Development of Chinese Reference Life Cycle Database (CLCD) – Guidelines, Documentation and Tools

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Abstract: During the development of Chinese Reference Life Cycle Database (CLCD) as a comprehensive process-based and national average database in China, the methodology, guidelines, documentation and tools were developed and briefly introduced in this paper, including selection of impact categories for CLCD and development of LCIA factors for Chinese LCAs, establishment of the core life cycle model of the fundamental industries, stepwise guidelines and documentation format for devleopment of UP and AP datasets, and the software solution for database devleopment.

Keywords: Chinese Reference Life Cycle Database (CLCD), guidance, documentation, eBalance

1 Introduction

The lacking of domestic LCA database was recognized as the primary obstacle to wide practice of LCA in China. To support increasing LCA studies of products which are mainly or partly manufactured in China, a process-based Chinese LCA database (CLCD) has been developed. The first version of CLCD has been

released in 2010 and continuously expanded [1].

During the development of CLCD, there were four major questions confronted as below, which might be shared by other developers who are working on regional and comprehensive databases.

- How to pre-select the scope of impact categories and related environmental interventions of the database, so that the database is capable of supporting regional LCA studies and decision-making ?
- What products should be selected as the starting point of data collection from enormous indurtrial products, to speed up the progress of development ?
- How to develop unit process (UP) datasets and aggregated process (AP) datasets consistently with satisfactory quality ?
- What tools and features are needed to facilitate the development and update of the database ?

To address those questions above, the CLCD methodology, guidelines, documentation and tools (i.e. eBalance [2]) were developed in the past years and will be briefly introduced in this paper.

2 LCIA methods in CLCD

During the selection of coverage of impact categories, the focus of regional policy, as well as inventory data availability and applicability of existing characterization models, should be the main concerns. In CLCD, several impact categories and inventories are selected, which all are associated with major environmental concerns in Chinese environmental policy (shown in Table 1).

Table 1: Impact categories and characterization models selected in CLCD

Impact category selected	Characteriaztion methods selected
Primary energy depletion potential	CML 2002, and NRDP*

Non-energy resource depletion potential	CML 2002, and PEDP*
Water resource depletion	n.a.
Global warming potential	IPCC 2007
Acidification	CML 2002
Eutrophication	CML 2002
Chemical Oxygen Demand	n.a.
Waste solids	n.a.
Respiratory inorganic	IMPACT 2002+

CLCD suggests the adoption of existing characterization models and factors, mainly mid-point factors, for selected impact categories as in Table 1. Nevertheless, regionalized factors for primary non-renewable energy and resource use are developed, based on CML ADP model and modified with self-sufficiency rate in China.

A set of normalization references, i.e. the national total environmental emission and resource extraction data in 2005 in China associated with selected impact categories, are obtained mainly from literatures.

A set of weighting factors are developed for CLCD by panel method. More than 30 participants of Chinese Conference on Life Cycle Management in 2009 were asked to evaluate and rank the selected impact categories as in Table 1. And then the weighting factors were calculated with the Analytic Hierarchy Process (AHP). Another set of weighting factors are developed by distant-to-target method, based on the national quantitative environmental targets as in Chinese Energy Conservation and Emission Reduction (ECER) policy.

3 Core life cycle model for fundamental industries

At the very beginning of development of a regional and comprehensive database, the primary question is what products should be selected to start data collection.

According to our survey of the Ecoinvent 2.0 database, it was found that the products which were used more than 10 times in the database account for only 14% of the total 4000 processes. It implies that a small portion of products are more important than others since they are widely used and more likely interlinked, which should be the start point of the development of a comprehensive database.

Therefore, a distinction was made between “fundamental products” and “normal products” in CLCD. The fundamental products are those widely used by and often interlinked with other products. They share the same life cycle model which is an interlinked network. This life cycle model is actually the model of fundamental industries, so-called core life cycle model in CLCD. Those fundamental products are the starting point of data collection, while othe normal products can be studied later after the core model and data available.

During development of CLCD, electricity generation and transmission is seleted as the starting point. When the data collection goes on, the core life cycle model appears. This is actually an operational way to define “fundamental products”. CLCD core model is continuously expanded and the content of version 1.0 is shown as in table 2.

