A practical guide to LCA

for students

designers and business managers

Cradle-to-Grave and Cradle-to-Cradle

The cover photo is part of the “Design Cork” book and project (www. designcork. com), directed by Ana Mestre and photographed by Paulo Andrade, for Susdesign, 2008.
The tree is a cork oak tree. Cork is an almost forgotten material, made out of the bark of the tree (the bark is harvested every nine years, without cutting the tree).
Ana Mestre (www.SUSdesign.org) has proven in her research that there are abundant opportunities to apply cork in innovative product designs. LCA and the method of the EVR (see Appendix IV) play an important role in that research, giving guidance on what to do and what to avoid. This is called ‘eco-efficient value creation’ [9].

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A practical guide to LCA for students designers and business managers

Cradle-to-Grave and Cradle-to-Cradle

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Preface

Life Cycle Assessment (LCA) is a well-defined method to calculate the environmental burden of a product or service. However, LCA has been made (needlessly?) so complex that it seems to be a job for specialists only. The specialists jargon ('functional unit', 'fate analysis', 'midpoints', 'endpoints', 'attributional modelling', etc.) makes it even more impossible for non-specialists to find out what they need to know to make an LCA.

The recent LCA manual of the International Reference Life Cycle Data System of the EU is an excellent document for those people who like to become expert. The focus is on all the (theoretical) aspects of LCA: 80% of the text is on how to make an LCI (Life Cycle Inventory) and perform the Life Cycle Interpretation, including data quality checks and formalities on the reporting. However, the vast majority of students, designers, architects and business managers (and their consultants) never make LCI emission lists, nor write extensive reports on the interpretation. Most of them apply LCIs of databases of other parties (like the Ecoinvent database), apply existing single indicator systems (like eco-costs, carbon footprint, CED, BEES, Recipe, etc.), and draw simple conclusions on what seems to be the best solution in terms of environmental burden.

Students tend to make LCAs by using computer software. They quickly learn how the input works, regard the calculation as a black box, and watch how the output varies with the input. Basically, they make the LCA by instinct and common sense.
However, not all students are equal: some appear to have a much better instinct and common sense than others. Some issues in LCA are too complex to be tackled by common sense only. So these people need a little help and practical guidance.

When I realized the abovementioned situation, I decided to write this Practical Guide to LCA, starting with the common sense, and build on it with practical solutions for, sometimes, complex issues (like recycling). The examples are given in eco-costs; however, most of the examples are identical for other single indicators, like BEES, Ecological Scarcity, Ecoindicator 99, Recipe, Carbon Footprint, etc.

After two years of intensive use of the First Edition, the Second Edition as issued, with two extra issues: how to define the Functional Unit and the Declared Unit, and how to structure recycling calculations. The Third Edition is based on eco-costs 2012 data.

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1 Introduction

1.1 For whom is this guide?

This guide has been written to assist anyone who is interested in the environmental burden of their design:

- students who must design products and services which are better for the future in terms of environmental burden
- designers of products who are interested in selecting better materials, or who design innovative products (or product systems) with minimum use of materials and energy
- architects who are interested in optimizing the use of materials and minimizing the use of energy
- business managers who want to introduce 'green' products (and wonder how green their products are)
- consultants in the field of business strategy, product innovation, or in the field of government advice

This group of users is not so much interested in all the ins and outs of LCA: they just want to have quantitative guidance in the decisions they have to take. They don't want to spend much time on LCA, since their primary task is the introduction of innovative products and services. They often have no dedicated computer software, no licenses on LCI databases[1], and no budget available for specialized LCA consultant firms.
They want to do it themselves, but the time they can spend on the issue is limited. They are not interested in formalities and deliberations on accuracy: they just are interested in results.

There a 3 common misunderstandings about LCA:

1. To make an LCA requires a lot of time (at least 2 - 3 month) and a lot of money. This is true for the formal, classical, 'full' LCA according to ISO 14040 and ISO 14044. However the LCA of this guide takes only 2 - 4 hours (when the required input data are available), or a few days when several alternatives are studied. We

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1 LCI = Life Cycle Inventory. This is a long list of all emissions during the life cycle plus all the natural resources which are required. Making an LCI is often complex and laborious. The subsequent step in LCA is the LCIA (Life Cycle Impact Assessment), where these long lists are compressed to a few category indicators or to one single indicator. See Appendix I and II.

