Journal of Cleaner Production 101 (2015) 118–121

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Note from the field

Test of US federal life cycle inventory data interoperability

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ARTICLE INFO

Article history:
Received 5 March 2015
Received in revised form
27 March 2015
Accepted 28 March 2015
Available online 7 April 2015

Keywords:
Life cycle inventory
Public databases
Government
Harmonization

ABSTRACT

Life cycle assessment practitioners must gather data from a variety of sources. For modeling activities in the US, practitioners may wish to use life cycle inventory data from public databases and libraries provided by US government entities. An exercise was conducted to test if a practitioner could gather and use data from existing US federal sources together to build a life cycle assessment model in standard software. As a result, issues were identified that US federal agencies need to overcome in order to provide functionally interoperable life cycle inventory data to the public. These same challenges apply more broadly to using life cycle inventory data from different sources.

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1. Introduction

Life cycle assessments (LCA) are quantitative studies used to identify and estimate potential environmental impacts of products or technologies (SAIC and Curran, 2006). LCA models link together datasets describing direct and indirect activities used to provide materials and energy to make, use, and dispose of these products. LCA models are complete only when all these activities are modeled "cradle-to-grave" such that all raw resources used and pollutants released from these activities are included. To fulfill the needs of their vast scope, LCAs typically use life cycle inventory (LCI) data collected from various sources. These sources may include original data collected by the practitioner along with data from one or more external sources. Thousands of LCA studies have been published, but often without making data from the studies available in a useable form. Therefore, users generally draw upon data from public and private entities that provide life cycle databases or libraries. LCA software provide some of these data preloaded and permit the user to develop new data that will automatically connect to background datasets in order to create LCA models and perform life cycle impact assessment. When practitioners wish to load in and use datasets from new sources, these may not be interoperable, limiting the ability to use these datasets.

Globally, a number of public entities in Europe, Asia, and the Americas provide life cycle data as a public service (Ciroth et al., 2014). In the United States, the US Life Cycle Inventory (US LCI), a public-private partnership managed by the National Renewable Energy Laboratory (Trusty and Deru, 2005), was the primary source of public LCI until a few years ago. While the US LCI continues to be a source of data, a number of federal agencies and laboratories provide – or have near-term goals of providing – LCI via databases, libraries, or models including the US Department of Agriculture National Agricultural Library (McCarthy and Cooper, 2012), Argonne National Laboratory (Wang, 2007), NIST (Lippiatt et al., 2010), and the US EPA (Ingwersen et al., 2015). As none of these databases themselves portends to be a complete LCI database that represents all economic activities in the US, practitioners wishing to use public data would likely need to use more than one of these sources. In acknowledgment of this need, US federal entities providing life cycle data have begun to collaborate to make data interoperable. This study is intended to inform that effort. The basic procedures and results were presented to federal colleagues for consideration at a meeting of a Technical Working Group on Federal LCA Data Interoperability in February 2015. This paper further elaborates the methods and results of this study.

2. Methods

To identify and elucidate current issues with federal LCA data interoperability with regard to basic model functionality, an exercise was performed to attempt to create a simplified LCA model integrating LCI data from five different federal entities from the perspective of an LCA practitioner. LCI data included either unit

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http://dx.doi.org/10.1016/j.jclepro.2015.03.090
0959-6526/Published by Elsevier Ltd.

processes, describing "gate-to-gate" activities, or aggregated datasets, describing "cradle-to-gate" activities. The exercise was restricted to publically available LCA data and software tools with the exception of data from the practitioner's institution, representing primary data. Minimal effort was made to adapt or convert data from its publically available formats, as expected from practitioners with access to data in LCA software and limited time and resources to fully recreate data in the format of choice.

A product system had to be designed that could potentially integrate data from various entities. Application of nitrogen fertilizer to a corn field was determined to be a product system that could be used to integrate data from the EPA National Risk Management Research Laboratory (EPA-NRMRL), USDA National Agricultural Library (USDA-NAL), Argonne National Laboratory (ANL), National Energy Technology Laboratory (NETL), and National Renewable Energy Laboratory (NREL). Table 1 lists the unit processes used and their sources.

