Title:

Technical briefing notes
Workshop 3

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1 Introduction

The 3rd eLCAr Stakeholder Workshop will take place in **Wolfsburg on December 6th,2012.**

During two previous stakeholder workshops, during June in Zurich and during October in Aachen, the opportunity to interact with stakeholders from various backgrounds was used to assess their needs and expectations towards a guideline. Following, draft chapters were presented and discussed with the stakeholders. These workshops and their results were of great significance for the course of the project.

This document aims is supposed for stakeholders who attend the third eLCAr stakeholder workshop. Reworked chapters and drafts of previously undisclosed chapters will be available for download. Hence, sections in this document referring to the guidelines are rather brief. Workshop contents that are not included in the guidelines, namely testing of the guidelines and developed training materials will be described more detailed.

We are looking forward to another workshop with constructive ideas and fruitful discussions!

1.1 The eLCAr project

The project "*E-Mobility Life Cycle Assessment Recommendations*"– short eLCAr – aims to prepare user friendly guidelines for the conduction of Life Cycle Assessment (LCA) studies on electric cars and their components based on the International Reference Life Cycle Data System (ILCD).

Building on the existing ILCD Handbook, we aim at addressing all key issues concerning the LCA of electric vehicles with a particular focus on the specific requirements of people working with them on a regular basis.

In that context the eLCAr project organizes three workshops to exchange with the practitioners and other important stakeholder communities in the field of the life cycle assessment of electric vehicles and their components.

1.2 Aim of workshop 3

During the 3rd eLCAr Stakeholder Workshop the guidelines as a whole will be presented including the introduction of some previously undisclosed general chapters. It is shown how the guidelines are supposed to be used and the results from use case applications are illustrated.

Furthermore, some open discussions from previous workshops are picked up and it is illustrated how they have been addresses by the project.

For an easy application and swift dissemination of the guidelines, learning and training materials have been developed, whereas different learning modes are covered. The concept behind these is explained and examples of the different modes are shown to obtain further feedback on how to optimize them in the light of stakeholder needs.

1.3 Agenda

9.00 am	Introduction

- Registration and Coffee-

Welcome and Introduction to the workshop aims

Presentation of the final structure and the new general chapters

Introduction of the section about electricity production mix (appertaining to LCI)

-Coffee Break-

11.00 am	Course of the project

Goal and Scope definition: Overview and changes since Workshop 2

LCI: Overview and changes since Workshop 2

-Lunch-

1.30 pm	How to use the Document

How to apply the guidelines in practice

-Coffee Break

2.30 pm	Testing the guidelines and Learning Materials

Results from testing the guidelines

Introduction of the different Learning material types

Discussion based on specific questions from participants, open points from previous sessions etc.

-Coffee Break

3.45 pm	Feedback session

Feedback on all aspects presented during the workshop

Revisiting of questions and comments that were left open in previous sessions

Wrap up & Goodbye

5.00 pm	End

2 Guidelines

2.1 The new Chapters

The guidelines presented at the second eLCAr workshop focused on chapters 5, 6 and 7 of the general ILCD Handbook, which cover Goal definition, Scope definition and the Life Cycle Inventory Analysis. These chapters comprise some of the most important topics of LCA which is why they have been addressed early in the project.

The next version of the guidelines will contain a number of new chapters. Firstly, a chapter on battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) will set the technological context of the guidelines. The main aims of this chapter are two. For practitioners who are involved in projects addressing a specific component of the vehicle, this chapter should help clarify whether it is sufficient to make the LCA of the single component or if it is necessary to analyse the component when functioning within a complete vehicle system. To help in this decision, an *interdependency matrix* is presented which shows potential interactions between the various vehicle components and the performance of the vehicle. In case the practitioner identifies the need for analysing the entire vehicle but is not familiar with its technical aspects, the chapter also presents the basic information which should allow to define the main parameters of the system. Using this *common parameter platform*, the user should then be able to choose LCI datasets from available databases or collect his own data.

Further, the remaining chapters of the general ILCD Handbook, which had not been covered in the previous version, will be part of the guidelines presented at WS3. These are the chapters on Life Cycle Impact Assessment, Life Cycle Interpretation, Reporting and Critical Review. As for the other chapters, the aim is to start from the specific chapters in the general ILCD Handbook and to "translate" these to the case of the LCA of electric vehicles.

