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Opportunities and Challenges of Quality-Assured contributions of Life Cycle Data Network for Web-shared Publication.

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ABSTRACT
This paper presents recent achievements and original solutions towards increased availability, quality and interoperability of LCID (Life Cycle Inventory Data), developed through European Commission-led activities and based on wide stakeholder consultation and international dialogue. An overview of related activities, such as the ILCD (International Reference Life Cycle Data System), the ELCD (European Reference Life Cycle Database) and the ILCD Entry-Level quality requirements are presented. The focus is then on the LCDN (Life Cycle Data Network).Purpose The European Commission's Integrated Product Policy Communication, 2003, defined LCA (Life Cycle Assessment) as the 'best framework for assessing the potential environmental impacts of products'. Since then, the use of LCA and life cycle approaches has been developing in a wide range of European policies, and its use has also significantly grown in business. Increasing the availability of quality-assured LCI (Life Cycle Inventory) data is the current challenge to ensure the development of LCA in various areas. Methods One solution to increase availability is to use LCI data from multiple database sources but under the condition that such LCI data are fully interoperable. A non- centralised data network of LCI datasets complying with minimum quality requirements that was politically launched in 2ND month of 2014, already includes several database nodes from different worldwide sources and has the potential to contribute to the needs of the international community.

KEYWORDS: Data quality, LCA, ELCD, Entry-level requirements, Life cycle data (LCD).

1. INTRODUCTION

i. Technical and Scientific context:

Data from database sources can be considered interoperable when, if used in LCA studies, they lead to results that are coherent with the defined goal and scope. In fact, when two or more LCI databases are combined in an LCA study, the practitioner has to ensure that the underlying assumptions, methods and level of completeness (intrinsic properties) are comparable between the databases used (Suh et al. 2013). Intrinsic properties reflect data content and quality, while the use of different data exchange formats and nomenclature of elementary flows (extrinsic properties) is a technical issue when exchanging datasets from multiple databases and using different LCA software applications; currently left to the expense and technical competence of users of multiple databases, with associated risks. Increasing the availability of quality-assured LCI data is a key challenge to ensure the uptake of LCA in various areas of policy and business. One solution to increase is to use LCI data from multiple database sources (Suh et al. 2013). This appears to align well to worldwide community needs, where data are foreseen to come from many companies, associations, governments and research projects. However, this also requires that LCI data are fully interoperable. Equally, data must have sufficient quality to facilitate defendable LCAs. An alternative is to develop large, databases worldwide in isolation, reflecting somewhat practice-to-date, resulting in duplication, as well as leading to differences that make combination As argued by Suh et al. (2013), building a global LCI database from scratch with a harmonised method and wide process coverage would require significant resources. This statement brings the discussion back to the opportunity of using interoperable datasets from multiple providers in a network of databases. Moreover, facilitating international networking of data, rather than reliance on any single provider, is seen as essential in the 'Shonan Guidance Principles' (Sonnemann and Vigon 2011). In

summary, although LCA databases have been developing globally, the main challenges for satisfactory interoperability
and quality assurance still concern the data format and nomenclature of datasets and the documentation. Moreover, several of the 'Shonan Guidance Principles' have not been implemented systematically. costly and/or infeasible.

