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Draft of “Goal Definition” in the LCA of electric vehicles.

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Date: 2012/08/23

Version: v01

This document is an excerpt from the guidelines on the LCA of electric vehicles which are currently being developed within the eLCAr project. It addresses the Goal Definition and should be considered as “work in progress”. Feedback and suggestions are therefore very welcome.

Being an excerpt, it may appear that some technical terminology and concepts are used without the required definitions. In the complete version of the guidelines the contents shown in this excerpt will come after an introductory chapter on the main principles of Life Cycle Assessment.

We are thankful to Christian Bauer (Paul Scherrer Institute) for valuable comments.

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013).

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1 Goal definition

The goal definition is the first phase of a life cycle assessment (LCA) study. Its aim is to describe and state the key objective of the analysis and, ultimately, to clarify the question which is at the heart of the study. Since it lays the foundations for the rest of the work, its precise definition is of fundamental importance for avoiding erroneous methodological steps and misinterpretation of the results.

In the goal definition, following six aspects shall be addressed and documented:

- Intended application(s) of the deliverables/results
- Limitations due to the method, assumptions, and impact coverage
- Reasons for carrying out the study and decision-context
- Target audience of the deliverables/results
- Comparative studies to be disclosed to the public
- Commissioner of the study and other influential factors.

1.1 Intended application

The goal definition shall firstly state the intended application(s) of the LCA results in a precise and unambiguous way (e.g. “Comparative assertion of the overall life cycle environmental impacts associated with driving 1km in an electric vehicle with 120km range having (a) a lithium-ion battery Type A with 100 Wh/kg and (b) a lithium-ion battery Type B with 120Wh/kg energy density”).

Overall, by stating the intended application the practitioner describes the main objective of the study and the specific research¹ question addressed.

1.1.1 Component vs. vehicle system analysis

The aim of this Handbook is to give guidance on the LCA of electric vehicles and of their components. When the focus of an LCA study lies on a specific component of electric vehicles, then the practitioner needs to carefully evaluate, starting from the goal definition, whether his analysis can be limited to the life cycle of the specific component of interest or whether the perspective has to be moved to analysing the impacts of the component working within a complete vehicle. In fact, in many cases the latter case will be the correct solution.

Consider, for example, the above intended application on the two types of Lithium-Ion batteries. The starting point of the analysis lies with the two batteries which are characterised by different energy densities. If battery Type B has a higher energy density than A, then a vehicle using battery B will

¹ Academic, industrial, institutional, etc.: research intended as investigation for solving/ identifying particular issues.

1 need a lower quantity of battery to achieve the same driving range of A. Since the vehicle needs a
2 lower quantity of battery, its total weight will be lower and, through that, the consumption of the
3 vehicle will be reduced. On the other hand, if the vehicle is run with the same quantity of batteries,
4 then using battery B will allow to reach a longer driving range and reduce the frequency of charging.
5 Since the different characteristics of the two batteries lead to such different scenarios for the vehicle
6 infrastructure and usage which, in turn, will lead to different environmental impacts, it is necessary
7 to define exactly how the batteries are exploited within the vehicle system in order for the
8 comparison to be meaningful. Analysing the two isolated batteries, without taking into account their
9 influence on the vehicle system, would lead to incomplete results and potentially wrong conclusions.

10
11 Whenever a component leads, for example through changes in its weight, to such “part-system”
12 interactions which may influence the performance of the vehicle, then the perspective of the LCA
13 shall be set on the life cycle of the vehicle-component system and not on the component alone. This
14 aspect must already be considered in the intended application of the goal definition.
15

16 **1.2 Method, assumption and impact limitations**

17 If the study is subject to specific limitations due to methods, assumptions and impacts evaluation,
18 which may restrict the usability of the results, then these shall be clearly stated within the goal
19 definition.
20

