ALD

POSITIVE IMPACT BOND FRAMEWORK

SEPTEMBER 2018

1 INTRODUCTION

ALD Automotive ("ALD" or the "Company") is a global leader in mobility solutions providing full service leasing and fleet management services across 43 countries to a client base of large corporates, SMEs, professionals and private individuals. A leader in its industry, ALD places sustainable mobility at the heart of its strategy, delivering innovative mobility solutions and technology-enabled services to its clients, helping them focus on their everyday business.

With 6,300 employees worldwide, ALD manages 1.59 million vehicles (at end June 2018). ALD is listed on Euronext Paris, compartment A (ISIN: FR0013258662; Ticker: ALD) and its share is included in the SBF120 index. ALD's controlling shareholder is Societe Generale.

1.1 ALD AUTOMOTIVE'S SUSTAINABILITY AMBITIONS

ALD implements a global approach, with a focus on sustainable products and services as well as responsible business conduct in terms of employment, environmental and social commitments.

ALD 's CSR policy strives to follow four general principles of action:

- Shape the future of sustainable mobility: minimize the impact of its operational activities on the environment and public health, which means maintaining an automobile fleet that restricts pollution and greenhouse gas emissions, and creating solutions for a more sustainable mobility;
- Ensure constant attention to the well-being of its employees and developing our human capital within the framework of Societe Generale group policies, with ALD specifics linked to our DNA and business model;
- Spread a responsible business culture and practices in all aspects of the business, with a focus on business ethics (culture & conduct) and positive sourcing
- Control and reduce its own consumption of natural and energy resources through a rational and optimised usage, towards carbon neutrality

This first of these principles is anchored is the Company's business model and covers the following areas:

- Be an active player in the organisation of future urban, sustainable mobility. ALD places a strategic focus on investing in new mobility solutions that will transform the usage of the car (for example car and ride sharing, mobility as a service), fostering new behaviours that will gradually shift the model away from the one user = one car traditional scenario.
- Guide our clients towards low emission cars. Our responsibility is to improve our clients' fleet and limit fuel consumption and greenhouse gases (GHG) emissions. To this end, the Company's view is to prescribe responsibly: identify the right vehicle for the right usage and enable its clients to make informed decisions, with a view to continuously reducing the environmental impact of its fleet and facilitate the transition away from traditional combustion engines. This involves continually improving the tools to help our customers to measure their carbon footprint, facilitate the adoption of green vehicles, promote eco-driving, providing knowledge about technologies, laws and taxation, and mobility trends.
  The project falls within this objective of greening the fleet.

1.2 RATIONALE

Greenhouse gas emissions from cars and vans are widely seen as one of the major issues to address to tackle climate change: road transport is responsible for a significant 20% of emissions within the European Union, but gathers an even greater share of public attention.

Awareness has also increased for the issue of pollution, especially in urban areas. The transport sector accounts for around half of Nitrogen Oxydes (NOx) emissions, and generates vast amounts of particulates (PM), both seen as a serious concern for public health. In an attempt to limit CO_2 emissions, public policies have encouraged the wide adoption of diesel, an energy that has proved more efficient than petrol in terms of CO_2 emissions, but is now known as having generated much more local pollutants (e.g. NOx and PM), even though the latest generations of diesel (under the Euro6-d norm) have shown tremendous progress. All in all, climate and environmental issues coincide and sometimes collide[1].

Hence the need to decarbonize the product line-up, and accelerate adoption of "electrified" product solutions (Battery Electric Vehicles, Plug-in Hybrids, and Hybrids) that can potentially generate a positive impact on all factors.

The intrinsic nature of the leasing fleet, which is by far younger (hence technologically more up to date, and environmentally respectful) than the average car park, places a company like ALD ahead of the average. Although the environmental footprint of the fleet is largely dictated by the product offering (car manufacturers) and utilisation by end users (clients), ALD – owning the assets, and acting as a prescriber in the vehicle choice – must play its part to create a more sustainable mobility. This intention is already materialised is our green fleet KPIs: as at 31 December 2017, the Company's total low emission fleet consisted of 69,433 electric or hybrid vehicles, a 47% increase compared to 2016. Results at the end of June 2018 confirm this trend.

As this trend is set to continue, ALD intends to finance the growth of its green fleet through the issuance of Positive Impact Bonds.

2 ALD POSITIVE IMPACT BOND FRAMEWORK

ALD has prepared its Positive Impact Bond Framework (the "Framework") in accordance with the UN Environment Finance Initiative's Principles for Positive Impact Finance (2017) and the Green Bond Principles (2018)[2].

The Principles for Positive Impact Finance are a set of voluntary guidelines to guide financiers and investors in their effort to increase their positive impact on the economy, society, and the environment. By jointly considering the three pillars of sustainable development and by basing themselves on an appraisal of both positive and negative impacts, the Principles propose a holistic approach to sustainability issues. In doing so, they build on and complement existing frameworks such as the ICMA's Green and Social Bond Principles (instrument

[1] Aware of the importance to consider climate and environmental impacts, ALD is closely following the progress of the sector on the measurement of its impacts.

[2] See Section 3 detailing the alignment of ALD's Positive Impact Finance Framework with the Green Bond Principles.

specific), the Principles for Responsible Investment (sector specific), the Equator Principles (risk focused), among others, to provide a broad, common framework to achieve the financing of sustainable development.

In alignment with the Principles for Positive Impact Finance, the Framework is presented through the following key pillars:

1. Definition
2. Frameworks
3. Assessment
4. Transparency

2.1 DEFINITION

> Principle 1: Positive Impact Finance is that which serves to finance Positive Impact Business.
> It is that which serves to deliver a positive contribution to one or more of the three pillars of sustainable development (economic, environmental and social), once any potential negative impacts to any of the pillars have been duly identified and mitigated.
> By virtue of this holistic appraisal of sustainability issues, Positive Impact Finance constitutes a direct response to the challenge of financing the Sustainable Development Goals (SDGs)

Positive Contribution

As an international mobility company, ALD's commitment is to act every day to improve its clients' fleet and to limit fuel consumption and GHG emissions. As such the company identified the clean vehicle leasing and fleet management business as being one of its key Positive Impact Businesses. The scope of this inaugural Positive Impact Bond will therefore cover vehicles that have a clear positive contribution to the environment and that support the development of clean transportation and the transition to a low carbon future.

Direct response to SDGs

ALD's Positive Impact Bond will support achieving the United Nations Sustainable Development Goals "Good Health and Well-Being" (SDG 3), "Industry, Innovation and Infrastructure" (SDG 9),,"Sustainable Cities and Communities" (SDG 11), and "Climate Action" (SDG 13), contributing in particular to the specific targets mentioned below:

SDG	TARGET
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	9.4: By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
11 SUSTAINABLE CITIES AND COMMUNITIES	11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
13 CLIMATE ACTION	UN SDG 13 consists in taking urgent action to combat climate change and its impacts. The fleet management and long-term vehicle leasing sector can contribute to this goal by investing in the reduction of GHG emissions from transport operations through a shift to lower carbon technologies.
3 GOOD HEALTH AND WELL-BEING	3.9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.

2.2 FRAMEWORK

> Principle 2: To promote the delivery of Positive Impact Finance, entities (financial or non-financial) need adequate processes, methodologies, and tools, to identify and monitor the positive impact of the activities, projects, programmes, and/or entities to be financed or invested in.

Identification

An amount equivalent to the net proceeds of the Positive Impact Bond issuance will be exclusively used to finance or refinance “Eligible vehicles” that contribute to the development of clean transportation and the transition to a low carbon future. Eligible vehicles will be defined as per the eligibility criteria defined below.

Selection of the vehicles qualifying for Positive Impact

A Positive Impact Bond Committee (the "Committee") has been created to ensure the respect of the Framework and oversee the entire issuance process. The Committee is composed of ALD representatives from the following departments: CSR department, Finance department and Investor Relations department.

The Finance Department defines and monitors the financial eligibility of potentially eligible vehicles (see financial exclusion criteria below). The CSR department then identifies the eligible vehicles based on the eligibility criteria below. Once the portfolio of eligible vehicles is duly selected, it will be validated by the Positive Impact Bond Committee.

This Positive Impact Bond Committee will also be responsible for managing any future update to the Framework, including expansions of the use of proceeds. Any changes to the Framework will be published on ALD's website.

- **Eligibility Criteria**

✓ Electric vehicles (EV) and fuel cell vehicles are considered as automatically eligible under the Framework.

✓ Hybrid electric vehicle (HEV) and plug-in hybrids vehicles (PHEV) with tailpipes CO_2 emissions at or below **85- grams of CO_2**[3] per passenger kilometer travelled (g CO_2 / pkm) are considered as eligible.

- **Exclusion Criteria**

Financial exclusion criteria – the Finance Department will monitor the financial eligibility of potential eligible vehicles by excluding:

× vehicles already pledged or benefiting from a specific funding program

× vehicles from ALD's subsidiaries that are not benefitting from a direct funding through the company's treasury center.

Technical exclusion criteria – net proceeds from ALD's Positive Impact Bond will not be allocated to the following vehicle motorization types[4]:

× conventional internal combustion engine (ICE) vehicles

× liquefied petroleum gas vehicles

× biofuel vehicles

× natural gas vehicles

[3] The CO_2 emissions threshold criteria will be assessed based on emissions data provided by vehicle manufacturers and was defined as per Climate Bond Initiative (CBI) recommendation. Note that ALD may update this threshold for future issuance to align with the International Energy Agency (IEA) Mobility Model, as specified in the CBI's Standard for Low Carbon Land Transport.

[4] Note that ALD may update the list of excluded vehicle motorization types to take into account potential technological evolution or disruption that would impact the environmental performance of vehicles in the future. Such update would be reflected in a revised framework.

By defining a maximum GHG emissions threshold and by excluding vehicle motorization types associated with carbon or land-use intensive technologies, this selection process allows to mitigate potential negative environmental impacts. It is aligned with existing market and regulatory standards with regards to clean vehicles such as:

- The Climate Bond Initiative's Standard for Low Carbon Land Transport[5] (version 1.0 dated February 2017) which recommends "adopting a cautious approach of placing vehicles within broad technology categories which are either known to have direct tailpipe emissions of less than the emissions threshold in all cases (e.g., battery and fuel cell vehicles) and those which are not (e.g. conventional internal combustion engine, liquefied petroleum gas and natural gas vehicles)". Under Climate Bond Initiative standards, hybrid vehicles are considered as "potentially eligible (depending on threshold)".
- The European Commission CO_2 emission standards for passenger cars [6]: EU legislation sets mandatory emission reduction targets for new cars. The 2015 target was set at 130grams of CO_2 per kilometer (g CO_2/km). By 2021, the fleet average to be achieved by all new cars is 95 grams of CO_2 per kilometer.