2 'Fast Track' LCA's have the single indicator as a starting point, which reduces the complexity of the LCA

2 The system you want to study

2.1 Different system concepts

Life Cycle Assessment (LCA) is a well-defined method to calculate the environmental burden of a product or service. The basic calculation structure of LCA is depicted in Fig. 2.1. The calculation is based on a system approach of the chain of production and consumption, analysing the input and the output of the total system:

- input:
    - materials (natural resources and recycled materials)
    - energy
    - transport
- output:
    - the product(s) and/or service
    - emissions to air, water and soil
    - by-products, recycling products, feedstock for electrical power plants
    - waste for landfill, waste incineration, or other types of waste treatment

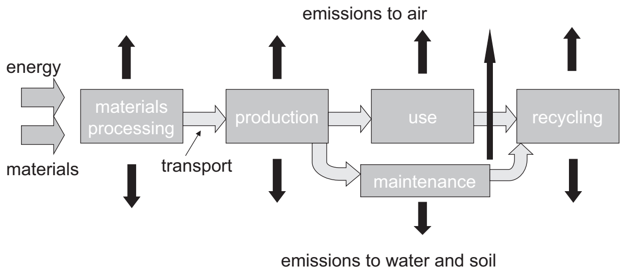

Figure 2.1

The basic calculation system of LCA

Each LCA starts with the definition of the Processes inside the 'black boxes' of Fig. 2.1. Such a process definition is unique for each case. When the definition of the process system is wrong (or not suitable for the goal of the study), the output of the calculation will be wrong. The biggest mistakes in practice are caused by a system definition which is too narrow: sub-processes are not included which appear to be important (and other details are included which have hardly any influence on the output). The definition of the system is often an iterative process as such: by trial and error it is discovered what is important in a certain case.

Some C2C specialists claim that the cradle-to-grave dogma of LCA leads to wrong approach in design. They have a point that the cradle-to-grave dogma may lead to wrong design decisions (i.e. opportunities for recycling are overlooked). However, this

3 The step by step approach and LCA as an iterative process

3.1 The Fast Track method, step by step

'Fast Track' refers to an LCA which is made by means of look-up tables (e.g. in Excel). This is in contrast with the 'Rigorous' LCA as described in the Handbook of LCA [3]. The basic idea is, that the easiest way to make an LCA is to multiply the inputs and outputs of the Life Cycle Inventory (= list of emissions, required materials and required energy) directly by factors for the single indicators, and build look-up tables (by means of computer systems like Simapro and LCI databases like Ecoinvent) for the most common materials (cradle-to-gate) and processes (gate-to-gate or gate-to-grave). See Fig. 3.1 and 3.2.

Ecocosts2012_LCA_data_on_emissions_and_recources_depletion - Microsoft Excel niet-commercieel gebruik

	A	B	C	D	E	F	G	H	I	J	K
66	5	**Impact cat.**	**Global Warming Potential 100 years, IPPC 2013**			**weighting factor**			**eco-costs (euro)**		**multiplier**
67	6	Air	(unspecified)	(E)-1-Chloro-3,3,3-trifluoroprop-1-ene	102687-65	1.49	kg CO2 eq / kg		0.20		**0.135**
68	7	Air	(unspecified)	(E)-1,2,3,3,3-Pentafluoroprop-1-ene	0 5595-10-	0.079	kg CO2 eq / kg		0.01		
69	8	Air	(unspecified)	(Perfluorobutyl)ethylene	019430-93	1.36E-01	kg CO2 eq / kg		0.02		
70	9	Air	(unspecified)	(Perfluoroctyl)ethylene	021652-58	9.29E-02	kg CO2 eq / kg		0.01		
71	10	Air	(unspecified)	(Perfluorohexyl)ethylene	025291-17	0.108	kg CO2 eq / kg		0.015		
72	11	Air	(unspecified)	(Z)-1,1,1,4,4,4-Hexafluorobut-2-ene	000692-49	1.68	kg CO2 eq / kg		0.227		
73	12	Air	(unspecified)	(Z)-1,2,3,3,3-Pentafluoroprop-1-ene	005528-43	0.233	kg CO2 eq / kg		0.031		
74	13	Air	(unspecified)	(Z)-1,3,3,3-Tetrafluoroprop-1-ene	029118-25	0.285	kg CO2 eq / kg		0.04		
75	14	Air	(unspecified)	1-Undecanol, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,11-	087017-97	0.69	kg CO2 eq / kg		0.09		
76	15	Air	(unspecified)	1,1,1,3,3,3-Hexafluoropropan-2-ol	000920-66	182	kg CO2 eq / kg		24.57		
77	16	Air	(unspecified)	1,2,2-Trichloro-1,1-difluoroethane	000354-21	5.92E+01	kg CO2 eq / kg		7.99		
78	17	Air	(unspecified)	2,3,3,3-Tetrafluoropropene	000754-12	0.352	kg CO2 eq / kg		0.05		
79	18	Air	(unspecified)	Acetate, 1,1-difluoroethyl 2,2,2-trifluoro-		30.84	kg CO2 eq / kg		4.16		
80	19	Air	(unspecified)	Acetate, 2,2,2-trifluoroethyl 2,2,2-trifluoro-	000407-38	6.84	kg CO2 eq / kg		0.92		
81	20	Air	(unspecified)	Acetate, difluoromethyl 2,2,2-trifluoro-	002024-86	27.06	kg CO2 eq / kg		3.65		
82	21	Air	(unspecified)	Acetate, methyl 2,2-difluoro-	000433-53	3.27E+00	kg CO2 eq / kg		0.44		
83	22	Air	(unspecified)	Acetate, methyl 2,2,2-trifluoro-	000431-47	5.24E+01	kg CO2 eq / kg		7.07		
84	23	Air	(unspecified)	Acetate, perfluorobutyl-	209597-28	1.66E+00	kg CO2 eq / kg		0.22		
85	24	Air	(unspecified)	Acetate, perfluoroethyl-	343269-97	2.06	kg CO2 eq / kg		0.28		

