GreenDelta

LCIA methods

Impact assessment methods in Life Cycle Assessment and their impact categories

Version: 1.5.4

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Authors: Aitor P. Acero, Cristina Rodríguez, Andreas Ciroth

Changelog

Version	Author	Changes	Date
Version 1.0	Acero, Rodríguez, Ciroth	1st release	31 January 2014
Version 1.1	Acero, Rodríguez, Ciroth	Corrected normalization factors for CML 2001	3 February 2014
Version 1.2	Acero, Rodríguez, Ciroth	Added Social LCIA method, updated TRACI 2.0 to TRACI 2.1, updated ILCD 2011	17 February 2014
Version 1.3	Acero, Rodríguez, Ciroth	Updated TRACI 2.1 to add some ecoinvent specific flows	1 April 2014
Version 1.4	Acero, Rodríguez, Ciroth	Corrected CML and ReCiPe version	28 April 2014
Version 1.4.1	Acero, Rodríguez, Ciroth	Deleted EDIP 2003 methods as they need further revision. Only in EcoSpold and openLCA 1.4 formats	4 September 2014
Version 1.4.2	Acero, Rodríguez, Ciroth	Added normalization/weighting factors for intermediate endpoint categories in ReCiPe. Only in EcoSpold and openLCA 1.4 formats	17 October 2014
Version 1.5	Acero, Rodríguez, Ciroth	ReCiPe 8 methods upgraded to version 1.10 from May 2014. Only in EcoSpold and openLCA 1.4 formats	30 October 2014
Version 1.5.1	Acero, Rodríguez, Ciroth	Some missing factors in ReCiPe 8 methods added. Only in EcoSpold and openLCA 1.4 formats	11 November 2014
Version 1.5.2	Acero, Rodríguez, Ciroth	Cumulative Energy Demand method added. Added normalisation/weighting factors for intermediate endpoint	5 January 2015

		categories in Eco-Indicator 99. Weighting reference unit corrected. Only in EcoSpold and openLCA 1.4 formats	
Version 1.5.3	Acero, Rodríguez, Ciroth	ReCiPe methods: deleted wrong FEP CFs, added missing FETP End (I) CFs, added new FDP CFs (Update method to v.1.11). Only in EcoSpold and openLCA 1.4 formats. Further information in: http://www.openlca.org/documents/14826/1a4eca5a-1b08-4471-ab87-e6efd66702c9	4 February 2015
Version 1.5.4	Acero, Rodríguez, Ciroth	CML methods updated to v.4.4.: abiotic depletion impact categories updated, CFs for new flows in reference date added, CFs which were originally from ecoinvent LCIA methods were deleted or updated. Only in EcoSpold and openLCA 1.4 formats. Further information in: http://www.openlca.org/files/openlca/Update_info_openLCA_LCIA_methods_1_5_4.xlsx	16 March 2015

Content

1 Introduction

The availability of diverse sources for life cycle inventory databases and Life Cycle Impact Assessment (LCIA) methods should be an asset to better perform life cycle assessment studies. However, the variability of nomenclature used in each source for e.g. the compounds and compartments of the elementary exchanges impedes a straightforward combination of the different data. Thus, an intense work has been conducted for openLCA in order to align and harmonize the flows from different databases and LCIA methods.

The Nexus website (https://nexus.openlca.org/) contains currently over 30,000 data sets, from different sources, which can be used independently or combined in a single system in openLCA. And we are happy to be able to provide now a comprehensive pack of Life Cycle Impact Assessment (LCIA) methods suitable for all the data sets in Nexus. This pack is meant to replace the previous "impact methods" archive that was kindly provided by ecoinvent, which was mainly addressing ecoinvent flows.

In addition, a pack containing a social LCIA method is also provided in order to use it with the Social Hotspots Database, which is also available at Nexus.

2 How to use the LCIA methods packs in openLCA

The packs with the different methods can be downloaded from the openLCA website (http://www.openlca.org/downloads):

LCIA methods

With premission of the ecoinvent centre, we are happy to be able to provide here, for free, the latest LCIA methods of the ecoinvent database. Import them as ecospold into openLCA. You should have created the openLCA database with reference data, since then the elementary flows that are used in these methods will be already available. If you have any comments, please let us know!

LCIA Methods ecoinvent 2.2 Nov. 2010 (ZIP, 3.2 MB)

LCIA method pack for openLCA nexus - a comprehensive package of impact assessment methods for use with all different databases available in the nexus system - including ecoinvent 3, GaBi, ELCD. Including normalisation and weighting as far as this is foreseen by the method. Please observe the licence (Commons Attribution-ShareAlike 4.0 International) while using it. And please provide feedback - thanks in advance.

The pack is available in several versions.

EcoSpold01 as zip archive (10 MB), without normalisation values as the format does not allow this.

As database for openLCA 1.3.4 (olca file, 19 MB), with normalisation and weighting factors.

As database for openLCA 1.4 (zolca file, 15 MB), with normalisation and weighting factors.

An extensive documentation for the implemented methods in the pack is available here (800 kB pdf).

2.1 openLCA LCIA methods

openLCA LCIA methods are currently provided in three formats: ecospold1, .olca and .zolca. This is due to the impossibility of including normalization and weighting data in ecospold 1 format. Ecospold 1 and .olca formats are intended to be used with openLCA 1.3.4 or previous versions. The .zolca format should be used with openLCA 1.4 beta III version or later.

In all cases**, it is necessary that the databases using these LCIA methods contain reference data from openLCA**. Otherwise, the results of the impact assessment would be 0 for all categories.

.zolca file

The zolca file should be used in version 1.4 beta III or later. It contains characterization factors for the different impact categories and normalization and weighting factors for some of the methods (see section 3 for further details about the methods). The .zolca can be imported as a new complete database or, in openLCA 1.4. beta IV or later versions, into an existing database with reference data. In this last case, data already existing in the database would be maintained and the LCIA methods would be included (fig. 1, 2). Please note that LCIA calculation results are only displayed in openLCA 1.4 beta IV or later versions.

