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EUROPEAN ENVIRONMENTAL DATABASES. OPENDAP, SPANISH CONTEXT.

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Abstract. With the aim of facilitating sustainability assessment through Life Cycle Assessment, the Eduardo Torroja Institute of Construction Sciences. CSIC is developing a public database of environmental information: OpenDAP. One of the objectives of this database is to be compatible with other European databases but to be fully open, public and free of charge. With the participation in the project "Wood for Sustainable Construction Task Force", whose coordinator was the University of Cordoba, 10 EPDs have been developed for different wood products and species, with a detailed study of each stage, using a spreadsheet and field studies for data collection.

In this article we aim to demonstrate the need for environmental quantification of services and products in the construction sector, due to the importance of the global impact of this sector. With common procedures that allow us to obtain comparable and useful results for the final client who selects them. Both for generic and specific products, being stable and exportable. Allowing us to compare, reduce and improve our sustainability.

Keywords: LCA, databases, EPD, OpenDAP, environment.

1. Introduction

Life cycle analysis (LCA) involves the study of a product or service from the moment of its conception (eco-design) to its ultimate end (cradle to grave). It should include phases beyond the system boundaries, tending towards the circular economy as a model (favouring reuse and recycling), from cradle to cradle. Sustainability assessment through LCA should be at environmental, social and economic levels. Gerta, J. & Traverso, M. [1] conducted a study on the analysis of sustainability through LCA in the construction sector. In 171 cases reviewed between the years 2010 and 2021, only 11 % of the cases conducted a complete study on sustainability assessment with a life cycle approach. The rest are based analyses, which do not include the three pillars of sustainability, with the economic and especially the social pillars being the least evaluated. The calculation of impacts is also oriented towards the interests of the owner, which gives a partial and incorrect view.

The construction sector is responsible for 33 % of global energy consumption, 40 % of raw material consumption and generates 40 % of solid waste [2, 3]. Life Cycle Sustainability Assessment at product and building level at an early stage (from design or choice of materials) can be a great responsibility and brings great benefits for the improvement of environmental, social and economic sustainability. Through the European Technical Committee CEN/TC 350, Sustainability in Buildings [4], standards such as ISO 14025 [5] are defined, which defines common requirements, criteria and life cycle structure for Environmental Product Declarations (EPD). EPDs are an environmental communication tool that presents the life cycle performance of a product or service in a standardised and verifiable form. Its calculations are based on LCA, which consists of four phases. In the first phase, the objectives and scope are defined, where issues such as system boundaries, allocations, data quality, etc. are set, which can substantially vary the results according to the selected criteria. Studies such as the one carried out by Kellenberger et al. [6], estimate that a simplification in which transport, construction and end-of-life stages are eliminated, in energy terms, represents a 27–42 % reduction in the results obtained with respect to the consideration of all the stages. The calculation of stages A1–3 is the most common analysis due to the possibility of knowing the data reliably and closely (raw material extraction (A1), raw material transport (A2) and manufacturing (A3) stages).

The second phase is data collection, one of the most extensive and complex phases. It can be based on literature, field research or specialised databases such as Ecoinvent, GaBi, ELCD, etc. Software such as GaBi, SimaPro or OpenLCA is commonly used for its calculation (phase three of the LCA). The evaluation phase of the data obtained is based on generally preestablished methodologies. These are classified and characterised according to ISO standards 14040 and 14044 [7, 8]. The most popular methods are the ILCD, Ecoindicator99, ReCiPe, CML, etc.

Environmental Product Declarations (EPD) for construction products, standardised by EN 15804 [9], can have different scopes depending on the stages considered within the product life cycle. Product Category Rules (PCR) are the documents that define the EPD requirements for a product category or product family. They are currently being developed by the Standardisation Committees. Until now, these PCRs have been developed by Programme Managers, with their own, non-comparable criteria. These Programme Managers display in stable and verified databases the lists of the EPDs they carry out, such as Global EPDs, Environdec, EPD Norge, etc. There are also platforms that similarly classify and display these EPDs with different quality and traceability options. Examples of these platforms are EcoPlatform, Ókobaudat or OpenDAP.