2.2 Changes in Goal, Scope and modelling approaches

Taking up the feedback from WS2 the scope definition and the LCI modelling framework have been modified regarding the following issues. To further support the analysis of part-system interactions, the interdependency matrix has been revised and integrated in the guidelines. The interdependencies between the single components of an electric vehicle have been verbalized so that the matrix now contains brief descriptions in the table elements. Following the intense discussion at WS2 about the differences in the characteristics and the service delivered by ICEVs and BEVs, further pieces of advice on the definition of the functional unit have been included in the guidelines. No general solution can be given but the additions to the guideline should help the LCA practitioner to find the right functional unit for his or her specific case. The steel recycling example in the context of solving multifunctionality with system expansion and substitution was described in more detail and separately for production and end-of-life phase. In the case of batteries, the guidelines have been further detailed and now include advice on how to address the life time of

batteries as well as concerning a more specific description of the batteries and their components for system boundary definition.

2.3 Use phase and Electricity mixes

2.3.1 Use phase

In response to the feedback obtained at WS2 and in order to further support practitioners, various modifications have been implemented in the recommendations concerning the use phase.

Firstly, the methodological guidance for consumption calculation is being extended by describing some key aspects which must be considered when analysing how the energy required for moving the vehicle is affected by the electric drivetrain. This ultimately allows to quantify how much electric energy is taken from the battery for a given mechanical energy, due to the propagation from the wheels through the transmission, electric motor and power electronics. Recommendations on how to address the influence of these components are given. These aspects are important for practitioners involved in the optimization of electric drivetrains which need to assess changes in the consumption due to the novel components.

Further, as suggested by stakeholders at WS2, possible consumption contributions deriving from the de-fogging of the windshield, which may require to simultaneously activate heating and air conditioning devices, are being addressed. This is important due to its relevance in the context of safety and because the simultaneous use of heating and air conditioning devices may lead to unexpected contributions even when the climate is mild. Also, more precise indications on how to deal with the power values of various auxiliaries will be given.

2.3.2 Electricity mixes and networks

The electricity mix and network aspects have not been presented in the previous versions of the guidelines and are now newly introduced. Therefore, the main results and ideas for the guidelines (short extract from the guidelines) are presented in this chapter and a detailed presentation will be held during the third workshop in Wolfsburg.

2.3.2.1 Electricity mixes

The electricity mix used for the EV charging has, similar to the energy consumption, a high influence on the results of the use phase. Depending on the chosen energy generation source, the LCA results can be highly influenced in a positive or negative direction assessing the same electric vehicle. To reduce this source of uncertainty and to ensure a comparability of results - at least within Europe- guidance with respect to the choice of electricity mixes for the charging energy of EV during the use phase are presented. In more detail, for the electricity mix, the consumption electricity mix shall be chosen.[1]

[1] In chapter 7.7 of the ILCD the relationship of the production mix, the consumption mix and the supply mix is explained.

For **Situation A**, average or generic electricity mix data has to be used to fulfill the technological, geographical and time-related representativeness. Therefore, national, time specific electricity mixes have to be used. However, to ensure the comparability among studies within the EU using the eLCAr guidelines, the electricity mix of the EU-27 electricity mix data (average data) has to be included into the analysis. In addition to these two electricity mixes, further mixes, e.g. power plant specific electricity generation data sets (e.g. wind power plants) may be used.
Situation B requires the use of the mix of marginal technologies. This is necessary from a technological point because some generation technologies for example hydropower in Germany are scalable due to technological and economic restrictions.[2] Hence, a higher demand for electricity results not in a higher installed capacity of e.g. hydro power plants in Germany. Instead, it shifts the energy generation towards available technologies (e.g. coal power plants) which are the marginal technologies in some countries. From a time-related perspective, the average data for electricity mix cannot be used for a study looking more than some years in the future. These studies have to use short-term or long-term marginal processes for the electricity generation that are based on future scenario data and best available technologies (BAT).

However, if the impact on the electricity generation is in the foreground system of the LCA e.g. to show the impact of a higher RES integration due to EVs, the electricity mix has to be included as primary data based on a detailed model of the electricity generation system. However, the single power plant technologies can be based on secondary data for this analysis. This approach has to be chosen also for LCAs of Vehicle-2-Grid services of EV fleets because the controlled charging process influences the energy generation significantly and cannot be neglected by using average data.

For the electricity mix as secondary data, existing data sets can be used (e.g. European Reference Life Cycle Database (ELCD))[3] (e.g. DE electricity mix, consumption mix at consumer, 230V).