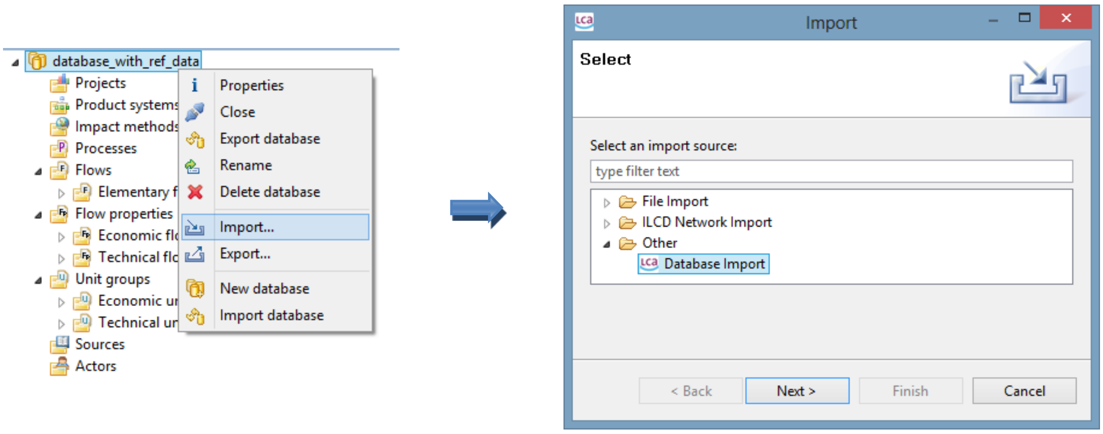

Figure 1. Option 1: Import .zolca file into an existing database

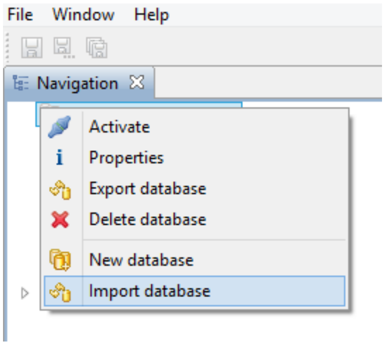

Figure 2. Option 2: Import .zolca file as a new complete database

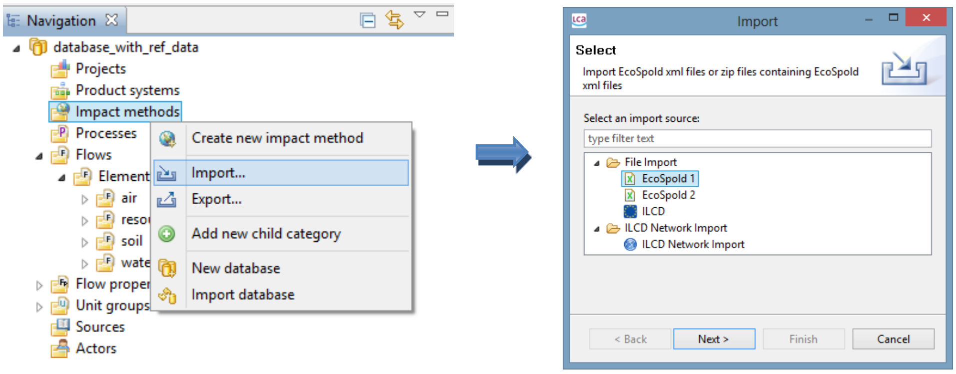

Figure 3. Import ecospold 1 file into an existing database

ecospold 1 file

The EcoSpold01 file contains characterization factors for the different impact categories but not normalization factors. It should be imported into an existing database in openLCA containing reference data. As it does not contain normalization data, it is recommended to use it only when the impact assessment must be done in a previously created database using a version of openLCA previous to 1.4 beta.

.olca file

The olca file contains characterization factors for the different impact categories and normalization and weighting factors for some of the methods (see section 3 for further details about the methods). It can be used in openLCA 1.3.4 or previous versions. The file should be imported as a complete database in openLCA. The process data sets can be imported into the database afterwards.

Please note that openLCA 1.3 databases can be migrated into the new openLCA 1.4 database format (i.e. .zolca) after installing the correspondent plugin:

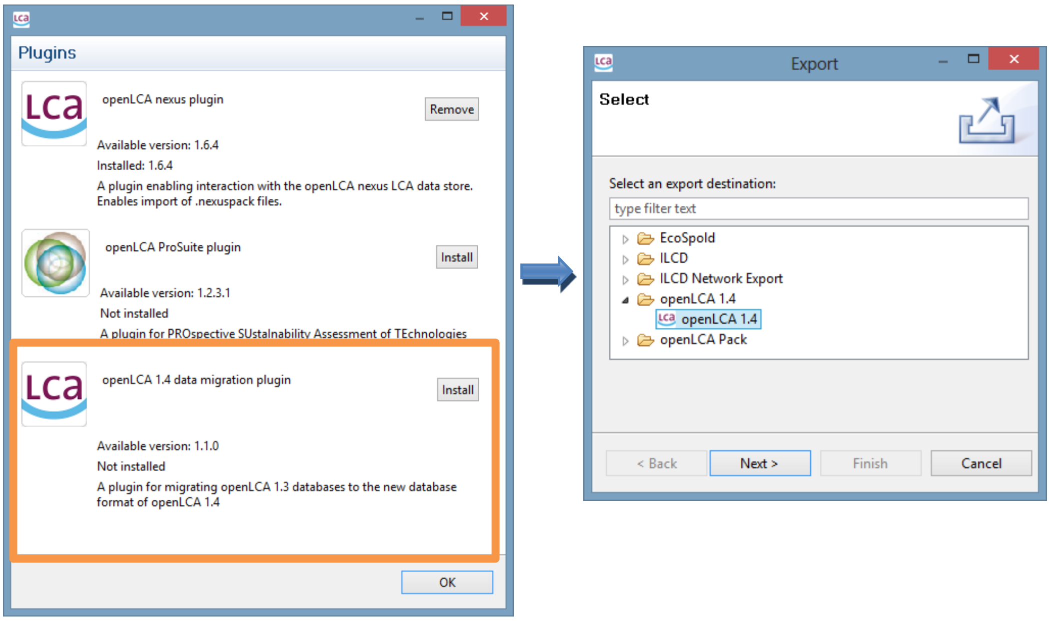

Figure 4. Migration of openLCA 1.3 databases (.olca) to openLCA 1.4 format (.zolca)

Please be aware that the normalization and weighting results are currently only available using the "Quick Results" option in the calculation wizard.

2.2 Social Hotspots Database (SHDB) LCIA Method

The SHDB method is provided in ecospold1 format. It does not contain normalization data and it is intended to be used with the Social Hotspot Database. As the elementary flows used are different to those in the openLCA reference list (i.e. environmental elementary exchanges), it is not necessary to use a database with reference data. This file can be used with all openLCA versions.

Once the methods are imported, the LCIA calculation can be done as explained in the wiki:

www.openlca.org/documentation/index.php/Elements_in_the_application#Impact_Assessment

www.openlca.org/documentation/index.php/Calculation_wizard

3 Environmental Impact Assessment Methods

3.1 Impact assessment methods in the pack

By tradition, an LCIA method is understood as a set of LCIA impact categories. This is also reflected in openLCA, where you select an LCIA method prior to calculating a product system or project. In order to facilitate the choice of the method that better adapts to your needs, this section provides detailed information about each of the methodologies contained in the pack.

One of the main characteristics of the openLCA LCIA methods pack comparing to the ecoinvent pack is the number of characterization factors included. As the ecoinvent pack mainly contains ecoinvent flows and compartments, the addition of specific flows from other databases and a general mapping of the compartments (e.g. characterisation factor for "air-high population density" takes the characterization factor from "air-unspecified" if a specific value was not provided) lead to a considerable increase of the factors available. Figure 5 shows the number of factors per method included in each pack.