ii. Policy context

European Commission (EC)'s Integrated Product Policy Communication (European Commission 2003), as 'best framework for assessing the potential environmental impacts of products', LCA (Life Cycle Assessment) has been increasingly used in support of policy and business in the European Union (EU). For instance, in the context of the Directive 2009/28/EC, an LCA-based GHG (greenhouse gases) assessment method is used to promote the use of energy from renewable sources (European Union 2009). LCA results can be used as support for setting eco label (European Union 2010) and GPP criteria (European Commission 2008a) in a range of product groups. The use of LCA in application contexts such as, e.g. environmental management system schemes has been promoted in the Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan (European Commission 2008b). LCA is also very important in waste policies, including the Waste Framework Directive (European Union 2008): for example, in its article 4, the directive calls for the identification, using life cycle thinking, of the 'options that deliver the best overall environmental outcome; when applying the so-called waste hierarchy. The life cycle approach has also been playing a major role for the implementation of the EU's thematic strategy on the sustainable use of natural resources (European Commission 2005a) and in the thematic strategy on prevention and recycling of waste (European Commission 2005b). In 2011, the EC launched several flagships. These provide a core focus for policy development. In the flagship initiative 'A Resource-Efficient Europe' and related roadmap (European Commission 2011), life cycle thinking has been stated as one of the engines to boost smart, sustainable and inclusive growth in the EU. In such a context, the EC further engaged in turning consumption and production more sustainable, through 'improving products and changing consumption patterns' and by 'boosting efficient production'. Life cycle thinking is also foreseen in response to the development of indicators at the EU-scale in relation to the social and environmental benefits and burdens associated with trade and consumption (European Commission 2012). To this aim, beside strengthening the more consolidated product policies (e.g. eco label, GPP, Eco design Directive), LCA gained further importance as the methodological background to address and develop the Product Environmental Footprint (PEF) and the Organisation Environmental Footprint (OEF) Guides (European Commission 2013a). Both PEF and OEF guides are annexed to the COM Building the Single Market for Green Products (European Commission 2013b) and are intended as references to conduct LCA in the EU. Although from the data supply side, pro-active business associations recognise the importance of providing high quality consistent data that reflects the life cycle reality of their goods and services, the supply of such data is supported by a growing body of experts in consultancies (mainly small- and medium-sized enterprises, SMEs) and by various research groups; with altogether at least 100 small life cycle service providers in Europe and beyond. There are now at least 25 broad LCA databases and 40 LCA software tools that are available (Sanfélix et al. 2013). This increasing complexity creates technical and methodological issues not always easy to be managed. PEF and OEF can be considered a significant step towards improved measurement and communication of the environmental performance of products and organisations in relation to meeting specific policy and business interests. EF guides build on ISO 14044 requirements and facilitate reproducibility and comparability through the establishment of data quality requirements that are further detailed in the Product Environmental Footprint Category Rules (PEFRCs) and the Organisation Environmental Footprint Sectorial Rules (OEFSRs) (Galatola and Pant 2014).

2.OVERVIEW OF PAST EC-LED ACTIVITIES ON LCI DATA

i.Setting reference LCI database for EU: JRC(Joint Research Centre) is the European Commission's in-house science service which employs scientists to carry out research in order to provide independent scientific advice and support to EU policy. Within the EPLCA, a first version of the European Reference Life Cycle Database (ELCD) was released in 2006. Having a European market scope, the ELCD provides key background life

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cycle data for LCA practitioners and database developers. The database incorporates LCI data from front-running EU-level business associations, as far as possible. This is complemented with other sources for key materials, energy carriers, transport and waste management. These are periodically reviewed. Datasets are typically LCI results with parameterised unit processes for transport services. The respective datasets are officially provided and approved by the named business association or other provider. In June 2009, a second version of the ELCD was released, where the number of LCI datasets with European scope was increased to over 300 (see Table 1). A further update and expansion was completed in 2nd month of 2013 with the third version of the ELCD. Beyond including additional datasets covering new sectors, several datasets of the third version of the ELCD underwent—and successfully passed—a third party review against specific quality requirements, called 'ILCD entry level requirements', which will be described in the next section. Features of various versions and figure of the ELCD database are summarised in Table 1 and figure 1 respectively. While the ELCD supports the availability of a lot of the core background data used in most LCAs with recommendations, it equally has a focused scope. While the scope is under review, it cannot be comprehensive, nor does it aim to be this. It therefore must also be part of a broader network of data, complementing the wide range of other data and sources that are required to complete LCAs.