Positive Impact Evaluation

Aware of the importance of adopting a life cycle perspective to assess the environmental impacts of electric and hybrid vehicles, ALD has collaborated with Quantis, a recognized environmental advisory firm with a leading expertise on Life Cycle Assessment, in order to develop a robust assessment of the Positive Impacts delivered through this Bond.

Based on its in-depth knowledge of transport environmental topics, Quantis assisted ALD in developing a dedicated impact assessment methodology and tool, calculating for the fleet of eligible vehicles, the related estimated climate and environmental benefits. This methodology assesses the GHG, NOx and PM emissions of the eligible vehicle fleet and allows to compare them with the ones of a baseline fleet composed of equivalent ICE vehicles, considering the various phases related to the life of the vehicles (production, use, end of life) but also the countries in which the vehicles are used (see Quantis methodology attached at the end of this document).

Based on this methodology, ALD will prioritise in its selection among the eligible vehicles (identified in accordance with the eligibility and exclusion criteria defined above), those with the greatest net positive contribution to climate and environment, using GHG savings as a primary filter, and NOx as a secondary filter.

Management of Proceeds

The Positive Impact Bond proceeds will be managed by ALD's Finance Department. ALD intends to select sufficient Eligible vehicles to ensure the total amount of investment related to the portfolio of Eligible vehicles equals the proceeds of the Bonds issued under the Framework. As such, if a portion of Eligible vehicles exits ALD's fleet during the life of the Positive Impact Bonds, additional Eligible vehicles will be added to the portfolio.

ALD commits on a best effort basis to reach full allocation no longer than 2 years after issuance date.

ALD will track the net proceeds through its internal accounting system and hold any unallocated proceeds within its regular cash management operations. The Finance Department will ensure the financial eligibility of potential eligible vehicles by monitoring the financial exclusion criteria detailed above.

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[5] https://www.climatebonds.net/files/files/Low%20Carbon%20Transport%20Background%20Paper%20Feb%202017.pdf

[6] https://ec.europa.eu/clima/policies/transport/vehicles/cars_en

2.3 ASSESSMENT

> Principle 4: The assessment of Positive Impact Finance delivered by entities, should be based on the actual impacts achieved

Assessment of Positive Impacts delivered

The impact assessment methodology developed with Quantis considers the various phases related to the life of the vehicles: production, use, end of life.

Such life cycle analysis demonstrates for all Bonds issued under the Framework the positive contribution to the climate while potential negative impacts have been duly identified and taken into account.

Aware of the importance to consider not only climate but also environmental impacts at large, ALD has extended the scope of the impact assessment methodology developed by Quantis, beyond GHG emissions. The robustness of overall NOx emission assessment enabled ALD to use avoided NOx data as a selection filter(as mentioned in the Positive Impact Evaluation section), despite limitations in availability of data at individual vehicle level on existing portfolio.

PM emissions have been considered but a number of limitations have led us to exclude this criteria from the portfolio fine-tuning:

- Lack of accurate PM tailpipe emissions theoretical data at the required granular level on the existing portfolio (both green and baseline fleet), and lack of robust measurement of real life PM tailpipe emissions on baseline fleet (e.g. effectiveness of particulate filters for diesel vehicles)
- And most importantly, while PM emissions are considered by policy makers as a pressing local urban issue (where data on real emissions is lacking – see above), the life cycle assessment methodology developed by Quantis demonstrated that majority of PM emissions – both for eligible and ICE vehicles – derive from production of vehicles and fuel/energy (i.e. mainly emissions in non-urban areas). When considering the use phase, PM emissions are mostly generated by tires and brake abrasion.

While this process revealed that the current state of the art of available databases makes it difficult to properly measure environmental impacts, ALD will closely follow the progress of the sector on the measurement of its impacts and will evolve its reporting as soon as an appropriate methodology is developed.

Reporting

ALD intends to produce annually and until the maturity of the Positive Impact Bond an impact reporting that will be made available on ALD's website.

ALD's CSR Department will oversee the reporting exercise, including collecting the relevant data from ALD's subsidiaries, and producing the impact reporting on the basis of the impact assessment methodology and tool developed by Quantis.

ALD commits to report on:

- ✓ Annual GHG emissions in tons of CO_2 equivalent (Scope 1)
- ✓ Annual GHG emissions reduction in tons of CO_2 equivalent (Scope 3)

ALD will endeavour to report on environmental metrics (primarily NOx) when data will become available – and reliable – at individual vehicle level[7].

Additionally, ALD will report on the following information related to the composition of the selected portfolio of eligible vehicles:

- ✓ The total amount of the portfolio of Eligible vehicles
- ✓ The number of Eligible vehicles
- ✓ The balance of unallocated proceeds (if any)
- ✓ The amount or the percentage of new vehicles vs. existing vehicles[8]
- ✓ The geographic breakdown of the Eligible vehicles
- ✓ The motorization breakdown of the Eligible vehicles (EV, PHEV, HEV, …)

Assessment of ALD's Positive Impact Framework

- Second-Party Opinion

Prior to issuance, ALD has commissioned Vigeo Eiris to conduct an external review of its Positive Impact Bond Framework and issue a Second Party Opinion on the Framework's environmental credentials and its alignment with:

- ✓ The Principles for Positive Impact Finance
- ✓ The Green Bond Principles and
- ✓ The Climate Bond Initiative's Standard for Low Carbon Land Transport[9].

The Second Party Opinion will be made available on ALD's website.

- Climate Bond Initiative Certification

As an approved verifier under the Climate Bonds Standards, Vigeo Eiris has reviewed ALD's Positive Impact Bond Framework with regards to the Climate Bond Initiative Standards and confirmed its alignment with the Pre-Issuance requirements of the Climate Bonds Standards, allowing the Bond to be certified at issuance. It is to be noted that a Limited Assurance Engagement has been taken to pre-issuance procedures while a post-issuance review will be performed within the year after the issuance.

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[7] Note that the Real Driving Emissions measurement, linked with the new WLTP homologation protocol, is only enforced on all new registrations since September 2018

[8] New vehicles refer to vehicles that were not included in the portfolio of Eligible vehicles at the date of the previous reporting

[9] https://www.climatebonds.net/files/files/Low%20Carbon%20Transport%20Background%20Paper%20Feb%202017.pdf

2.4 TRANSPARENCY

> Principle 3: Entities providing Positive Impact Finance should provide transparency and disclosure on:
> - The activities, projects, programs, and/or entities financed considered Positive Impact, the intended positive impacts thereof (as per Principle 1);
> - The processes they have in place to determine eligibility, and to monitor and to verify impacts (as per Principle 2);
> - The impacts achieved by the activities, projects, programs, and/or entities financed (as per Principle 4)

Through this Positive Impact Bond Framework, ALD commits to provide transparency and disclosure on:

- **The intended impacts**

  The issuance of Positive Impact Bond is expected to contribute to a low-carbon economy.

- **The methodologies, KPIs and processes to determine eligibility and verify impacts (see section '2.2 Framework')**

  ALD has developed a transparent methodology and processes to:

  - ✓ Select the vehicles qualifying for Positive Impact and mitigate potential negative impacts.
  - ✓ Assess the positive Impact through a transparent and robust Life Cycle Assessment developed with Quantis.
  - ✓ Manage the Positive Impact Bond net proceeds

- **The Reporting (see section '2.3 Assessment')**

  In accordance with market best practices such as the International Financial Institutions joint communication on Harmonized Framework for Impact Reporting (June 2018)"[10], ALD will endeavour to produce a reporting and to update it upon any material event that would affect the portfolio of Eligible vehicles.

  ALD will make public on its website a limited or reasonable assurance report provided by its external auditor or any other appointed independent third party. For each reporting, the auditors will verify:

  - ✓ The allocated and unallocated proceeds
  - ✓ The compliance of the Eligible vehicles with the defined eligibility criteria
  - ✓ The review of the impact reporting

[10] https://www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/June-2018/Framework-for-Social-Bond-Reporting-Final-140618v3.pdf

3 APPLICATION OF ICMA GREEN BOND PRINCIPLES

Green bond principles	Key features of ALD's Positive Impact Bond framework	*Framework reference*
Use of proceeds	An amount equivalent to the net proceeds of the Positive Impact Bond issuance will be exclusively used to finance or refinance "Eligible vehicles" that contribute to the development of clean transportation and the transition to a low carbon future.	*See section 2.1*
Process for project evaluation and selection	A Positive Impact Bond Committee (the "Committee") has been created to ensure the respect of the Framework and oversee the entire issuance process. **Eligibility Criteria** ✓ Electric vehicles (EV) and fuel cell vehicles ✓ Hybrid electric vehicle (HEV) and plug-in hybrids vehicles (PHEV) with tailpipes CO2 emissions at or below 85- grams of CO2 per passenger kilometer travelled (g CO2 / pkm) **Financial exclusion criteria:** × vehicles already pledged or benefiting from a specific funding program × vehicles from ALD's subsidiaries that are not benefitting from a direct funding through the company's treasury center **Technical exclusion criteria:** × conventional internal combustion engine (ICE) vehicles × liquefied petroleum gas vehicles × biofuel vehicles × natural gas vehicles	*See section 2.2*
Management of proceeds	ALD intends to select sufficient Eligible vehicles to ensure the total amount of investment related to the portfolio of Eligible vehicles equals the proceeds of the Bonds issued under the Framework. As such, if a portion of Eligible vehicles exits ALD's fleet during the life of the Positive Impact Bonds, additional Eligible vehicles will be added to the portfolio. ALD commits on a best effort basis to reach full allocation no longer than 2 years after issuance date. ALD will track the net proceeds through its internal accounting system and hold any unallocated proceeds within its regular cash management operations	*See section 2.2*
Reporting	ALD intends to produce annually until the maturity of the Positive Impact Bond: ✓ An impact reporting ✓ An allocation reporting	*See section 2.3*
External review	**External Consultant:** ALD collaborated with Quantis, to develop a Life Cycle Assessment methodology. **Second Party Opinion:** Vigeo Eiris has reviewed ALD's Positive Impact Bond framework and issued a second opinion confirming the framework's strong environmental credentials and its alignment with: ✓ The Principles for Positive Impact Finance ✓ The Green Bond Principles and ✓ The Climate Bond Initiative's Standard for Low Carbon Land Transport **Climate Bond Initiative Certification:** Vigeo Eiris reviewed ALD's Positive Impact Bond Framework with regards to the Climate Bond Initiative Standards and confirmed its alignment with the Pre-Issuance requirements of the Climate Bonds Standards, allowing the Bond to be certified at issuance. **Verification of the reporting:** limited or reasonable assurance report provided by its external auditor or any other appointed independent third party to be published on ALD's website.	*See section 2.3 and section 2.4*