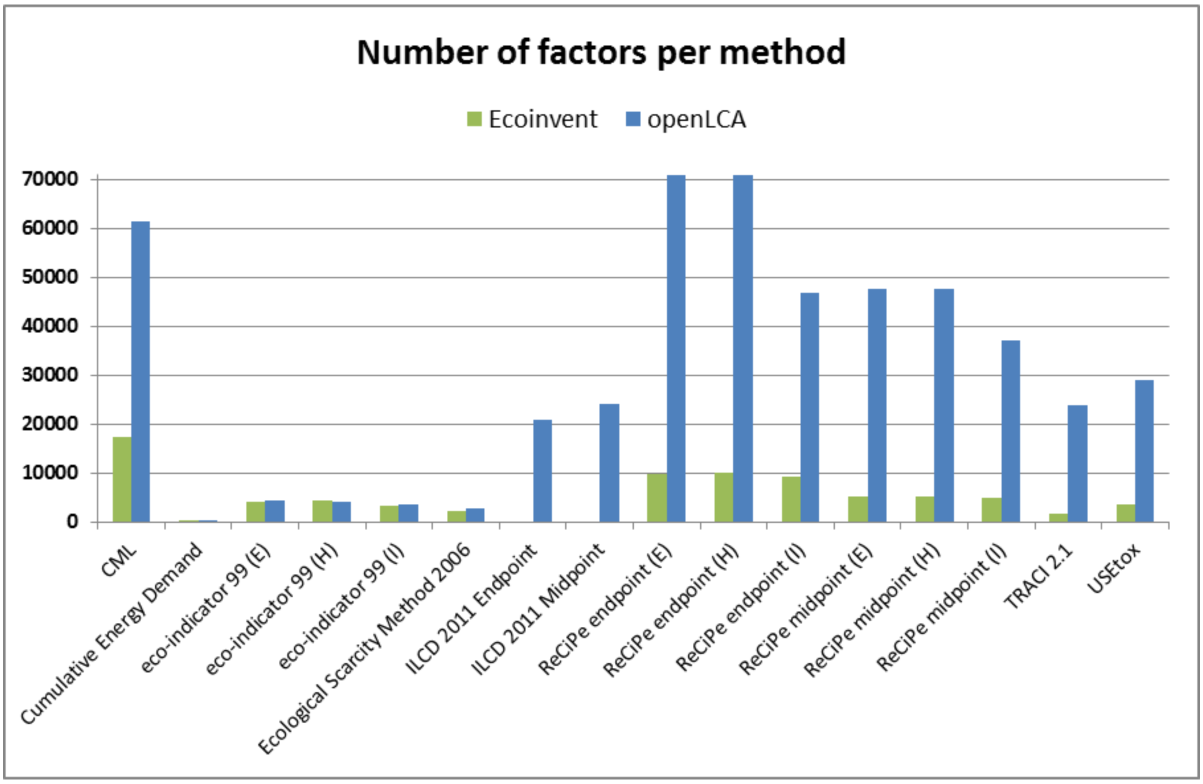

Figure 5. Number of factors per method and pack.

Evidently, additional factors result of applying normalization and weighting factors in openLCA methods such as eco-indicator 99 and ReCiPe. The ecoinvent pack contains factors for a specific normalization and weighting set, whereas openLCA includes the factors without the normalization applied and then the factors needed for calculating the normalized results if required (e.g. eco-indicator 99 (H) in ecoinvent is actually eco-indicator 99 (H,A) and openLCA provides normalization data for both H,A and H,H perspectives).Table 1 is an outline table describing the most common impact categories that can be found in the different methods.

METHODS	Acidification	Climate change	Resource depletion	Ecotoxicity	Energy Use	Eutrophication	Human toxicity	Ionising Radiation	Land use	Odour	Ozone layer depletion	Particulate matter/ Respiratory inorganics	Photochemical oxidation
CML (baseline)	✓	✓	✓	✓	-	✓	✓	-	-	-	✓	-	✓
CML (non baseline)	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	-	✓
Cumulative Energy Demand	-	-	-	-	✓	-	-	-	-	-	-	-	-
eco-indicator 99 (E)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	-
eco-indicator 99 (H)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	-
eco-indicator 99 (I)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	-
Eco-Scarcity 2006	-	-	✓	-	-	-	-	-	-	-	-	-	-
ILCD 2011, endpoint	✓	✓	-	-	-	✓	✓	✓	✓	-	✓	✓	✓
ILCD 2011, midpoint	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Endpoint (E)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Endpoint (H)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Endpoint (I)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Midpoint (E)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Midpoint (H)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Midpoint (I)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
TRACI 2.1	✓	✓	✓	✓	-	✓	✓	-	-	-	✓	✓	✓
USEtox	-	-	-	✓	-	-	✓	-	-	-	-	-	-

Table 1: Availability of impact categories per method. ✓ represents that the impact category is contained in the correspondent method and - that not.

3.1.1 CML

This method created by the University of Leiden in the Netherlands in 2001 contains more than 1700 different flows that can be downloaded from their website. It has been published in a handbook with several authors [1].

The method is divided into baseline and non-baseline, the baseline being the most common impact categories used in LCA. The following table shows the categories it contains:

Method: **CML (baseline)**	
Impact category group	**Name of the impact category in the method**
Acidification	Acidification potential - average Europe
Climate change	Climate change - GWP100
Depletion of abiotic resources	Depletion of abiotic resources - elements, ultimate reserves
	Depletion of abiotic resources - fossil fuels
Ecotoxicity	Freshwater aquatic ecotoxicity - FAETP inf
	Marine aquatic ecotoxicity - MAETP inf
	Terrestrial ecotoxicity - TETP inf
Eutrophication	Eutrophication - generic
Human toxicity	Human toxicity - HTP inf
Ozone layer depletion	Ozone layer depletion - ODP steady state
Photochemical oxidation	Photochemical oxidation - high Nox

Table 2: Impact categories included in the method CML (baseline)

Method: **CML (non-baseline)**	
Impact category group	**Name of the impact category in the method**
Acidification	Acidification potential - generic
Climate change	Climate change - GWP100 (incl. NMVOC average)
	Climate change - GWP20
	Climate change - GWP500
	Climate change - lower limit of net GWP100
	Climate change - upper limit of net GWP100
Depletion of abiotic resources	Depletion of abiotic resources - elements, economic reserve
	Depletion of abiotic resources - elements, reserve base
Ecotoxicity	Freshwater aquatic ecotoxicity - FAETP inf. (extended)
	Freshwater aquatic ecotoxicity - FAETP100
	Freshwater aquatic ecotoxicity - FAETP20
	Freshwater aquatic ecotoxicity - FAETP500
	Freshwater sedimental ecotoxicity - FSETP inf
	Freshwater sedimental ecotoxicity - FSETP100
	Freshwater sedimental ecotoxicity - FSETP20
	Freshwater sedimental ecotoxicity - FSETP500
	Marine aquatic ecotoxicity - MAETP inf. (extended)
	Marine aquatic ecotoxicity - MAETP100
	Marine aquatic ecotoxicity - MAETP20
	Marine aquatic ecotoxicity - MAETP500
	Marine sedimental ecotoxicity - MSETP inf
	Marine sedimental ecotoxicity - MSETP100
	Marine sedimental ecotoxicity - MSETP20
	Marine sedimental ecotoxicity - MSETP500
	Terrestrial ecotoxicity - TETP inf. (extended)
	Terrestrial ecotoxicity - TETP100
	Terrestrial ecotoxicity - TETP20
	Terrestrial ecotoxicity - TETP500
Eutrophication	Eutrophication - average Europe
Human toxicity	Human toxicity - HTP inf. (extended)
	Human toxicity - HTP100
	Human toxicity - HTP20
	Human toxicity - HTP500
Ionising Radiation	Radiation
Land use	Land use - land competition
Odour	Odour
Ozone layer depletion	Ozone layer depletion - ODP steady state (incl. NMVOC average)