Table2: Industries and products included in CLCD 1.0

Industries	Products
Energy	Coal fuels: coal,coke Oil fuels: crude oil, diesel, petrol, kerosene. Gas fuels: natural gas, liquefied petrolum gas, coke oven gas Electricity: coal-fired power, hydropower, mixed electricity Heat: steam
Metals	Iron and iron alloys, steel, aluminium, copper, zinc, lead, etc.
Non-mentals	Cement, glass, china, linestone, etc.
Chemicals	Inorganic materials: sulfuric acid, hydrochloric acid, nitric acid, sodium hydroxide,soda, titanium dioxide, oxygen, nitrogen,

	ammonia, chlorine, etc. Organic materials: ethylene, propylene, methanol, ethyne, Resin, plastic, rubber, fiber, paint etc.
Transportation	Road, rail, water transportation
pollution treatment	Waste gas treatment: desulfurization, denitration Waste water treatment: physical-chemical process, biological process

4 Development of Unit Process Dataset

During development of CLCD, a distinction has been made between unit process dataset and aggregated process dataset. An unit process dataset is a set of quantified inputs and outputs related to the reference of a process, which are generated from mathematical relations and raw data that are not related to the same reference yet. On the contrary, an aggregated process dataset is aggregation of existing datasets. The following section 4 and 5 will address the development and documentation of UP dataset and AP dataset respectively.

4.1 Definition of goal and scope

Definition of goal and scope is the first step in development of UP datasets to describe what process the dataset intends to represent. The main steps and documentation are described as follow.

Step 1: Define target representativeness of a UP dataset

The target representativeness of a UP dataset is defined and documented in terms of product, technology, producer, temporal and geographical representativeness as shown in Table 3.

Table 3: targeted representativeness and parallel decummentation

Documentation	in terms of
Product representativeness	Product name, specification, usage etc.
Technological representativeness	Technology (mix) name and description
Producers representativeness	Producer (group) name and description
Temporal representativeness	Reference year as raw data represent
Geographical representativenes	China, sometimes region specific

Since the main purpose of developing CLCD is to obtain Chinese national average inventory datasets, similar definition of representativeness is expected for most of datasets in CLCD, i.e. a Chinese market average dataset of a specific product produced by main Chinese market suppliers (including import) with main technology and mix in most recently years. This is also the benchmark for assessment of data quality by Pedigree matrix method later.

Step 2 : Define System boundary

Unit process boundaries are defined in terms of activity start point and end point. Meanwhile, included and excluded activities are described.

Step 3: Define Cut-off criteria

The following four cut-off rules are applied in development to ensure the consistency of CLCD.

- Selected environmental inpacts – Normally, impact categories and characterization model as in Table 1 are selected in CLCD.
- For elementary flows (resources and environmental emissions) – A flow can be excluded, if its contribution is smaller than 2% of the life cycle impact. However, the sum of the excluded flows must not exceed 5 % of total impacts.
- For material and energy inputs – A material or energy flow can be excluded if it’s less than 2% of the cumulative mass or cumulative energy, providing its environmental relevance is not significant. However, the sum of the excluded material flows must not exceed 5 %.
- Infrastucture and captial goods – Normally infrastucture and captial goods are excluded in CLCD.

eBalance supports to record the above-mentioned information in each unit process dataset.

4.2 Generation of unit process dataset

Generation of unit process dataset is divided into four steps as shown in Table 4.

Tab. 4: Generation of unit process dataset and documentation

Procedures	Documention
Preapare an inventory list	A complete inventory list
Collect raw data needed	Raw data, data representativeness and data sources
Calculate inventory data	Mathematic relations, inventory data and standard deviation
Provide other supportive information	Allocation, advice for users,etc.

Step 1: Prepare an inventory list

For the consideration of completeness, a list of inputs and outputs of the unit process is needed before data collection. This inventory list can be prepared by the steps below:

- Import an inventory list from existing datasets as reference;
- Label the flows which are cut off according to cut-off rules above;
- check and adjust the list according to the actual technology and practice.