ASSESSMENT OF ALD GREEN VEHICLE FLEET FOR POSITIVE IMPACT BOND ISSUANCE

METHODOLOGICAL REPORT

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2018

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PROJECT INFORMATION

Project title	Assessment of ALD green vehicle fleet for Positive Impact Bond issuance
Contracting organization	ALD Automotive
Liability statement	Information contained in this report has been compiled from and/or computed from sources believed to be credible. Application of the data is strictly at the discretion and the responsibility of the reader. Quantis is not liable for any loss or damage arising from the use of the information in this document.
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Associated files	This report is associated with the following electronic file: Quantis-ALD green Fleet Assessment Tool Version 4.xlsb

TABLE OF CONTENT

1. Glossary

- ADEME: Agence de l'environnement et de la maîtrise de l'énergie
- CO_2-eq: Carbon dioxide-equivalent
- EV: Electric Vehicle
- EPA: Environmental Protection Agency
- FU: Functional Unit
- GHG: Green House Gases
- HEV: Hybrid Electric Vehicle
- ICE: Internal Combustion Engine
- ICCT: International Council on Clean Transportation
- IF: Impact Factor
- LCA: Life Cycle Assessment
- LCIA: Life Cycle Impact Assessment
- NEDC: New European Driving Cycle
- NOx: Nitrogen Oxides
- NRC: Natural Resources Canada
- PEF: Product Environmental Footprint
- PHEV: Plug-in Hybrid Electric Vehicle
- PM: Particulate Matter

2. Executive summary

Context

ALD has set up a Positive Impact Bond Framework to finance or refinance a fleet of eligible vehicles that includes Electric Vehicles (EV) Plug-in Hybrid Vehicles (PHEV) & Hybrid Vehicles (HEV), operated in 22 countries, worldwide.

In order to assess the potential environmental benefits such a "green" fleet, ALD commissioned Quantis to develop a methodology that quantifies the net emissions savings, compared to a baseline Internal Combustion Engine (ICE) fleet, using a Life Cycle Assessment approach

Purpose of document

This document describes the methodology used for assessing the potential environmental benefits of ALD green fleet.

Methodology

The scope of the methodology covers:

- The whole life cycle of vehicles (Vehicle production, vehicle use and vehicle end-of-life-
- The assessment of three indicators:
    - Climate change (kg CO2-eq),
    - Particulate Matter emissions (kg PM),
    - NOx emissions (kg NOx).

The calculation steps are the following:

- A database containing the impacts (per km) of the vehicle models included in the green fleet and the baseline fleet is established.
- Contractual data on each vehicle of the green fleet is consolidated in order to establish the distance (in km) for each vehicle in each country, over a year.
- The impacts of the green fleet and the baseline fleet are assessed in parallel.
- The difference between the impacts of the baseline fleet and those of the green fleet corresponds to the potential environmental benefits of the green fleet.

Main data sources

The methodology relies as much as possible on the latest and most robust data in order to describe the life cycle of each vehicle model:

- ecoinvent for data on vehicle production and end-of-life,
- ADEME and EPA for tailpipe emissions,
- ICCT for real-world adjustment rates,
- eLCAr for components masses.

3. Introduction

3.1 Context

3.1.1 ALD Positive Impact Bond Framework

ALD has set up a Positive Impact Bond Framework to finance or refinance a fleet of eligible vehicles that includes Electric Vehicles (EV) Plug-in Hybrid Vehicles (PHEV) & Hybrid Vehicles (HEV), operated in 22 countries, worldwide.

In order to assess the potential environmental benefit of the fleet of Eligible Vehicles considered for the inaugural Positive Impact Bond issuance under the Framework, ALD commissioned Quantis to develop a methodology that quantifies the net emissions savings, compared to a baseline Internal Combustion Engine (ICE) fleet.

3.1.2 Life Cycle Assessment

LCA is a method that quantifies all the potential environmental impacts of a product or service, taking into account its entire life cycle.

Figure 1 – Overview of Life cycle assessment

Growing awareness of the importance of sustainable development has stimulated the development of such methods, which make it possible to understand, measure and reduce these impacts. The only tool for an overall assessment of potential environmental impacts is LCA. This method is governed by the standards of ISO 14040 and ISO 14044 of the International Organization for Standardization (ISO, [12.]).

This is an internationally recognized approach that quantifies the potential impacts on human health and the environment of a product, service or process from the extraction of raw materials to its elimination at the end of its life, through the distribution, production and use phases.

Life Cycle assessment has three major characteristics:

- It is based on the concept of function, i.e. it quantifies impacts in relation with the service provided by a product/process;
- It is multi-stage, i.e. it covers the whole lifecycle of the product/process/service;
- It is multicriteria, i.e. it covers different environmental impacts.

Among other applications, LCA identifies opportunities to improve the environmental performance of products and services at various stages of their life cycle, facilitates decision-making, and supports marketing and communication.

LCA has been identified as the most robust and exhaustive methodology for ALD Positive Impact Bond Framework.

3.2 Objective of the document

The objective of this document is to present the methodology developed for assessing the potential environmental impacts of the fleet of Eligible Vehicles operated by ALD.

4. Methodology

4.1 Objective of the methodology

The objective of the methodology is to assess the environmental footprint of a "green" fleet of vehicles, using a life cycle perspective, compared to a baseline fleet of "non-green" vehicles (i.e. Internal Combustion Engine vehicles).

4.2 Description of the methodology

4.2.1 Functional unit

The functional unit (FU) is a measure of the function of the studied system and it provides a reference to which the inputs and outputs can be related. In this methodology, the FU is twofold:

- At the level of a given vehicle, the functional unit is: **"to drive 1 km"**
- At the level of the fleet, the functional unit is: **"to operate the fleet during 1 year"**

4.2.2 Scope of the assessment

Life cycle steps

The assessment uses a life cycle approach (or "cradle-to-grave" approach), meaning that all significant activities required to fulfil the functional unit are included.

The following figure presents the life cycle steps that are included in the assessment.

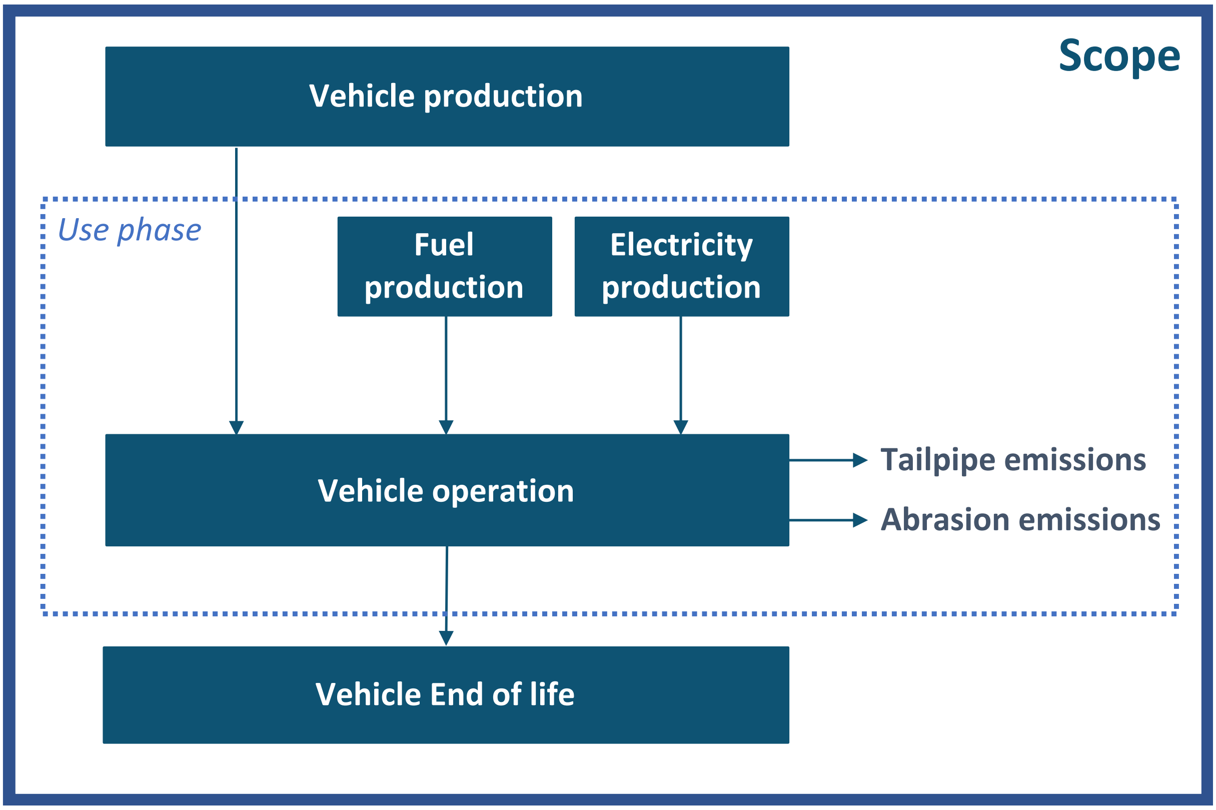


Figure 2 – Life cycle steps included in the assessment

<u>Environmental indicators</u>

Life Cycle Assessment can cover a wide range of environmental topics. For this methodology, a first selection of indicators has been considered, namely:

- Climate change,
- Photochemical ozone formation,
- Respiratory inorganics,
- Mineral resource depletion,
- Fossil resource depletion,
- Freshwater ecotoxicity,
- and two "elementary flow" indicators (i.e. indicators that capture direct emissions into the environment):
    - NOx emissions,
    - Particulate matter emissions.

This first selection covers potential environmental topics linked to the lifecycle of ICE and EV/PHEV/HEV:

- Consumption of fossil fuel (Fossil resource depletion);
- Tailpipe emissions (Climate change, Photochemical ozone formation, Respiratory inorganics, NOx emissions, Particulate matter emissions);

- Production and end-of-life of batteries (Mineral resource depletion, Freshwater ecotoxicity).