Method: **CML (non-baseline)**	
Impact category group	**Name of the impact category in the method**
	Ozone layer depletion - ODP10
	Ozone layer depletion - ODP15
	Ozone layer depletion - ODP20
	Ozone layer depletion - ODP25
	Ozone layer depletion - ODP30
	Ozone layer depletion - ODP40
	Ozone layer depletion - ODP5
Photochemical oxidation	Photochemical oxidation - EBIR (low NOx)
	Photochemical oxidation - high NOx (incl. NMVOC average)
	Photochemical oxidation - high NOx (incl. NOx, NMVOC average)
	Photochemical oxidation - low NOx
	Photochemical oxidation - MIR (very high NOx)
	Photochemical oxidation - MOIR (high NOx)

Table 3: Impact categories included in the method CML (non baseline)

CML (baseline) and (non baseline) contain normalization factors which include:

- EU25
- EU25+3, 2000 (Wegener Sleeswijk et al., 2008)
- The Netherlands, 1997
- West Europe, 1995
- World, 1990
- World, 1995
- World, 2000 (Wegener Sleeswijk et al., 2008)

The characterization factors included are from version 4.4 of April 2013 and have been obtained from: http://cml.leiden.edu/software/data-cmlia.html
For more information about the method, please visit:
http://cml.leiden.edu/research/industrialecology/researchprojects/finished/new-dutch-lca-guide.html

3.1.2 Cumulative Energy Demand

The method Cumulative Energy Demand (CED) for openLCA was created based on the method published by the ecoinvent centre [4]. However, the existence of elementary flows from different data sources in openLCA (e.g. GaBi, ELCD, NREL, etc.) required an extension of the ecoinvent list of characterisation factors. Additional data (e.g. gross calorific values of elementary flows) was obtained from the databases providing the correspondent elementary flows.
The aim of the method is to quantify the primary energy usage throughout the life cycle of a good or a service. The method includes the direct and indirect uses of energy, but not the wastes used for energy purposes.
The gross calorific value (GCV) of the different fuels and materials was used for determining the characterisation factors (CFs). Further details about the selection of the characterisation factors are included in the next section.
The CED method is structured in eight different impact categories, as shown in table 4.
No normalisation or weighting data is included in the method.

Method: **Cumulative Energy Demand (CED)**		
Impact category group	**Name of the impact category in the method**	**Reference unit**
Non-renewable resources	Fossil	MJ
	Nuclear	MJ
	Primary forest	MJ
Renewable resources	Biomass	MJ
	Geothermal	MJ
	Solar	MJ
	Wind	MJ
	Water	MJ

Table 4: Impact categories included in the method Cumulative Energy Demand

3.1.3 Eco-indicator 99

Eco-indicator 99 is probably still one of the most widely used impact assessment methods in LCA. It has replaced Eco-indicator 95, the first endpoint assessment method. It allowed the expression of the environmental impact in one single score.

This method analyses three different types of damage: human health, ecosystem quality and resources. Relevant information about Eco-indicator 99 is that the standard unit given in all the categories is point (Pt) or millipoint (mPt). Since the aim of this method is the comparison of products or components, the value itself is not most relevant but rather a comparison of values.

The method distinguishes three different cultural perspectives or “Archetypes”:

- H → Hierarchist (default)
- I → Individualist
- E → Egalitarian

The following tables show the impact categories in each of the sub-methods of Eco-indicator 99:

Method: **Eco-indicator 99 (E), (H) & (I)**		
Midpoint/endpoint	**Impact category group**	**Name of the impact category in the method**
Midpoint	Ecotoxicity	Ecosystem Quality - Land conversion (PDF·m^2)
	Ecotoxicity	Ecosystem Quality - Land conversion (PDF·m^2·year)
	Ecotoxicity	Ecosystems Quality - Acidification and Eutrophication
	Ecotoxicity	Ecosystems Quality - Ecotoxicity
	Human toxicity	Human Health - Carcinogenics
	Human toxicity	Human Health - Climate change
	Human toxicity	Human health - Ionising radiation
	Human toxicity	Human health - Ozone layer depletion
	Human toxicity	Human Health - Respiratory effects caused by inorganic substances
	Human toxicity	Human Health - Respiratory effects caused by organic substances
	Depletion of abiotic	Resources - fossil fuels
	Depletion of abiotic	Resources - minerals
Endpoint	Depletion of abiotic resources	Resources-total
	Human toxicity	Human Health-total
	Ecotoxicity	Ecosystems-total

Table 5: Impact categories included in the methods eco-indicator 99 (E), (H) & (I)

These intermediate endpoint categories are grouped into the three areas of protection: Human Health, Resources and Ecosystems. For calculating the ecosystem damage category, a factor of 0.1 is applied to the ecotoxicity impact category. For the rest of the impact categories, a factor of 1 is used.

The method contains different normalization and weighting factors for the various perspectives and an average approach for Europe:

- Europe EI 99 E/A
- Europe EI 99 E/E
- Europe EI 99 H/A
- Europe EI 99 H/H
- Europe EI 99 I/A
- Europe EI 99 I/I

The characterization factors for Eco-indicator 99 are also included in the CML 2001 documentation (see section 2.1).
For more information about the method, please see [2].

3.1.4 Ecological Scarcity Method 2006

The Ecological Scarcity Method calculates environmental impacts as pollutant emissions and resource consumption by applying "eco-factors". These eco-factors are different depending on the substance and are derived from environmental law or political targets. The more the level of emissions or consumption of resources exceeds the environmental protection target set, the greater the eco-factor becomes, expressed in eco-points (EP). Just like Eco-indicator 99, the main aim of this method is to compare products and improve processes and/or products.
The table below lists the impact categories of the method:

Method: **Ecological Scarcity Method 2006**	
Impact category group	**Name of the impact category in the method**
Depletion of abiotic resources	Total-Deposited Waste
	Total-Emission into Air
	Total-Emission into Groundwater
	Total-Emission into Surface Water
	Total-Emission into Top Soil
	Total-Energy Resources
	Total-Natural Resources
	Total-Total

Table 5: Impact categories included in the method Ecological Scarcity Method 2006

The characterization factors were obtained from: http://www.esu-services.ch/projects/ubp06/
For more information about the method, please visit:
http://www.bafu.admin.ch/publikationen/publikation/01031/index.html?lang=en

3.1.5 ILCD 2011

ILCD stands for International Reference Life Cycle Data System and it is a result of a project conducted by the Joint Research Centre (JRC) of the European Commission that analyzed several life cycle impact assessment methodologies to reach consensus on the recommended method for each environmental theme, at both midpoint and endpoint.

