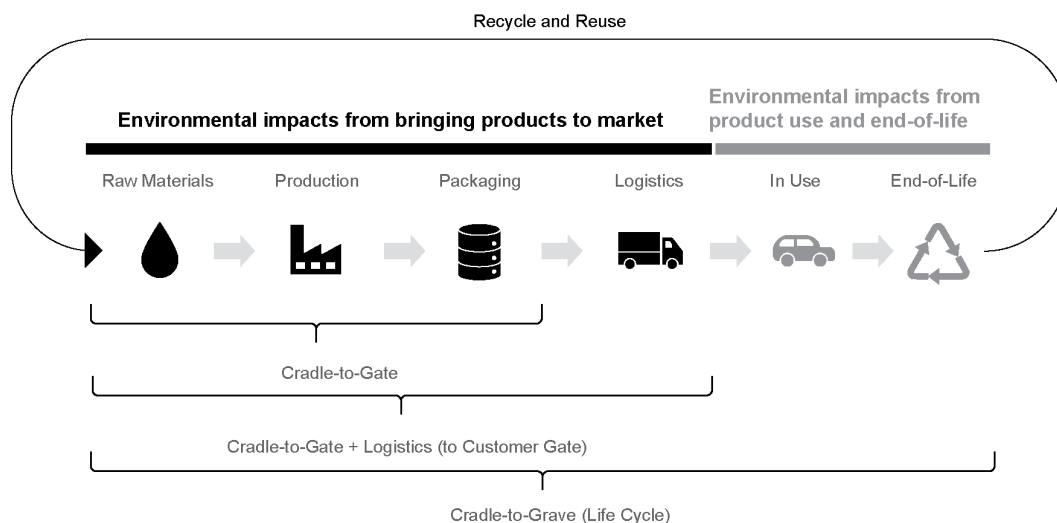


Figure 1—Overview of the Key Stages of the Lubricant Life Cycle

This best-practice document is not intended to be as prescriptive and detailed as product category rules (PCR). However, it could serve as the foundation for such definitions at a later date.

Lubricants for various application areas, that are consistent with the definition of a “lubricant” as provided in [3.1](#) and where sufficient data are available to describe the life cycle stages outlined in [Figure 1](#), are part of the scope

¹ “Lubricant” is defined in [3.1](#). For the purposes of this technical report, the term encompasses “lubricants and specialty products.”

for this technical report. The applicability of the methodology in this document to a specific case in hand can ultimately be decided by the practitioner executing the study. Examples of lubricants include but are not limited to the following:

- engine oils (both light and heavy duty);
- driveline fluids;
- greases;
- other industrial-type fluids, e.g. thermal management, hydraulic fluids, gear oils.

This technical report defines the CFP for a lubricant product on a life cycle ([Figure 1](#)) or cradle-to-grave basis. Therefore, to generate the CFP, the absolute GHG emission and removals at each stage of the life cycle are summed up ([Figure 2](#)) and converted to CO₂ equivalent (CO₂e). To generate a partial CFP, e.g. on a cradle-to-gate basis, the respective, absolute GHG emissions and removals at the applicable life cycle stages are summed up and converted to CO₂e.

