A review of online sources of open-access life cycle assessment data for the construction sector

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Abstract. The importance of life cycle sustainability in the construction sector is increasing in the light of rising awareness on sustainability issues in society. A means to identify more sustainable options is to assess and compare their sustainability performance. The standards ISO 21931-2 and EN 15643-1 to 5 establish the framework and requirements for sustainability assessment of buildings and civil engineering works. The standards require life cycle assessment (LCA) to be the basis for the environmental part of the sustainability assessment. LCA is a powerful evidence-based method but it requires extensive data. Access to free, easily available and preferably machine-readable LCA data is essential to increase the use of LCA in the construction sector and to make competition fair for all tenderers. This paper aims to compile existing online sources for open-access LCA data of interest for the construction sector. The purpose is to provide a reference document that facilitates the use of LCA in construction. An in-depth search of publications and internet resources was performed, focusing on European sources of Environmental Product Declarations (EPD) and process-based LCA datasets. A comprehensive overview of the European data sources available online and relevant to the construction sector is presented. This research work reveals the existence of numerous sources, often difficult and time-consuming to find. The overview in the paper facilitates finding online data needed for LCA, in many cases in a machine-readable format. This can contribute to increasing the use of LCA in the construction sector, which is important when developing buildings or civil engineering works that are more sustainable over their whole life cycle. A greater use and better integration of LCA in the design process contributes to evidence-based life cycle sustainability of our built environment.

1. Introduction

Sustainability assessment of buildings and civil engineering works throughout their life cycle is becoming increasingly important, evidenced for example by the recently published standard ISO 21931-2 [1]. The standards EN 15643-1 to 5 give the framework and requirements for sustainability assessment of buildings and civil engineering works [2–6]. They require life cycle assessment (LCA) to be the basis for the environmental part of the sustainability assessment.

Increasing use of LCA is important when developing building and civil engineering designs that are sustainable over their lifetime [7, 8]. There is a gap in the acquisition of large-scale data in the research on Sustainable Structural Design (SSD) [9]. Most of the studies in the SSD field use data from single case studies, and not from large-scale databases. A greater use and better integration of LCA and LCA-data from large-scale open-access databases in the structural design process would contribute to comparability of results and evidence-based life cycle sustainability of our built

environment. At the same time, open-access LCA data are disperse and often difficult to find. To allow for a widespread use of LCA, it is important to increase the access of data needed. There is a wide range of LCA data available online, often for free and sometimes in a machine-readable format, and the amount of data is rapidly increasing. Among the most widely used data sources are the Environmental Product Declarations (EPDs) of construction products. EPDs can be found in many online sources, although in many cases not yet in a machine-readable format.

This study aims to compile the sources of online open-access LCA data and EPDs available and relevant for the construction sector and to critically review their characteristics, with a focus on European sources. Online databases and other online data sources are in focus because they are easily accessible to a majority. The purpose of the study is to facilitate the performance of LCA in the construction sector.

Licensed softwares have been developed to perform LCA, GaBi and SimaPro being the leading ones [10–14]. The GaBi software uses the licensed GaBi database, ELCD, the licensed Ecoinvent database and U.S. LCI databases. SimaPro includes among others Ecoinvent, ELCD, U.S. LCI, IDEA, but also Input-Output (I-O) databases. Another licensed database is BEDEC-ITeC that is focused on the construction sector, containing data on energy, CO_2-equivalents and prices [15]. A review of 10 databases, oriented towards or including construction materials, pointed out that only a few databases contain data for building materials [10]. The authors compared the databases according to defined features and criteria, in order to allow the user to make a better-founded choice of database. The licensed Ecoinvent and GaBi databases were found as the more qualitative ones. A case study on building assessment compared five databases regarding greenhouse gas emission values specifically during the production phase [16]. The study underlined the need to develop and improve national open databases, licensed Ecoinvent and GaBi databases often being used owing to the lack of free databases. Because of the lack of open databases, LCA studies can today only be performed by experts with access to licensed softwares. This hinders a widespread use of LCA.