2.3.2.2 Distribution Network:

The distribution networks are an often unattended part of the LCA modeling for electric vehicles. However, depending on the charging method, the impact on the distribution grids should be considered in some LCA studies.

A detailed definition of scope and context of the LCA of EV is required to determine if consequences on the distribution grid have to be modeled. Moreover, to provide different charging powers and technologies, various types of charging stations exist built differently due to other technical requirements. For example, DC charging stations need different components than AC charging stations. Hence, each charging station has to be modeled individually if it is part of the foreground system. However, the chosen availability of charging infrastructure determines the number of

[2] The future development of expansion planning for power plants regarding each technology in each country depends on a number of different criteria such as technical feasibility, availability of resources, acceptance of the technology, costs that are highly country specific.

3 A detailed list of the available databases can be found in the LCA directory of the European Platform on LCA (http://lct.jrc.ec.europa.eu/).

charging stations per EV that has to be considered in a LCA for example if public and private charging stations are considered.

In addition, the impact on the distribution grid could be relevant for the LCA because for very high charging powers (e.g. over 22 kVA) or for high EV penetration rates result in a higher utilizations of distribution grids and hence in a higher demand for grid expansion.[4] This effect cannot be easily assessed within a LCA. Due to today's low penetration rates and charging stations with a low connection power (3.7 kW), it is reasonable to assume that the grids are able to manage the charging load of EVs up to a critical penetration rate without the need for grid expansions.

Therefore, for most studies within **Situation A**, the influence of a charging event on the distribution network should be small and its impacts could be neglected. The data sets for the electricity mix included the existing infrastructure in a satisfactory proportion. However, the charging station has to be included in the LCA modeling. The consideration of the provision of V2G services is not required due to a small impact of low EV penetration rates and low charging rates on the entire electricity system. However if the focus of the study lays on V2G services, the infrastructure for the provision of these services such as IT-control etc. have to be included in the assessment.

Situation B requires a details analysis of the grid impacts and of the number of required charging stations depending on the chosen availability (e.g. charging at home and at work). In the case of providing V2G services, a detailed assessment of the impact on the distribution grid as well as on the electricity generation has to be conducted. Normally the impact on the grid and the system are negligible if the penetration rate is quite low and if the load situation in the grid is not critical.[3] The application of V2G services to include a higher share of RES into the electricity system has to be analyzed taking the entire system into account analog to .

4 Expansion of the grid due to a high penetration rate of EV can only be assessed by using detailed grid calculations. The impact on the grid is highly depended on the actual grid situation and cannot be generalized. (Source: G4V, www.g4v.eu)

3 Testing the guidelines

The eLCAr guidelines aim at providing a high quality of LCA studies as they offer support during the conduction of the LCA and provide an easy handling. However, the impact of new guidelines is not directly assessable, because it often depends on the opinion of the practitioners and their subjective evaluation. Therefore assessment and testing of the guideline is necessary. The chosen approach for testing of the guidelines can be divided into two aspects:

- the **quality of LCA studies** covers the comparison of the final studies and LCA results and
- the **usability** contains all factors defining the usefulness and handling of the guidelines for the users.

3.1 Quality of LCA studies

The question one has to ask himself first when it comes to the quality of LCA studies is how the quality of guidelines can be assessed. The most important aspect for the quality of guidelines is the quantitative and qualitative impact of the used guidelines on LCA studies and especially on the results of these studies. In order to determine this impact, exemplary use cases will be conducted by following the guidelines. Afterwards they will be analyzed in order to draw conclusions about the impact of the used guidelines in comparison to studies without this guidance.

The analysis is divided into two parts: a qualitative and a quantitative evaluation. One aim of the qualitative investigation is to assess the **completeness** of studies, which leads to a high LCA quality. The quantitative evaluation is based on reproduction of an LCA with and without the specific guidelines and guidelines specific data basis. The aim is to show a quantitative improvement of the quality of the results depending on the guidelines. The impact of eLCAr guidelines can be measured by assessing the spread of the final Life cycle impact assessment results for e.g. specific impact categories such as the global warming potential. Due to the comparison between different LCA studies with and without guidance, the impact of the specific guidelines on the impact assessment can be evaluated.