Method: **ILCD 2011 recommended methods**			
Impact category group	**Recommended method**	**Midpoint / Endpoint**	**Comments**
Acidification	Seppala et al 2006 Posch et al 2008	Midpoint	Accumulated exceedance
	Van Zelm et al 2007	Endpoint	PNOF
Climate change	IPPC 2007	Midpoint	GWP100
	ReCiPe 2008	Endpoint	Human health
	ReCiPe 2008	Endpoint	Ecosystems
Depletion of abiotic resources	Ecological Scarcity Method 2006	Midpoint	Freshwater
	Van Oers et al 2002	Midpoint	Mineral, fossils and renewables
Ecotoxicity	ReCiPe	Midpoint	Freshwater

Method: **ILCD 2011 recommended methods**			
Impact category group	**Recommended method**	**Midpoint / Endpoint**	**Comments**
Eutrophication	Seppala et al 2006 Posch et al 2008	Midpoint	Terrestrial
	ReCiPe	Midpoint	Freshwater
	ReCiPe	Midpoint	Marine
	ReCiPe	Endpoint	Freshwater
Human toxicity	USEtox	Midpoint	Cancer human health effects
	USEtox	Midpoint	Non-cancer human health effects
	USEtox	Endpoint	Cancer human health effects
	USEtox	Endpoint	Non-cancer human health effects
Ionising radiation	Frishknecht et al 2000	Midpoint	Human health
	Garnier-Laplace et al 2008	Midpoint	Ecosystem
	Frishknecht et al 2000	Endpoint	Human health
Land use	Mila i Canals et al 2007	Midpoint	---
	ReCiPe	Endpoint	---
Ozone depletion	WMO 1999	Midpoint	ODP
	ReCiPe 2008	Endpoint	Human health
Particle matter	Rabl and Spadaro 2004	Midpoint	Respiratory inorganics (PM2.5)
	Humbert et al 2009	Endpoint	Respiratory inorganics (DALY)
Photochemical oxidation	Van Zelm et al 2008	Midpoint	Human health
	Van Zelm et al 2008	Endpoint	Human health
	ReCiPe	Endpoint	Mineral, fossils and renewables

Table 7: Impact categories included in the compilation of methods from ILCD 2011

These intermediate endpoint categories have been grouped into the three areas of protection: Human Health, Resource depletion and Ecosystems.

The characterization factors included are from version 1.0.5 of February 2013 and have been obtained from: http://eplca.jrc.ec.europa.eu/?page_id=86

Further information in the assessment done by the International Reference Life Cycle Data System can be obtained in http://eplca.jrc.ec.europa.eu/?page_id=86

3.1.6 ReCiPe

The main objective of the ReCiPe method is to provide a method that combines Eco-Indicator 99 and CML, in an updated version.. ReCiPe distinguishes two levels of indicators:

- Midpoint indicators
- Endpoint indicators with the following categories: damage to human health, damage to ecosystems and damage to resource availability

The table below shows the impact categories of this method:

Method: **ReCiPe endpoint (E, H & I)**				
Impact category group	**Name of the impact category in the method**	**E**	**H**	**I**
Acidification	Terrestrial acidification	TAPinf EQ-E	TAP100 EQ-H	TAP20 EQ-I
Climate change	Climate change	GWPinf HH-E GWPinf EQ-E	GWP100 HH-H GWP100 EQ-H	GWP20 HH-I GWP20 EQ-I
Depletion of abiotic resources	Metal depletion	MDPinf RD-E	MDP100 RD-H	MDP20 RD-I
	Fossil depletion	FDPinf RD-E	FDP100 RD-H	FDP20 RD-I
Ecotoxicity	Freshwater ecotoxicity	FETPinf EQ-E	FETP100 EQ-H	FETP20 EQ-I
	Marine ecotoxicity	METPinf EQ-E	METP100 EQ-H	METP20 EQ-I
	Terrestrial ecotoxicity	TETPinf EQ-E	TETP100 EQ-H	TETP20 EQ-I
Eutrophication	Freshwater	FEPinf EQ-E	FEP100 EQ-H	FEP20 EQ-I
Human toxicity	Human toxicity	HTPinf HH-E	HTP100 HH-H	HTP20 HH-I
Ionising radiation	Ionising radiation	IRPinf HH-E	IRP100 HH-H	IRP20 HH-I
Land use	Agricultural land occupation	ALOPinf EQ-E	ALOP100 EQ-H	ALOP20 EQ-I

Method: **ReCiPe endpoint (E, H & I)**				
Impact category group	**Name of the impact category in the method**	**E**	**H**	**I**
	Urban land occupation	ULOPinf EQ-E	ULOP100 EQ-H	ULOP20 EQ-I
	Natural land transformation	LTPinf EQ-E	LTP100 EQ-H	LTP20 EQ-I
Ozone layer depletion	Ozone depletion	ODPinf HH-E	ODP100 HH-H	ODP20 HH-I
Particulate matter	Particulate matter formation	PMFPinf HH-E	PMFP100 HH-H	PMFP20 HH-I
Photochemical oxidation	Photochemical oxidant formation	POFPinf HH-E	POFP100 HH-H	POFP20 HH-I

Table 8: Impact categories included in the method ReCiPe 8 endpoint (E, H & I)

Key:
E= Egalitarian / H= Hierarchist / I= Individualist
HH= Human Health / EQ = Ecosystem / RD= Resources

These intermediate endpoint categories have been grouped into the three areas of protection: Human Health, Resources and Ecosystems.

ReCiPe endpoint (E, H & I) contains the following normalization and weighting:

- Europe ReCiPe E/A; Europe ReCiPe H/A; Europe ReCiPe I/A
- Europe ReCiPe E/A, 2000; Europe ReCiPe H/A, 2000; Europe ReCiPe I/A, 2000
- Europe ReCiPe E/E; Europe ReCiPe H/H; Europe ReCiPe I/I
- Europe ReCiPe E/E; 2000, Europe ReCiPe H/H; 2000, Europe ReCiPe I/I, 2000
- World ReCiPe E/A; World ReCiPe H/A; World ReCiPe I/A
- World ReCiPe E/A, 2000; World ReCiPe H/A, 2000; World ReCiPe I/A, 2000
- World ReCiPe E/E; World ReCiPe H/H; World ReCiPe I/I
- World ReCiPe E/E, 2000; World ReCiPe H/H, 2000; World ReCiPe I/I, 2000

Method: **ReCiPe midpoint (E, H & I)**				
Impact category group	**Name of the impact category in the method**	**E**	**H**	**I**
Acidification	Terrestrial acidification	TAP500-E	TAP100-H	TAP20-I
Climate change	Climate Change	GWP500-E	GWP100-H	GWP20-I
Depletion of abiotic resources	Fossil depletion	FDPinf-E	FDP100-H	FDP20-I
	Metal depletion	MDPinf-E	MDP100-H	MDP20-I
	Water depletion	WDPinf-E	WDP100-H	WDP20-I
Ecotoxicity	Freshwater ecotoxicity	FETPinf-E	FETP100-H	FETP20-I
	Marine ecotoxicity	METPinf-E	METP100-H	METP20-I
	Terrestrial ecotoxicity	TETPinf-E	TETP100-H	TETP20-I
Eutrophication	Freshwater eutrophication	FEPinf-E	FEP100-H	FEP20-I
	Marine eutrophication	MEPinf-E	MEP100-H	MEP20-I
Human toxicity	Human toxicity	HTPinf-E	HTP100-H	HTP20-I
Ionising Radiation	Ionising radiation	IRPinf-E	IRP100-H	IRP20-I
Land use	Agricultural land occupation	ALOPinf-E LOP-E	ALOP100-H LOP-H	ALOP20-I LOP-I
	Natural land transformation	LTPinf-E LTP-E	LTP100-H LTP-H	LTP20-I LTP-I
	Urban land occupation	ULOPinf-E	ULOP100-H	ULOP20-I
Ozone layer depletion	Ozone depletion	ODPinf-E M2E-E	ODP100-H M2E-H	ODP20-I M2E-I
Particulate matter	Particulate matter formation	PMFPinf-E	PMFP100-H	PMFP20-I
Photochemical oxidation	Photochemical oxidant formation	POFPinf-E	POFP100-H	POFP20-I

Table 9: Impact categories included in the methods ReCiPe 8 midpoint (E, H & I)

ReCiPe midpoint (E, H & I) contains the following normalization and weighting factors:

- Europe ReCiPe Midpoint (E); Europe ReCiPe Midpoint (H); Europe ReCiPe Midpoint (I)
- Europe ReCiPe Midpoint (E), 2000; Europe ReCiPe Midpoint (H), 2000; Europe ReCiPe Midpoint (I), 2000

- World ReCiPe Midpoint (E); World ReCiPe Midpoint (H); World ReCiPe Midpoint (I)
- World ReCiPe Midpoint (E), 2000; World ReCiPe Midpoint (H), 2000; World ReCiPe Midpoint (I), 2000

The characterization factors included in the method pack are from version 1.11 of Agustu 2014 and have been obtained from: https://sites.google.com/site/lciarecipe/file-cabinet. The new normalization/weighting factors were taken from the SimaPro 8.0.3 implementation as indicated by the method developers.