This study mainly contributes to the Sustainable Development Goals (SDG) 9 and 12 defined by the United Nations [17]. It contributes to SDG 9 since it is intended to facilitate sustainable construction, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes. It contributes to SDG 12 since it supports in achieving sustainable management and efficient use of natural resources and in substantially reducing waste generation, and because it facilitates sustainable public procurement practices.

1.1. Definition of LCA and EPD

Life cycle assessment (LCA) is a method to better understand and assess the environmental impacts of products throughout their life cycle [18, 19]. LCA consists of a four-step iterative procedure: Goal and scope definition, Life Cycle Inventory (LCI), Life Cycle Impact Assessment (LCIA) and Interpretation. LCI is the data collection step. It draws up an inventory of all the flows in and out, involving several individual unit processes in a supply chain. It is the inventory of the direct environmental impacts and waste generation as well as the consumption of energy and raw materials or semi-finished products. LCIA is the decoding step. The basis of LCIA is provided by the LCI. LCIA corresponds to the application of current scientific methods to categorize and characterize the environmental impacts of the flows and results in indicator values to feed the interpretation.

EPDs are based on LCA and is a standardized format to present LCA results in a third-party verified and registered document [20]. To ensure harmonization of EPDs, the ISO 14025 standard gives a common procedure for developing EPDs and requirements of content of EPDs [21]. In Europe, the EN 15804 provides the core Product Category Rules (PCR) for EPDs of products in the construction sector [22]. In addition to this, different program operators develop PCRs for specific product groups. EPD is not a criteria-based certificate, but a Type III eco-label [23]. Type III eco-labels ensure the quality and format of data through transparent, comprehensive and third-party verified data, and conform to the ISO 14025 standard. No specific product property is evaluated, but the ecological footprint of it thanks to LCA. An EPD is created by the building product manufacturers

based on PCRs, sometimes with the help of online tools provided by program operators. The program operator publishes the EPD, which is always freely accessible.

1.2. Types of LCA data

There are generally two types of LCA data; process-based and Input-Output (I-O). Process-based data is based on unit processes, while I-O data is based on national economic and environmental statistics. As explained above, the life cycle inventory (LCI) corresponds to the data collection step. Different methods have been developed to manage the LCI: Process method, Economic Input-Output (EIO) method and Hybrid methods. The process method allows to collect the unit process data, depending on their availability, constituting LCI datasets. The EIO method leads to I-O tables which are product-by-product or industry-by-industry matrices, combining supply and use in a single table [24]**.** Some hybrid methods have been developed, using both unit process data and I-O data to provide more accurate LCA results. The fundamental idea behind the development of such methods is to take advantage of the qualities of both data types [25–28]**.**

1.3. Data formats

Some of the process-based datasets are only available for viewing, while some are downloadable in different formats. The most common formats are based on the machine-readable formats XML or Excel. The International Reference Life Cycle Data System (ILCD) is for example a XML-based format with eight available dataset types for the elements in the database [29]. It has been developed by the European Commission for greater consistency and quality assurance of LCA. In order to integrate EPD specific information (e.g. scenarios, modules, type of data), extensions was added to the ILCD format to form the ILCD+EPD format [30]. The Ecoinvent data formats Ecospold1 and Ecospold2 are also XML-based. The SPINE (Sustainable Product Information Network for the Environment) format is an information model used to create the Swedish Life Cycle Center (CPM) database. The EPDs are mainly provided in downloadable PDFs and in some cases in a machine-readable XML format such as ILCD.

2. Method

This work encompassed research on online EPD and open-access LCA data sources relevant to the construction sector with a focus on European sources. Global sources are mentioned briefly. To ensure a comprehensive study, a literature review was performed. Data sources specifically oriented towards construction or for multi-purpose are in the scope of this study. Open-access data sources containing full LCA data as well as data only on CO_2-equivalents and energy (single issue LCA) are included. For simplification, the sources were subdivided into two categories: (1) process-based LCA data and CO_2-eq./Energy data sources and (2) EPD data sources.

Websites provided a list of several data sources [31–34], which were useful to create a first list of sources to analyse. Additional information on the characteristics of the data sources were collected from contact persons. In order to provide an overview of the process-based LCA and CO_2-eq./Energy data and EPD data sources, information on their characteristics were summarized in tables.