One of the chosen use cases is the LCA of an electric vehicle. The vehicle sizes of this assessment is a compact vehicle (Golf type) using a li-ion battery with a total weight of 300 kg and a specific energy density of 110 Wh/kg leading to an overall battery capacity of 33 kWh. The battery's calendar life is 8 years. This means that two batteries are necessary for a typical vehicle lifetime of around 12 years. (The data for this use case is based on existing studies and information from the CPP).

Fehler! Verweisquelle konnte nicht gefunden werden. clarifies the type of analysis that will be conducted during the testing of the guidelines. The LCA results regarding different impact categories will be presented as a comparison to a reference case. In this example, the electricity mix B would be the reference case that is compared to electricity mixes of other countries or technologies such as hydro energy (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). For clarification, only four impact categories have been chosen for this example: Global warming potential, Acidification, Eutrophication, and Resources (based on CML 2001 for the LCIA).

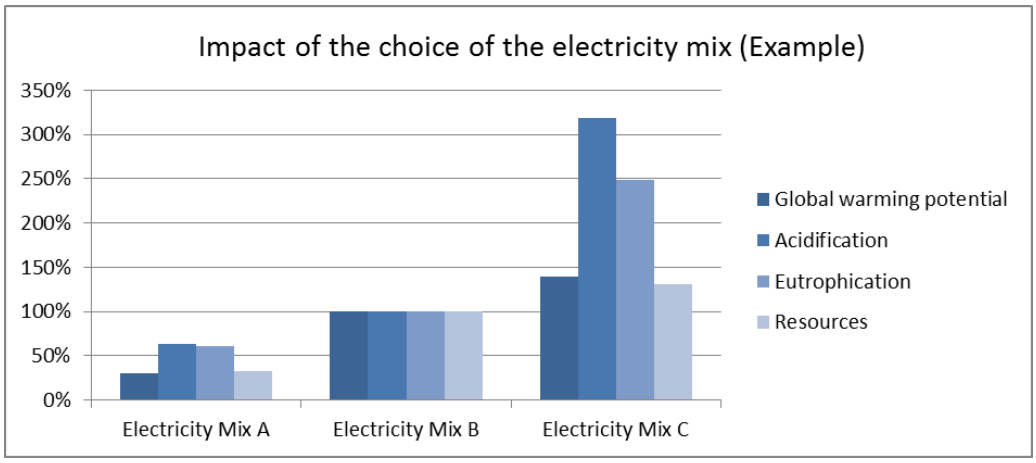

Figure 1: Exemplary result for an EV using different electricity mixes showing the relevant for guidelines regarding the electricity mix

This ongoing analysis is conducted for different aspects of the LCA comparing the impact on the studies with the aim to quantify the impact of the provisions given in the eLCAr guideline and the possible spread of the final Life cycle impact assessment results. These results will be used to assess the impact on the quality of LCA studies due to the eLCAr guideline.

In the 3rd eLCAr workshop, first results from the testing of the guidelines regarding the quality of the conducted studies will be presented to allow an impression of the usefulness of the guidelines for the conduction of LCA for electric vehicles and their components.

3.2 Qualitative evaluation

One aspect of the qualitative evaluation criteria is the **usability**. The usability of the guidelines is important for the evaluation of effects of LCA studies, because only if guidelines are understandable and usable an impact can be determinable. The expectations regarding new guidelines are that they can be easily used with a short training period and that the volume of the guidelines is compact with a reduced complexity compared to existing guidelines. The assessment of the evaluation criteria regarding the usability depends on the impression and opinion of the practitioners and can be evaluated with surveys and feedback within the last workshop. There are several evaluation factors for the usability. The **complexity** is an important criterion regarding the practicability of guidelines. A high **accuracy** of guidelines reduces the probability for misunderstandings and errors. Specific and accurate guidelines reduce the need of interpretation and hence ensure a higher quality of studies following the guidelines. The **comprehensibility** of the guidelines is very important to guarantee the practicability of the guidelines. It concentrates on attributes like language, syntax and structure of the guideline.

As described before the evaluation factors for the usability are very subjective and can only be assessed with help of the practitioners. Therefore, during the 3rd workshop in Wolfsburg a short survey will be conducted to evaluate the impressions regarding the qualitative aspects of the guidelines. The answers will be used as feedback for the guidelines and the training materials. Moreover, the survey can be used to evaluate the impressions and opinions of the practitioners regarding the presented evaluation factors.

4 Training Materials

The Electric Vehicle Life-Cycle-Assessment Recommendations document is the major outcome of eLCAr Project. In order to enable a swift and fast knowledge transfer and ease implementation of the guidelines a second project outcome is planned: Training Materials.