In this article we highlight the problems presented by the development of a life cycle analysis and its presentation by means of an EPD in the construction sector at the metadata, methodologies and results levels. This research stems from the work being carried out by the Eduardo Torroja Institute of Construction Sciences CSIC (IETcc) in Spain, whose ultimate goal is to develop the national database of environmental information on construction products: OpenDAP [10]. It is an official, public and free accessible database of environmental information on construction products, both generic and specific.

We will show how we work in the field of LCA, the factors that have the major influence on the results and the shortcomings found. At the same time, we will also present some of the environmental information calculated and the decisions we have been taking in order to move forward. In the study by Gerta, J. & Traverso, M. [1], the four most influential factors in this field of work, among the 19 case studies analysed, are: system boundaries, the software used, the database and the life cycle inventory analysis (LCIA) methodology.

It is during the development of our National Database (NDB) that we are encountering major challenges. That generates great doubts as to whether the "routes" for the calculation of the LCA are marked and agreed with full transparency, traceability and, therefore, whether results can be compared. And, above all, whether this information can be used as one of the criteria for the selection of materials, as well as for the overall environmental accounting in construction: the building.

2. Methodology

Responding to the need to provide stable and free environmental data, the project to develop a national database under the name of OpenDAP was launched in 2013. This project is carried out at the IETcc, which is a centre attached to the State Agency of the Spanish National Research Council (CSIC), the main implementing agent of the Spanish Science, Technology and Innovation System. Our research group, Advanced and Sustainable Construction, has been trying for years to envision the construction of the future as a way to adapt to and mitigate climate change.

2.1. Description of the structure of the OpenDAP DB as an example

Since 2013, this project has had to adapt to regulatory changes and updates. From a methodological point of view, the new UNE-EN 15804:2012+A2:2020 greatly modifies many pre-established concepts in the development of the EPD (largely due to its adaptation and convergence with another methodology that is evolving in parallel, such as the Product or Organisational Environmental Footprint, PEF or OEF):

- New impact categories are added.
- Cradle-to-gate reporting (A1–A3), end-of-life modules (C1–C4) and benefits and burdens beyond system boundaries (D) are mandatory, except in exceptional cases.
- Biogenic carbon is required as an input for certain products.
- The concepts of reference useful life (RUL) and end-of-life (EoL) equations are defined and improved.
- Guidelines are provided for the assessment of generic data.

Regarding this last point, the PNE-prEN 15941 standard [11] is currently being revised, which reconsiders the quality, content and traceability of these products, as well as their classification.

The classification and filtering system is the so-called ILCD, developed by the Joint Research Centre (JRC), which is the European Commission's science and knowledge service. The ILCD format establishes the fields that each environmental data item displayed in the database has to contain, and also defines its content. The fields can be optional or mandatory. The aim is to generate databases that contain the same structure and allow interoperability between them. OpenDAP is part of the international inData working group [12], whose main objective is to generate a European LCA data structure for construction products based on current standards. It follows the same format, but extends its content with additional fields whose data remain from the EPDs. The format is called ELCD+EPD. Within inData there are 11 countries represented (OpenDAP is the representative of Spain) that maintain a common database where their own databases converge.

STAGE A1. EXTRACTION OF RAW MATERIALS									
Stage and description	Machines	Input of material or energy		Units	Performance	Units	Input of material or energy (xx/funcional unit)	Units/UF	Conversion to kg
Felling	Chainsaw Stihl MS 261 C-BM	Diesel	0,33	l/h	3050	kg/h	0,1059	l/UF	0,0720
		Oil	Oil consumption is considered to be 5% of fuel consumption (Performance Oil Tecnology LLC., 2009)				0,0053	l/UF	0,0046

Figure 1. Spreadsheet development of one of the processes for 1 m^3 of laricio pine sawn timber [13].

The software for the structure of the database is Soda 4LCA, also developed by the JRC. This format allows the data to be viewed, sorted, imported, exported and searched in ILCD format. These data can be downloaded in XML or simply visualised, so that they can be exported and worked on in any external calculation tool.

2.2. Participation in the Sustainable Timber Construction Operational Project

The project consisted of developing an intelligent tool for the appropriate selection and prescription of wood-based products for construction to be incorporated in sustainable buildings, providing technical and environmental contents to these products. The IETcc was a member of this project, which ended in September 2020. Together with the University of Cordoba, they led the environmental development tasks [13].