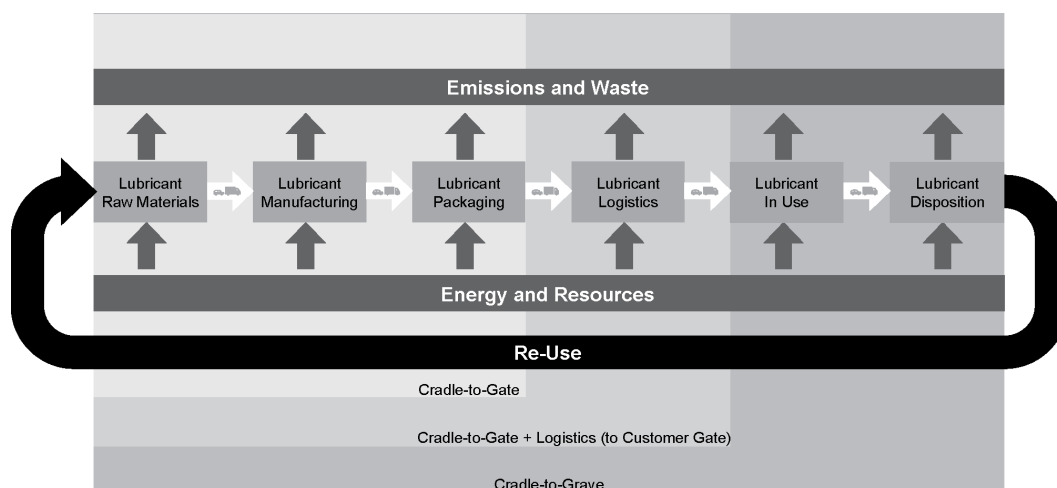


Figure 2—Definition of Scopes for Carbon Footprint of Product (CFP) Assessments

With the focus on the carbon content of the lubricant itself, [Figure 3](#) examines in more detail the potential losses of the lubricant to the environment after the production (after cradle-to-gate + logistics) and until final disposition. These potential losses should be accounted for and included in the assessment if a cradle-to-grave scope of the CFP is intended to be covered.

This technical report provides general methodological recommendations in [Section 4](#), while more detailed considerations along the stages of the life cycle are covered in [Section 5](#). The life cycle stages falling into the cradle-to-gate + logistics scope are covered in [5.1](#) through [5.4](#). To complete the cradle-to-grave scope, [5.5](#) and [5.6](#) cover the “in use” and “end-of-life” life cycle stages, respectively, in more detail.

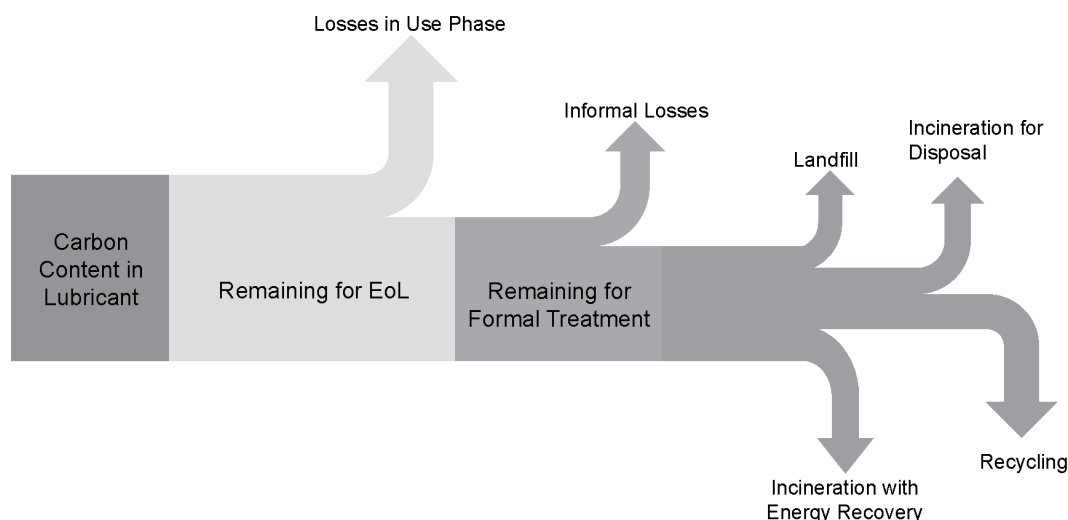


Figure 3—Tracing Carbon Content through the “In Use” and “End-of-Life” Stages of the Life Cycle

While the cradle-to-grave scope includes losses in the “in use” stage (e.g. partial combustion of lubricant during use), certain “in use benefits” should stand separately, in addition to the carbon footprint (CFP). “In use benefits”, also referred to as “avoided emissions” or “comparative emissions”, rely on a relative comparison between two scenarios, one where the product exists and one where it is replaced by a reference product or functionally relevant baseline ^[19]. “Avoided emissions” are discussed briefly in [Section 6](#) of this technical report and could involve calculations that assess the following:

- avoided emissions from extension of the oil drain interval (ODI), thereby reducing the volume of lubricant required across the lifetime of the application;
- avoided emissions during the use of the lubricant product, through fuel economy due to efficiency improvements, thereby reducing the volume of fuel required to travel a certain distance or operate for a certain period of time.