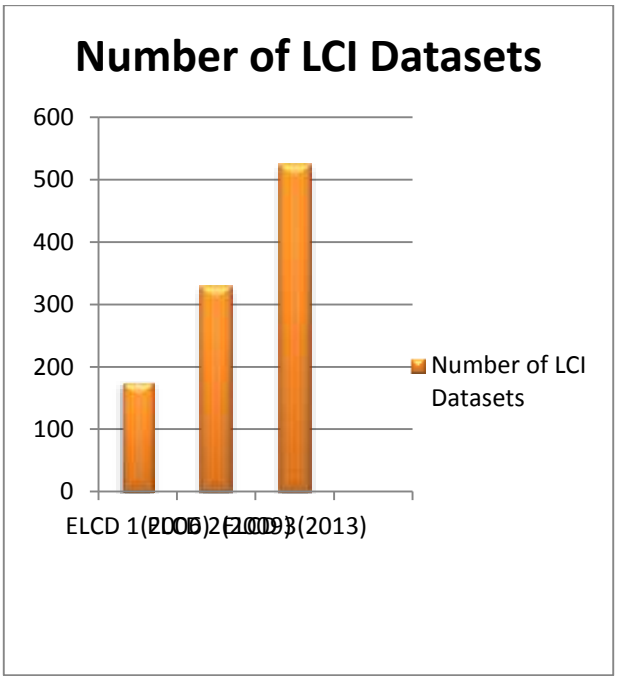

Fig.1: Features of various versions of the ELCD database.

TABLE1: Summary of various versions of the ELCD database

SI NO.	ELCD database version	Year of Launch	LCI datasets Number	Features of Quality
1.	ELCD 1	2006	176	-------
2.	ELCD 2	2009	329	Compliance with ILCD format and ILCD nomenclature required. No review process established.
3.	ELCD 3	2013	524	Compliance with ILCD entry-level requirements. 223 reviewed datasets, 190 compliant datasets.

TABLE 2: ILCD entry-level requirements

SI NO	Compliance area	ILCD entry-level

1.	Nomenclature	►To be compliant with 'ILCD Handbook – Nomenclature and other conventions' document (including use of ILCD reference elementary flows). ►Terminology use not to be enforced. ►Minor deviation are allowed regarding the inclusion of commonly accepted aggregated elementary flows (e.g. VOC) permitted.
2.	Data quality	►Minimum quality rating not to be defined. ►Data quality to be stated using ISO quality criteria. ►Technological, geographical and time-related representativeness to be documented.
3.	Documentation	►ILCD format to be used. ►Minimum documentation extent to be specified to allow data quality rating.
4.	Method	►Applied modelling framework(s) and allocation/substitution approaches to be documented. ►ISO 14040 and 14044 compliant process-based LCA.
5.	Review	►Qualified independent external reviewer in line with ISO14044 requirements, BUT separate review report is not required (review documented in dataset). ►'Qualified reviewer' required (based on ISO 14025): (knowledge of relevant sector and knowledge of represented process or product). ►Qualified independent internal reviewer in line with ISO 14044 requirements, BUT separate review report is required in addition to documentation provided within data set.

ii.Setting-up meaningful and practicable data quality requirements: the ILCD handbook, minimum requirements have been established to provide users with useful information on data quality to guarantee minimum extent of documentation and to facilitate increased methodological consistency amongst datasets. This was built on ISO 14040 through an extensive international stakeholder process, providing further guidance and specification for different application contexts. This includes minimum requirements, the ILCD entry level requirements. Part of this is a structured review procedure. To be compliant with the ILCD entry-level requirements, a reviewer should certify the compliance of a dataset against the requirements of each of five compliance areas, as described in Table 2. After an extensive review of existing formats used by various data providers as well as several meetings involving key stakeholders from around the globe and building on previous UNEP-SETAC-led initiative draft conclusions, the ILCD dataset format was developed to ensure wide compatibility and to allow incorporating the complete documentation within the dataset itself (European Commission 2010). Datasets compliant to the requirement on documentation provide to the users the information needed to assess data quality in a given context, as foreseen in ISO 14040. Moreover, such requirements on documentation can facilitate the use of the dataset in combination with other datasets and ensure consistency in terms of methodological choices such as applied cut-off, solutions for multi-functionality issues and system boundaries definition. From an IT perspective, having a common format for a minimum set of fields reduces costs to users and potential room for error. The compliance areas 'data quality' (e.g. data representativeness) and 'method' have been defined according to the ISO and specific documentation requirements. Specific information regarding methodological choices and representativeness must be provided in the datasets. Data, which are collected according to several technical guidance going beyond ISO (e.g. EF guides), can be used together coherently. The review process aims at transparently communicating dataset quality by making review

reports accessible to users, especially in the case of independent internal reviews. Specific requirements on review have been defined to increase the overall robustness of the process. Moreover, in some cases, review reports shall be annexed to the dataset providing additional information to user.