One of the tasks of this project was to carry out 10 WTPs of different wood products and species, belonging to the first and second transformation industries, performing their LCA from "cradle to grave". The flows of production, installation, end of life and reuse or recycling were established. For this purpose, questionnaires in sawmills and in industries of second processing of timber and also specific referenced literature were mainly used, always in the Spanish geographical area. UNE-EN 16485:2014 [14], as PCR for wood products, was followed. The calculation was performed without using any software or specialised database, exposing our limitations and simplifications. The data collection, the inventory of data and the representativeness of each sector involved in the manufacture of each product in Spain were promoted.

The processes basically consisted of machinery in the forest, or sawmill or second processing of timber (stages A1–A3), transport machinery (A2-A4-C2), the installation stage which combined lifting and fastening machinery, the dismantling stage (C1) (to simplify, this stage was consider the reverse of the installation), the waste treatment stage (C3) and dumping (C4), where it is considered that 100 % is reused or recycle, with the benefits being passed on to module D. As a result, the input flows considered are basically the inputs of diesel, oil (lubricant), petrol and a small amount of steel for the fastenings of the installation stage. With the exception of the manufacturing stage, whose main input flows are electricity and oil consumption.

Currently, the consultation of these DAPs, as well as the complete tool (search engine and intelligent selector of wood products) can be consulted on the Maderia website [13].

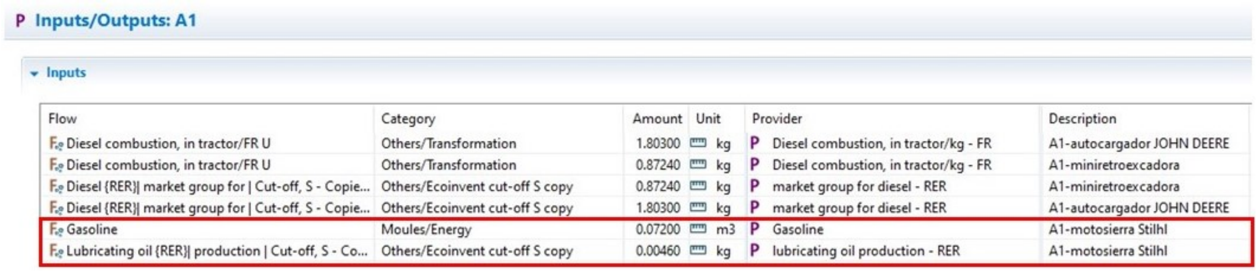
This work was carried out using a spreadsheet. Each process (e.g. consumption of a chainsaw in the forest) was detailed and accounted in the corresponding life cycle stage. Subsequently, the inputs necessary to carry out that process were disaggregated (example: oil and petrol consumption of the chainsaw in the bush, Figure 1) and after disaggregating the components of each substance (according to referenced and recognised sources), they were multiplied by the characterisation factors, the sums of which gave as a result the impacts for that process. This was replicated for each process and each stage. The limits of the system were set by the CPR PCR and the capacity to obtain such information. The study assumes a lack of data on waste, packaging, etc., but has very good quality input data taken directly from the manufacturer.

2.3. Use of free environmental software and databases

The work carried out within the Sustainable Timber Construction (GO MADERA) task force the need to use a calculation tool. OpenLCA [15] is a free and open source tool for sustainability and life cycle assessment. It is compliant with current regulations, provides a data quality system, allows importing and working with different free and commercial databases, and allows importing calculation methods compatible with them, as well as exporting results to ILCD editors. It has a download platform for free databases and paid options, as well as methods and examples.

Following the work done in GO MADERA, we wanted to replicate the results with the same input data. The database was another handicap of the previous project. Agribalyse was the database selected. It is a French life cycle inventory (LCI) database for the agricultural and food sector, published in 2020 and free of charge. The database contains certain field machinery, which, while not matching those of the timber industry, maintains certain approximations.