The exercise was divided into 4 steps. Following each step, the outcome of each dataset was evaluated on a pass/fail basis. Reasons for failing a step were used to identify specific challenges to interoperability. Step 1 consisted of acquisition of the data and the associated metadata as well as documentation. This included searching LCI libraries or databases maintained by the selected agencies and laboratories. Step 2 consisted of import into a standard LCA software package. For this exercise, openLCA 1.4.1 (GreenDelta, 2014) was chosen because of its support for import of data using standardized LCI formats including Ecospold and ILCD and its availability free of charge to users. Step 3 included combining these processes automatically into a single model for analysis. The process for analysis was created (Application of N fertilizer) with the EPA-NRMRL N fertilizer and the USDA-NAL Sprayer as direct inputs to link the datasets in this analysis (Fig. 1), with the NREL, NETL, and ANL datasets interchangeably providing gasoline USDA-NAL Sprayer. A background, proprietary but widely used LCI database, Ecoinvent v2.2, was imported into the software to provide data to support cradle-to-gate impact calculations (Frischknecht and Rebitzer, 2005). Step 4 included calculating LCIA using a standard LCIA methodology available in the LCA software. The standard LCIA method pack for openLCA in Ecospold 1 format was imported into the software and the TRACI 2.1 and Recipe Midpoint (H) methods were used for impact assessment.

3. Results and discussion

Pass/fail results from the exercise are summarized by step in Table 2.

The EPA-NRMRL N fertilizer data failed Step 1 because it is not available to the public. The USDA-NAL sprayer and NETL petroleum models and associated metadata and documentation were both available from websites maintained by the respective agencies. The NREL petroleum LCI was available from the US Life Cycle Inventory but associated documentation was not available. The ANL petroleum model is built into the GREET 2014 model (2014). A user with basic familiarity with the GREET 2014 model can view data for Conventional Gasoline refining and follow the links to acquire related documentation. Except for the NREL and USDA datasets, which shared formats (although varied in comprehensiveness), datasets from each agency/lab were available in different formats. They ranged from containing little to no metadata, and would require the user to have some familiarity with each of the different formats to read and understand the data.

Three of the five datasets were available in internationally standardized data exchange formats. These included the EPA NRMRL N fertilizer in Ecospold 1 and the USDA-NAL Sprayer and NREL Petroleum in ILCD. These three of datasets passed Step 2. The NETL and ANL petroleum datasheets were available as Excel spreadsheets and in the native model format, respectively, neither of which can be imported directly into openLCA software, thus failing Step 2.

In Step 3, the simplified product system using the created 'Application of N fertilizer' process was unable to automatically connect the datasets. Names and units of product flows had to be manually altered to link the datasets. None of the datasets were able to automatically link to the background Ecoinvent 2.2 database to support full cradle-to-gate impact assessment. USDA-NAL provides "crosswalk" processes for other datasets that would help link data to Ecoinvent 2.2, but this did not exist for the Sprayer dataset.

In Step 4, impact assessment results were only partially calculated for the product system, yielding an incomplete analysis. Impact assessment was only functional for the elementary flows in the datasets with corresponding characterization factors in the impact methods. A record of the elementary flows created during the import procedures in the openLCA database was kept to determine if new and thus possibly uncharacterized flows were introduced upon import of each dataset. This record is available in the Appendix. Approximately 90% of the elementary flows in the NREL petroleum dataset were included in the openLCA reference flows or LCIA method flows; for the EPA and USDA-NAL datasets it was only 52% and 43%, respectively. Many of the new flows introduced are the same chemicals as those already present, just with different names or spellings. For instance, the flow 'Chromium' to the 'water/unspecified' compartment with unit of mass was including in the NREL data but the name 'Chromium, ion' in the same compartment and units was expected in the LCIA method. Because there was no exact match, this flow was therefore not included in the impact assessment.

The interoperability issues exposed in this exercise are listed in Table 3. Data, metadata, and documentation must be available and compatible for data to be interpreted in a consistent way throughout an LCA model. When data are not available in the internationally recognized exchange formats such as Ecospold or ILCD, importing and using these data in life cycle software is generally not possible. Once data are in the software, if naming conventions or other mechanisms do not exist to make product flows consistent, datasets will not connect with each other, or to background LCI databases. This can be remedied by creating

Table 1
US Federal LCI unit processes evaluated.

Unit process name	Process location	Provider	Retrieved from
Application of N fertilizer	US	Original	NA
N fertilizer	US	EPA-NRMRL	EPA Internal sources
Work, sprayer for corn, 2014 fleet, 0–50 H P	US-IL	USDA-NAL	LCA Commons (http://lcacommons.gov)
CG Refining	US	ANL	GREET 2014 (http://greet.es.anl.gov/)
Petroleum refinery	US	NETL	NETL Unit Process Library (www.netl.doe.gov/research/energy-analysis/life.../unit-process-library)
Petroleum refinery	US	NREL	US LCI Database (http://lcacommons.gov/nrel)