iii. Reviewing ELCD 3 against ILCD entry-level requirements: The third release of the ELCD focused on data quality assurance and consistency. To this aim, between 2011 and 2013, 223 datasets of the ELCD 3.0 have been screened against the ILCD entry-level requirements (Table1). Datasets to be reviewed have been selected in order to be representative of key sectors such as energy and raw material production and also taking into account data providers' willingness to actively participate in the review process. As a result from the review exercise, 190 ILCD entry-level compliant datasets can currently be found in the ELCD 3, where information on dataset quality as well as compliance with the ILCD entry-level requirements can be found in the documentation under the 'validation section'. The review reports have been attached to datasets and are directly accessible through the European Platform on LCA website. According to the review process, more than 86 % of the datasets directly met the criteria expressed by the ILCD Entry level requirements. Observed non-compliances were actually limited to lack of or misleading documentation (13 % of reviewed datasets) and problems with format/nomenclature (1 % of reviewed datasets). exercise to define key needs for not compliant datasets towards full compliance. The review process was also beneficial because owners of the datasets that did not pass the quality check immediately started a revision of the datasets to improve them.

3.The Life Cycle Data Network (LCDN)

i. Main features of the Life Cycle Data Network:

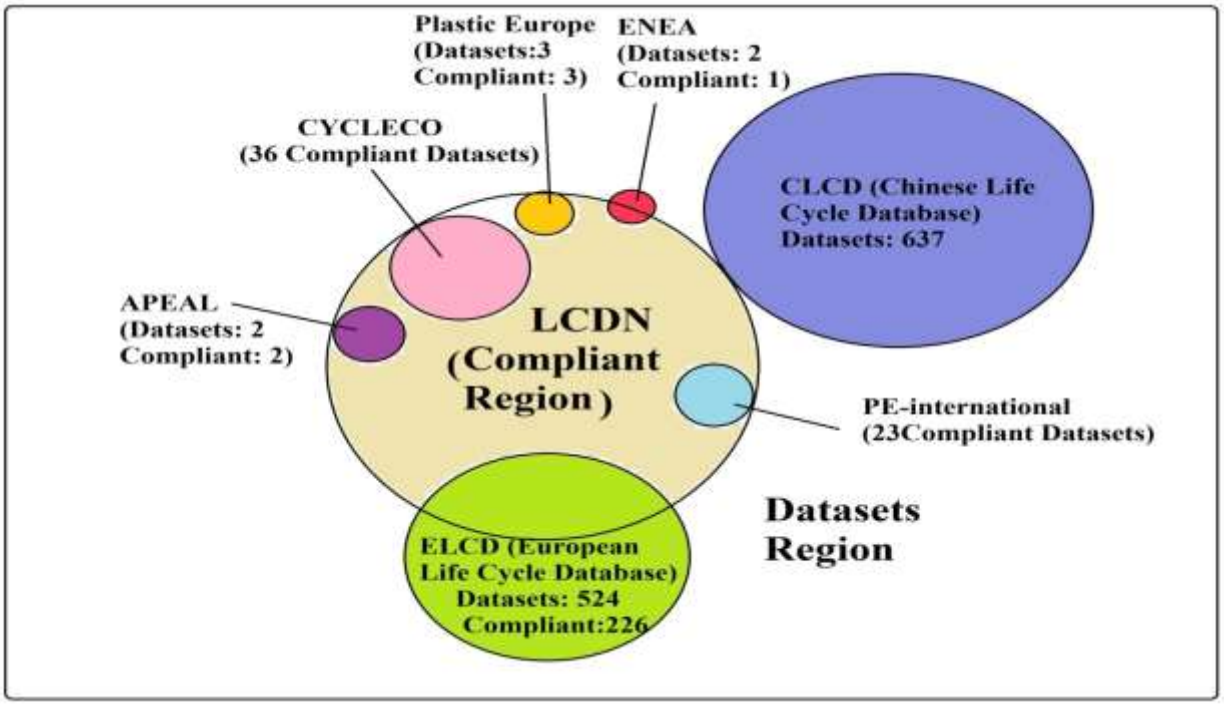

Fig. 2: Current participants in the Life Cycle Data Network (LCDN)