As a compatible calculation method, the OpenLCA 2.1.1 method package was used, including the "EPD 2018" method, which contains calculations in accordance with UNE-EN 15804:2012+A1:2014. This standard is in force and in coexistence with the new version until the end of October 2022. It was impossible to find a method that had the parameters for the up-



P Inputs/Outputs: A1

Inputs

Flow	Category	Amount	Unit	Provider	Description
Diesel combustion, in tractor/FR U	Others/Transformation	1.80300	kg	Diesel combustion, in tractor/kg - FR	A1-autocargador JOHN DEERE
Diesel combustion, in tractor/FR U	Others/Transformation	0.87240	kg	Diesel combustion, in tractor/kg - FR	A1-miniretroexcadora
Diesel {RER}| market group for | Cut-off, S - Copie...	Others/Ecoinvent cut-off S copy	0.87240	kg	market group for diesel - RER	A1-miniretroexcadora
Diesel {RER}| market group for | Cut-off, S - Copie...	Others/Ecoinvent cut-off S copy	1.80300	kg	market group for diesel - RER	A1-autocargador JOHN DEERE
Gasoline	Moules/Energy	0.07200	m3	Gasoline	A1-motosierra Stilhl
Lubricating oil {RER}| production | Cut-off, S - Co...	Others/Ecoinvent cut-off S copy	0.00460	kg	lubricating oil production - RER	A1-motosierra Stilhl

Figure 2. Screenshot of stage A1 in the OpenLCA programme.

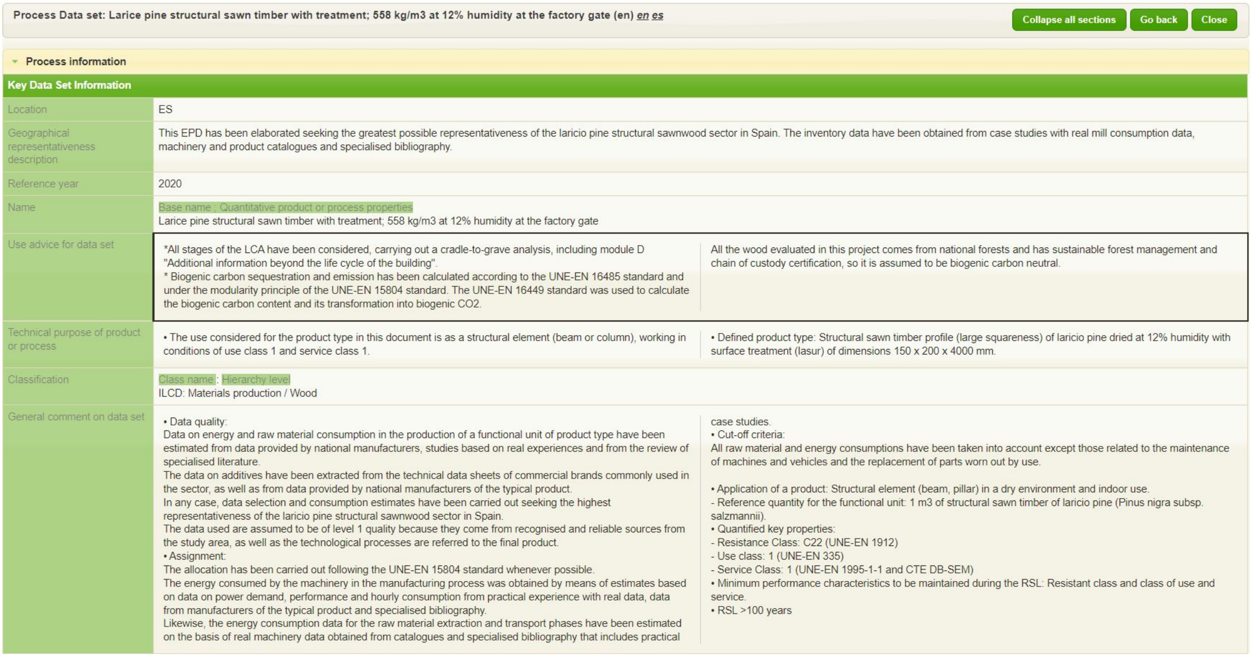


Figure 3. Screenshot of OpenDAP in ILCD+EPD format.

dated version of the standard (15804+A2), and was compatible with Agribalyse or another free database. Compatibility between the database and the calculation method is another important point to take into account. If this is not the case, there will be elementary flows that are not recognised by the methods and will not be taken into account for their computation. With this work, we have come to calculate the 7 indicators of the 15804+A1 and the water scarcity indicator.