Based on this first selection, a subset of indicators has been selected in order to focus on the most important indicators while simplifying the outcome of the assessment tool. The following subset of environmental indicators is assessed:

- Climate change impacts, expressed in kg of CO_2-eq, (see 6.5, page30)
- NOx emissions, expressed in kg of NOx,
- PM emissions, expressed in kg of PM.

These indicators have been selected according to the following criteria:

- The indicator covers a significant environmental topic of the transport industry, and notably of private cars (Climate change - see 6.5.1, page 30);
- The indicator is commonly communicated in the transport industry (Climate change, NOx emissions, PM emissions);
- Data regarding the indicator is publicly available (Climate change, NOx emissions, PM emissions).

4.2.3 Vehicle motorization

The green fleet includes personal vehicles of the following types:

- EV,
- HEV Petrol,
- HEV Diesel,
- PHEV Petrol (incl. Range extender),
- PHEV Diesel.

The baseline fleet includes:

- ICE Petrol,
- ICE Diesel.

4.2.4 Vehicle segments

The vehicles are categorized according to the Euro Car Segment, with subcategorization for J and M segments:

- A - mini cars,
- B - small cars,
- C - medium cars,
- D - large cars,
- E - executive cars,
- F - luxury cars,
- J - Sport utility cars, with the following breakdown:
    - Compact SUV,
    - Mid-Size SUV,
    - Full Size SUV,
- M – Multi purpose cars, with the following breakdown:
    - Compact MPV ,
    - Mini MPV,
- S – Sports cars.

4.2.5 Time related Scope

When assessing the environmental impacts at fleet level, the considered scope is 1 year of operation.

4.3 Overall approach for calculations

The overall approach consists in:

- Assessing environmental impacts for each model of the green fleet, per km;
- Selecting a baseline vehicle for each model of the fleet and assessing environmental impacts for each model of the baseline fleet, for per km;
- Calculating the overall impacts of the green fleet and the baseline fleet by applying the contractual distance for each vehicle;
- Calculating the difference between baseline and green fleets.

The following figure presents an overview of the calculations:

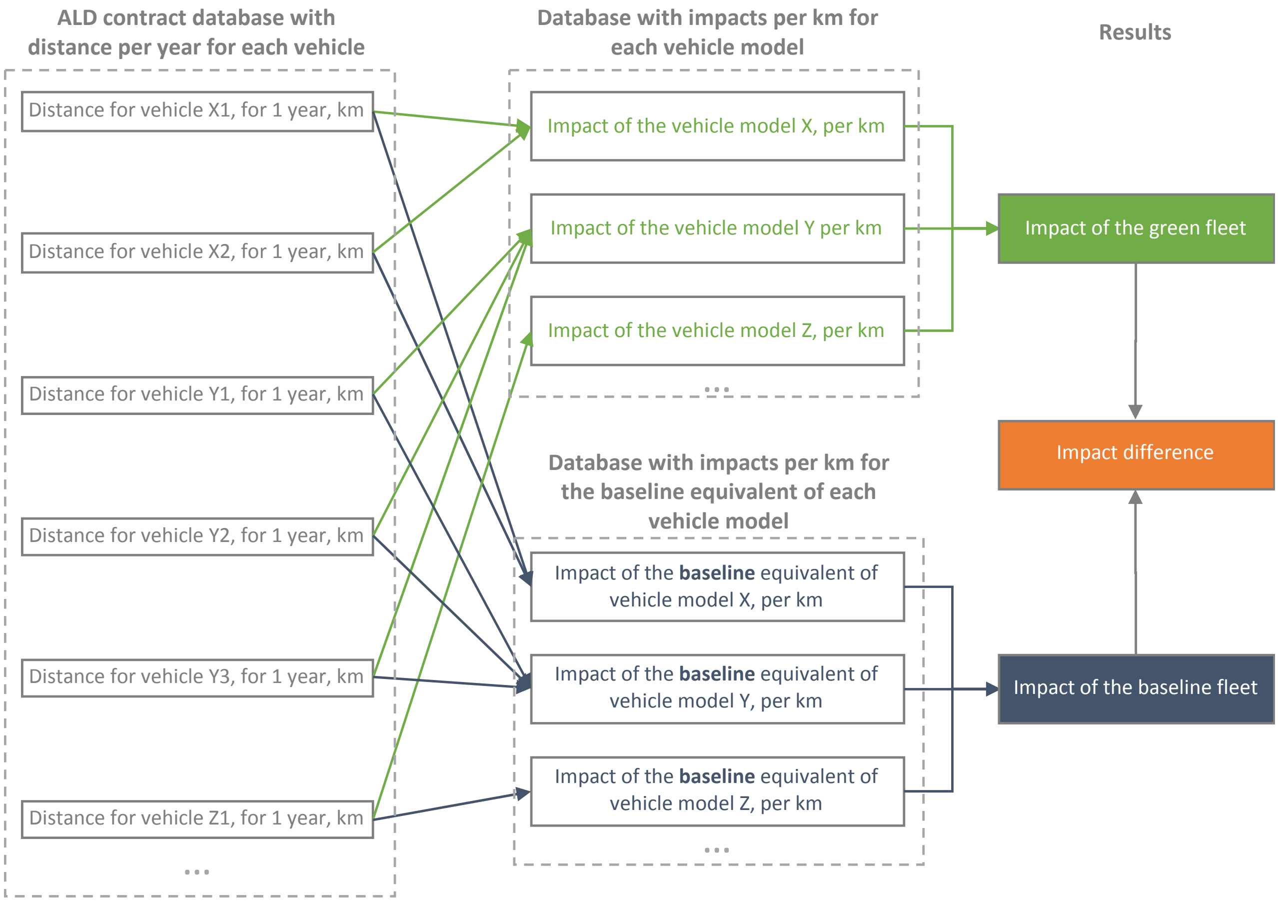


Figure 3 – Overview of the calculations

The following sections presents:

- The assessment of environmental impacts per km, for a given vehicle:
  - For vehicle production,
  - For vehicle end-of-life,
  - For vehicle use;
- The assessment of environmental impacts at fleet level.

4.4 Vehicle production: assessing environmental impacts for per km

The environmental impacts of the production of a vehicle model per km are calculated as follows:

- Each vehicle is linked to a vehicle model and a vehicle motorization
    - *e.g. the vehicle "IONIQ 1.6 GDI HEV Tecno DCT" is linked to the vehicle model "IONIQ HYBRID" and to the vehicle motorization "Hybrid Petrol".*
- Each vehicle model is associated with:
    - A segment,
    - A mass (in kg).
- The mass of each vehicle model is broken down into the mass of components, according to its segment and motorization:
    - The mass of battery, electrical powertrain and ICE are assessed using the data presented in *Table 1*, page 24.
    - The remainder (i.e. the total mass minus the mass of the components) is considered to correspond to the glider mass.
- The lifespan of each component is used to assess the mass of components per km, using the following data:
    - Battery lifespan: 100 000 km (source: eLCAr [1.])
    - Lifespan of other components: 250 000 km (source: ALD and ICCT [2.]
    - [1])
- The impact of the production of each component is assessed using impacts factors (IF) from the ecoinvent database [3.], which provides data per kg of components (see focus box hereunder),
- The impacts of the different components are summed in order to obtain the impacts of the whole vehicle model, per km.

The following figure presents the overview of this approach.

[11] ICCT uses a similar assumption, i.e. 241,402 kilometers (150,000 miles) - https://www.theicct.org/sites/default/files/publications/ICCT_feebates_may2010.pdf

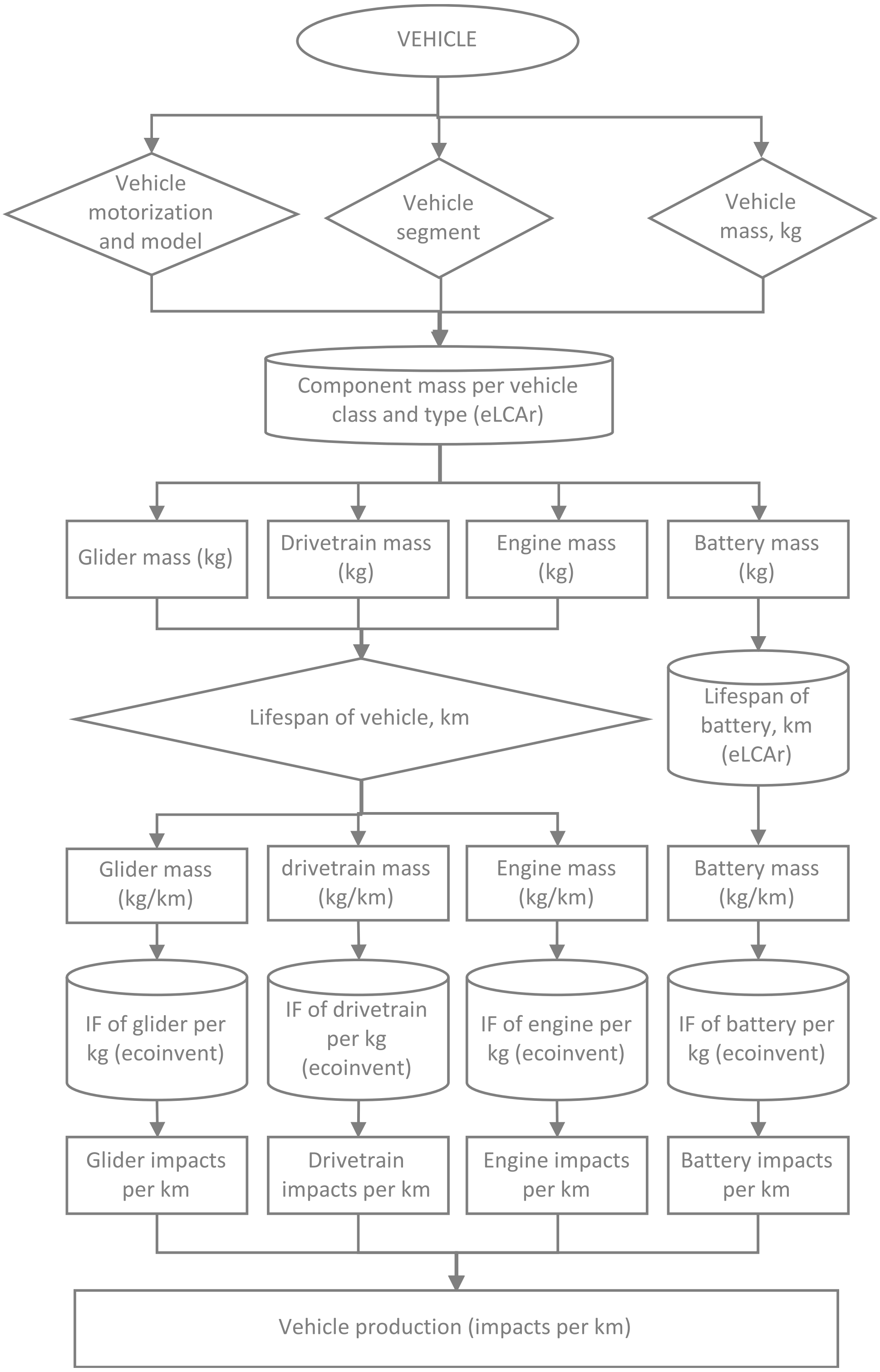


Figure 4 – Calculation steps and data sources for vehicle production assessment

FOCUS BOX – the ecoinvent database

The ecoinvent database [3.] is the world's largest and most widely used Life Cycle Assessment database. This database contains "Life Cycle Inventories" (LCI), i.e. datasets describing energy, resources, materials and emissions required to produce/use 1 unit of a given activity (For example, it contains the LCI of the production 1 kg of steel, 1kg of aluminium or the consumption of 1kWh of electricity in France or China).

