LAPPEENRANTA–LAHTI UNIVERSITY OF TECHNOLOGY LUT
School of Energy Systems
Department of Environmental Technology
Sustainability Science and Solutions
Master's thesis 2021

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ISSUES IN THE EPD VERIFICATION PROCESS OF A PRE-VERIFIED EPD GENERATOR AND THE DEFINITION OF VERIFICATION POINTS

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ABSTRACT

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2021

99 pages, 18 figures, 9 tables, and 3 appendices

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Keywords: life cycle assessment, environmental product declaration, third-party verification, pre-verification, software

Life Cycle Assessment (LCA), defined in ISO 14040, can be used to assess environmental impacts of product systems. To better use the results of LCA, many ecolabels, such as the type III product declaration, have been created. Known as EPDs, these declarations provide quantified, transparent, and verified LCA information of products and services. This paper aims to identify issues coming up during EPD verification in the context of One Click LCA (OCL). In its first half, the paper gives an overview of the LCA methodology and introduces the main topics required to understand the Environmental Product Declaration (EPD). In the second half, the study focuses on finding any issues coming up in the verification of EPDs, and what could be done to solve them. One solution, the definition of verification points, is identified beforehand and will be implemented during the study. This definition is done to better demonstrate the links between the software, its generated documents, and demands of the verification.

EPDs are published by EPD-Program Operators (PO) and most often used for regulatory compliance and certifications. Significant issues still affecting EPDs include a lack of knowledge, uncertain comparability, and costs. OCL is an LCA software aiming to achieve an efficient EPD process through a tool pre-verification. A review of the verification logs of EPDs made with OCL has been conducted to get a view about any issues still remaining in tool. Results of this review show that verifiers comment frequently on the tool users reporting of system boundaries, inventory data and modelling. As a result of the study, verification points were defined for 110 demands, around half of which could be automatically solved by the software. Improvements were identified for 14 items, offering solutions to further 16 % of the verification points. As a conclusion, if the suggested improvements are implemented, and the verification points are successfully put into use, there is a possibility to achieve significant time and cost savings in the verification processes of the EPDs made with the tool.

TIIVISTELMÄ

Lappeenrannan–Lahden teknillinen yliopisto LUT
School of Energy Systems
Ympäristötekniikan koulutusohjelma
Sustainability Science and Solutions

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EPD verifiointiprosessin ongelmat esiverifioidussa EPD-työkalussa ja verifiointipisteiden määrittely

Diplomityö

2021

99 sivua, 18 kuvaa, 9 taulukkoa ja 3 liitettä

Työn tarkastaja: Professori, TkT Risto Soukka
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Hakusanat: elinkaarimallinnus, ympäristöseloste, kolmannen osapuolen verifiointi, esiverifiointi, tietokoneohjelma

Standardissa ISO 14040 määritellyn elinkaaren arviointimenetelmän (LCA) avulla voidaan arvioida tuotejärjestelmien ympäristövaikutuksia. LCA:n käyttöä varten on luotu ympäristömerkkejä, kuten tyypin III ympäristöseloste. Nämä paremmin EPD:nä tunnetut ympäristöselosteet tarjoavat määrällisiä, läpinäkyviä ja varmennettuja LCA-tietoja tuotteista ja palveluista. Tämän tutkielman tarkoituksena on tunnistaa One Click LCA:lla (OCL) tehtyjen EPD:iden verifiointien aikana esiin tulevia ongelmia. Ensimmäisellä puoliskollaan paperi esittää yleiskatsauksen LCA metodologiaan ja esittelee tärkeimmät aiheet, joita tarvitaan ymmärtämään EPD:n nykytilaa. Toisella puoliskolla tutkimuksessa keskitytään tunnistamaan ongelmia, joita EPD:iden verifioinneissa ilmenee, ja myöhemmin myös siihen miten niitä voitaisiin ratkaista. Yksi mahdollinen ratkaisu, verifiointipisteiden määrittely, on tunnistettu etukäteen ja toteutetaan tutkimuksen aikana. Tämä määrittely tehdään, jotta ohjelmiston, sen luomien asiakirjojen ja verifioinnin vaatimusten yhteydet kyettäisiin osoittamaan paremmin.

EPD:tä julkaisevat EPD-ohjelmien operaattorit, ja niitä käytetään pääasiassa säännösten noudattamiseen ja sertifiointeihin. EPD:hen edelleen vaikuttavia merkittäviä ongelmia ovat tiedon puute, epävarma vertailukelpoisuus ja kustannukset. OCL on LCA-ohjelmisto, jonka tavoitteena on saavuttaa tehokas EPD-prosessi esiverifioinnilla. OCL:llä tehtyjen EPD:iden verifiointilokikirjoja on tutkittu, jotta saataisiin käsitys työkalussa vielä olevista ongelmista. Tämän tarkastelun tuloksista voidaan nähdä, että verifioijat kommentoivat usein työkalun käyttäjien raportoimista järjestelmän rajoista, inventaariotiedoista ja mallinnuksesta. Tutkielman tuloksena verifiointipisteitä saatiin määriteltyä 110 eri vaatimukselle, joista noin puolet voitiin ratkaista automaattisesti ohjelmiston avulla. Parannusmahdollisuuksia tunnistettiin 14, jotka toteuttamalla verifiointipisteitä voidaan ratkaista vielä 16 % lisää. Johtopäätöksenä voidaan todeta, että jos ehdotetut parannukset toimeenpannaan, ja verifiointipisteet saadaan onnistuneesti käyttöön, niin työkalulla tehtyjen EPD:iden verifiointiprosesseissa on mahdollista saavuttaa merkittäviä ajan ja kustannusten säästöjä.

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Abbreviations

CO_2	Carbon Dioxide
c-PCR	Complementary Product Category Rules
DAP	Declaración Ambiental de Producto (Environmental Construction Product Declaration)
DAP	Declarações Ambientais de Produto (Environmental Construction Product Declaration)
EPD	Environmental Product Declaration
EN	European Norm
FDES	Fiche de Déclaration Environnementale et Sanitaire (An Environmental and Sanitary Declaration Chart)
GPI	General Program Instructions
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
OCL	One Click LCA
PCR	Product Category Rules
PO	Program Operator
TC	Technical Committee

Units

kWh	Kilowatt-hour

Organisations

CEN	European Committee for Standardization
EAA	European Aluminium Association
IBU	Institut Bauen und Umwelt (Institute for Construction and Environment)
IFT	Institut für Fenstertechnik (Institute for Window Technology)
ISO	International Organization for Standardization
ITB	Instytut Techniki Budowlanej (**Building Research Institute)**

UL Underwriters' Laboratories

RTS Rakennustietosäätiö (Building Information Foundation)

SCS Scientific Certification Systems

SUGB Schweizerischer Überwachungsverband für Gesteinsbaustoffe (Swiss Monitoring Association for Rock Building Materials)

BRE Building Research Establishment

MRPI Milieu Relevante Product Informatie (Environment Relevant Product Information)

NSF National Sanitation Foundation

ZAG Zavod za gradbeništvo (Institute of Civil Engineering)

1 INTRODUCTION

With the growing interest towards environmental impacts and the increasingly severity of forecasts on climate change it has become a necessity for many countries to put more emphasis on considering these issues in their own policy making. The European union has set a target for 55 % reduction in greenhouse gas emission by 2030 and complete carbon neutrality by 2050 (European Comission, 2020). Many singular countries are also tightening their emission target. As an example of ambitious emission targets, the Finnish government aims to achieve carbon neutrality already by 2035 (Finnish Government, 2019). This puts increasing pressure on the private sector to also start decreasing their own environmental impacts.

The construction sector is no different as it has become one of the largest users of raw materials globally, consuming app. 3 billion tons of raw materials and 50 % of the worlds steel production annually (World Economic Forum, 2016, p. 9). However, in the construction sector, the focus of decreasing environmental impacts has so far been mostly in the operational energy use, mostly neglecting the material consumption. This has been noticed, and attention has been brought in the recent years to the embodied carbon of buildings. meaning the carbon emitted outside the operation of the building, such as manufacturing of raw materials. Adams et al. has tackled this issue in their 2019 World Green Building Council report about bringing embodied carbon upfront According to the report, embodied carbon accounts for roughly 11% of the world’s total carbon emissions. Also, adding to this is the increasing rate of urbanization of the world, which forces both the public law makers and actors in the construction sector to re-evaluate the focus of their climate actions and place more emphasis on the whole life cycle of buildings. (Adams et al., 2019, pp. 7–23).