Such calculations of avoided emissions are of strong industry interest but are also complex matters. Future updates to this technical report may include a more comprehensive treatment of these topics.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14040,² *Environmental management — Life cycle assessment — Principles and framework*

ISO 14044, *Environmental management — Life cycle assessment — Requirements and guidelines*

ISO 14067, *Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification*

ISO 14021, *Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling)*

ISO 14071, *Environmental management — Life cycle assessment — Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006*

² International Organization for Standardization, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.

WRI Greenhouse Gas Protocol,³ *Product Life Cycle Accounting and Reporting Standard*

BSI PAS 2050,⁴ *Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

additive package

A combination of additive components that provide targeted lubricant performance.

NOTE Further information on additives can be found in [5.1.2](#).

3.1.2

avoided emissions

Based on a relative comparison between two scenarios—one where the product exists and one where it is replaced by a reference/functionally equivalent baseline product—it can be shown that the former leads to reduced emissions.

[adapted from World Resources Institute, *Estimating And Reporting The Comparative Emissions Impacts Of Products*, 2019]

NOTE High-level discussion on the topic of “avoided emissions” is provided in [Section 6](#).

3.1.3

biogenic carbon

“Carbon derived from biomass”.

[Source: ISO 14067:2018, Section 3.1.7.2]

NOTE For biogenic carbon in lubricants, see [4.8](#).

3.1.4

biomass

“Material of biological origin, excluding material embedded in geological formations and material transformed to fossilized material”.

[Source: ISO 14067:2018, Section 3.1.7.1]

“NOTE 1 Biomass includes organic material (both living and dead), e.g. trees, crops, grasses, tree litter, algae, animals, manure, and waste of biological origin”.

“NOTE 2 In this document, biomass excludes peat”.

3.1.5

blends

Mixes of different components designed to meet a specific ratio in composition.

³ World Resources Institute, 10 G Street, NE, Suite 800, Washington, DC 20002, www.ghgprotocol.org.

⁴ British Standards Institution, 389 Chiswick High Road, London W4 4AL United Kingdom, www.bsigroup.com.

3.1.6

carbon content

Carbon (both fossil and biogenic carbon) contained in the molecules that make up the lubricant product.

3.1.7

carbon dioxide equivalent (CO₂e)

“A unit for comparing the radiative forcing of a GHG to that of carbon dioxide”.

[Source: ISO 14067:2018, Section 3.1.2.2]

NOTE For a lubricant, the mass of applicable GHGs is converted into CO₂ equivalents by multiplying the mass of the GHG by the corresponding global warming potential over a 100-year time frame (GWP-100).

3.1.8

carbon footprint of a product (CFP)

“The sum of GHG emissions and GHG removals in a product system, expressed as CO₂ equivalents and based on a life cycle assessment using the single-impact category of climate change”.

[Source: ISO 14067:2018, Section 3.1.1.1]

NOTE 1 A definition of a carbon footprint for a lubricant on a cradle-to-grave basis is provided in [Section 1](#).

NOTE 2 In line with ISO 14067:2018, Section 3.1.1.7, carbon offsetting is not allowed in the quantification of a CFP or a partial CFP.

3.1.9

carbon neutral

“Carbon neutral refers to a product (as a product system) that has a CFP of zero or a product for which the emissions determined as the CFP have been reduced to zero through offsetting”.

“In relation to a product, carbon neutral requires that all the GHG emissions from all stages of the product life cycle, and within the specified product system, have been reduced, removed or accounted for through a system of offsetting or credits, or by other means”.

[Source: ISO 14021:2016 + Amd 1:2021, Sections 7.17.3.1 and 7.17.3.2]

3.1.10

circular economy

“A model of production and consumption that involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible”.

[Source: Bibliography Reference [9]]

3.1.11

cradle-to-gate

All upstream stages until the production gate. This includes the following life cycle stages: raw materials, production, and packaging (if applicable).

NOTE For “cradle-to-gate + logistics,” the logistics to the customer gate is added to the scope of the above definition of cradle-to-gate.

3.1.12

cradle-to-grave

All stages of the lubricant life cycle ([Figure 1](#)) are included in this scope, typically covering the following: raw materials, production, packaging, logistics, in use, and end-of-life.