For further information about the method please visit: https://sites.google.com/site/lciarecipe/

3.1.7 TRACI 2.1

EPA has developed TRACI, the Tool for the Reduction and Assessment of Chemical and other environmental Impacts, to assist in impact assessment for Sustainability Metrics, Life Cycle Assessment, Industrial Ecology, Process Design, and Pollution Prevention. Methodologies were developed specifically for the United States using input parameters consistent with U.S. locations for the following impact categories:

Method: **TRACI 2.1**	
Impact category group	**Name of the impact category in the method**
Acidification	Acidification
Ecotoxicity	Ecotoxicity
Eutrophication	Eutrophication, total
Climate Change	Global Warming
Human toxicity	Human Health - air pollutants criteria
Human toxicity	Human Health - carcinogenics
Human toxicity	Human Health - non-carcinogenics
Ozone layer depletion	Ozone Depletion
Photochemical oxidation	Smog Formation
Resource depletion	Resource depletion – Fossil fuels

Table 10. Impact categories included in TRACI 2.1

The characterization factors were kindly provided by the US EPA. The normalization factors were obtained from [5]. TRACI 2.1. contains normalization data for the following reference systems:

- US 2008
- US 2008 – Canada 2005

The normalization factors are shown as the geographical areas total potential environmental impact per year, and as the impact in person-years.

For more information about TRACI, please check:
http://www.epa.gov/nrmrl/std/traci/traci.html

3.1.8 USEtox

USEtox [6],[7] is a method to calculate environmental impact based on scientific consensus to identify and obtain human and eco-toxicological impact values of chemicals in life cycle impact assessment. The main output includes a database of recommended and interim characterization factors including environmental fate, exposure, and effect parameters for human toxicity and ecotoxicity.
Characterization factors for metals are considered interim and, therefore, should be interpreted with care.

The characterisation factors included correspond to the results of the USEtox model version 1.01 from 15th February 2010 and were obtained from www.usetox.org. Both the inorganic and organic results are included in the different impact categories. The mapping of USEtox compartments to those in openLCA reference data was performed following the indication from USEtox website.
The following table shows the impact categories that are contained in this method:

Method: **USEtox**	
Impact category group	**Name of the impact category in the method**
Ecotoxicity	Freshwater ecotoxicity
Human toxicity	Human health - carcinogenic
	Human health - non-carcinogenic
	Human health - total impact

Table 12: Categories included in the method USEtox

3.2 Limitations

The characterisation factors in the methods refer to elementary flows contained in the reference data of openLCA. This data includes all the elementary flows from the databases available in the Nexus site and additional flows used in the methods. There are numerous elementary flows from the methods that are not included in the reference list. The ones that have been added to openLCA reference data are:

- those flows whose chemical compound exists in any of the Nexus databases but for different compartments, and
- those flows recurrently appearing in various methodologies using the same nomenclature.

It has not been considered a priority to map the rest of the elementary flows because they are not currently used by any of the most important LCA databases available.
The mapping between the elementary flows in the methods and those in the openLCA list was done by comparing compartments, names, CAS numbers and formulas from the original files with our reference data. However, the last two were not always available in the documentation provided by the method developers, which made the correct identification of the correspondent flows more difficult. In addition, several errors were encountered in the original files during the mapping due to incorrect CAS numbers or synonyms. Moreover, in some cases, duplicate flows with different characterisation factors were observed. For them, the flow with higher characterisation factors, as conservative approach, were kept.
Some elementary flows from ecoinvent (e.g. Aluminium, 24% in bauxite, 11% in crude ore, in ground; Carbon dioxide, fossil) were not included as such in the original documentation of any methodology. Therefore, data from the ecoinvent pack of methods was used in our compilation.
There are some methods from the ecoinvent pack that have not been included already in the openLCA compilation, such as IPCC 2007 or Impact 2002+, which will be added in the near future along with other methodologies. IPCC 2007 is already included though as climate change category in many of the other methods that are already present in the method pack.

3.3 Impact categories

A short description of the most commonly used impact categories has been included in this document as an additional support for those beginner LCA practitioners.

3.3.1 Acidification

Acidic gases such as sulphur dioxide (SO_2) react with water in the atmosphere to form “acid rain”, a process known as acid deposition. When this rain falls, often a considerable distance from the original source of the gas (e.g. Sweden receives the acid rain caused by gases emitted in the UK), it causes ecosystem impairment of varying degree, depending upon the nature of the landscape ecosystems. Gases that cause acid deposition include ammonia (NH_3), nitrogen oxides (NOx) and sulphur oxides (SOx).

Acidification potential is expressed using the reference unit, kg SO_2 equivalent. The model does not take account of regional differences in terms of which areas are more or less susceptible to acidification. It accounts only for acidification caused by SO_2 and NOx. This includes acidification due to fertiliser use, according to the method developed by the Intergovernmental Panel on Climate Change (IPCC). CML has based the characterisation factor on the RAINS model developed by the University of Amsterdam.

Impact category	**Acidification**
Definition	Reduction of the pH due to the acidifying effects of anthropogenic emissions
Impact indicator	Increase of the acidity in water and soil systems
Considerations	• Acidifying potential of oxides of nitrogen and sulphur
Damage categories (endpoint)	Damage to the quality of ecosystems and decrease in biodiversity
Unit	Kg SO_2 equivalent

Table 13: Acidification category outline

3.3.2 Climate change

Climate change can be defined as the change in global temperature caused by the greenhouse effect that the release of “greenhouse gases” by human activity creates. There is now scientific consensus that the increase in these emissions is having a noticeable effect on climate. This raise of global temperature is expected to cause climatic disturbance, desertification, rising sea levels and spread of disease.

Climate change is one of the major environmental effects of economic activity, and one of the most difficult to handle because of its broad scale.

The Environmental Profiles characterisation model is based on factors developed by the UN’s Intergovernmental Panel on Climate Change (IPCC). Factors are expressed as Global Warming Potential over the time horizon of different years, being the most common 100 years (GWP100), measured in the reference unit, kg CO_2 equivalent.

Impact category	**Climate change**
Definition	Alteration of global temperature caused by greenhouse gases
Impact indicator	Disturbances in global temperature and climatic phenomenon
Considerations	• Greenhouse gases[1] and their global warming potential (GWP), e.g. methane, sulphur hexafluoride, etc.
Damage categories (endpoint)	Crops, forests, coral reefs, etc. (biodiversity decrease in general) Temperature disturbances Climatic phenomenon abnormality (e.g. more powerful cyclones, torrential storms, etc.)
Unit	Kg CO_2 equivalent

Table 14: Climate change category outline

[1] Greenhouse gases (GHG): gas that absorbs and emits radiation within the thermal infrared range.