The increasing environmental awareness, scale of construction sectors emissions and the necessity of evaluating all the stages of a buildings life cycle have created a demand for a more complete view on the environmental performance of buildings. This information can be acquired by conducting Life Cycle Assessment (LCA), which is a method for assessing the environmental performance of product and processes. The most common application for

LCA is the calculation of carbon footprints, but with the same methodology other environmental parameters such as resource depletion or water usage can be assessed. In short, LCA, depending on the scope of the study, gives a look into the total inputs and outputs of a product system throughout its life cycle. With this method it is possible to gain comprehensive knowledge of environmental impacts of a product's whole life cycle

In the construction sector the main purpose of LCA is usually to determine the environmental impacts of entire building projects. This is done to help designers and constructors get better knowledge of the emissions of all the relevant processes and material flows connected to the project. However, this can only be achieved if reliable and transparent information about the environmental performance of the constituent building products is available. One of the ways this can be done is by utilizing standard compliant and verified Environmental Product Declarations (EPD). These EPDs are in turn also created by conducting LCA, but this time on the level of singular building materials or components.

This thesis was made as part of a project for One Click LCA Ltd, a Finnish software and consulting firm based in Helsinki, who specializes in the sustainability issues of the construction industry. Their main business is the development and support of One Click LCA (OCL), which is an online LCA software that focuses on the assessment life cycle impacts of buildings. The software is used by architects, structural engineers, environmental consultants, and others to calculate environmental impacts of their respective areas of responsibility during building projects. Alongside building LCAs the software offers tools for the creation of structure, process, and infrastructure project LCAs, Greenhouse Gas reporting, Circularity Assessment, Life Cycle Costing and most relevantly for this study, EPDs.

The main target of study is the OCL Pre-Verified EPD tool, with which most of the EPDs made by One Click LCA Ltd and its customers are created. The aim of this master's thesis is to identify what issues, if any, currently affect this Pre-Verified EPD tool. Specifically, what practical issues can be found during the verification processes of EPDs made with the tool and make improvement suggestions based on the findings. As an integral part of this process, the study also aims to identify and define a set of verification points. These points aim to solve some of the already known issues in the verification process by helping the verifier see the link between the checks they make during the verification process and the software.

This study is divided into two parts, theory section and the empirical section. In the theory section, the study goes through the basic background information on the topic of LCA and EPD, as well as presenting the current market situation of EPDs and the main issues affecting its wider adoption. In the empirical section, the OCL-software is presented, and the review of the verification communication logs is conducted. Here the possible improvements to the software, alongside the verification points definition is explained. The paper ends with the presentation of the results and concluding statements about the findings and insights gained during the study.

2 LIFE CYCLE ASSESSMENT

Life Cycle Assessment (LCA) is an analysis methodology, created to help in assessing the environmental impacts of products and systems. Its advantages lie in its multifunctionality and ability to give detailed information on emissions as well as the material, and energy flows of products and systems. This information can be used in product development and process improvement even without considering the emissions, but the most obvious benefit is its potential to provide support for the optimization of the environmental performance of the target if the study. (ISO, 2006a, p. 8).

The LCA can also be used in policy making processes, which is increasingly important as the environmental strategies of many countries are developing. Companies can use LCA in strategic planning in relation to the public sector making more and more tighter emission targets for example, as well as in marketing to provide environmentally conscious clients with better information on the impacts of their products. (ISO, 2006a, p. 34).

The LCA process, in compliance with ISO 14040, follows several principles. It is a transparent, iterative, relative, and comprehensive analysis of the material and energy flows during the life cycle of a system under study. It is a primarily scientific and environment focused method which gives comprehensive information about the inputs and outputs of a system. A distinctive feature of LCA in comparison to other environmental assessment methods, for example environmental impact assessment, is that it is based on a reference unit and all the impact are defined in relation to it. (ISO, 2006a, p. 23).

2.1 The LCA Framework

The standard ISO 14040 provides principles and a framework for conducting LCA. It consists of four distinct phases: goal and scope definition, inventory analysis, impact assessment, and interpretation. The framework is visualized in Figure 1 and more detailed descriptions are provided (ISO, 2006a, p. 23)

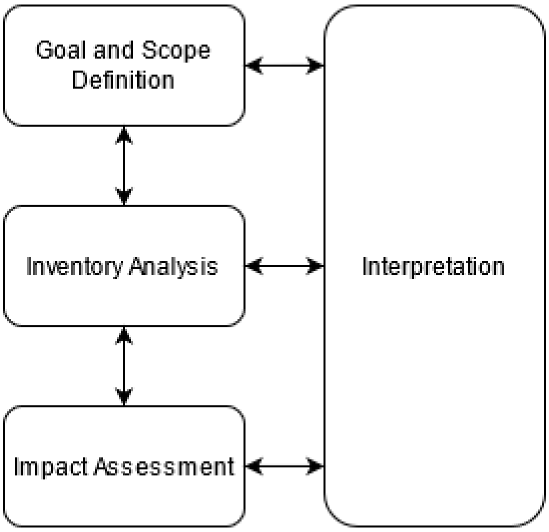

Figure 1. LCA Framework according to ISO 14040 (ISO, 2006a, p. 23).

The LCA starts with the definition of goal and scope, which in turn begins with the definition of the study goals. Here the study's primary objectives and the life cycle stages included are defined. The goals define the reasons and the intended application of the study. The degree of publicity of the study should also be disclosed, as in whether or not the study is going to be used in publicly presented comparative assertions. (ISO, 2006b, p. 23).

The scope also needs to be well defined in order to make sure that the study is compassing enough and of sufficient detail in comparison to the goals. It should include the definition of the system under study. This includes any processes happening within said system, the functional unit, the system boundaries, allocation methods, chosen impact categories, as well as the assumptions, limitations and the quality criteria present in the study. The study must also report what kind of critical review is applied (e.g., third party verification). (ISO, 2006b, pp. 23–25).

During the definition of the scope of the study, the functional unit is one of the most important things that need to be defined. The functional unit represents the main function of the product system under study in a quantified form. Its primary purpose is to act as a reference to the flows of the system. To allow for this, the functional unit requires a reference flow, which is the quantity of output form the product system that is needed in order to fulfil the intended function. All the inputs and outputs of the system are calculated so that they are considered in proportion to the functional unit's reference flow. (ISO, 2006b, p. 25).

Inventory analysis or LCI for short, of the LCA is a central part of the life cycle assessment. It can also be seen as the most scientific part of the study as it includes quantified analysis of the foreground and background data relevant to the system under study.(Klöpffer and Curann, 2014, pp. 21–22). In practical terms, this stage can be roughly divided into two distinct parts, the gathering of information, and the processing of said information into a form where it can be appropriately used in the next phase of the LCA. The former consisting of the processes where the material and energy flows related to the processes under study are identified and quantified. This includes, for example, gathering information about what raw materials an organization or a company has bought for use in manufacturing. Another example would be the collection of energy consumption data of the facilities of said organization.(ISO, 2006a, p. 35).

The gathered information has to include all the inputs and outputs going in and out of the system, taking into account the system boundaries established in goal and scope. This generally includes all the material and energy inputs, auxiliary inputs, waste generation, co-products, and all the emissions to air, land and water happening within the system. The limitations present in the gathering all this information needs to be reported when it causes flows to be left out of the study. (ISO, 2006b, p. 33).

The handling of the gathered data includes calculation procedures to make the information usable, such as taking the total collected inventory raw material and energy data and dividing that, so it's focused on just the reference unit, and allocation which means the division of the gathered inventory data between multiple product systems. Allocation is used to handle situations where the studied system has multiple output products or uses recycling processes. (ISO, 2006a, p. 34).

Life Cycle Impact Assessment (LCIA), often shortened as impact assessment, is the phase in LCA where the environmental performance of the studied system is measured. It includes the following procedures: impact category and category indicator selection, characterization model selection, impact data assignment to the appropriate LCI flows, and the calculation of the resulting impact category indicator results. In essence, during LCIA the conductor of the study chooses the emission factors that are most appropriate for the studied systems. These are then then assigned to the flows gathered during inventory analysis and multiplied with each other to provide the total emissions of the system. Impact assessment depends heavily on the choices made in the goal and scope part of the study. As such it is not a complete assessment and instead consists of specific impact categories and life cycle stages and other details decided in goal and scope. (ISO, 2006a, p. 34).

The last phase of LCA, although one which needs to be constantly reflected during the other stages, is the interpretation. Interpretation stage structure as presented in ISO 14044 contains the following actions: identification of the significant issues based on the previous LCI and LCIA phases, evaluation of the sensitivity, completeness, and completeness of the assessment, and the conclusions, limitations and recommendations of the study based on the results. (ISO, 2006b, p. 54).

This is the phase where the main hot points in terms of environmental impacts, and their relation to the material and energy flows are identified and assessed. Any deficiencies or limitations must be disclosed, and their possible impact on the study evaluated. The interpretation also includes the documentation of the main caveats of the study in terms of data selection and handling, and their effect on the results of the study are also taken into consideration by the way of sensitivity analysis. The interpretation phase ensures that the other phases match each other properly. Also, this phase checks the plausibility and correctness of the end results.(ISO, 2006a, p. 39)

2.2 Environmental claims and declarations

The LCA method done following the ISO 14040 and ISO 14044 is a systematic and comprehensive method for assessing environmental burdens. However, for companies and other entities wanting to communicate and report their efforts for better environmental performance and transparency, it is not enough. For this reason, a more directed approach is needed. This can be done in the form of environmental labels and declarations (ecolabels).