3.1.13

comparative assertion

“An environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function”.

[Source: ISO 14044:2006, Section 3.6]

3.1.14

comparative emissions

A difference in emissions based on a relative comparison between two scenarios: one where the product exists and one where it is replaced by a reference/functionally relevant baseline product.

NOTE A high-level discussion on the topic is provided in [Section 6](#).

3.1.15

components

Different constituent parts (e.g. base oil and additives) from which a lubricant is blended.

3.1.16

critical review

“A process intended to ensure consistency between a life cycle assessment and the principles and requirements of international standards on life cycle assessment”.

[Source: ISO 14044:2006, Section 3.45]

“NOTE 1 The principles are described in ISO 14040:2006, Section 4.1”.

“NOTE 2 The requirements are described in ISO 14044:2006, Section 6”.

3.1.17

cut-off criteria

“Specification of the amount of material or energy flow or the level of environmental significance associated with unit processes or product systems to be excluded from a study”.

[Source: ISO 14044:2006, Section 3.18]

NOTE Information on cut-off criteria as they pertain to lubricants can be found in [4.5](#).

3.1.18

direct land use change (dLUC)

“A change in the human use of land within the relevant boundary”.

[Source: ISO 14067:2018, Section 3.1.7.5]

“NOTE 1 In this document, the relevant boundary is the boundary of the system under study”.

“NOTE 2 Land use change happens when there is a change in the “land-use category” as defined by the IPCC (e.g. from forest land to cropland)”.

3.1.19

embedded carbon

See “carbon content”.

3.1.20

end-of-life

The final stage in the life cycle of a product.

3.1.21**environmental impact**

“A change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization’s environmental aspects”.

[Source ISO 14001:2015, Section 3.2.4]

3.1.22**environmental aspect**

“An element of an organization’s activities or products or services that interacts or can interact with the environment”.

[Source ISO 14001:2015, Section 3.2.2]

“NOTE 1 An environmental aspect can cause (an) environmental impact(s). A significant environmental aspect is one that has or can have one or more significant environmental impact(s)”.

“NOTE 2 Significant environmental aspects are determined by the organization applying one or more criteria”.

3.1.23**feedstock**

Raw materials entering a process of refinement or synthesis step.

NOTE For lubricants, examples could be a used lubricant entering a re-refinement process or naphtha being converted via synthesis to an additive component.

3.1.24**fuel economy**

A coefficient relating distance traveled by a vehicle with the amount of fuel consumed.

3.1.25**global warming potential (GWP)**

“An index based on the radiative properties of GHGs that measures the radiative forcing following a pulse emission of a unit mass of a given GHG in the present-day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide (CO₂)”.

[Source: ISO 14067:2018, Section 3.1.2.4]

NOTE For calculating CFPs for lubricants, the GWPs over 100-year horizon (GWP-100), as published by the IPCC, should be used for conversions of the impacts of other GHGs to CO₂ equivalent.

3.1.26**greenhouse gas (GHG)**

“A gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth’s surface, the atmosphere, and clouds”.

[Source: ISO 14067:2018, Section 3.1.2.1]

NOTE 1 For a lubricant, at a minimum, the following GHGs should be considered: CO₂, CH₄, and N₂O. For a list of GHGs, see the latest IPCC Assessment Report ^[10].

“NOTE 2 Water vapor and ozone, which are anthropogenic, as well as natural GHGs, are not included in the CFP and partial CFP”.

“NOTE 3 The focus of this document is limited to long-lived GHGs; therefore, it excludes climate effects due to changes in surface reflectivity (albedo) and short-lived radiative forcing agents (e.g. black carbon and aerosols)”.

3.1.27**greenhouse gas emissions**

“Releases of GHG into the atmosphere”.

[Source: ISO 14067:2018, Section 3.1.2.5]

3.1.28**greenhouse gas emission factor**

“A coefficient relating activity data with the GHG emission”.

[Source: ISO 14067:2018, Section 3.1.2.7]

3.1.29**greenhouse gas (GHG) removal**

“The withdrawal of GHG from the atmosphere”.

[Source: ISO 14067:2018, Section 3.1.2.6]

3.1.30**indirect land use change (iLUC)**

“A change in the use of land that is a consequence of direct land use change, but that occurs outside the relevant boundary”.