21 A typical example of limitation concerns studies which only address greenhouse gas emissions. Since
22 other impacts, like resource and energy consumption and specific damages to human health and the
23 ecosystem are not analysed in such studies, their results and conclusions will neglect key
24 environmental aspects. Hence, limitations (be it methodological, on assumptions or on evaluated
25 impacts) must be taken into account during interpretation and need therefore to be exactly stated
26 already in the goal definition.
27

28 More examples on the various influences of limitations can be found in paragraph 5.2.2 of the
29 general ILCD Handbook.
30

31 **1.3 Reasons for carrying out the study and decision-context**

32 The goal definition shall also explain the reasons for carrying out the study, name the drivers and
33 motivations and identify the decision-context. Stating the reasons, drivers and motivations is
34 important as these indicate the quality ambitions and set a basis to judge, among other things, data
35 quality or special review needs. Clearly, an LCA made by an engineer in an eco-design company and
36 made for him to get an initial understanding of the main impacts which can be associated with a
37 specific device will have different quality needs compared to one made within a governmental
38 institution whose results will determine the development of public policy regulation.
39

40 Strictly linked to the reasons, drivers and motivations is the concept of the decision-context which
41 defines whether or not the results of the study will be used to support a decision on the analysed
42 system. If the study does not involve decision support, then it will typically be of a more descriptive

1 nature. If, instead, it aims at supporting a decision making process between two or more options,
2 then a key problem is to take into account the different consequences which the various options may
3 cause. For example, if Product X is produced instead of Product Y, will an increase in material Z be
4 necessary? And how will this increase in material be produced: will existing markets and their
5 infrastructure cover the needs or will it be necessary to install new production facilities for material
6 Z? Hence, not only is it important to consider whether a study involves decision support or not, it is
7 also important to define the extent of the consequences which the decision may have.

8
9 Since modelling the Life Cycle Inventory (LCI) requires to take into account these differences, the
10 general ILCD Handbook defines 3 different situations (A, B and C) which are addressed with different
11 methodology and quality needs: While studies which fall within Situation A and B involve decision
12 support, studies within Situation C are of a descriptive character. As a stakeholder consultation²
13 identified that LCA in the context of electric mobility would mostly aim at comparisons for some sort
14 of decision support, Situation C will not be addressed in this Handbook.

15
16 Focusing on studies which imply decision support, it is important to stress that the above refers to
17 changes in the background³ system that are caused via market mechanisms, i.e. in reaction to
18 changed demand and supply resulting from the analysed decision since this may in turn lead to
19 substantial structural changes in, for example, the raw material or energy supply chain. Clearly,
20 different scenarios with respect to changes in the supply chain will correspond to different
21 environmental impacts.

22
23 In this context, Situation A “micro-level decision support”, is meant for cases in which the
24 consequences of the decisions (based on the results of the analysis) will have small-scale influences
25 on the systems connected to the life cycle of the products of interest. An example could be an LCA
26 study on two existing brands of vehicles of similar type and technology with the aim of informing
27 purchases. While such a study will influence the decision of some citizens with respect to which
28 vehicle to buy, the materials, resources and infrastructure connected to the two options will be so
29 similar, that a shift in the production volume of one with respect to the other is not likely to produce
30 a substantial change in, for example, the amount of steel or energy vectors used by the automotive
31 market. Hence, for these cases, it is expected that the overall systems, which are connected to the
32 products of interests through market-mechanisms, will be able to absorb the changes (i.e. the
33 consequences of the decision) without major influences on the infrastructure.

34
35 Situation B, “meso/ macro-level decision support” addresses cases in which the decisions taken as a
36 result of the analysis can have large-scale, structural effects on the systems linked to the product of
37 interest. For example, a 20% increase in the share of renewable energies in the electricity-mix of a
38 country, would most probably strongly influence the production/ import of a number of raw
39 materials required for the production of the new plants (possibly requiring new raw materials
40 production facilities to be built) as well as cause the decommissioning of part of the non-renewable
41 electricity production plans. An LCA which aimed at analysing such a strategic topic would fall under
42 Situation B.

²First eLCAr workshop.