LCDN (Life Cycle Data Network) consists of a non centralised database, where several providers are facilitated in sharing data. Such a data network is a concrete action towards the creation of new dynamics, including opening of new data markets, where data availability can be increased in parallel to data quality thanks to well-defined entry-level requirements that assure better interoperability and coherence as well as a convenient basis for comparison of available data. The LCDN is based on an IT infrastructure developed ad hoc, which is provided for free to organisations willing to participate. The IT development has been coordinated by JRC with the support of the Karlsruhe Institute of Technology (KIT) and by the Institute Brasileiro Information Technology

(IBICT). A two-fold IT infrastructure of the LCDN allows the data to be published under the conditions decided by the data developer (e.g. for free, for fee, via registration, etc.) and allowing data developers to retain the full copyright and independently manage their databases/sets. At the first level of the IT infrastructure, partners publish datasets directly from their own web-based node; at the second level of the infrastructure, the LCDN webpage serves only as searching tool and as reference point providing essential information to users and providers. Once the datasets are self-uploaded into the node (1st level), the node owner can register selected datasets to the so-called LCDN registry (2nd level), only under the condition that ILCD entry-level requirements are met. The LCDN was conceived so that datasets in the network can come from any data developer/owner, including international organisation (providing international databases), states (providing national databases), industry associations (providing sectorial databases), business (providing commercial databases), SMEs (providing a few datasets on commercial products/processes) and even research groups (providing a few datasets on innovative processes). The developer/ owner is responsible for maintenance and updates of their database, which forms a node in this network.

ii. Current status of the Life Cycle Data Network (LCDN): The LCDN has been officially launched on 2ND month of 2014 by two directorate generals of the EC, DG Joint Research Centre and DG Environment, involving seven initial partners (Fig. 2). Since the launch, several further commitments to participate have been received from key actors in the worldwide LCA community. Discussions are ongoing with other front-runners from governments and business. The ELCD 3 is participating to the LCDN as 'JRC ELCD node' with the successfully reviewed 190 datasets mentioned. Around 100 other datasets are currently being reviewed against the ILCD Entry-level requirements. All compliant datasets are registered to the LCDN.

4. RESULT AND CONCLUSIONS

This thesis presents recent a achievement and original solutions towards increased availability, quality and interoperability of life cycle inventory data, developed through European Commission-led activities and based on wide stakeholder consultation and international dialogue. An overview of related activities, such as the International Reference Life Cycle Data System (ILCD), the European Reference Life Cycle Database (ELCD) and the ILCD Entry-Level quality requirements are presented. The focus is then on the Life Cycle Data Network (LCDN). The European Commission's efforts and past achievements concerning life cycle data that allowed the development of the ILCD format and nomenclature have been highlighted in the paper. Moreover, recent achievements have been detailed in the article. For example, ILCD entry-level requirement are key towards creation and implementation of a common language for LCI data and are essential support for the end-users of LCI data. It was moreover shown how compliance with ILCD entry-level requirements supports a consistent LCA framework application through the definition of common minimum specifications for LCI datasets intrinsic properties and, hence, enables the coherent use of LCI data. The establishment of the ELCD review process against the ILCD entry level requirements is another concrete step towards quality assurance of LCI datasets. Finally, the LCDN is a contribution to the implementation of the 'Shonan Guidance Principles towards emancipating the LCA community from the reliance on any single provider. One of the aims is to enlarge the number of nodes registered to the LCDN and to encourage the development of ILCD entry-level compliant datasets. JRC is also currently running projects focused on increasing interoperability between the ILCD data format and other available ones. Moreover, an ongoing initiative aims at defining a common elementary flows nomenclature, through establishing a working group and involving advisory group members of the EPLCA and some international partners.

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