These allow for the results of LCA to be presented in a more easily communicable and understandable way, which is of great interest to companies wishing to communicate and promote the environmental impacts of their products. These labels are governed by the ISO 14020 family of standards, which cover three different types of ecolabels.

The standard ISO 14020 itself mainly describes the general principles by which these labels are developed and how they are meant to be used. It is meant to be used in tandem with three other standards currently in force, which are more specific in their purpose. These are the ISO 14024, ISO 14021, and ISO 14025, which each govern a specific type of environmental label. These are the type I, type II, and type III environmental labels/declarations. (ISO 14020, 2000, pp. 1–2). The main attributes of the different types of ecolabels are presented in Table 1. The principles behind the type I environmental label and type II self-declared environmental claims are explained below the table. The type III is introduced more thoroughly in chapter 3.

Table 1. Different ecolabel types and their main attributes (Sonnemann and Margni, 2015, pp. 67–71).

Feature	**Type I**	**Type II**	**Type III**
Standard	ISO 14024	ISO 14021	ISO 14025
Type of information presented	Qualitative	Self-declared	Quantitative
Used to	Demonstrate environmental performance compared to other similar products	Inform about the environmental aspects about a product	Demonstrate quantified information about products environmental impacts
Main audience	Consumers	Consumers	Business, such as commercial and public procurers
Level of verification	Third party	Not required	Independent (Internal or external)

Examples	Nordic Swan	Company's own environmental declaration that is not verified independently	ECO Platform EPDs

Type I environmental labels (ecolabel) are governed by ISO 14024, which defines the procedures to operate a type I environmental label program. These programs award logos for fulfilling certain criteria within some pre-defined frameworks. The main principles of the ecolabels as mentioned in ISO 14024 are their voluntary nature, life cycle consideration approach, transparency, and verifiability. The evaluation for the ecolabel should consider the whole life cycle of the product or service and be measured with scientifically backed evidence. The criteria for this evaluation are based on indicators like material and energy consumption, or the number of hazardous substances in the product. (ISO 14024:1999, 1999, pp. 2–5).

This type of ecolabel is mainly used to identify products and services which are proven to be less harmful to the environment than their average counterparts on the market. The label therefore gives a qualitative description about the relative status of the product, but generally does not offer quantitative values. Type I ecolabel programs all employ a third-party certification process. Examples of type I ecolabel programs are the Nordic swan and the EU Ecolabel, which are both part of the international federation for ecolabeling, Global Ecolabelling Network (GEN). (Sonnemann and Margni, 2015, pp. 68–69).

In contrast to the type I ecolabel, the type II self-declared environmental claims do not come from a program set up for their management and instead they are, as the name suggests, brought out independently by their author organizations. Their main use case could be seen to be more informative than demonstrative, more in the vein of marketing the environmental aspects than giving accurate information. The type II environmental claims are governed by ISO 14021, which defines the requirements for its creation and use. (Sonnemann and Margni, 2015, pp. 70–71).

The standard requires that type II self-declaration claims must be truthful and accurate, specific to the environmental impact the claim is aimed at, clear on the nature of the product (a complete product or just a part of one), with a clear explanation on the claims being made, and consider the life cycle aspects of the product. The standard also defines how certain specific symbols can be used in the self-declared claims. For example, the mobius loop recycling symbol must fulfil certain graphical requirements and contextual clarity. In general, the standard requires the user of self-declarations to avoid ambiguity in their claims and follow the principle of being precise and simple. The declaration should not leave room for speculation about the possibility that claims of environmental performance could be extrapolated to cover other topics than what is pointed at by the declaration. (ISO, 2016, pp. 19–21).

3 ENVIRONMENTAL PRODUCT DECLARATION

The Environmental Product Declaration (EPD), or as it is defined in ISO 14025:2006 standard, the type III environmental declaration, is a standardized document that can be used to demonstrate quantified information about the environmental effects of the life cycle of a product. The information contained within these EPDs is based on the LCA-methodology, performed according to the ISO 14040 and ISO 14044 standards. EPDs are always made using predefined rulesets, go through independent verification, and are published following the guidelines set by EPD program operators. (ISO, 2006c, p. 1)

As they provide quantified information about the impacts of different product, one of their applications includes using them as inputs in other LCA studies. This way they can act as a great source of information to be used in calculating the life cycle impacts of building and infrastructure projects, providing information at product level accuracy. By using EPDs, LCA practitioners do not have to rely on average data and can instead gain much greater accuracy on the emissions of the specific products chosen for the project. This also makes it possible to choose products with lesser emissions at the very beginning of the project. (Adams et al., 2019, p. 27).

This has been noticed by many organizations involved with researching the life cycle emissions of buildings and has thus been also picked up by government regulators. Because of this there is an increased pressure from the public sector aimed at manufacturers to provide EPDs for their products. Regulators now see EPDs as one of the main tools in the effort to decarbonize the construction sectors embodied carbon, which has unfortunately been previously neglected in the global efforts to combat climate change. (Adams et al., 2019, p. 28).

3.1 EPD market situation

The number of EPDs on the market is steadily growing with many being published each year by a multitude of different EPD programs. A 2021 infographic collated by a sustainability expert Jane Anderson (2021) presents data for EN 15804 compliant published third party verified EPDs for the years 2011-2021. The data shows that approximately 10 000 EPDs have so far been published as of January 2021 with a particularly large increase between the January of 2020 and January of 2021. The numbers are presented in Figure 2.

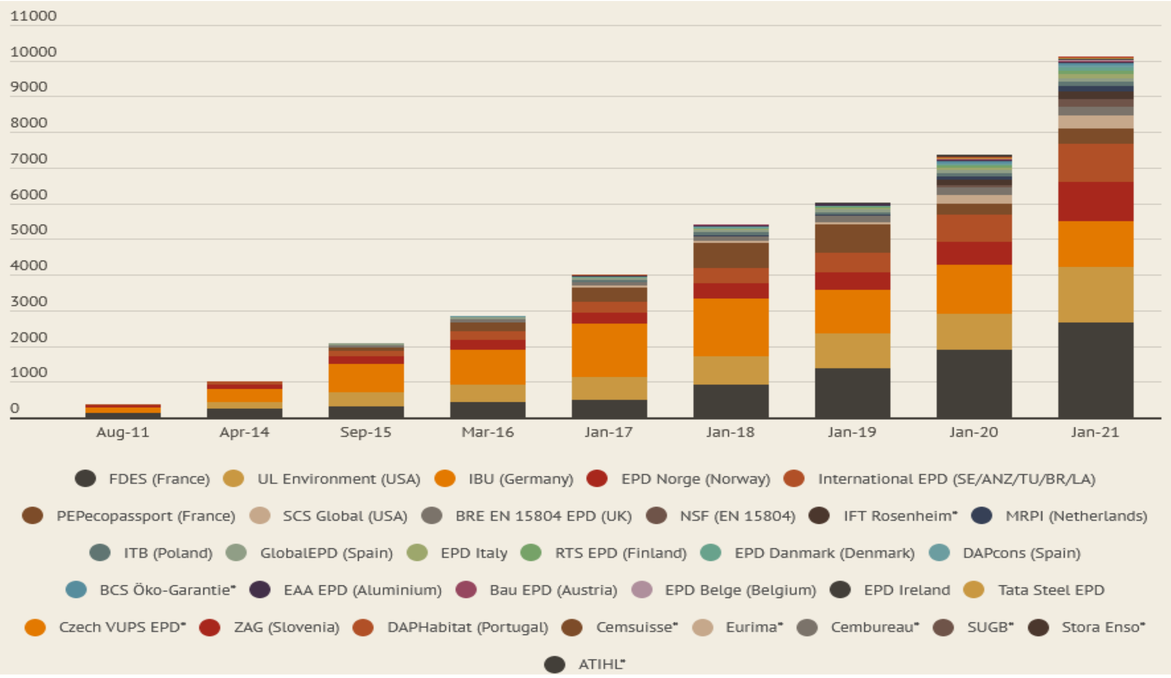

Figure 2. Growth in the amount of construction product EPDs for EN 15804 (Jane Anderson, 2021).

There has been growth across almost all the active program operators, but there are a few which are the main drivers of sudden increase. The FDES and UL Environment, EPD programs of France (FDES refers to the name of EPDs in France administered by the French national reference database) and USA respectively, have seen high growth and together they have published over 4000 of the 10000 EPDs currently on the market. Other large program operators include IBU, EPD Norge, and EPD International. (Jane Anderson, 2021).