3.3.3 Depletion of abiotic resources

There are many different sub-impacts to be considered in this case. In a general way, this impact category in referred to the consumption of non-biological resources such as fossil fuels, minerals, metals, water, etc.

The value of the abiotic resource consumption of a substance (e.g. lignite or coal) is a measure of the scarcity of a substance. That means it depends on the amount of resources and the extraction rate. It is formed by the amount of resources that are depleted and measured in antimony equivalents in some models or water consumption (in m^3), kg of mineral depletion and MJ of fossil fuels.

Impact category	**Depletion of abiotic resources**
Definition	Decrease of the availability of non-biological resources (non- and renewable) as a result of their unsustainable use
Impact indicator	Decrease of resources
Considerations	• Distinctions between renewable and non-renewable resources
Damage categories (endpoint)	Damage to natural resources and possible ecosystem collapse
Unit	Depending on the model: • Kg antimony equivalent • Kg of minerals • MJ of fossil fuels • m^3 water consumption

Table 15: Depletion of abiotic resources category outline

3.3.4 Ecotoxicity

Environmental toxicity is measured as three separate impact categories which examine freshwater, marine and land. The emission of some substances, such as heavy metals, can have impacts on the ecosystem. Assessment of toxicity has been based on maximum tolerable concentrations in water for ecosystems. Ecotoxicity Potentials are calculated with the USES-LCA, which is based on EUSES, the EU's toxicity model. This provides a method for describing fate, exposure and the effects of toxic substances on the environment. Characterisation factors are expressed using the reference unit, kg 1,4-dichlorobenzene equivalent (1,4-DB), and are measured separately for impacts of toxic substances on:

- Fresh-water aquatic ecosystems
- Marine ecosystems
- Terrestrial ecosystems

Impact category	**Ecotoxicity**
Definition	Toxic effects of chemicals on an ecosystem
Impact indicator	Biodiversity loss and/or extinction of species
Considerations	• Toxicological responses of different species • Nature of the chemicals in the ecosystem
Damage categories (endpoint)	Damage to the ecosystem quality and species extinction
Unit	Depending on the model: • Kg 1,4-DB equivalent

- PDF (Potentially Disappeared Fraction of species)
- PAF (Potentially Affected Fraction of species)

Table 16: Ecotoxicity category outline

3.3.5 Eutrophication

Eutrophication is the build-up of a concentration of chemical nutrients in an ecosystem which leads to abnormal productivity. This causes excessive plant growth like algae in rivers which causes severe reductions in water quality and animal populations. Emissions of ammonia, nitrates, nitrogen oxides and phosphorous to air or water all have an impact on eutrophication. This category is based on the work of Heijungs, and is expressed using the reference unit, kg PO_4^{3-} equivalents.

Direct and indirect impacts of fertilisers are included in the method. The direct impacts are from production of the fertilisers and the indirect ones are calculated using the IPCC method to estimate emissions to water causing eutrophication.

Impact category	**Eutrophication**
Definition	Accumulation of nutrients in aquatic systems
Impact indicator	• Increase of nitrogen and phosphorus concentrations • Formation of biomass (e.g. algae)
Considerations	Transportation of the nutrients (air, water, wash-off from land)
Damage categories (endpoint)	Damage to the ecosystem quality
Unit	Depending on the model: • Kg PO_4^{3-} equivalent • Kg N equivalent

Table 17: Eutrophication category outline

3.3.6 Human toxicity

The Human Toxicity Potential is a calculated index that reflects the potential harm of a unit of chemical released into the environment, and it is based on both the inherent toxicity of a compound and its potential dose. These by-products, mainly arsenic, sodium dichromate, and hydrogen fluoride, are caused, for the most part, by electricity production from fossil sources. These are potentially dangerous chemicals to humans through inhalation, ingestion, and even contact. Cancer potency, for example, is an issue here. This impact category is measured in 1,4-dichlorobenzene equivalents.

Impact category	**Human toxicity**
Definition	Toxic effects of chemicals on humans
Impact indicator	Cancer, respiratory diseases, other non-carcinogenic effects and effects to ionising radiation
Considerations	• Toxicological responses of humans • Nature of the chemicals in the human body
Damage categories (endpoint)	Human health
Unit	Depending on the model: • Kg 1,4-DB equivalent

- DALY (Disability-adjusted life year)[2]

Table 18: Human toxicity category outline

3.3.7 Ionising radiation

Ionising radiation is an impact category in LCA related to the damage to human health and ecosystems that is linked to the emissions of radionuclides throughout a product or building life cycle. In the building sector, they can be linked to the use of nuclear power in an electricity mix.

The category takes into account the radiation types α-, β-, γ-rays and neutrons. The characterization model considers the emissions and calculation of their radiation behaviour and burden based on detailed nuclear-physical knowledge. The unit the impact is given is kg of uranium-235 (U^{235}).

Impact category	**Ionising radiation**
Definition	Type of radiation composed of particles with enough energy to liberate an electron from an atom or molecule
Impact indicator	Effects of the radiation (health decline, cancer, illnesses, etc.)
Considerations	• Radiation behaviour of the substances • Toxicological responses of humans and other species
Damage categories (endpoint)	Human health and ecosystem quality
Unit	Depending on the model: • Kg U^{235} equivalent • DALY

Table 19: Ionising radiation category outline

3.3.8 Land use

The study is based on the UNEP/SETAC land use assessment framework (Milà i Canals et al., 2007, Koellner et al., 2012) and focuses on occupation impacts, i.e. the use of land. The damage is expressed as “potentially disappeared fraction of species” (PDF) per m^2 or m^2a (square metre of land per year). To finally calculate land use impacts in LCA studies, these characterization factors have to be multiplied with the land occupation:

Occupation impact = Land occupation (m^2a) * Characterization factor (PDF/m^2)

Impact category	**Land use**
Definition	Impact on the land due to agriculture, anthropogenic settlement and resource extractions
Impact indicator	Species loss, soil loss, amount of organic dry matter content, etc.
Considerations	• Analysis of the land area to be altered • Observations of biodiversity that could be damaged
Damage categories (endpoint)	Natural resource (non- and renewable) depletion
Unit	Depending on the model: • PDF/m^2 • m^2a

[2] DALY = YLD (years lived with disability) + YLL (years of life lost)

Table 20: Land use category outline

3.3.9 Ozone layer depletion (Stratospheric ozone depletion)

Ozone-depleting gases cause damage to stratospheric ozone or the "ozone layer". There is great uncertainty about the combined effects of different gases in the stratosphere, and all chlorinated and brominated compounds that are stable enough to reach the stratosphere can have an effect. CFCs, halons and HCFCs are the major causes of ozone depletion. Damage to the ozone layer reduces its ability to prevent ultraviolet (UV) light entering the earth's atmosphere, increasing the amount of carcinogenic UVB light reaching the earth's surface. The characterisation model has been developed by the World Meteorological Organisation (WMO) and defines the ozone depletion potential of different gases relative to the reference substance chlorofluorocarbon-11 (CFC-11), expressed in kg CFC-11 equivalent.