Assessing the LCI of a given activity using a characterization method leads to the calculation of the "Impact factors" (IF) of this activity (e.g. the consumption of 1kWh of electricity in a given country corresponds to X kg CO_2-eq, the emission of Y kg of Particulate Matter and the emission Z kg of NOx).

In this methodology, the impact factors of different activities linked to the lifecycle of vehicles are assessed in order to assess the impacts of the whole fleet.

4.5 Vehicle end-of-life: assessing environmental impacts per km

The environmental impacts of the end-of-life of a vehicle model per km are calculated as follows:

- The first calculation steps required to assess the mass of each component per kilometre are the same as for the calculation of the vehicle production (see previous section).
- The impacts of the end-of-life of each component in a given country are assessed using:
  - Impact factors (IF) from the ecoinvent database [3.], which provides data per kg of component (see focus box above),
  - An end-of-life scenario, which provides, for each operating country, a breakdown between recycling and landfilling, with a distinction between the battery and the rest of the vehicle. Data is based on statistical data for all components (Eurostat [4.], Sakai et al [5.]) and on EU objectives for batteries [6.]. (see *Table 2*, page 25)
- The impacts of the different components are summed in order to obtain the impacts of the whole vehicle model, per km, in a given country.

The following figure presents the overview of this approach.

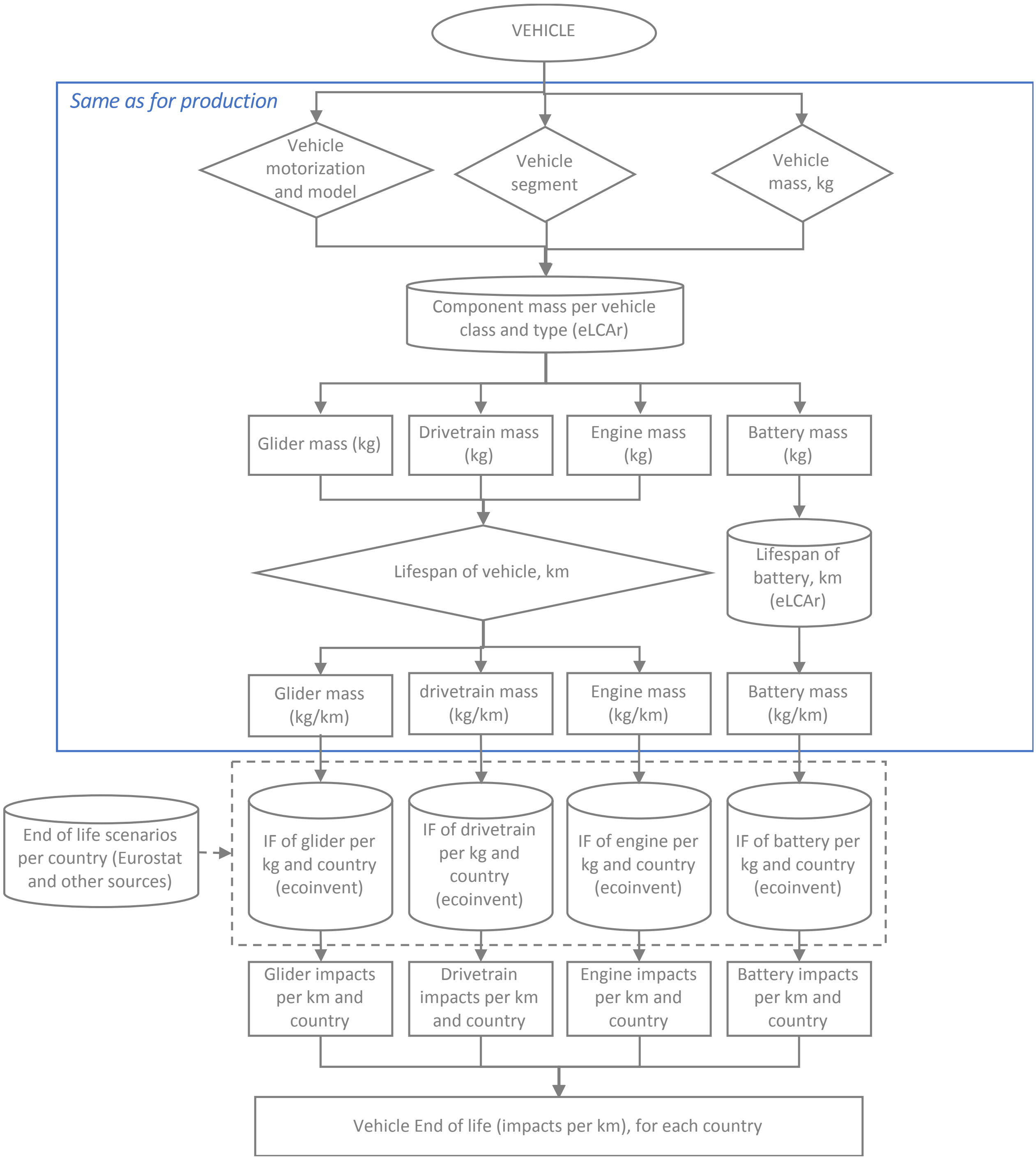
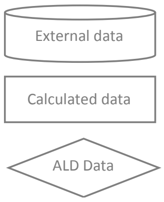


Figure 5 – Calculation steps and data sources for vehicle end-of-life assessment



4.6 Vehicle use: assessing environmental impacts per km

The environmental impacts of the use phase of a vehicle model per km are calculated as follows:

- The calculation is split between the following blocks:
  - Fuel and electricity production,
  - Tailpipe emissions,
  - Abrasion emissions.
- **Fuel and electricity production per km:**
  - The fuel consumption (in L/100km) and electricity consumption (in kWh/100km) are retrieved from the following sources:
    - ADEME [7.], which uses NEDC testing,
    - US Environmental Protection Agency [8.] which uses EPA Federal testing,
    - Natural Resources Canada [9.], which uses Government of Canada-approved 5-cycle testing,
    - EV Database [10.], which uses a real range testing,
    - As well as manufacturers' technical datasheet for vehicle models not available in the previous sources.
  - For PHEV Vehicles, which use both electricity and fuel as an energy source, the data for all-electric and all-fuel modes are retrieved. A ratio electric/fuel per km is taken from eLCAr [1.] in order to obtain an average per kilometer.
  - The fuel and/or electricity consumption is in some cases adjusted using a "Real-World Adjustment Rate" from ICCT [2.] (See Focus Box hereunder).
  - The impact of the production of fuel production and electricity production per country is assessed using impact factors (IF) from the ecoinvent database [3.], which provides data for 1 kg of petrol[2], 1 kg of diesel[3] and 1 kWh of electricity for the different operating countries (see focus box above).
- **Tailpipe emissions per km:**
  - CO_2 emissions are derived from fuel consumption, using the assumption of 2,3 kg of CO_2 per Liter of petrol and 2,67 kg k of CO_2 per Liter of diesel.
  - PM and NOx emissions are taken from ADEME [7.]. For vehicle models non-available in the ADEME database, the average PM and NOx emissions of the corresponding energy types (Hybrid Diesel, PHEV Petrol, PHEV Diesel, Hybrid Petrol, Range extender) are applied to the models.

---

[2] Density for petrol: 0.735 kg/L

[3] Density for diesel: 0,84 kg/L

FOCUS BOX – Real-World Adjustment Rate

For fuel consumption and tailpipe CO_2 emissions

For values stemming from ADEME (which uses NEDC testing) and from manufacturers, a "Real-World Adjustment Rate" is applied in order to consider the divergence between official and real-world measurements. The source for the Real-World Adjustment Rate is the ICCT [2.].

The baseline for the Real-World Adjustment Rate provided by ICCT is 45% for company vehicles (i.e. official consumptions and emissions are multiplied by 1,45 in order to obtain the real-world values).

Note: the values of the Real-World Adjustment Rates are provided for CO2 emissions by ICCT. It is considered to also apply to fuel consumption.

This baseline value is adjusted per country, by taking into account measured divergence for main geographical zone (see *Table 3*, page 26). The following figure presents the evolution of the divergence over the years.

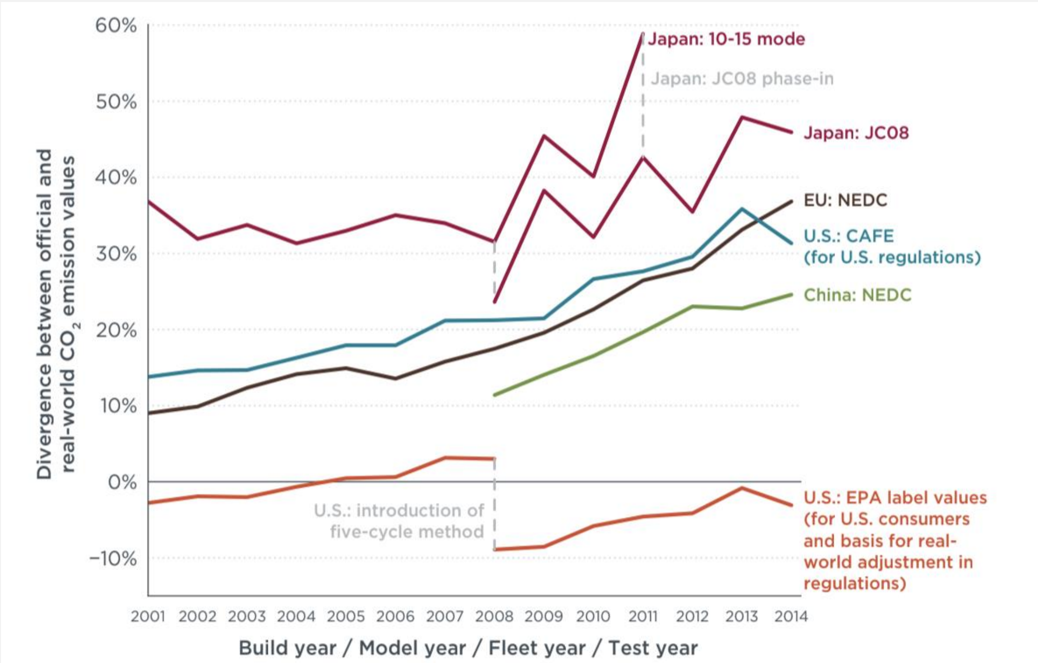


Figure 6 – Divergence between official and real-world CO2 emissions for new passenger cars in the EU, the United States, China and Japan (ICCT).