In USA, the main source of the increase in EPDs is in the concrete industry, where the which has been very active in making EPDs for their products. Here, the local legislation plays a large role. As an example, in the city of Portland, any concrete used in public construction projects must have an EPD (City of Portland, 2020). This makes it difficult to get publicly funded project without having an EPD.

In Europe the use of EPDs has been established at EU level with the regulation Construction Products Regulation 305/2011/EU. It presents the EPDs as the primary method for demonstrating the impacts of construction products. Many national governments have also been active in producing environmental legislation. Newest additions to this are the French RE 2020 legislation (2020), the Swedish Klimatdeklaration (2021), the Finnish low-carbon construction roadmap (2020), and the UK London Plan

EPD adoption in Europe has been studied by Passer et al. in their 2015 paper about reviewing experiences of with EPDs in different European nations. The study found out that EPDs have gained interest as a tool for communicating environmental policy. According to the findings of the study the EPD is seen by companies as a way to tell the public, or any relevant stakeholders that they are interested in environmental issues. The highlights France and Germany, both of where strong moves have been made towards the wider acceptance of EPDs.

In France the approach leans more toward mandatory legal requirements. There any manufacturer of construction products making environmental claims must have an EPD registered in the national EPD database. In Germany, the approach is more voluntary. The EPDs are recognized by two major building certification systems DGNB and BNB. In these systems the use of EPDs is actively promoted and it gets the user advantages in a building LCA calculation that is part of the certification. (Passer et al., 2015, pp. 1203–1204).

This type of using EPDs in certification is one of the strongest voluntary drivers for their use. Alongside the previously mentioned German certifications, EPDs can be used to achieve higher scores in BREEAM and LEED as well. BREEAM assigns points for demonstrating lowered impacts by applying LCA and for including products which have an EPD. (Building Research Establishment, 2016, pp. 264–265). The same is done by LEED but with different weighting and points allocation (U.S. Green Building Council, 2020, pp. 164–182).

3.1.1 Issues with EPD adoption

Having gone through the main drivers of the EPD, next the issues negatively affecting its adoption on the market. A study was done in 2015 by members of two Spanish universities to find out which factors affected EPD demand in Europe. This study was conducted as an online questionnaire aimed towards companies (with around 55 responding) that have had EPDs previously published. As a result of the study, they found that the disadvantages to carrying out EPD projects reported by most companies were a general lack of knowledge about EPDs and that they can be hard to understand, inadequate international standardization, and the cost of EPDs. (Ibáñez-Forés et al., 2015).

Similar issues are also mentioned in a survey by IGBC (Icelandic Green Building Council). According to its results, one of the main issues for the use of EPDs is a lack of demand in the market. The same study also highlights other obstacles for EPDs. These include a lack of knowledge and understanding about EPDs, the cost of EPDs, and the low level of synchronization and common practise. (IGBC, 2015).

These issues mentioned mentioned by Ibáñez-Forés et al (2015) and IGBC (2015) are also present in several other studies that investigate the uses and issues of EPDs. Understandability related issues are shown in a 2020 study conducted as a survey about the uses of LCA and EPD information. Here it is pointed out that the information contained within an EPD is highly technical and obscure for non-practitioners and because of this it can be difficult to understand how to use and replicate them. The study also notes that there is large variability in the methods chosen even by practitioners in their use of EPDs and LCA data in comparisons. For example, when looking for the product with less impact, the practitioners understanding played a large role in what methods they used in interpreting the results. (Galindro et al., 2020, pp. 966–968).

Comparability has been identified as one of the main points of a study conducted in 2018 about the use of EPDs in a construction project vying for a LEED certification. This paper presents a case study about the opinions of three different stakeholders on the use of EPDs in the project. The stakeholders include the client, designer, and the contractor, which were interviewed and asked several questions on their perspective of the potential benefits and concerns of the EPD. The study was not strictly from the perspective of the EPD creators, but it shows the same concerns that afflict them. One of the main highlights of the study was that, especially from the viewpoint of the designer, the lack of harmonization between PCRs and therefore between the methodology behind the creation of EPDs causes concerns about their comparability. (Gelowitz and McArthur, 2018, p. 436).

The study also points out that as there exists a lack of firm regulation on the organizations developing PCRs, the number of different methodologies for creating EPDs have been formed even between similar PCRs. Since EPDs cannot really be compared if created with different methodologies, this creates a situation where an increasing amount of EPDs on the market are not comparable with each other even within the same product categories. (Gelowitz and McArthur, 2018, p. 436).

Cost is an issue that is relevant to most EPD creators, and as mentioned by Ibáñez-Forés et al (2015), is a factor brough up often. The price of creating EPDs has been studied by Tasaki et al. (2017), and the total cost of an EPD has been found to vary between 10 000 - 30 000 €. The median price is also reported and stands at around 12 826 €. The total costs are composed of the LCA and EPD preparation, verification, registration (publication), possible running fees and other unspecified costs. The largest share of the costs come from the LCA and EPD preparation, with a share of around 53 %. The next largest is the verification which is around 18 %, and the rest are equally divided between the remaining categories. The study has also investigated the time intensity of each of the stages. As with the costs the LCA and EPD preparation takes up the largest amount of time, app. 59 %, and the verification coming up next about 29 %. The rest 20 % of the time are spent during the registration. (Tasaki et al., 2017, p. 729).

This price is quite high, especially from the viewpoint of the prospective EPD owner, especially if they see only a limited number of use cases for it. Issues of costs are presented in context by Gelowitz and McArthur (2018). According to their study the high cost of EPDs create a barrier for small and mid-size companies, who do not have the resources to fund such expenses. (Gelowitz and McArthur, 2018, p. 439).

In addition to these issues, EPD adoption is affected by the EPD creators' and users' not seeing a large amount of use cases. Andersen et al. (2019) studying EPDs and their use as a competitive parameter in the sustainable building sector looked at what are the largest issues with a wider adoption of EPDs. The study focused on the Danish market and was aimed to identify why they have been falling behind some other markets in EPD. Their study was composed of interviews and workshops, which aimed to discover if and how EPDs are viewed as a competitive parameter. According to the study, the only use case for EPDs clear enough to be understood by the many, is building certification schemes.

The study points out that this lack of uses has led to the various actors (manufacturers, builders etc.) in the construction industry to try and shift the responsibility of creating EPDs to others. This has resulted in a circle of inaction in which the lack of demand creates a situation where no one seems to be pressured to be the first adopter. According to the study this indicates that there is a need for most of the stakeholders moving together simultaneously so that progress could be made. (Andersen et al., 2019, p. 7).

3.2 Third-party verification

When discussing about the advantages of using EPDs as a source of environmental data, one of the first things that comes up is that the data they provide is reliable and trustworthy. This perception of quality allows companies producing EPDs to get validity for their environmental policies and claims in the eyes of governments, NGOs and clients. What creates this image is independent verification, required from EPDs by ISO 14025. The verification is a review of the EPDs underlying LCA study, i.e., its data, methodology and results. Verification allows the EPD owner to prove that the information they provide about, for example, about their climate actions, are not just marketing, but verified facts.

The standard ISO 14025 defines the independent party as not having been involved in the execution of the LCA or in the development of the verification. This independent verifier may be an internal or an external actor in relation to the author organization depending on the stated target audience. In situations where the target group is defined as only business-to-business, the standard leaves the issue to the discretion of the program operator. However, in any situation where the EPD is to also be used in business-to-consumer communication, the verification must be carried out by a third party. (ISO, 2006c, p. 45)

The third-party reviewer (most often referred to as the verifier) is a person or a group of people approved and certified by the program operator to verify the methods and results of a prospective EPD. The verifier checks the LCA study, and the documents provided by the EPD author against the appropriate standards and PCR of the program operator to ensure compliance. The verification checks for example that the data received from the manufacturer is plausible i.e., if the input and outputs are balanced and that the resulting emissions are in line with other similar products, that the life cycle inventory is applicable to the studied product, that modelling is correct, that impact factors are correct, and that all allocations and calculations are correctly applied. (ISO, 2006c, pp. 41–44)

3.2.1 Verification checklists

To help the work of the verifiers and to ensure consistency in the checks performed, the program operators have published verification checklists. These checklists include a list of mandatory and optional compliancy checks which the verifier needs to go through and cross check with the EPD documents provided by the author. The checks include both editorial and technical aspects. The checklists presented in this chapter are based on the minimum requirements set for verification by Eco platform in their paper Audit and Verification Guidelines for ECO EPD Programme Operators. (ECO Platform, 2020, p. 24).

The checklists also act as the verification report that needs to be submitted by the verifier. It includes rules and mandatory statements as required by the program operator. More importantly it contains a verification statement that the verifier signs which confirms that the EPD and its underlying study has been thoroughly checked and verified by the verifier according to the appropriate standards and the PCR. (ECO Platform, 2020, p. 24)

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The beginning of the verification checklist for two EPD programs the RTS EPD-System and the International EPD System are presented in Table 2 and Table 3. Both documents are freely available on their respective websites. Both checklists are adapted from the checklist published in the EPD verification guidance paper of ECO Platform (ECO Platform, 2020, pp. 25–36).