Figure 2 shows the A1 step in the OpenLCA software. The quantities entered coincide with those in Figure 1. When using the Agribalyse database, when we enter the entry "Gasoline or Lubricating oil", each of them has a series of elementary flows associated with it that make up these entries. This makes the calculation more complete.

2.4. Publishing the OpenDAP database

The ultimate aim of this work is to develop an official, public and freely accessible database with national character and international links. The OpenDAP website [10] can currently be consulted and its contents and criteria can be studied in depth. In the "Search" section there is a direct link to the database itself where the EPDs generated in the GO MADERA project (currently under construction) can be consulted in ILCD+EPD format as shown in Figure 3. Fully compatible and interoperable with the rest of the European environmental databases that have followed the criteria set by the European Commission.

3. Results and discussion

As a first result, Table 1 shows the comparative environmental impacts obtained for the functional unit of 1 m^3 of laricio pine structural sawn timber for use as a structural element (beam or pillar), in dry environment and indoor use. The middle column shows the results obtained by means of a spreadsheet and a detailed field study; and the left column shows the results obtained by using OpenLCA. The inputs and quantities of matter and energy were in both cases the same. And the right column shows the ratio between the two.

In general, the results are quite different. The impacts with very small ratios are because the OpenLCA results are larger, due to the simplifications assumed in the spreadsheet. The ODP impact has very marked

	Spreadsheet analysis (cradle to grave)	**OpenLCA** (cradle to grave)	**Ratio**
	(except module D)	(except module D)	$\frac{\text{Spreadsheetanalysis}}{\text{OpenLCA}}$
Contribution to the Global Warming, GWP [kg CO_2eq]	2.19E+02	8.21E+02	0.27
Destruction of the stratospheric ozone layer, ODP [kg CFC-11eq]	2.13E-03	1.40E-04	15.21
Acidification of land and wáter, AP [kg SO_2eq]	3.17E-01	2.86E+00	0.11
Eutrophication, EP [kg PO_4^{3-}eq]	5.89E-02	5.60E-01	0.11
Formation of ground level ozone, POCP [kg ethylene eq]	1.93E-02	-	
Abiotic resourse depletion (fossil), ADP fossil [MJ]	6.85E+02	1.02E+04	0.07
Abiotic resourse depletion (elements), ADP elements [kg Sb eq]	-	1.11E-03	
Photochemical oxidation [kg NMVOC]	-	2.51E+00	

TABLE 1. Comparison of the environmental impacts obtained according to the calculation made in a spreadsheet and in the OpenLCA software for the same product.

	Spreadsheet (A) A1–A3	Ratio (A)/(B)	**OpenLCA (B)** A1–A3	Ratio (A)/EPD(1*)	**EPD (1*)** A1–A3	Ratio (A)/EPD(2*)	**EPD (2*)** A1–A3	Ratio (A)/EPD(3*)	**EPD (3*)** A1–A3	Ratio EPD(2*)/EPD(3*)
GWP	1.57E+02	2.12	3.33E+02	-0.44	-7.55E+02	-0.48	-6.95E+02	2.41	1.38E+02	-5.03
ODP	9.22E-04	0.06	5.47E-05	120503.26	4.54E-10	2.69	2.03E-05		-	
AP	1.17E-01	11.47	1.34E+00	5.33	2.52E-01	3.56	3.77E-01	6.42	2.09E-01	1.80
EP	2.57E-02	11.03	2.84E-01	5.54	5.12E-02	5.73	4.95E-02	5.65	5.02E-02	0.99
POCP	8.82E-03		-		8.24E-02		6.19E-02		1.80E-02	3.44
ADP fossil	3.78E+02	10.09	3.81E+03	11.88	3.21E+02	3.92	9.72E+02	8.45	4.51E+02	2.15
ADP elements	-		2.33E-04	16.77	1.39E-05	0.21	1.12E-03	2.01	1.16E-04	9.66

TABLE 2. Comparison of the results of the sum of stages A1-2-3 according to the spreadsheet of the GO MADERA project, in the OpenLCA software and with three EPDs declaring similar products and their corresponding ratios.

differences. Reviewing OpenLCA, the most influential process is diesel production and within this, there is a single stream, methane, possibly not considered in the spreadsheet.