For NOx and PM tailpipe emissions

The Real-World Adjustment Rate for NOx emissions provided by ICCT is presented in *Table 4*, page 27. Due to the lack of similar data for tailpipe PM emissions, the same adjustment rate as for NOx is applied to PM emissions.

- **Abrasion emissions per km:**

The abrasion emissions cover the PM emissions due to tyre, road and brake abrasion. The amount of PM emitted is assessed using data from the ecoinvent database [3.], which provides quantity of PM per km and per kg of vehicle. The values for ICE are different from those of HEV/PHEV/EV, as those types of vehicle recover braking energy, leading to less abrasive emissions.

- **Use phase impacts per km:**

The impacts of the different blocks are summed in order to obtain the impacts of the whole vehicle model, for 1 km, in a given country.

The following figure presents the overview of this approach.

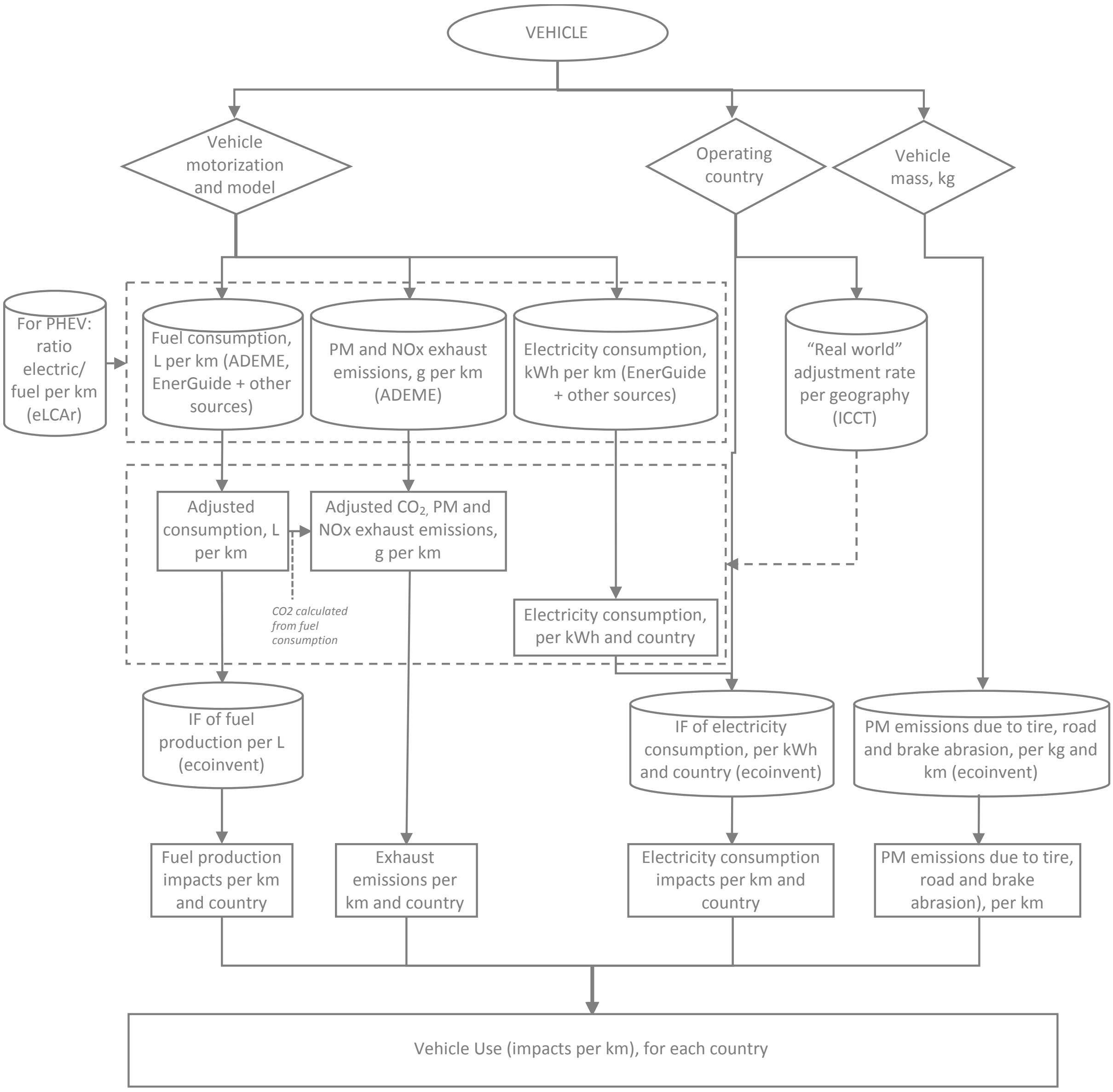
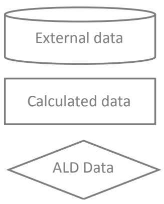


Figure 7 – Calculation steps and data sources for vehicle use assessment



4.7 Baseline fleet definition

The baseline fleet corresponds to an ICE-equivalent of the green fleet. In order to select the most appropriate equivalent vehicles (i.e. the ICE vehicle that would have been chosen if a EV/HEV/PHEV had not been chosen), the following approach has been used:

- The baseline fuel type (diesel or petrol) depends on the operating country and the vehicle segment. The choice has been made according to the fleet leasing market in each country (based on ALD's expertise [13.]). The baseline fuel type per segment and per country is presented in *Table 6*, page 29.
- For each fuel type and each segment, a baseline model has been selected according to two criteria:
  - The baseline model has a petrol and a diesel version
  - For a given segment, the baseline model has horsepower similar to vehicle included in ALD's green fleet.

The choice of model has also been informed by typical practice in the corporate leasing market (based on ALD's expertise [13.]).

The baseline vehicles are presented in *Table 5*, page 28.

5. References

List of data sources (all websites accessed in June 2018):

[1.] eLCAr project (http://www.elcar-project.eu/)

[2.] International Council on Clean Transportation (https://www.theicct.org/)

[3.] ecoinvent (http://www.ecoinvent.org/)

[4.] Eurostat (online data code: env_waselvt), Reuse and Recycling rate for end-of-life vehicle, 2015

[5.] Sakai et al., 2014, An international comparative study of end-of-life vehicle (ELV) recycling systems, Journal of Material Cycles and Waste Management - February 2014, Volume 16, Issue 1, pp 1–20

[6.] Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006

[7.] ADEME Car Labelling (http://carlabelling.ademe.fr/index/)

[8.] EPA - Fuel Economy (https://fueleconomy.gov/)

[9.] Natural Resources Canada – 2017 Fuel Consumption Guide (https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/pdf/transportation/tools/fuelratings/2017%20Fuel%20Consumption%20Guide.pdf)

[10.] EV database (https://ev-database.uk/)

[11.] IPCC Intergovernmental Panel on Climate Change (http://www.ipcc.ch/)

[12.] ISO International Organization for Standardization (https://www.iso.org/)

[13.] ALD's corporate leasing market expertise

[14.] European Commission, Product Environmental Footprint Category Rules Guidance, version 6.3, May 2018 (http://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_guidance_v6.3.pdf)

6. Appendix

6.1 Components masses

Table 1 – Assumptions for the components masses

kg	EV			ICE		PHEV/HEV			
CAR SEGMENT	**Glider**	**Electric Powertrain**	**Battery**	**Glider (drivetrain included)**	**Engine**	**Glider**	**Engine**	**Battery**	**Electric Powertrain**
A	Remainder	50	200	Remainder	150	Remainder	100	80	100
B	Remainder	50	200	Remainder	150	Remainder	100	80	100
C	Remainder	100	300	Remainder	150	Remainder	100	100	100
D	Remainder	100	300	Remainder	150	Remainder	100	100	100
E	Remainder	100	300	Remainder	150	Remainder	100	100	100
F	Remainder	100	300	Remainder	150	Remainder	100	100	100
J - Compact SUV	Remainder	100	300	Remainder	150	Remainder	100	100	100
J - Mid-Size SUV	Remainder	100	300	Remainder	150	Remainder	100	100	100
J - Full Size SUV	Remainder	150	400	Remainder	250	Remainder	150	150	150
M - Compact MPV	Remainder	100	300	Remainder	150	Remainder	100	100	100
M - Mini MPV	Remainder	100	300	Remainder	150	Remainder	100	100	100
S	Remainder	100	300	Remainder	150	Remainder	100	100	100

Source : eLCAr [1.]

6.2 Recycling rates per country

Table 2 – Recycling rates per country

Country code	Country	Recycling rate for vehicle (all components except battery) Source: [4.][5.]	Recycling rate for batteries Source: [6.]
AUT	Austria	86%	50%
BEL	Belgium	92%	50%
CHE	Switzerland	86%	50%
CHN	China	85%	50%
CZE	Czech Republic	90%	50%
DEU	Germany	88%	50%
DNK	Danemark	86%	50%
ESP	spain	85%	50%
FIN	Finland	84%	50%
FRA	France	87%	50%
GBR	Great Britain	86%	50%
HUN	Hungary	95%	50%
IND	India	85%	50%
ITA	Italy	85%	50%
LUX	Luxembourg	86%	50%
MEX	Mexico	80%	50%
NLD	Netherland	86%	50%
NOR	Norway	85%	50%
POL	Poland	95%	50%
POR	Portugal	85%	50%
ROU	Romania	85%	50%
SWE	Sweden	85%	50%

Sources: [4.][5.][6.]