Impact category	**Ozone layer depletion**
Definition	Diminution of the stratospheric ozone layer due to anthropogenic emissions of ozone depleting substances
Impact indicator	Increase of ultraviolet UV-B radiation and number of cases of skin illnesses
Considerations	• Atmospheric residence time of ozone depleting substances • EESC (Equivalent Effective Stratospheric Chlorine)
Damage categories (endpoint)	Human health and ecosystem quality
Unit	Kg CFC-11 equivalent

Table 21: Ozone layer depletion category outline

3.3.10 Particulate matter

Particulate Matter is a complex mixture of extremely small particles. Particle pollution can be made up of a number of components, including acids (such as nitrates and sulphates), organic chemicals, metals, and soil or dust particles. A multitude of health problems, especially of the respiratory tract, are linked to particle pollution. PM is measured in PM_{10} equivalents, i.e. particles with a size of 10 µm.

Impact category	**Particulate matter**
Definition	Suspended extremely small particles originated from anthropogenic processes such as combustion, resource extraction, etc.
Impact indicator	Increase in different sized particles suspended on air (PM10, PM2.5, PM0.1)
Considerations	• Environmental behaviour of the particles
Damage categories (endpoint)	Human health
Unit	Kg particulate matter

Table 22: Particulate matter category outline

3.3.11 Photochemical oxidation (Photochemical ozone creation potential)

Ozone is protective in the stratosphere, but on the ground-level it is toxic to humans in high concentration. Photochemical ozone, also called "ground level ozone", is formed by the reaction of volatile organic compounds and nitrogen oxides in the presence of heat and sunlight. The impact category depends largely on the amounts of carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxide (NO), ammonium and NMVOC (non-methane volatile organic compounds). Photochemical ozone creation potential (also known as summer smog) for emission of substances to air is calculated with the United Nations Economic Commission for

Europe (UNECE) trajectory model (including fate) and expressed using the reference unit, kg ethylene (C_2H_4) equivalent.

Impact category	**Photochemical oxidation**
Definition	Type of smog created from the effect of sunlight, heat and NMVOC and NOx
Impact indicator	Increase in the summer smog
Considerations	• Meteorology, the chemical composition of the atmosphere and emissions of other pollutants
Damage categories (endpoint)	Human health and ecosystem quality
Unit	Depending on the model: • Kg ethylene equivalent • Kg NMVOC • Kg formed ozone

Table 23: Photochemical oxidation category outline

4 Social Impact Assessment Method

The social LCIA method provided for openLCA is intended to be used with the Social Hotspots Database (SHDB).

The SHDB is at present the only existing, comprehensive database for social assessments over the entire life cycle. It provides social risk data on a sector and country level, and it is integrated with a global input-output model derived from the GTAP database.

Further information about the SHDB can be found in http://socialhotspot.org/
A detailed explanation of how to use the SHDB in openLCA is available in
http://www.openlca.org/documents/14826/3ca0b8e1-3f79-49fd-b3a4-23161405b864

The social indicators included in the method are:

Method: **Social LCIA Method**	
Impact category	**Reference unit**
Child Labour	Child Labour medium risk hours (CL med rh)
Collective bargaining	Collective bargaining medium risk hours (CB med rh)
Corruption	Corruption medium risk hours (CO med rh)
Drinking water	Drinking water quality medium risk hours (DQ med rh)
Excessive working time	Excessive working time medium risk hours (EW med rh)
Forced Labour	Forced Labour medium risk hours (FL med rh)
Gender Equity	Gender Equity medium risk hours (GE med rh)
High Conflict	High Conflict medium risk hours (HC med rh)
Hospital Beds	Hospital Beds medium risk hours (HB med rh)
Improved Sanitation	Improved Sanitation medium risk hours (IS med rh)
Indigenous Rights	Indigenous rights medium risk hours (IR med rh)
Injuries & Fatalities	Injuries and fatalities medium risk hours (IF med rh)
Legal System	Legal System medium risk hours (LS med rh)
Migrant Labour	Migrant Labour medium risk hours (ML med rh)
Poverty Wage1	Poverty Wage 1 medium risk hours (PW1 med rh)
Poverty Wage2	Poverty Wage 2 medium risk hours (PW2 med rh)
Poverty Wage3	Poverty Wage 3 medium risk hours (PW3 med rh)
Toxic & Hazards	Toxic and hazards medium risk hours (TH med rh)

Table 24: Social indicators included in Social LCIA Method

5 References

[1] Guinée, J.B.; Gorrée, M.; Heijungs, R.; Huppes, G.; Kleijn, R.; Koning, A. de; Oers, L. van; Wegener Sleeswijk, A.; Suh, S.; Udo de Haes, H.A.; Bruijn, H. de; Duin, R. van; Huijbregts, M.A.J. Handbook on life cycle assessment. Operational guide to the ISO standards. I: LCA in perspective. IIa: Guide. IIb: Operational annex. III: Scientific background. Kluwer Academic Publishers, ISBN 1-4020-0228-9, Dordrecht, 2002, 692 pp.

[2] Goedkoop M., Spriensma, R. : The Eco-indicator 99 - A damage oriented method for Life Cycle Impact Assessment. Methodology Report". Amersfoort 2001, Third edition

[3] Hauschild, M., Potting, J.: Spatial differentiation in Life Cycle impact assessment – The EDIP2003 methodology. Institute for Product Development. Technical University of Denmark. Environmental News No. 80, 2005.

[4] Hischier R., Weidema B., Althaus H.-J., Bauer C., Doka G., Dones R., Frischknecht R., Hellweg S., Humbert S., Jungbluth N., Köllner T., Loerincik Y., Margni M. and Nemecek T. (2010) Implementation of Life Cycle Impact Assessment Methods. ecoinvent report No. 3, v2.2. Swiss Centre for Life Cycle Inventories, Dübendorf.

[5] Ryberg, M., Vieira, M.D.M., Zgola, M., Bare, J., Rosenbaum, R.K. Updated US and Canadian normalization factors for TRACI 2.1. Clean Technologies and Environmental Policy (ISSN: 1618-954X) (DOI: http://dx.doi.org/10.1007/s10098-013-0629-z), 2013.

[6] Rosenbaum, R.K., Bachmann, T.M., Gold, L.S., Huijbregts, M.A.J., Jolliet, O., Juraske, R., Koehler, A., Larsen, H.F., MacLeod, M., Margni, M.D., McKone, T.E., Payet, J., Schuhmacher, M., van de Meent, D., Hauschild, M.Z., 2008. USEtox - The UNEP-SETAC toxicity model: Recommended characterisation factors for human toxicity and freshwater ecotoxicity in life cycle impact assessment. The International Journal of Life Cycle Assessment 13, 532-546.

[7] Hauschild, M.Z., Huijbregts, M.A.J., Jolliet, O., Macleod, M., Margni, M.D., van de Meent, D., Rosenbaum, R.K., McKone, T.E., 2008. Building a Model Based on Scientific Consensus for Life Cycle Impact Assessment of Chemicals: The Search for Harmony and Parsimony. Environmental Science and Technology 42, 7032-7037.

6 Contact

If you have any questions or comments, please let us know.

GreenDelta GmbH, Müllerstrasse 135, 13349 Berlin, GERMANY
Cristina Rodríguez, Dr. Andreas Ciroth
gd@greendelta.com
Tel. +49 30 48 496 - 031 | Fax +49 30 48 496 – 991

GreenDelta