3. Result

The data sources found were subdivided into two main categories: process-based LCA data and CO_2-equivalents/energy data sources (Table 1) and EPD data sources (Table 2). The tables contain information on: the name of the data source, the geographical region covered, the provider of the data source, the version and date of the data source presented, format of the data, the number of data sets/EPDs contained, the main topics (e.g. materials) covered, and references to the data sources. The format “online” means that the data can be viewed online but cannot be downloaded. It is important to mention that many of the LCA data sets and EPDs contained in the different data sources are overlapping, i.e. they exist in several of the data sources.

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Table 1. Comparative table of online open-access process-based LCA and CO_2-equivalents/energy data sources.

	Data source	Location	Provider	Version (date)	Format of data	Number of data sets	Main topics	Ref.
LCA data	Baubook	Austria	Baubook GmbH (joint company of IBO and Energieinstitut Vorarlberg)	Continuously updated	Online, XML	~1 300	CM, HVAC	[16, 35–37]
	CPM LCA	Sweden	Swedish Life Cycle Center (O), Chalmers University of Technology (M)	2018	SPINE, ILCD	748	CM, E, EoL, MP, T, W	[10, 38, 39]
	Eco-Profiles	Europe	PlasticsEurope	January 2019	Excel, PDF, ILCD, ecoSpold	~80	I, Pl	[10, 40, 41]
	GEMIS	Germany	IINAS (International Institute for Sustainability Analysis and Strategy)	4.95 (February 2017)	Excel	~10 000	EE, FF, R, Raw materials, T	[42–44]
	Life Cycle Data Network (LCDN)	Europe	Joint Research Centre (JRC) of the European Commission	December 2019	ILCD	2 360	Ch, E, EoL, Me, T	[10, 45]
	ProBas	Germany	Federal Environment Agency	12.02.2015	Online, PDF, XML	>8 000	CM, DP, E, T, S	[46, 47]
CO_2-eq./Energy data	Base Carbone	France	ADEME agency	16.0 (March 2019)	Online, CSV	2 608	CM, Me, Pl	[48, 49]
	KBOB - Ökobilanzdaten	Switzerland	KBOB (Coordination Conference of the Construction services and buildings of the public buildings owners)	2009/1:2016	Excel	600	CM, E, HVAC, T, W	[50]
	Klimatkalkyl	Sweden	Trafikverket (Swedish Transport Administration)	6.1 (April 2019)	Online	50	CM, T	[51]
	OpenDAP	Spain	IETcc (Institute of Construction Science Eduardo Torroja)	n/a	Online, ILCD	~1000	C, E, T	[52]

Note: C: Commercial, F: Free, M: Maintainer, O: Owner
Ch: Chemicals, CM: Construction materials, DP: Disposal Processes, E: Energy, EE: Electrical and Electronic, EoL: End-of-Life, FF: Fossil Fuels, I: Industrial processes or products, Me: Metals, MP: Multi-Purpose, Pl: Plastics, R: Renewables, S: Services, T: Transport, W: Wastes.

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Table 2. Comparative table of online EPD data sources.