³ In the final version of the guidelines, the terms „background“ and „foreground systems“ are introduced in an apposite chapter on general LCA.

1 Due to the different influence (and, therefore, environmental impacts) which these two situations
2 can have, a different focus will have to be used in the realization of the LCI and, in general, in some
3 parts of the LCA. For this reason it is important to identify the decision-context which is best suited
4 for the specific problematic.

5
6 In the context of the LCA of electric vehicles, identifying whether a study falls within Situation A or B
7 poses various challenges. On the one hand, to date electric cars are responsible for a very small share
8 of the automotive market as opposed to internal combustion engine (ICE) vehicles. Even though
9 more and more car manufacturers are entering the market with new models and the number of
10 electric vehicles is increasing, it is reasonable to expect that their share will stay small compared to
11 conventional vehicles in the near future and that their market will not cause substantial changes in
12 the overall material and resource flows. Hence, the LCA of electric vehicles which focus on the short-
13 and possibly mid-term would typically fit in Situation A. On the other hand, there is a strong
14 possibility that electric cars will reach mass production in the mid- to long-term. In this case,
15 structural changes might be expected, for example, with respect to electricity production and
16 distribution or the production of some key substances like Lithium or rare earths like Neodymium.
17 LCAs in the context of electric vehicles, which aim at understanding these structural implications,
18 would then fall under Situation B. Moreover, some of today's research projects aim at reaching the
19 technological breakthroughs which may lead to a mass distribution of electric vehicles. The
20 perspective on the consequences of a wide-spread use of electric vehicles in the context of specific
21 research breakthroughs should therefore not be neglected.

22
23 Overall, it seems reasonable to assume that a major part of today's research and development
24 projects in industry or in research institutions which deal with vehicle systems have a stronger focus
25 on the near- to mid-term use of electric vehicles. This Handbook will therefore focus mainly on
26 Situation A. Nevertheless, since, as argued above, electric vehicles are likely to reach mass
27 production and lead to substantial structural changes, guidance on some key aspects of Situation B
28 will be given as well.

29
30 More information on the distinction between Situation A and B can be found in paragraph 5.3 of the
31 general ILCD Handbook.

32 33 **1.4 Target audience**

34 The goal definition shall identify the target audience of the study, i.e. to whom the results of the
35 study are intended to be communicated. Apart from influencing some formal aspects, particularly in
36 the reporting part of the LCA (a report describing an LCA for a "technical audience" will use a
37 different language as opposed to one directed to governmental political decision makers), the
38 identification of the target audience is key for choosing the appropriate critical review needs of the
39 study.

40
41 Hence, since various target audiences (e.g. technical vs. non-technical, internal vs. external) typically
42 imply these different requirements on, among other things, reporting or critical review due to the
43 specific audiences' needs, the target audience must be stated already in the goal definition.

1 **1.5 Comparisons to be disclosed to the public**

2 The goal definition shall furthermore explicitly state whether the LCA study includes a comparative
3 assertion intended to be disclosed to the public. This aspect is important since, due to the influence
4 which this assertion may have on, for example, companies, institutions or consumers, a number of
5 mandatory requirements on the execution, documentation, review and reporting of such LCAs exists.
6

7 To avoid a by-passing of these requirements by showing results of different products but without
8 explicitly making an assertion as to superiority or equality, also comparative, but not assertive LCA
9 studies shall meet these requirements, as far as applicable (for exceptions and further restrictions,
10 see paragraph 5.2.5 of the general ILCD Handbook).