Table 2. An excerpt of the IES verification checklist with verification points. (EPD International AB, 2021a).

1	GENERAL INFORMATION	M/O	REFERENCE	OK	N/A
1.1	Commissioner of LCA study, LCA practitioner	M	EN 15804 ch. 8.2	☐	☐
1.2	Date of issue of LCA report	M	EN 15804 ch. 8.2	☐	☐
1.3	Statement that the Life Cycle Assessment study has been performed in accordance with the requirements of EN 15804 and applicable PCRs	M	EN 15804 ch. 8.2 and applicable PCR	☐	☐
1.4	Any other independent verification of the data given in the LCI/LCA documentation?	O		☐	☐
2	STUDY GOAL	M/O	REFERENCE	OK	N/A
2.1	Reasons for performing the Life Cycle Assessment	M	EN 15804 ch. 8.2	☐	☐
2.2	Intended application (e.g. for EPD, databases, publication etc.)	M	EN 15804 ch. 8.2	☐	☐
2.3	Target group (B2B, B2C, …)	M	EN 15804 ch. 8.2	☐	☐
3	FUNCTIONAL UNIT / DECLARED UNIT	M/O	REFERENCE	OK	N/A
3.1	Functional / Declared unit, including relevant technical specification	M	EN 15804 ch. 6.3.1/6.3.2 and/or applicable PCR or additional specific requirements for certain product groups in applicable c-PCR	☐	☐
3.2	Indication of a factor for the conversion into kg	M		☐	☐
3.3	If product groups (similar products from one manufacturer and/or from different production plants) are formed as averages: -Description of the type of average -Description of how the average has been calculated. -Does the description of the average represent what is declared in the epd?	M	EN 15804 ch. 8.2	☐	☐

Table 3. An excerpt of the RTS verification checklist. (The Building Information Foundation RTS Sr, 2017).

1	**General information - availability**	**Reference**	**Mandatory / optional**	**Deviations from requirements**	**Done**
.1	Commissioner of LCA study, LCA practitioner	EN15804 ch.8.2	M		
1.2	Date of issue of LCA report	EN15804 ch.8.2	M		
1.3	Statement that the Life Cycle Assessment study has been performed in accordance with the requirements of EN 15804 and. applicable PCRs	EN15804 ch.8.2 + applicable PCR	M		
1.4	Any other independent verification of the data given in the LCI/LCA documentation?		O		
2	**Study goal – availability of info**	**Reference**		**Deviations from requirements**	**Done**
2.1	Reasons for performing the Life Cycle Assessment	EN15804 ch.8.2	M		☒
2.2	Intended application – (e.g., for EPD, databases, publication etc.) Is the LCA designed in such a way that it allows B2B communication for environmental assessments of buildings?	EN15804 ch.8.2	M		☒
2.3	Target group (B2B, B2C, …)	EN15804 ch.8.2	M		☒
3	**Functional unit / Declared unit – availability of info**	**Reference**	**Mandatory / optional**	**Deviations from requirements**	**Done**
3.1	Functional / Declared unit, including relevant technical specification	EN15804 ch.6.3.1/6.3.2 and/or applicable PCR or additional specific requirements for certain product groups	M		☒
3.2	If product groups (similar products from one manufacturer and/or from different production plants) are formed as averages: · Calculation rules for the formation of averages · Representativeness of averages	EN15804 ch.8.2	M		☒

The checklist column structure from left to right in the above figures consists of the description of the check, what point in the applicable standards the demands of the check originate from, and then a place to mark whether or not the study under verification fulfils the checked compliancy issue. The checks range from the very simple, for example asking to check if the authors name is written on the EPD, to complex, checking if the mass flows in the material being studied are correctly accounted for.

The checklists are divided into two sections. The first is dedicated for checks concerning the LCA project report which details all the aspects of the study, such as the description of the product, its application, technical characteristics, raw material composition, manufacturing material and energy flow inventory, all the environmental profiles needed to produce the impact results from the inventory, as well as all the assumption and limitations present in the study. This part is meant to check that the study is done correctly, and all necessary documentation is correct and present in the report. (ECO Platform, 2020, p. 25)

The second part goes through the actual EPD document. Many checks here are actually very similar to the previous part so if the project LCA report was compliant with the relevant standards and PCR, the verifier only needs to confirm that the same information that the information in the EPD is the same. As well as confirming that the information in project report and EPD match, the verifier needs to also make sure that all the necessary declarations and disclaimers are in place, and that no mandatory information is left out. (ECO Platform, 2020, p. 37).

The differences between the IES and RTS checklists are mostly structural, meaning that some of the same points covered are located under different categories, but still cover the same topics The largest difference generally is that the RTS list is outdated and references EN15804+A1 (The Building Information Foundation RTS Sr, 2017, p. 1). This does not render it unusable, but it does makes some of its references obsolete and to be checked with greater care when verifying an EPD for the EN15804 standard. Because of this outdated structure there are few differences, like the approach towards CO_2 offsetting, IES forbids it, but RTS states that such claims need certificates (EPD International AB, 2021a, p. 6).

One major actual difference content wise is the additional “Part C” in the lists of both POs which contains some program specific checks not explicitly stated in the original ECO Platform list. The RTS gives some direct requirements for additional or clarifying information (The Building Information Foundation RTS Sr, 2017, p. 12). IES on the other hand has mainly listed generic checks for compliance with other relevant standards to ensure that any requirements in said standards, but not listed in the part for LCA report and the part for EPD, are considered in the verification (EPD International AB, 2021a, p. 16).

The checklist may also include the dialogue between the EPD author and the verifier as an integrated document. This dialogue is commonly presented as a table which has row representing points brought up by the verifier. The points are then answered by the author of the EPD and documented onto a separate column of the table in the same row as the verifiers original comment. This dialogue is necessary for the verification but not necessarily integrated onto the verification checklist report (ECO Platform, 2020, p. 36).

3.2.2 Verification process in practise

As is noted in a study about certification procedures for EPDs, there are no official guidelines for EPD verification (Magerholm Fet and Skaar, 2006a, p. 49). The principles and demands are defined in the ISO 14025, but the practise is largely left to the program operators and individual verifiers (ISO, 2006c, pp. 41–44). The guidelines and checklist created by Eco platform gives a framework for the checks made and mandates the keeping of a communication log for its member program operators but does not obligate any specific procedure for the communication (ECO Platform, 2020, p. 36). Due to this lack of formal procedure, information about the practices of verification processes have been gotten through practical experience.

During the writing of this paper, the author has participated in the verification processes of two EPDs. In one as the EPD author and in one as a consultant for the EPD author. From this a reasonable understanding of the general outline of an EPD verification has been gained. A simple flowchart of the general process structure is presented in Figure 3.

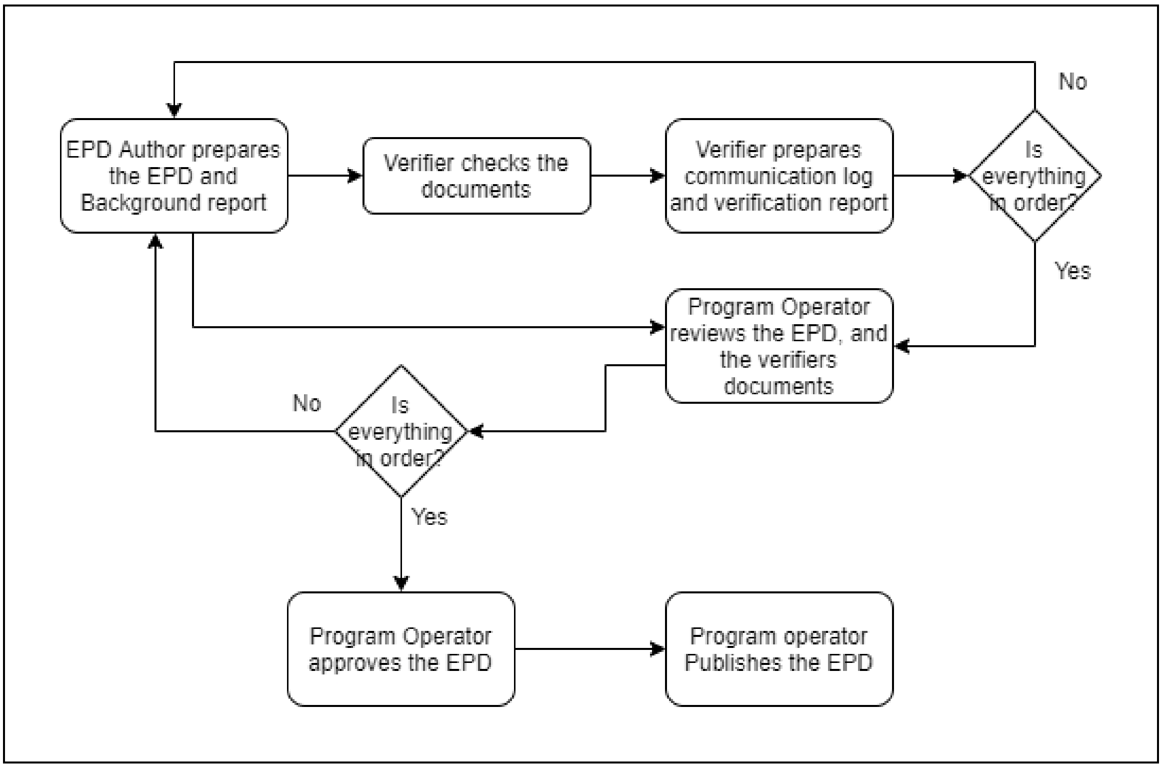

Figure 3. Third-party verification process flow chart presenting the EPD verifications of the projects that the author has taken part in.