6.3 Real-world adjustment rates

Table 3 – Real-World Adjustment rate per country for CO_2

Country code	Country	CO_2 emissions divergence used in the assessment (company cars)	Comment	CO2 emissions divergence (baseline per country for private car)
AUT	**Austria**	46,9%		37,5%
BEL	**Belgium**	46,9%		37,5%
CHE	**Switzerland**	46,9%	Hypothesis: similar to EU	37,5%
CHN	**China**	30,0%		24,0%
CZE	**Czech Republic**	46,9%		37,5%
DEU	**Germany**	46,9%		37,5%
DNK	**Danemark**	46,9%		37,5%
ESP	**Spain**	46,9%		37,5%
FIN	**Finland**	46,9%		37,5%
FRA	**France**	46,9%		37,5%
GBR	**Great Britain**	46,9%	Hypothesis: similar to EU	37,5%
HUN	**Hungary**	46,9%		37,5%
IND	**India**	30,0%	Hypothesis: similar to China	24,0%
ITA	**Italy**	46,9%		37,5%
LUX	**Luxembourg**	46,9%		37,5%
MEX	**Mexico**	39,4%	Hypothesis: similar to US	31,5%
NLD	**Netherland**	46,9%		37,5%
NOR	**Norway**	46,9%	Hypothesis: similar to EU	37,5%
POL	**Poland**	46,9%		37,5%
POR	**Portugal**	46,9%		37,5%
ROU	**Romania**	46,9%		37,5%
SWE	**Sweden**	46,9%		37,5%

Source: ICCT [2.]

Table 4 – Real-World Adjustment rate per fuel type for NOx

Source: ICCT (2016)	NOx emission limit, in g per km	Real World emissions, in g per km	NOx emissions divergence coefficient
Diesel	0,08	0,6	**750%**
Petrol	0,06	0,05	**83%**

Source: ICCT [2.]

6.4 Baseline fleet

Table 5 – Baseline vehicles

Segment	Fuel type	Vehicle mass (kg)	ICE Baseline vehicle	Make
A	Petrol	923	500 TwinAir 0.9 (85ch) Dualogic Start/Stop	Fiat
B	Petrol	1070	NOUVELLE POLO 1.0 TSI (95ch) DSG7 (16"/17")	Volkswagen
C	Petrol	1241	GOLF 1.5 TSI 3P (130ch) EVO BVM6 (17"/18")	Volkswagen
D	Petrol	1430	508 1.6 THP (165ch) EAT6	Peugeot
E	Petrol	1450	E 200	Mercedes
F	Petrol	2175	S 560	Mercedes
J - Compact SUV	Petrol	1770	TIGUAN 1.4 TSI (150ch) DSG6 4MOTION (18" et +)	Volkswagen
J - Full Size SUV	Petrol	2130	LAND CRUISER 5P (280ch) VVT-i 7PL (Lounge/Lounge Pack Techno)	Toyota
J - Mid-Size SUV	Petrol	2075	GLE 400 4MATIC	Mercedes
M - Compact MPV	Petrol	1379	TOURAN 1.4 TSI (150ch) DSG7 7PL (17")	Volkswagen
M - Mini MPV	Petrol	1403	C-MAX 1.5 EcoBoost (150ch) S&S BVA6 (16'')	Ford
S	Petrol	1900	QUATTROPORTE	Maserati
A	Diesel	922,5	500 1.3 MultiJet 16V (95ch) Start/Stop Euro 6	Fiat
B	Diesel	1350	NOUVELLE POLO 1.6 TDI (80ch) BVM5	Volkswagen
C	Diesel	1412	GOLF 1.6 TDI 3P (115ch) BVM5 (17"/18")	Volkswagen
D	Diesel	1430	508 GT Line 2.0 BlueHDi (150ch) BVM6	Peugeot
E	Diesel	1780	E 200 d	Mercedes
F	Diesel	1970	S 350 d	Mercedes
J - Compact SUV	Diesel	1770	TIGUAN 2.0 TDI (150ch) BVM6 4MOTION (18" et +)	Volkswagen
J - Full Size SUV	Diesel	2130	LAND CRUISER 5P (177ch) D-4D BVM6 7PL (Life)	Toyota
J - Mid-Size SUV	Diesel	2075	GLE 350 d 4MATIC	Mercedes
M - Compact MPV	Diesel	1379	TOURAN 2.0 TDI (150ch) DSG6 7PL (17")	Volkswagen
M - Mini MPV	Diesel	1403	C-MAX 1.5 TDCi (120ch) S&S PowerShift (18'')	Ford
S	Diesel	1900	QUATTROPORTE DIESEL	Maserati

Source: ALD's corporate leasing market expertise [13.]

Table 6 – Baseline fuel type per segment and per operating country (P: Petrol, D: Diesel)

Country code	A	B	C	D	E	F	J - Compact SUV	J - Full Size SUV	J - Mid-Size SUV	M - Compact MPV	M - Mini MPV	S
AUT	D	D	D	D	D	D	D	D	D	D	D	D
BEL	P	D	D	D	D	D	D	D	D	D	D	D
CHE	D	D	D	D	D	D	D	D	D	D	D	D
CHN	P	P	P	P	P	P	P	P	P	P	P	P
CZE	P	D	D	D	D	D	D	D	D	D	D	D
DEU	P	D	D	D	D	D	D	D	D	D	D	D
DNK	P	D	D	D	D	D	D	D	D	D	D	D
ESP	D	D	D	D	D	D	D	D	D	D	D	D
FIN	P	D	D	D	D	D	D	D	D	D	D	D
FRA	P	D	D	D	D	D	D	D	D	D	D	D
GBR	P	P	D	D	D	D	D	D	D	D	D	D
HUN	P	D	D	D	D	D	D	D	D	D	D	D
IND	P	P	D	D	D	D	D	D	D	D	D	D
ITA	P	D	D	D	D	D	D	D	D	D	D	D
LUX	P	D	D	D	D	D	D	D	D	D	D	D
MEX	P	P	P	P	P	P	P	P	P	P	P	P
NLD	P	P	P	P	P	P	P	P	P	P	P	P
NOR	P	P	D	D	D	D	D	D	D	D	D	D
POL	P	D	D	D	D	D	D	D	D	D	D	D
POR	D	D	D	D	D	D	D	D	D	D	D	D
ROU	P	D	D	D	D	D	D	D	D	D	D	D
SWE	P	D	D	D	D	D	D	D	D	D	D	D

Source: ALD's corporate leasing market expertise [13.]

6.5 Climate change indicator

6.5.1 Indicator selection

The climate change has been included in the methodology because it is a main environmental topic of the transport industry. In order to demonstrate this, environmental single scores of the operation of a typical ICE vehicle and an electric vehicle have been assessed. Single score aggregate multicriteria assessments into a single indicator, and enable the identification of indicators that contribute mainly to the overall single score.

In order to obtain an environmental single score, a normalization and weighting process has been applied to a multicriteria assessment:

- Step 1 – **Normalization**, i.e. the comparison of each environmental indicator to a common reference, in this case the impacts of an average Earthling, as provided by European PEF (Product Environmental Footprint) initiative [14.]. In other words, the impacts of driving with a car (ICE and EV) are compared to the average impacts of one human being.
- Step 2 – **Weighting**, i.e. the application of weighting factors on normalized results. The weighting approach used for this assessment correspond to the weighting factors provided by European PEF (Product Environmental Footprint) initiative [14.], which have been established using a panel-based approach; i.e. reflecting the ranking of environmental indicators by worldwide experts.

The outcome of this assessment, when applied to the operation of an ICE vehicle and an electric vehicle, showed that in both cases, the climate change potential impact is the major contributor to the overall environmental single score.

6.5.2 Indicator description

The characterization method used for climate change is IPCC 2013 [11.], with a timeframe of 100 years. IPCC 2013 is the successor of the IPCC 2007 method, which was developed by the Intergovernmental Panel on Climate Change. IPCC characterization factors for the direct (except CH_4) global warming potential of air emissions. They are:

- not including indirect formation of dinitrogen monoxide from nitrogen emissions.
- not accounting for radiative forcing due to emissions of NOx, water, sulphate, etc. in the lower stratosphere + upper troposphere.
- not considering the range of indirect effects given by IPCC.
- not including indirect effects of CO emissions.

The IPCC 2013 method considers the following greenhouse gases:

- (E)-1-Chloro-3,3,3-trifluoroprop-1-ene
- (E)-1,2,3,3,3-Pentafluoroprop-1-ene

- (Perfluorobutyl)ethylene
- (Perfluoroctyl)ethylene
- (Perfluorohexyl)ethylene
- (Z)-1,1,1,4,4,4-Hexafluorobut-2-ene
- (Z)-1,2,3,3,3-Pentafluoroprop-1-ene
- (Z)-1,3,3,3-Tetrafluoroprop-1-ene
- 1-Propanol, 3,3,3-trifluoro-2,2-bis(trifluoromethyl)-, HFE-7100
- 1-Propanol, i-3,3,3-trifluoro-2,2-bis(trifluoromethyl)-, i-HFE-7100
- 1-Propanol, n-3,3,3-trifluoro-2,2-bis(trifluoromethyl)-, n-HFE-7100
- 1-Undecanol, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,11-nonadecafluoro-
- 1,1,1,3,3,3-Hexafluoropropan-2-ol
- 1,2,2-Trichloro-1,1-difluoroethane
- 2,3,3,3-Tetrafluoropropene
- Acetate, 1,1-difluoroethyl 2,2,2-trifluoro-
- Acetate, 2,2,2-trifluoroethyl 2,2,2-trifluoro-
- Acetate, difluoromethyl 2,2,2-trifluoro-
- Acetate, methyl 2,2-difluoro-
- Acetate, methyl 2,2,2-trifluoro-
- Acetate, perfluorobutyl-
- Acetate, perfluoroethyl-
- Acetate, perfluoropropyl-
- Butane, 1,1,1,2,2,3,3,4,4-nonafluoro-, HFC-329p
- Butane, 1,1,1,3,3-pentafluoro-, HFC-365mfc
- Butane, perfluoro-
- Butane, perfluorocyclo-, PFC-318
- Butanol, 2,2,3,3,4,4,4-heptafluoro-
- Butanol, 2,2,3,3,4,4,4-heptafluoro-1-
- Butanol, 2,2,3,4,4,4-hexafluoro-1-
- Carbon dioxide, biogenic
- Carbon dioxide, fossil
- Carbon dioxide, land transformation
- Carbon monoxide
- Carbon monoxide, biogenic
- Carbon monoxide, fossil
- Carbon monoxide, land transformation
- Chloroform
- Cis-perfluorodecalin
- Decane, 1,1,...,15,15-eicosafluoro-2,5,8,11,14-Pentaoxapenta-