Data source	Location	Developer / Provider	DB / PO	Number of EPDs (2019 unless otherwise stated)	Format of data	Main topics	Ref.
Bau-EPD	Austria	The Bau EPD GmbH	PO & DB	34	PDF	CP	[53]
CENIA	Czech Republic	Czech Environmental Information Agency (Ministry of the Environment)	PO & DB	48	PDF	CP	[54]
DAPconstrucción	Spain	CAATEEB (PO), Agenda de la construcció sostenible (P)	PO & DB	43	PDF	CP	[55, 56]
EcoPlatform EPD	Europe	ECO Platform (P)	PO & DB	962 (2018)	PDF	CP	[57]
EPD Danmark	Denmark	Teknologisk Institut (Danish Technological Institute)	PO & DB	38	PDF	CP	[58]
EPD Italy	Italy	EPD Italy	PO & DB	57	PDF	CP	[59]
EPD Ireland	Ireland	IGBC (Irish Green Building Council)	PO & DB	97	PDF	BM, BP, BS	[60]
EPD Norge	Norway	The Norwegian EPD Foundation	PO & DB	>500	PDF	BM, E, FP, Ch	[61]
EUCoMDat	Europe	The EPD registry	DB	743	PDF, Online, ILCD+EPD	CP	[62]
GreenBookLive	Europe	BRE Global	DB	70	PDF	CP	[63]
IBU	Germany	InstitutBauen und Umwelt e.V. (Institute for Construction and Environment)	PO & DB	2 790	PDF, XML	BM, BP, BS	[23]
INIES	France	Alliance HQE-GBC	DB	2 862 (2017)	Online, PDF	CP, EE, HVAC, S	[64]
ITB EPD	Poland	Instytut Techniki Budowlanej (Building Research Institute)	PO & DB	86	PDF	CP	[65]
Ökobaudat	Germany	Federal Ministry of the Interior, Building and Community	DB	1 203	HTML, XML, CSV	BM, C, DP, E, T	[66]
RTS EPD	Finland	Building Information Foundation	PO & DB	38	PDF	CP	[67]
The International EPD System	43 countries	EPD International AB	PO & DB	>1 100	PDF, ILCD+EPD	CP, MP	[68]
TurCoMDat	Turkey	Metsims Sustainability Consulting (D), SÜRATAM (FS), The EPD registry (P)	DB	281	PDF, XML, Online, ILCD+EPD	CM, E, W	[62, 69, 70]
UKCoMDat	UK	Metsims Sustainability Consulting (D), UK Ecolabel Centre (P), The EPD registry (P)	DB	352	PDF, XML, Online, ILCD+EPD	CP, CM	[62]

Note: BM: Building materials, BP: Building products, BS: Building Services, C: Construction, Ch: Chemicals, CM: Construction materials, CP: Construction products, D: Developer, DB: Database, DP: Disposal Processes, E: Energy, EE: Electrical and Electronic, FP: Furniture and Packaging, FS: Financial Support, HVAC: Indoor climate control, MP: Multi-Purpose, P: Provider, PO: Program Operator, S: Services, T: Transport, W: Wastes.

Some global LCA and EPD databases are under development, underlining the increasing interest on the subject and the will to spread the use of LCA worldwide. WoCoMDat - World Construction Materials EPD/LCA Database – is under development and sponsored by The EPD Registry, following international standards and norms [62]. The EPD Registry already provides construction materials databases for the UK and Turkey, UKCoMDat and TurCoMDat, but also a European one called EUCoMDat. The EPD Registry is thus a database composed of three, and soon four, construction-oriented databases. The Global LCA Data Access (GLAD) is still a beta version, but the purpose of GLAD will be to provide an open global network through the coalition of several dataset providers [71]. Users will be able to download and convert datasets from different LCA databases worldwide.

4. Discussion

There is currently no single source that contains all online open-access LCA and EPD data relevant for the construction sector. Instead data is dispersed and can be found in various formats in many different sources. Some of the data sources overlap information; many of the entries listed in the tables exist in several of the sources. However, the current trend is to gather existing data in global networks such as GLAD and the EPD registry, and to provide data in the common machine-readable ILCD format.

This review facilitates finding the LCA and EPD data relevant for the construction sector and reduces the time needed to retrieve data. This can contribute to a more widespread use of LCA. Ideally, open-access data would be sufficient to perform LCAs or EPDs without licensed softwares, contributing to fair competition.

The review is limited to online open-access European data sources relevant to the construction sector and, therefore, important sources outside Europe are not included in Tables 1 and 2, neither are common licensed European sources (e.g. GaBi and Ecoinvent). Minor data sources, often included in the larger data sources reviewed in this work, have not been listed in the tables to avoid redundancy. To the authors' knowledge, tables 1 and 2 present a comprehensive overview of the data sources within the scope of the work, yet due to the dispersity of the sources, the difficulties to find them and language limitations, some data sources of local scope and with limited use in the construction sector may have been overlooked.

5. Conclusion

This study provides an overview of online open-access European life cycle assessment data sources relevant to the construction sector. The study facilitates finding open-access LCA and EPD data and thereby promotes the use of LCA in the construction sector and fair competition for all tenderers. A greater use and better integration of LCA in the design process contributes to evidence-based life cycle sustainability of our built environment.

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