These verifications have started when the EPD author or an otherwise authorized body contacts the verifier and sends them the EPD and the project report. After receiving them, the verifier checks the delivered documents and the EPD software model, if such is available, and marks up any shortcomings. These are documented in a dialogue which is one of the documents that needs to be provided to the program operator upon applying for the EPD to be published.

Once the verifier has checked everything, they will send the dialogue back to the author. If there are issues with the EPD then the author must address them. For example, the model for calculation the emissions could be wrong, the inventory might have something clearly missing, or the EPD document might simply not have some of the mandatory statements written correctly. Once the author has fixed everything and documented them into the verification dialogue, they will send it back the to the verifier for a next round of checks. This might go on for a few more rounds of checking if either the author is not properly applying the necessary fixes, or the verifier is not comprehensive enough in their checking and new issues come up as old ones are fixed.

3.3 Variation in the application of EPD verification

Most often, in relation to their verification status, EPDs cite compliance with ISO 14025. In order to claim that the declaration is a type III EPD, defined and in compliancy with ISO 14025, it must go through an independent verification. A market situation overview was carried out by Hunsager et al. (2014) about the EPD programs and PCRs on the market. They reviewed 27 EPD programs around the world and analysed their performance with various metrics, one of them verification. All programs reviewed adhered to the third-party verification in compliancy with ISO 14025 except one, the Japanese JEMAI (Japan Environmental Management Association for Industry).

It therefore seems that the third-party EPD verification is diligently followed by most POs around the world. However, the definition of this independence of a third party in the current standard and market environment leave some room for interpretation. Also vague is the definition of the target audience, as EPDs are usually available on the manufacturers website, making the targeting of EPDs somewhat obsolete. Looking at the study it also mentioned that 13 of the 27 review POs enforced external third-party verification by default, regardless of the target audience (Hunsager et al., 2014, pp. 792–793). This means that the rest are applying alternative methods in cases where they only state business-to-business use.

Because of this, there are currently a couple of different methods to conduct EPD verification in use. These include the actual external third-party verification introduced previously, an internal independent in-house verification, and a software-based system verification. For the sake of comprehensiveness, also included here is the option for self-declaration option.

The first option to be covered is the ISO 14025 compliant independent verification, but without the verifier being an external third party. Examples of these are some EPDs published in the Norwegian EPD-system (Magerholm Fet and Skaar, 2006b, p. 52). There the EPD verification is done through an internal verification system where the verification procedure is part of a ISO 14001 Environmental management system audit. The benefit here is that the price for the company is lowered as no external verifier needs to be contacted. For the same reason the efficiency of the process is somewhat higher. Downside of this is the possible uncertainty about the actual independence and impartiality of the internal verifier, and therefore the quality of the verification itself.

Next is the software-based verification. Examples for such a computer verification would be the many concrete EPDs currently being published in the US by the National Ready Mixed Concrete association. These are made with EPD tools prepared by partners of the concrete association, which have been themselves verified. The EPDs of many of these tools are not verified themselves however but the EPDs produced by them are often not verified individually. (National Ready Mixed Concrete Association, 2021). This ensures very low cost and high efficiency for the process. The downside is that it may not provide top quality results unless every variable is considered in the computer-based verification.

Lastly there is the no-verification option, meaning the declaration is self-declared and actually in compliance with ISO 15024. The price of these can be very low for the authoring organization. However, as no body verifies the data there is a chance of poor quality due to human error, negligence, or outright data manipulation. The data can of course be of good quality but as there is no verification this is left to the user to decide based on their trust on the company. Because of this, trust for self-declared environmental data can be quite low, which is the reason why some of them disguise themselves as verified EPDs.

3.3.1 Problems with EPD verification variability

The verification is a powerful method to achieve credibility and transparency in the market. This is because it offers users of these declarations some guarantee that the same comprehensive level of scrutiny is applied for every published EPD. This allows them to be trusted as a source of environmental information. However, there are issues with the ambiguity of the independency requirement given in the standard.

As an example, Jane Anderson, an LCA and EPD expert who has been very active in the European LCA standardization schemes, has written articles about EPD and its verification status. In her articles, she has called out a manufacturer who has presented their self-declared environmental declaration in such a way that it is easy to mix them up with a strictly third party verified EPDs. The communication and reporting style all pointing towards their declaration being a third-party verified EPDs, even citing compliancy with EN 15804 as the core PCR, but which turned out to be a ISO 14021 compliant self-declaration upon closer inspection. (Anderson, 2021).

The different kinds of verifications have their own place in the market for environmental information. and they do offer advantages over the classical third-party verification such as increased responsiveness and lower costs. However as pointed out by Anderson (2021), when not communicated properly, they cause uncertainty in the methods used in verification and may mislead people looking for actual EPDs. Andersons articles were about self-declarations presenting themselves as EPDs, so the critique is not directly pointed at these variations of third-party verification, However, as pointed out in chapter 3.1.1, EPDs are already affected by uncertainty about their comparability and a lack of information, and so the variation in verification types may create distrust and uncertainty in the EPD market.

4 ENVIRONMENTAL DECLARATION PROGRAMS

A type III environmental declaration program, or EPD program, as defined by ISO 14025 is a scheme for the development, use and publishing of type III environmental product declarations. An EPD program is conducted by a program operator (PO). A program operator is an organization or a group of organizations that operate an EPD program and manage the necessary responsibilities defined for it by the standard. The operator may be a company, multiple companies, public institutions, or industry associations.

The main responsibility of the program operator is to administer the type III EPD program and to prepare, communicate and update the General Program Instructions (GPI). The GPI serves as the main guidance document for the proper operation of the EPD program and therefore includes instructions that govern the PCR and EPD creation process. The program operator must maintain and develop this document and to make sure it stays up to date with latest standard approved processes and documentation. (ISO, 2006c, p. 21)

Alongside the development of the GPI, they must also facilitate and aid the development of Product Category Rules (PCR) for their program. These documents set guidelines and requirements for creating EPDs for certain product groups. The goal of PCRs is to allow for easier comparability between EPDs made by different authors. This is done by enforcing the same life cycle scenarios and calculation rules on products with similar applications. (ISO, 2006c, p. 25)

The PO must also set up a publicly available database for the published EPD and PCRs and ensure the integrity and consistency of these documents. Also, to facilitate proper disclosure of any conflicts of interest, the PO must also make sure that the identity of all the organizations involved in the program development. (ISO, 2006c, p. 21).

4.1 EPD Program Operators and Product Category Rules

In this chapter, the program operators, their organisation, and operation are introduced. Their systems for managing PCRs and their main PCRs are also covered. There are several program operators active on the market but to introduce them all would be outside the scope of this study. Therefore, a smaller sample group representing the program operators was chosen. The program operators detailed here are the International EPD System, EPD Norge, and RTS. These operators were considered here due to their geographical, i.e., Nordic, relevance and their relevance to the software acting as the basis of the practical part of this study.

In the construction sector, alongside the POs and their PCRs, the creation of EPDs complies with the European standard "EN 15804 Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products" and its two amendments A1 and A2. The standard has been drafted by the CEN/TC 350, a body of the CEN (European Committee of Standardization), which produces standards on the sustainability of construction works.(CEN/TC 350, 2019, pp. 3–4).

The standard acts as the common core PCR for most program operators in Europe and is used as the base for most of their main construction product PCRs. It specifies the main rules for what needs be considered in the EPD and how the information must be presented. The main aim of PCRs in general is to ensure that the EPDs are consistent and comparable. By acting as the main reference to a wide amount of Program operators, it has established many commonly accepted interpretations of the ISO standards. The standard gives guidelines and rulings on how to conduct important LCA processes like LCI, LCIA and how to develop scenarios for life cycle stages outside the main product stage (raw materials and manufacturing) processes. (CEN/TC 350, 2019, p. 5).