Step 2: Collect raw data needed

Raw data are data that have not been referred to the quantitative reference of the unit process. In CLCD, raw data are normally acquired from sources, such as Chinese statistics, yearbooks and reports, Chinese emission control standards and cleaner production standards, industry guidance or design specification, professional literatures (e.g. technical works, journal paper, etc.), Chinese industrial emission eoefficient manual, IPCC reports, existing datasets and life cycle databases.

Step 3: Calculate inventory data

Often used mathematical relations in CLCD to deliver national average datasets includes (1) calculation based on total amounts from statistics or bookkeeping, especially for material and energy input; (2) calculation based on physical or chemical rules, e.g. mass balance, especially for emissions; (3) calculation based

on (semi)empirical formula from design or technology specification.

Step 4: Provide other supportive information

Supportive information are documented, such as justification for selection of mathematic relations and raw data, information for allocation and suggestions for users, etc.

eBalance supports to import inputs or outputs from other databases and further adjust them. All raw data and mathematical relations can be recorded and calculated in eBalance, which remarkably facilitate the data collection and update.

4.3 UP dataset check and review

UP dataset check is conducted by the dataset developer, including completeness check, plausibility check and uncertainty analysis.

- Completeness check includes the completeness of the inventory list, which is described the step 1 in 4.2 and the completeness of activities, which will be documented also.
- Plausibility check is mainly carried out by mass balance calculation. Total mass balance check is compulsory and the deviation is documented. Element, component or energy balance check is conducted where possible. For key inventory data, alternative data (sourece) and mathematical relations should be investigated to evaluate the plausibility of data.
- Uncertainty analysis based on pedigree matrix method is under developmnet, which will deliver a standard deviation for each inventory data. In CLCD, ranking of pedigree matrix method will be applied on raw data leve instead of inventory data or unit process level.

UP dataset review refers to validation and assessment the data quality by independent reviewer. Data quality review covers goal and scope definition, generation of UP dataset and UP check results based on expert judgement. Data

document review will assure the readability of the document.

5 Developmet of aggregated process dataset

Development of aggregated process dataset includes five steps:

Step 1: Definition of goal and scope.

Similar information is documented in goal and scope definition of an AP dataset.

Step 2: Establishment of life cycle model.

Life cycle model is established in eBalance. In case imported goods contribute a considerable portion of market supply in China, datasets from Ecoinvent and ELCD database will be applied to model the production overseas.

Step 3: Itreation of unit process data collection:

Once the LCI results derived from the life cycle model, sensitivity and uncertainty analysis is planned to be conducted to identify the inventory data with high sensitivity and high uncertainty [3]. For the inventory data with high sensitivity and uncertainty, alternative data sources and mathematical relations should be investigated. This step is summaried as Fig. 1:

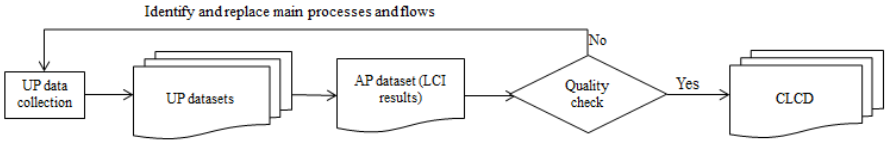

Fig. 1. Itreation of unit process data collection

Step 4: Consistency check

This step aims to check the consistency of all unit processes in the life cycle model which deliver the AP dataset, in tems of allocation methods, selected impact categories.

Step 5: AP dataset review

AP dataset review comprises data quality review and data document review. Data quality review covers data goal and scope definition, generation of AP dataset and AP check results based on expert judgement. Data document review assures readability of AP documentation.

6 Conclusions

During the development of CLCD, the methodology, guidelines, documentation and tools were developed to facilitate efficient and quality work. They addressed the major questions in devleopment of a regional and comprehensive database, such as selection of impact categories based on environmental policy concerns, establishment of the core life cycle model of regional fundamental industries, stepwise guidelines and documentation format for devleopment of UP and AP datasets in a consistent way with satisfactory quality, and software solution to facilitate efficient database devleopment. It may provide a reference for development of a regional and comprehensive database in other countries.

Reference

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