As a second result in this article, and to reinforce the environmental impact data obtained in the GO MADERA project, in Table 2 we make a comparison of this first EPD obtained in OpenLCA and locate three similar published EPDs. The stages selected were the sum of A1–3 because they are those declared in these three EPDs.

- The EPD 1* has as its functional unit 1 m^3 EGGER sawn timber planed. Realised under the programme IBU – Institut Bauen und Umwelt e.V. The owner of the EPD is Fritz EGGER GmbH & Co. OG. It uses the software and DB GaBi 6 from 2013.
- EPD 2* has as functional unit 1 m^3 radiata pine sawn board. It is carried out under The International EPD® System operated by EPD International AB. The owner of the EPD is Baskegur, the Basque Timber Association. It uses the SimaPro 8.1 software and the Ecoinvent 3.1 database.
- EPD 3* has as functional unit 1 m^3 of Swedish sawn dried timber of spruce or pine with a moisture content of 16 %. Carried out under The International EPD® System operated by EPD International AB. The owner of the EPD is Swedish Wood. Uses SimaPro 8.5.2.0 software and DB Ecoinvent 3.4.

The analysis of the results was calculated using the ratio between the results obtained in OpenLCA and the rest. The most similar ratios are located in the GWP. Analysing the OpenLCA results, the impact results are influenced to a greater extent by the diesel production processes and secondly by the production of low voltage electricity. Simplification in the GO WOOD project would explain these divergent results.

Regarding the other EPDs compared, we see that their ratios also show discrepancies, always with higher values compared to the OpenLCA results. This comparison with other EPDs is not very regulatory. On the one hand, they are of similar products and with different system boundaries and allocations. Their

CPRs are different because they are EPDs based on the rules of different programme managers. But, even EPD 2* and 3* which share the same Administrator and have used the same type of DB and calculation program (in different versions), have large discrepancies in all impacts except eutrophication, as their ratio shows.

This analysis only shows that the EPDs are a document, as of today declarative. They are not useful for comparison, they cannot be analysed and they are not useful for decision-making. The new updates of the regulations try to generate convergences, such as the development of common PCRs. Even so, there is a notable lack of a common, transparent and free route. Until now, programme administrators have provided quality assurance to their EPDs through their own regulations and external verifications. The JRC is creating this common route by providing a reporting format (ILCD) and software for database development (Soda4LCA). It promotes the generation of shared inventory data, but these do not have the required traceability. The inData initiative tries to make up for the lack of nearby data by converging formats from other European databases. But it is necessary to develop a national database that characterises the technologies of each process, which are as up to date as possible and specific to each geographical area: a national database.

A software, with calculation methods according to current regulations (15804+A2), and an inventory database is necessary for the complete development of any EPD. The work we have done with a spreadsheet has allowed us to master and understand each process. But the large number of components that influence each process makes it almost impossible to execute at that level with quality.

4. Conclusion

Climate change is one of the greatest challenges of our time and its adverse effects undermine the ability of all countries to achieve sustainable development. The Sustainable Development Goals (SDGs) and their translation into the 2030 Agenda were agreed to mitigate climate change. These commitments must turn current policies on their head. Environmental assessment and quantification at the product and building level must achieve even stronger, clearer and more binding guidelines.

At product level, environmental quantification is being driven by initiatives at European level with support for both EPD and PEF development. At the building level, methodologies such as LEVEL seek to unify a common calculation method. It is necessary to quantify and qualify and, with this, to be able to decide. We must build with environmental knowledge. There must be a regulatory framework that establishes strong criteria setting limit values, as is the case in other areas of construction (acoustic, structural or thermal conditions).

Now the field of construction is complex and is constantly expanding. The interaction between the agents that make up this community, it is essential and powerful for its continuity and effectiveness. In short, LCA studies involve a very complex analysis and calculation, that at the level of building is exponential. The multitude of factors that are involved in each stage of their life cycle, and amplitude of each branch, would the infinite formulation. Therefore, we act with simplifications and modelling that allow advance testing, development lines and national data set. The environmental analysis of a building involves an assessment and prior knowledge of the user, the designer and manufacturer, which should direct their business models. With this drive shaft OpenDAP emerge: offer information.

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