4.1.1 EPD International AB

The International EPD system (IES) is an EPD program operated by EPD International AB based in Stockholm, Sweden and owned by the IVL Swedish Environmental Research Institute. They are the world's first operational EPD program and were founded in 1998.

They are the originator of the EPD and PCR, and they follow the ISO 14025, TS/14027, 14040 standards in their operations. More specifically, for the building sector they are compliant with the ISO 21930 and the European EN 15804 standards. They operate globally with many organisations to publish EPDs in nearly 50 countries. (EPD International AB, 2021b)

The management of the International EPD System is divided between a board of directors, an EPD secretariat, a technical committee (TC), and the International advisory board (IAP) a. The board of directors is responsible for the overall program as well as for the strategic and financial aspects, makes sure that the other entities are functioning, and elects the members of the technical committee. However, the main part of the programs management is divided between the other three bodies. The EPD secretariats main task is the operational management of the program. This includes management of the General Program Instruction (GPI), guiding and overseeing the development of PCRs, and managing the database of approved and published EPDs and PCRs. In short, the secretariat is the main body for the day-to-day activities of the program. (EPD International AB, 2021c, p. 5).

Both the committee and the international advisory board are responsible for advising the secretariat in its duties, the main difference being that the former is responsible for technical issues, and the latter for the market issues surrounding EPDs. The TC consists of a panel of LCA experts and acts as the reviewing body for PCR and EPD verifier applications. It supports the secretariat in LCA methodology related issues. The IAB membership in contrast consists mostly of different major stakeholders whose task is to follow the general market situation of EPDs and the IES EPD program in general. (EPD International AB, 2021c, p. 6).

The PCR is developed according to the framework set by EPD International and complements the GPI. The PCR is developed by a PCR Committee. This committee is directed by the PCR Moderator, but the overall process oversight as well as the appointment of the moderator is done by the PO. In the final stages of development, the last affirmation is given by the TC, after which the PCR is published. The GPI gives detailed procedure for the development of the PCR. It contains four phases: Initiation, preparation, open consultation, and review, approval, and publication. The PCRs can be developed by groups of companies or institutions alongside trade associations and interest groups. The process is generally required to be co-operational and involving of multiple corporations. However, singular organisation are allowed to produce PCRs alone if their in-house competence is high enough, or they employ outside expert consultants. (EPD International AB, 2021c, p. 16).

The main PCR of IES for the building sector is the Construction Products PCR 2019:14, which is in its version 1.11 at the time of writing. The PCR serves as the core ruleset for the EN 15805 compliant construction product EPDs. It also acts as the basis for the implementation of complementary PCRs (c-PCRs) which are product group specific iterations of the main PCR and may contain additional rules and demands. (EPD International AB, 2021d, pp. 1–2)

4.1.2 The Norwegian EPD Foundation

EPD Norge is an EPD program based in Norway operated by The Norwegian EPD Foundation. Founded in 2002 by the Norwegian Business and Industry Association, it has since published over 1100 EPDs. They operate mainly in Norway but EPD authors outside Norway can and do publish their EPDs through their EPD program. As with EPD International they are also partners with ECO platform and their EPDs often come with the ECO platform approval. EPD Norge also has mutual recognition agreements with other program operators such as the IES. (EPD Norge, 2021)

Just like other EPD program operators EPD Norge also follows the responsibilities detailed in ISO 14025 for type III environmental declaration program operators. The program is run by a board and a secretariat, as well as a technical committee which supports the former two. In addition, they have established a professional forum, the EPD-Forum, for discussion about EPD and LCA related topics. At EPD Norge the board oversees the development of the GPI, makes sure that the other entities are functioning, and elects the members of the technical committee. The secretariat is responsible for the operational management of the program and through that it acts as the main communicator between all the necessary stakeholders and the program. It publishes EPDs, facilitates the development of the PCRs and follows the development of standards to make sure the PCRs are in line. The technical committee's main task is to provide consultation to the other two bodies on the topics of LCA, checking of applications for external verifiers and EPDs and their final approval. (EPD Norge, 2019, pp. 9–10).

In contrast to the other bodies EPD Norge, the EPD forum does not have direct power in operation or decision making of the program. The forums' main purpose is to assist the secretariat by proposing different initiatives. These can include possible products that might be relevant to the program, new groups for cooperation, new PCRs, and ways to develop the LCA methodology. (EPD Norge, 2019, pp. 10–11).

Just like in IES the framework for the development of PCRs in EPD Norge are set in their GPI. This development is overseen and led by the PCR Governor who establishes and runs the work of a PCR Group. The group is composed of experts and stakeholder from relevant fields in relation to the product group of the PCR. Their task is the actual development and preparation of the PCR (EPD Norge, 2019, p. 13).

The PCR system of EPD Norge, is based on a two-part system., part A and part B. Part A is the common PCR for a given product type, like construction products or packaging, and part B is specific to a certain product category. The main PCR in EPD Norge is the "Part A: Construction Products and Services" which governs most EPDs made for the construction sector. This part A can be used alone when using a declared unit (i.e., mass, volume, or length) but requires part B if the use stage of the products life cycle is included and a functional unit is defined. The program also offers a couple of other standalone PCRs, which combine the attribute of the A and B but most of their PCRs fall within this two part method. (The Norwegian EPD Foundation, 2021, pp. 5–6).

4.1.3 Building Information Foundation RTS sr

In Finland, the main EPD program operator is the Building Information Foundation RTS sr (in Finnish: Rakennustietosäätiö RTS sr). The RTS manages the Finnish EPD-system. The RTS is somewhat different from the previously mentioned program operators in that it is not primarily a program operator, and instead is primarily a private, not-for-profit organization which develops and maintains a comprehensive information database about building products, regulations, and guidelines. The RTS also acts as a certifier for M1 emissions classification. (The Building Information Foundation RTS Sr, 2020a, p. 4).

The entirety of the RTS comprises of multiple committees who get nominated by the General manager. These committees act in the various building industry activities, one of which is the main EPD-system committee, namely the PT18 RTS EPD Principal Committee. Their hold the decision-making power of the program and thus lead the development of the program Rules and Guidelines document. They also make decisions on the development of the RTS PCR, and have the final say on the acceptance of the program's verifiers. (The Building Information Foundation RTS Sr, 2020b, p. 6).

The operational duties of the RTS EPD program fall on the secretary of the PT18 RTS EPD. Their task is to keep the programs PCR in good order and up to date with the relevant standards, such as EN 150804, and to be the voice of the program, i.e., manage cooperation and provide information to stakeholders outside the committee. They are also responsible for the publication of EPDs approved by the workgroup. (The Building Information Foundation RTS Sr, 2020b, p. 6).

The third body of the EPD program is the RTS EPD Work Group, whose primary task is to approve or reject EPDs sent to RTS for publication. They are overseen and approved by the PT18 RTS EPD committee and consists of the secretary of the PT18, and of people with academic and NGO Backgrounds. Alongside the approval of EPDs, their tasks include the pre-handling of issues related to the RTS PCR development and the to be the first body to check any possible complaints coming to RTS concerning EPDs. (The Building Information Foundation RTS Sr, 2020b, p. 7).

In contrast to the other program operators mentioned RTS only has one PCR document, the RTS PCR, which considers construction products. The program does not offer any complementary PCRs but does accept their use if they do not conflict with the RTS PCR (The Building Information Foundation RTS Sr, 2020b, pp. 10–11). As mentioned before, the updating of the PCR is done by the PT18, but no further process has been setup for development of additional PCRs. The PCR largely follows the guidelines of EN 15804+A2:2019 and references it often but there are some specific points here RTS requires more from the EPD author. These include certain tables and data presentation forms some of which are detailed in RTS' own model EPDs. (The Building Information Foundation RTS Sr, 2020c, p. 4).

4.1.4 Other program operators

Alongside the Nordic program operators there is a large number of national program operators and international organizations which work within the EPD market. Other very relevant program operators which were not mentioned previously are the French INIES, US based UL Environment, and the German IBU. These three are also the largest program operators by the sheer volume of EPDs they publish. However, due to their large domestic markets they also place a lot of weight to specific local demands. This is somewhat true to nearly all national program operators, like the RTS, but both the French INIES and UL environment require, for example, many additional impact indicators in addition to the ones mandated by the EN 15804+A2:2019.

Another organization very relevant to the field is ECO platform, an umbrella organization for type III EPD program operators, which facilitates mutual recognition between its associate partners. It was set up by the major program operators to increase cooperation and harmonization of EPD and PCR development in the construction sector. It maintains and develops a database of all ECO EPDs, meaning EPDs published by associate program operators. All the program operators presented in this chapter are members of ECO Platform. (Eco Platform, 2021).