[Source: ISO 14067:2018, Section 3.1.7.6]

“NOTE 1 In this document, the relevant boundary is the boundary of the system under study”.

“NOTE 2 Land use change happens when there is a change in the “land-use category” as defined by the IPCC (e.g. from forest land to cropland)”.

3.1.31**informal losses**

Used oil entering informal treatment channels (e.g. used oil available for collection but not arriving in formal treatment channels).

NOTE Further details on formal and informal used oil treatment can be found in [5.6.1](#).

3.1.32**life cycle assessment (LCA)**

“The compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a product system throughout its life cycle”.

[Source: ISO 14067:2018, Section 3.1.4.3]

3.1.33**lubricant**

“A product that is capable of reducing friction, adhesion, heat, wear, or corrosion when applied to a surface or introduced between two surfaces in relative motion or is capable of transmitting mechanical power”.

[Source: Bibliography Reference [11]]

3.1.34**non-energy product**

A product that is not intended to be combusted for energy production.

NOTE It is acknowledged that, in two stroke applications, the lubricant will inevitably be combusted, but this is not its main intended function.

3.1.35

oil drain interval

The interval between the instances when most of the lubricant in an application is changed. This can be measured in distance (e.g. kilometers or miles) or time (e.g. hours of operation).

3.1.36

partial carbon footprint of a product

“The sum of GHG emissions and GHG removals of one or more selected process(es) in a product system, expressed as CO₂ equivalents and based on the selected stages or processes within the life cycle”.

[Source: ISO 14067:2018, Section 3.1.1.2]

NOTE An example of a partial carbon footprint of a lubricant would be a cradle-to-gate footprint.

3.1.37

primary data

“The quantified value of a process or an activity obtained from a direct measurement or a calculation based on direct measurements”.

[Source: ISO 14067:2018, Section 3.1.6.1]

“NOTE 1 Primary data need not originate from the product system under study because primary data might relate to a different but comparable product system to that being studied”.

“NOTE 2 Primary data can include GHG emission factors and/or GHG activity data (defined in ISO 14064-1:2006, Section 2.11)”.

NOTE 3 For further details on data sources for lubricants, see [4.6](#).

3.1.38

raw materials

“Primary or secondary material that is used to produce a product”.

[Source: ISO 14044:2006, Section 3.15]

“NOTE Secondary material includes recycled material”.

3.1.39

re-refined base oil

Lubricant base stock derived in part or completely from used oil via refinery processes.

3.1.40

Scope 1 emissions

“Direct GHG emissions occur from sources that are owned or controlled by the company; for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc., or emissions from chemical production in owned or controlled process equipment”.

[Source: Bibliography Reference [28]]

3.1.41

Scope 2 emissions

“GHG emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated”.

[Source: Bibliography Reference [28]]

NOTE Scope 2 emissions as used in this technical report also include imported steam.

3.1.42

secondary data

“Data that do not fulfil the requirements for primary data”.

[Source: ISO 14067:2018, Section 3.1.6.3]

NOTE For further details on data sources, see [4.6](#).

3.1.43

sensitivity analysis

“Systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a study”.

[Source: ISO 14044:2006, Section 3.31]

3.1.44

value chain

A series of consecutive steps that are needed to create a finished product. At each step of the chain, value is added.

3.2 Acronyms and Abbreviations

For the purposes of this document, the following acronyms and abbreviations apply.

API	American Petroleum Institute
ATIEL	Technical Association of the European Lubricants Industry
BO	base oil
CC	complete combustion (all embedded carbon released as CO ₂)
CD	combustion for disposal
CFP	carbon footprint of product
CHP	combined heat and power
CHR	combustion with heat recovery
DEFRA	Department for Environment, Food and Rural Affairs
dLUC	direct land use change
EF	emission factor
EoL	end-of-life
EPA	Environmental Protection Agency
GHG	greenhouse gas
GLEC	Global Logistics Emissions Council
GWP	global warming potential
HDPE	high-density polyethylene
IBC	intermediate bulk containers
ICCA	International Council of Chemical Associations
iLUC	indirect land use change
IPCC	Intergovernmental Panel for Climate Change