The development of the training materials started with the definition of the target group, described in section 4.1. The different training modes will be explained in detail in 4.2. The training concept follows a modular approach whenever possible, which is described in section 4.3. Interactive elements used in the different training modes are described in section 4.4. All training materials that are disclosed will be tagged by an icon representing a small electric vehicle as shown in Figure 5.

Figure 2: This icon of an eCar will tag all training materials. To illustrate the modular approach, different parts of the car are highlighted to present the different modules available.

4.1 Target Group

The target group of the training materials are basically all kinds of practitioners from industry, but specifically all practitioners from projects of the European Green Car Initiative. Although the target group sounds focused, the realistic focus is much wider. Of course, all possible learners do have in common the background of LCA and/or electric vehicles and their components. Still, they have different approaches to the topic: Different knowledge levels on the LCA Methodology; different technical backgrounds; only experiences in certain electric vehicle component assessment and no experience in a full vehicles perspective; LCA experts, that are completely new to the technical field of electric vehicles; new employees, students or entrants, that have to perform a study without any experience; experts for LCA of electric vehicle, that just need some orientation; decision makers, who want to understand the results of a conducted study. Hence, there is a high diversity of the target group segments based on preexisting knowledge, experience and intentions.

Further on the overall target group can also be segmented according to different learning preferences: Whereas some individuals prefer to learn a group in seminar training, others prefer to learn on their own with accompanying training materials.

The following figure illustrates the different dimension of the target groups:

Figure 3: Different dimensions and segments of target groups and the actual focus of training materials

Of course not all specific needs and preference of each target group segment are satisfiable. Nevertheless a broad coverage is emphasized as illustrated by the green circle in figure 3.

As users do not only differentiate in their background knowledge but also in their preferences about how to learn, the training materials concept includes a set of different learning modes:

- Seminar trainings
- Self-learning script
- E-Learning

The set up of the three training modes and all accompanying documents is described in the following chapter.

4.2 Training modes

The training Materials concept includes different learning modes to account for differences in background knowledge of learners but also in their preferences about how to learn. In general, all training types aim on supporting written information with graphical representation wherever possible to facilitate a good memorizing of the content. All training modes include interactive elements to help deepen the newly acquired knowledge.

An overview of the training modes is given in Figure 4, they are explained in detail in the following.

Figure 4: Set of different training modes and accompanying materials

4.2.1 Seminar

For learners who prefer to assess new topics together with others, the **seminar training** is a suitable learning method. Goal of the project is to provide necessary infrastructure that facilitates trainers to conducting seminars. This infrastructure includes

- presentation slides including all necessary information
- presentation texts providing import information that should be included in the oral presentation of the slides
- groups exercises to be conducted by the seminar participants

The seminar training is suitable for professionals as well research and formation. The trainers do also have the opportunity to adapt the presentation content and course of action according their individual style of teaching.

4.2.2 Self-Learning Script

The guidelines itself are written in a very understandable manner so that another text based interpretation of the guidelines is not necessary. The self-learning script is intended for users who nevertheless search for further support in assessing the guidelines. Therefore it has the character of a “working book”. This working book leads the learner through the guidelines document with accompanying exercises and further useful information such as references to studies and literature that is not found in the guidelines.

In a survey that was conducted during the second eLCAr stakeholder workshop, the majority of the stakeholders recommended the length of the self-learning script not to exceed 45 pages. The self-learning-script is expected to have a length of 35-45 pages.

4.2.3 e-Learning Platform

The training mode web-based training (WBT) does include characteristics of both previous training modes. It is made available via a moodle platform.

Individual learners who prefer assessing new topics in an auditive way can use the modules, featuring powerpoint-like slides with narration. As the learner affects the pace, the learning speed always suits. Exercises are available in the training mode as well. They are integrated into the moodle platform and are, if possible, directly evaluated giving a feedback about the learning results.

The exercises integrated in the moodle platform are mostly so-called quick-tests. In this context quick-tests are a general term to summarize different kinds of short and often rather basic tests like multiple choice or mapping exercises. These can be automatically evaluated or rated, which is not possible for more extensive tasks like free texts or tasks involving calculations.

The course for individual learners offers full time flexibility. Following the modular approach it is possible to access every module in free order. Modules that are not requires by the learner can be skipped. Further on a forum is available to facilitate discussions of open questions and other topics with other learners.