11 **1.6 Commissioner of the study and other influential factors**

12 Finally, the goal definition shall identify who commissioned the LCA study, financing or other
13 organisations that have any relevant influence on the study, including the LCA experts that perform
14 it. This aspect is key for the transparency on the reasons for carrying out the study and for
15 highlighting potential conflicts of interest.
16

Provisions 1: Goal definition

- I. SHALL: Unambiguously identify the intended application of the deliverable of the LCA study.
- II. SHALL: When the foreground system focuses on a specific component of electric vehicles and this component causes “part-system” interactions which influence the performance of the vehicle, then the LCA shall address the life cycle of the entire vehicle-component system. This shall already reflect in the definition of the intended application.
- III. SHALL: Unambiguously identify and state initially set limitations for the use of the LCA study. These can be caused by the following:
 - Impact coverage limitations such as in Carbon footprint calculations
 - Methodological limitations of LCA in general or of specific method approaches applied
 - Assumption limitations: Specific or uncommon assumptions / scenarios for the analysed systems.
- IV. SHALL: Unambiguously identify the internal or external reason(s) for carrying out the study and the specific decisions to be supported by its outcome.
- V. SHALL: Unambiguously identify the audience(s) to whom the results of the study are foreseen to be communicated. Further, the type of audience (e.g. internal, external, technical, non-technical, public, etc.) shall also be stated.
- VI. SHALL: Unambiguously state whether the study involves comparisons or comparative assertions and whether these are foreseen to be disclosed to the public.
- VII. SHALL: Identify the commissioner of the study and all other influential actors such as co-financiers, LCA experts involved, etc.

1 1.7 Goal definition example⁴

2 A company which produces Lithium-ion batteries with 100Wh/kg energy density is interested in a
3 new type of battery technology with 120Wh/kg energy density. The research and development unit
4 of the company wants to investigate whether this new technology could lead to a product which may
5 substitute the one currently sold. In the analysis, technological as well as environmental aspects shall
6 be taken into account, since sustainability is a key trait of the company. After having identified a
7 viable production process, it is decided to make a first assessment on the environmental impacts
8 which this new technology may bring in order to consider whether or not to continue investing in it
9 and, possibly, build the required production system. The research and development unit entrust an
10 internal LCA practitioner from the sustainability assessment group with the conduction of the
11 analysis. As a preliminary study, the practitioner decides to limit the analysis to the carbon footprint.
12 Moreover, recognizing the “part-system” interactions between batteries and vehicle and considering
13 that the main customer of the battery company is a manufacturer of a specific vehicle type, the
14 practitioner decides to perform the LCA analysing the overall carbon footprint of the two batteries
15 functioning in the vehicle of their main customer (further addressed as Customer X Vehicle) with a
16 driving range of 120km. The results shall be presented to the research and development unit of the
17 company.

18

19 A goal definition for this scenario could be the following:

20 Intended application:

21 Comparative assertion of the impacts associated with driving 1km in an electric vehicle of Customer X
22 having (a) a lithium-Ion battery Type A with 100 Wh/kg or (b) a lithium-Ion battery Type B with
23 120Wh/kg battery energy density and a total driving range of 120km.

24

25 Limitations:

26 The analysis is intended as preliminary study and focuses therefore only on the carbon footprint.

27

28 Reasons for carrying out the study and decision context:

29 If the preliminary results show that an improvement larger than X% in terms of carbon footprint may
30 be obtained with the Type B battery, then further resources will be invested in order to make a
31 detailed LCA, covering damages to human health, to the ecosystem and resource consumption. If the
32 preliminary study shows that no or minor improvements will be achieved, then the possibility of
33 switching to the alternative technology will be abandoned. The analysis will be performed assuming
34 that the decision deriving from the results will have a negligible impact on the supply chains involved
35 in the life cycle of the products.

36

37 Target audience:

38 The results are intended for an internal and technical audience.

39

40 Comparative assertion:

41 The study will perform a comparative assertion, but the results will not be disclosed to the public.

42

43 Commissioner of the study:

⁴ The example and the numbers therein have been invented for a purely didactical purpose.

1 The study has been commissioned by the research and development unit of the company and will be
2 performed by Mr. of the internal sustainability assessment group.

3

4 While the ILCD decision-context has not been explicitly mentioned in the above goal definition, the
5 practitioner would document (for himself and for use in the actual development of the study) that
6 this case falls within Situation A.

7

8