Introduction | materials depletion | water scarcity | ecocosts emissions 2012 | materials list in Simap 2012 | ecocosts emissions 2007 (old) | materials list 2007 (old

Figure 3.1

Screenshot of part of the look-up table for eco-costs of pure emissions[16]

It isn't necessary then to bother about classification, characterisation, normalisation, etc. (which are steps in the formal rigorous LCA process), and it has the advantage that the designer or engineer sees immediately which materials or processes are causing the most eco-burden.

[16] See www.ecocostsvalue.com tab data Excel file Ecocosts2012_LCA_data_on_emissions_and_resource_depletion

5 End of Life and By-products

5.1 By-products and waste

The way by-products and waste are dealt with in LCA is discussed for the last 15 years. The reason is that there is no 'one truth' for these calculations: more solutions are possible. This LCA guide will not describe and discuss all possibilities; however, it will describe the practical and logical solutions for designers and engineers. The approach of this manual is to keep the LCA calculation in line with the technical structure of the product system, and in line with the requirements of ISO 14040 and 14044. The issue is related with the so-called 'allocation' of eco-burden in LCA.

The basic structure of an LCA calculation is depicted in Fig. 5.1. The basic idea is that all inputs (materials, energy, and transport) and emissions (to air, water, and soil) of a product system cause eco-burden.
Outputs are the products and services which are delivered by the system, as well as by-products, energy, waste, and materials to be recycled.

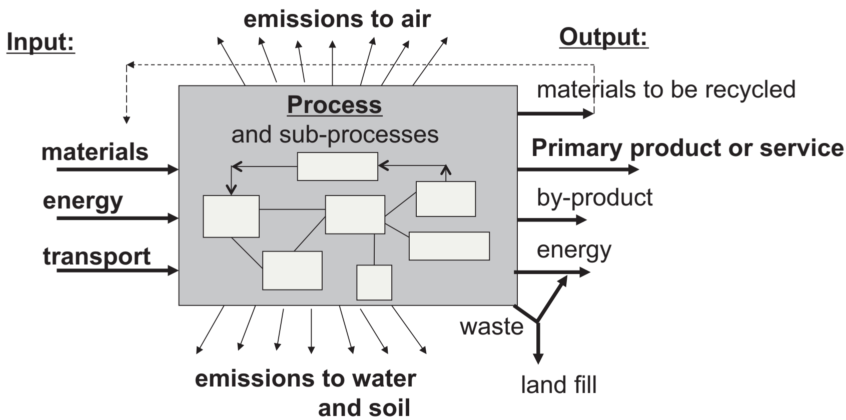

Figure 5.1

The basic structure of a system in LCA

In this guide we use the following practical definitions for output flows:

- By-products are products which can be used directly in other product systems (e.g. wood chips from saw mills can directly be applied in chipboard, saw dust can directly be applied in MDF plates)
- Energy is electricity or heat which is used by another system. This is also a form of by-product. (e.g. heat and/or electricity from combustion of wood chips and saw dust).