The e-learning mode can not only be used individually but also by groups. For the latter, trainers can register in order to get administrator's rights. Registered trainers are by default be given a copy of the course for individual users. This will enable them to permit assessing the contents to their seminar participants.

Registered trainers will be able to adjust this course according to their needs, adding, changing and disabling contents as it suits their approach. Forums will facilitate the interaction between participants, providing a place for discussing exercises and further-reaching questions. A calendar function is available to plan milestones and the progressing of the course. Trainers can also enable grading. While using the individual WBT only a qualitative evaluation will be given.

This trainer accompanied e-learning mode can be hold solely electronically or in combination with seminar training.

4.3 Modular approach

The concept for the training materials takes the great variability within the group of users into account. The concept follows a **modular approach,** meaning that the contents of the chapters can be assessed individually. Every module is self-contained as far as possible, so that it can be understood on the basis of knowing the fundamentals of LCA. The modules will be numbered along the order given in the ILCD handbook. They can be assessed in this order or any order a user chooses.

The training material icon is used to highlight the different modules as displayed in the figure 5.

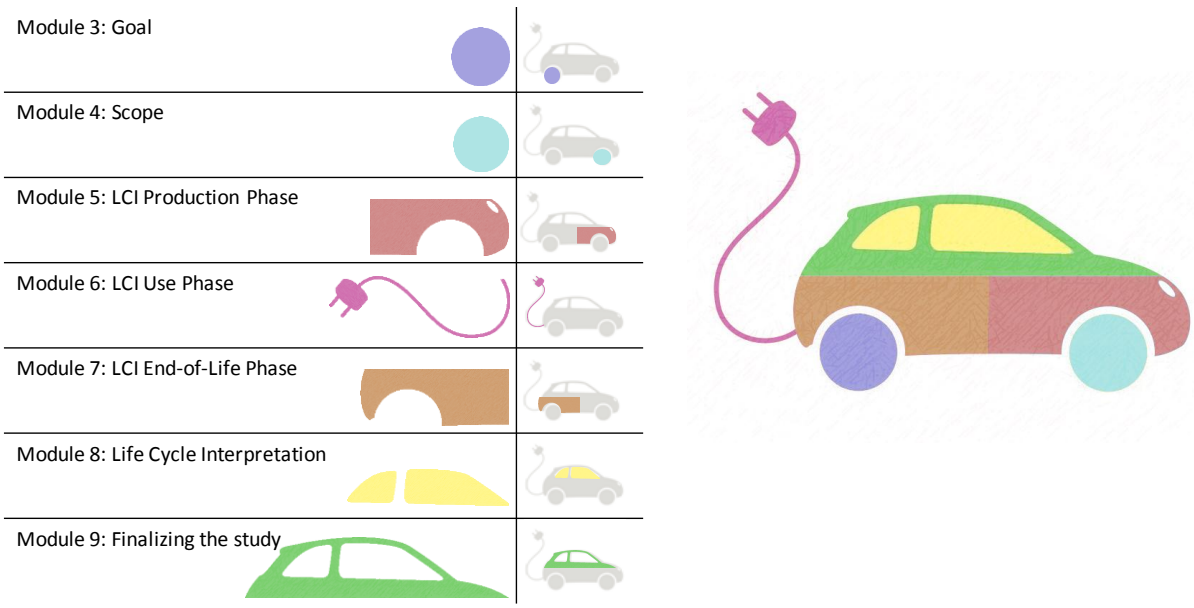

Figure 5: Modules as segments of the eCar icon

For users who are inexperienced in the field of LCA, module 1 supplies basic information on LCA. The second Module provides an explanation on how to use the guidelines. For more experienced users, the modular approach offers the possibility of taking shortcuts in order to do the training more quickly or to assess only the topics they want to deepen.

Different training modes can be mixed as well, assessing different modules in different training types.

4.4 Interactive elements

All training modes include interactive elements in order to help deepen the newly acquired knowledge. The interactive elements partly differentiate between the different learning modes. For instance, questions animating group discussions are concentrated in particular on the trainer materials for seminars. Nevertheless, sometimes similar questions do appear for instance in the self-learning script. In this case the sample answer in the results section of the self-learning script will point out key points of the topic.

For the interactive part the broad target group has influence again. There will be tasks with different complexity in order to suit beginners in the field as well as more experienced learners.

Samples of all training modes are shown during the workshop and feedback is collected.