Software: CEENE method

Our research group at Ghent University Belgium works on environmental sustainability in terms of resource use. We have brought forward characterisation of natural resource use by a thermodynamic approach: the **Cumulative Exergy Extraction from the Natural Environment / CEENE** in the following papers:

▪ J. Dewulf, M.E. Bösch, B. De Meester, G. Van Der Vorst, H. Van Langenhove, S. Hellweg, M.A.J. Huijbregts. Cumulative Exergy Extraction from the Natural Environment (CEENE): a comprehensive Life Cycle Impact Assessment method for resource accounting. Environmental Science and Technology 41(2007) 8477-8483.

▪ R.A.F. Alvarenga, J. Dewulf, H. Van Langenhove, M.A.J. Huijbregts. Exergy-based accounting for land as a natural resource in life cycle assessment. International Journal of Life Cycle Assessment 18 (2013) 939-947.

▪ S. E. Taelman, S. De Meester, T. Schaubroeck, E. Sakshaug, R. A. F. Alvarenga, J. Dewulf. Accounting for the occupation of the marine environment as a natural resource in life cycle assessment: An exergy based approach. (2014) Resources Conservation and Recycling 91(2014) 1–10.

In the table below, we present an overview of the zip files we can share containing the XML of the three versions of CEENE, corresponding with different databases and software.

▪ CEENE 2007 (Dewulf et al., 2007) is based on the characterisation factors of the ES&T paper and fully compatible with the elementary flows of ecoinvent v.2.

▪ CEENE 2013 (Alvarenga et al., 2013) is an update: main difference is the characterisation factors for land use as published in the IJLCA paper.

▪ CEENE 2014 (Taelman et al., 2014): the characterization factors for marine resources (biomass and sea surface occupation) as published in the RC&R paper are implemented, resulting in the extended CEENE 2014 version.

The characterization factors developed are compatible with the databases Ecoinvent, Input output database, and the compatibility with the European Life Cycle Database (ELCD) is being developed.

Two versions of the international **ecoinvent database** containing Life Cycle Inventory data are highlighted; Ecoinvent v2.2 and Ecoinvent v3.1. The main differences are documented in the reports offered by the Ecoinvent centre (http://www.ecoinvent.org/). The files are offered for the LCA software packages SimaPro and OpenLCA. However, considering the updates of SimaPro, the data from Ecoinvent v2.2 is connected to SimaPro 7.3.3, while SimaPro 8.0.4 is interlinked with Ecoinvent v3.1.
The data for the life cycle inventory data and life cycle impact assessment methods is offered in .csv format relying on SimaPro, while for OpenLCA the data exchange format are EcoSpold 1 and EcoSpold 2, corresponding with the databases Ecoinvent v2.2 and Ecoinvent 3.1 respectively.

The factors developed in the CEENE method are also being adapted to be compatible with the ELCD (**European reference Life Cycle Database**). Most of the ELCD flows can be matched with the ecoinvent flows, however some of them cannot. Some flows related to marine occupation, which are available in the CEENE method, are missing in the ELCD database. Similarly, some ELCD flows corresponding to freshwater bodies do not have characterization factors from CEENE as the latest version of CEENE only accounts for land and marine occupation. Therefore, work is in process in collaboration with the DG JRC (Joint Research Center) to fully adapt the CEENE method to the ELCD database, which in parallel is also being updated to be more consistent.

The files provided for both databases show the CEENE scores in different resource categories: renewables, fossils, minerals,… Making a sum results in the full natural resource footprint in exergy.

Finally, CEENE 2013 is integrated into an input-output (IO) model (**Exiobase)**. The characterization factors are presented in excel format. Information about the calculations is presented by Huysman et al. (2014). Until now, the IO-CEENE is compatible with Exiobase v1, while this is pending for Exiobase v2.

▪ S. Huysman, T. Schaubroeck, J. Dewulf. Quantification of spatially differentiated resource footprints for products and services through a macro-economic and thermodynamic approach. Environmental Science and Technology (2014).