- Decane, 1,1,3,3,4,4,6,6,7,7,9,9,10,10,12,12-hexadecafluoro-2,5,8,11-tetraoxado-
- Decane, 1,1,3,3,5,5,7,7,8,8,10,10-dodecafluoro-2,4,6,9-tetraoxa-
- Decane, 1,1,3,3,5,5,7,7,9,9-decafluoro-2,4,6,8-tetraoxanonane-
- Dinitrogen monoxide
- EPTE-furan
- Ethane, 1-(difluoromethoxy)-1,1,2,2-tetrafluoro-
- Ethane, 1-chloro-1,1-difluoro-, HCFC-142b
- Ethane, 1-chloro-2,2,2-trifluoro-(difluoromethoxy)-, HCFE-235da2
- Ethane, 1-ethoxy-1,1,2,2,2-pentafluoro-
- Ethane, 1,1'-oxybis[2-(difluoromethoxy)-1,1,2,2-tetrafluoro-
- Ethane, 1,1-dichloro-1-fluoro-, HCFC-141b
- Ethane, 1,1-dichloro-1,2-difluoro-, HCFC-132c
- Ethane, 1,1-difluoro-, HFC-152a
- Ethane, 1,1,1-trichloro-, HCFC-140
- Ethane, 1,1,1-trifluoro-, HFC-143a
- Ethane, 1,1,1-trifluoro-2-bromo-
- Ethane, 1,1,1,2-tetrafluoro-, HFC-134a
- Ethane, 1,1,1,2-tetrafluoro-2-bromo-, Halon 2401
- Ethane, 1,1,2-trichloro-1,2-difluoro-, HCFC-122a
- Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113
- Ethane, 1,1,2-trifluoro-, HFC-143
- Ethane, 1,1,2,2-tetrafluoro-, HFC-134
- Ethane, 1,1,2,2-tetrafluoro-1-(fluoromethoxy)-
- Ethane, 1,1,2,2-tetrafluoro-1,2-dimethoxy-
- Ethane, 1,2-dibromotetrafluoro-, Halon 2402
- Ethane, 1,2-dichloro-
- Ethane, 1,2-dichloro-1,1,2-trifluoro-, HCFC-123a
- Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114
- Ethane, 1,2-difluoro-, HFC-152
- Ethane, 2-chloro-1,1,1,2-tetrafluoro-, HCFC-124
- Ethane, 2-chloro-1,1,2-trifluoro-1-methoxy-
- Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-123
- Ethane, chloropentafluoro-, CFC-115
- Ethane, fluoro-, HFC-161
- Ethane, hexafluoro-, HFC-116
- Ethane, pentafluoro-, HFC-125
- Ethanol, 2-fluoro-
- Ethanol, 2,2-difluoro-

- Ethanol, 2,2,2-trifluoro-
- Ethene, 1,1-difluoro-, HFC-1132a
- Ethene, 1,1,2-trifluoro-2-(trifluoromethoxy)-
- Ether, 1,1,1-trifluoromethyl methyl-, HFE-143a
- Ether, 1,1,2,2-Tetrafluoroethyl 2,2,2-trifluoroethyl-, HFE-347mcc3
- Ether, 1,1,2,2-Tetrafluoroethyl 2,2,2-trifluoroethyl-, HFE-347mcf2
- Ether, 1,1,2,2-Tetrafluoroethyl 2,2,2-trifluoroethyl-, HFE-347pcf2
- Ether, 1,1,2,2-Tetrafluoroethyl methyl-, HFE-254cb2
- Ether, 1,1,2,3,3,3-Hexafluoropropyl methyl-, HFE-356mec3
- Ether, 1,1,2,3,3,3-Hexafluoropropyl methyl-, HFE-356pcc3
- Ether, 1,1,2,3,3,3-Hexafluoropropyl methyl-, HFE-356pcf2
- Ether, 1,1,2,3,3,3-Hexafluoropropyl methyl-, HFE-356pcf3
- Ether, 1,2,2-trifluoroethyl trifluoromethyl-, HFE-236ea2
- Ether, 1,2,2-trifluoroethyl trifluoromethyl-, HFE-236fa
- Ether, 2-chloro-1,1,2-trifluoroethyl difluoromethyl-, HCFE-235ca2 (enflurane)
- Ether, bis(2,2,2-trifluoroethyl)-
- Ether, di(difluoromethyl), HFE-134
- Ether, difluoromethyl 1,2,2,2-tetrafluoroethyl-, HFE-236ea2 (desflurane)
- Ether, difluoromethyl 2,2,2-trifluoroethyl-, HFE-245cb2
- Ether, difluoromethyl 2,2,2-trifluoroethyl-, HFE-245fa1
- Ether, difluoromethyl 2,2,2-trifluoroethyl-, HFE-245fa2
- Ether, ethyl 1,1,2,2-tetrafluoroethyl-, HFE-374pc2
- Ether, ethyl trifluoromethyl-, HFE-263m1
- Ether, i-nonafluorobutane ethyl-, HFE569sf2 (i-HFE-7200)
- Ether, n-nonafluorobutane ethyl-, HFE569sf2 (n-HFE-7200)
- Ether, nonafluorobutane ethyl-, HFE569sf2 (HFE-7200)
- Ether, pentafluoromethyl-, HFE-125
- Fluoridate, 1,1-difluoroethyl carbono-
- Fluoridate, methyl carbono-
- Fluoroxene
- Formate, 1,1,1,3,3,3-hexafluoropropan-2-yl-
- Formate, 1,2,2,2-tetrafluoroethyl-
- Formate, 2,2,2-trifluoroethyl-
- Formate, 3,3,3-trifluoropropyl-
- Formate, perfluorobutyl-
- Formate, perfluoroethyl-
- Formate, perfluoropropyl-
- Halothane

- Heptanol, 3,3,4,4,5,5,6,6,7,7,7-undecafluoro-
- Hexane, perfluoro-
- HFE-227EA
- HFE-236ca12 (HG-10)
- HFE-263fb2
- HFE-329mcc2
- HFE-338mcf2
- HFE-338pcc13 (HG-01)
- HFE-43-10pccc124 (H-Galden1040x)
- HG-02
- HG-03
- Methane, (difluoromethoxy)((difluoromethoxy)difluoromethoxy)difluoro-
- Methane, biogenic
- Methane, bromo-, Halon 1001
- Methane, bromochlorodifluoro-, Halon 1211
- Methane, bromodifluoro-, Halon 1201
- Methane, bromotrifluoro-, Halon 1301
- Methane, chlorodifluoro-, HCFC-22
- Methane, chlorotrifluoro-, CFC-13
- Methane, dibromo-
- Methane, dibromodifluoro-, Halon 1202
- Methane, dichloro-, HCC-30
- Methane, dichlorodifluoro-, CFC-12
- Methane, dichlorofluoro-, HCFC-21
- Methane, difluoro-, HFC-32
- Methane, difluoro(fluoromethoxy)-
- Methane, difluoro(methoxy)-
- Methane, fluoro-, HFC-41
- Methane, fluoro(fluoromethoxy)-
- Methane, fluoro(methoxy)-
- Methane, fossil
- Methane, iodotrifluoro-
- Methane, land transformation
- Methane, monochloro-, R-40
- Methane, tetrachloro-, CFC-10
- Methane, tetrafluoro-, CFC-14
- Methane, trichlorofluoro-, CFC-11
- Methane, trifluoro-, HFC-23

- Methyl acetate
- Methyl formate
- Methyl perfluoroisopropyl ether
- Nitrogen fluoride
- Nonanol, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,9-pentadecafluoro-
- Octa deca fluoro octane
- Pentafluorobutene-1
- Pentane, 2,3-dihydroperfluoro-, HFC-4310mee
- Pentane, perfluoro-
- Pentanol, 2,2,3,3,4,4,5,5-octafluorocyclo-
- Pentanone, 1,1,1,2,2,4,5,5,5-nonafluoro-4-(trifluoromethyl)-3-
- Perfluorobut-1-ene
- Perfluorobut-2-ene
- Perfluorobuta-1,3-diene
- Perfluorocyclopentene
- Perfluorodecalin (trans)
- Perfluoroheptane
- Perfluoropropene
- PFC-9-1-18
- PFPMIE
- Propanal, 3,3,3-trifluoro-
- Propane, 1-ethoxy-1,1,2,2,3,3,3-heptafluoro
- Propane, 1-ethoxy-1,1,2,3,3,3-hexafluoro-
- Propane, 1,1,1-trifluoro-, HFC-263fb
- Propane, 1,1,1,2,2-pentafluoro-, HFC-245cb
- Propane, 1,1,1,2,2,3-hexafluoro-, HFC-236cb
- Propane, 1,1,1,2,2,3,3-heptafluoro-, HFC-227ca
- Propane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)-
- Propane, 1,1,1,2,3-pentafluoro-, HFC-245eb
- Propane, 1,1,1,2,3,3-hexafluoro-, HFC-236ea
- Propane, 1,1,1,2,3,3,3-heptafluoro-, HFC-227ea
- Propane, 1,1,1,3,3-pentafluoro-, HFC-245fa
- Propane, 1,1,1,3,3,3-hexafluoro-, HCFC-236fa
- Propane, 1,1,1,3,3,3-Hexafluoro-2-(difluoromethoxy)
- Propane, 1,1,1,3,3,3-hexafluoro-2-(fluoromethoxy)-
- Propane, 1,1,1,3,3,3-hexafluoro-2-methoxy-(9CI)
- Propane, 1,1,2,2-tetrafluoro-3-methoxy-
- Propane, 1,1,2,2,3-pentafluoro-, HFC-245ca

- Propane, 1,1,2,3,3-pentafluoro-, HFC-245ea
- Propane, 1,3-dichloro-1,1,2,2,3-pentafluoro-, HCFC-225cb
- Propane, 2,2-difluoro-, HFC-272ca
- Propane, 3,3-dichloro-1,1,1,2,2-pentafluoro-, HCFC-225ca
- Propane, perfluoro-
- Propane, perfluorocyclo-
- Propanol, 2,2,3,3-tetrafluoro-1-
- Propanol, 3,3,3-trifluoro-1-
- Propanol, pentafluoro-1-
- Sulfur hexafluoride
- Tetrafluoroethylene
- trans-1,3,3,3-Tetrafluoropropene
- Trifluorobutanol
- Trifluoroethyl acetate
- Trifluoromethylsulfur pentafluoride
- Trifluoropropene, HFC-1243zf
- Vinylfluoride