5 THE VERIFICATION PROCESS IN A PRE-VERIFIED EPD TOOL

The purpose of this chapter is to introduce the basic functionalities of the studied LCA software and the issues it faces with the demands of the verification process. The software in question is One Click LCA, is developed by One Click LCA Ltd. It is a web-based solution for carrying out LCA, primarily in the construction sector.

The Pre-Verified EPD Generator is an LCA calculation tool part of the One Click LCA software. Its purpose is to make EPD creation simpler, faster, and cheaper. It aims to achieve this by pre-verification of the tool (One Click LCA Ltd, 2021a). The tool has a pre-defined structure which needs to be filled by the user and is verified in advance by a third-party verifier and accepted by an EPD program operator. The tool follows a questionnaire type structure which has data search boxes from which the user chooses datapoints to model their product. The questionnaire also includes text fields that ask for specific textual information required by the relevant standards and the agreements made in the pre-verification of the tool itself. (One Click LCA Ltd, 2021b).

The different questionnaires are presented as tabs which each represent a distinct phase in the project flow. The tabs cover Product and author descriptions, LCA modelling, and background documentation. For demonstration the first questions of the “Product description” and “Materials (A1-A3)” -tabs of the EPD-tool are presented in Figure 4 and Figure 5. The overall questionnaire structure of the software is shown in

Figure 4. An LCA model design view on the Product description tab of the EPD Generator. (One Click LCA Ltd, 2021b).

Figure 5. An LCA model design view on the Materials (A1-A3) tab of the EPD Generator. (One Click LCA Ltd, 2021b).

The tool functions essentially as a preliminary setter of system boundaries, as well as a designator of inventory and emissions data in the correct modules as mandated in the standard EN 15804+A2:2019. The tools queries are divided into sections according to the standards' modularity principle, into A1-A3, A4, A5, B1-B7, C1-C4, and modules, into which the user enters appropriate emissions profiles according to the tools instructions. (One Click LCA Ltd, 2021b).

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These modules describe the life cycle stages in the construction product's context and define the way the life cycle inventory and emissions must be presented when creating EPDs for the construction sector according to EN 15804+A2:2019. A1-A3 describes the products stage (A1 is raw materials, A2 transport to manufacturing, and A3 is manufacturing), A4-A4 describe the construction stage (A4 is transport to the construction site and A5 includes the installation procedures), B1-B7 describes the use stage (B1-B5 includes use, maintenance, repair and refurbishment materials and processes), and finally C1-C4 describe the end of life of the product (C1 is deconstruction, C2 transport to waste treatment, C3 includes processes required for recycling, recovery and re-use, and C4 is final disposal). Finally D module describes benefits and loads beyond the system boundary. The tool sections and their question structure according to the modular structure are presented in Appendix I. (CEN/TC 350, 2019, pp. 15–17).

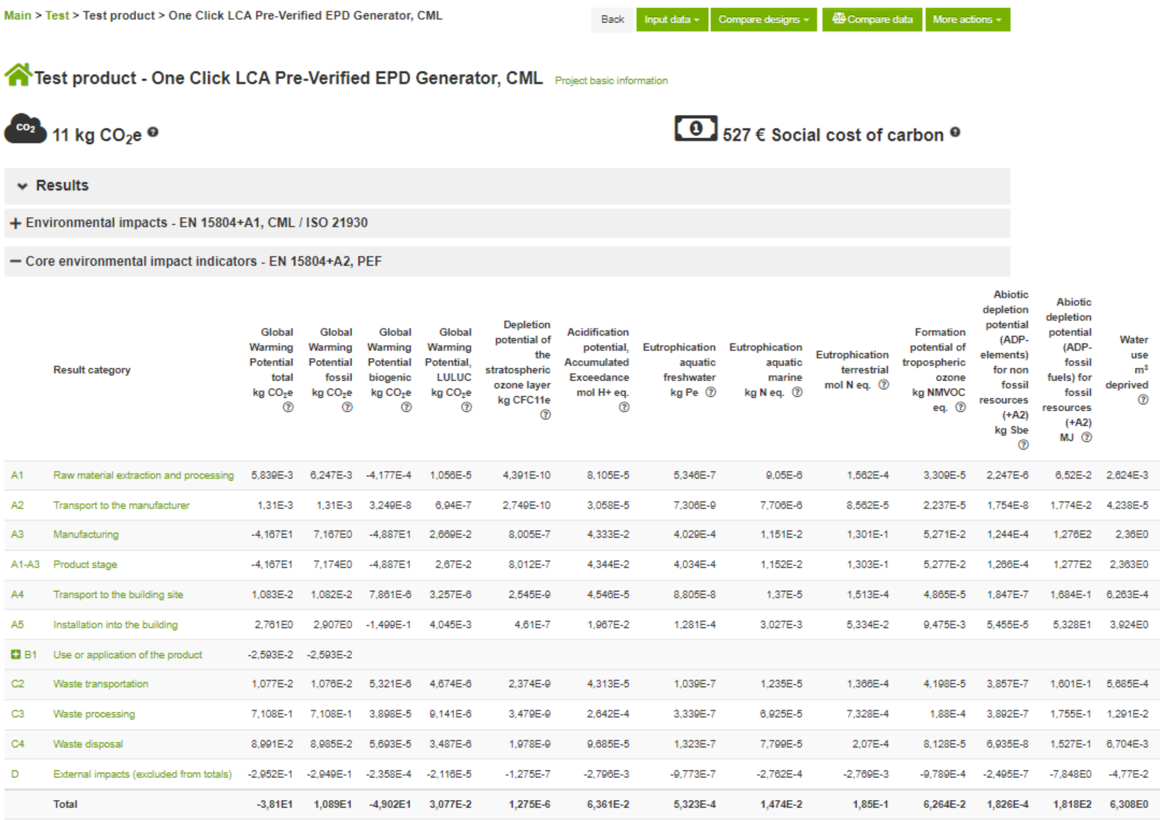
In the context of the LCA methodology, the tools use is placed in the Inventory assessment and Life Cycle Impact Assessment phase of the study. However, as the inventory gathering is limited to the manufacturer data (the LCA data is already in the tool) and that has to happen outside the tool, most of the work the user does with the tool is part of the impact assessment, and consists of matching appropriate LCA datasets with their manufacturing data (consumed materials and energy, generated wastes etc,). The goal and scope are also largely pre-determined by the nature of the tool, which is to produce third party verified EPDs for both Business-to-Business and Business-to-consumer communication. The scope can still somewhat be changed as per the allowed inclusion and exclusion of the life cycle modules according to EN 15804+A2:2019, but apart form that it is fixed. The scope is also quite heavily restricted in terms of data inclusion as the user does not have access to change foreground data or the methodology within the used data.

The principal background LCA database used in the tool is the Ecoinvent 3.6 database, which provides a very comprehensive and robust inventory of LCA profiles (One Click LCA Ltd, 2021a). Ecoinvent follows and builds upon the LCA methodology conceived by ISO (Weidema et al., 2013, p. 6). The LCA profiles used in the OCL software are based on Ecoinvents 'allocation, cut-off by classification' system model. This method is based on the 'polluter pays principle' which assigns full responsibility of emissions and wastes to the product system which generates them. This principle is one of the two underlying principles in the system boundary setting of EN 15804+A2:2019, the other being the previously mentioned 'modularity principle (CEN/TC 350, 2019, p. 20). Ecoinvent data includes all the necessary impact indicators required in an EPD according to EN15804+A2:2019 and can therefore be used in making EPDs declaring compliance with the new standard amendment.

The tool use is roughly divided into two areas, documentation, and modelling. First of these is the user simply writing into free text fields according to instructions given by the numerous help texts in the tool. Some of these text fields can be seen in Figure 4. The second is slightly more complicated but still quite straightforward, at least in relation to its functionality in the tool. In the second method of using the software is modelling, presented in Figure 5, where the user picks datapoints by entering keywords into the search fields. After receiving inputs form the user, the tool presents LCA datapoints form the OCL database in a drop-down menu. In the EPD tool these are mostly Ecoinvent datapoints, but depending on the user, others may be added. EPDs are also available, but their use is discouraged as most of the EPDs currently in use are based on the old standard amendment EN 15804+A1:2013, and thus cannot be used to make EPDs compliant with the new standard amendment. The user chooses datapoints that best match the materials, energy, and waste processing used in the product system that is being modelled.

Results for the life cycle assessment calculations are given in the "Results"- tab in table format. The tools main impact results are given according to the requirements of EN 15805+A2:2019. These include Global Warming Potential (GWP), Ozone Depletion

Potential (ODP), Acidification potential (AP), and Eutrophication potential (EP). Full presentation of the core environmental indicators according to the EN 15804+A2:2019 are presented in Figure 6.


Main > Test > Test product > One Click LCA Pre-Verified EPD Generator, CML

Back | Input data | Compare designs | Compare data | More actions

Test product - One Click LCA Pre-Verified EPD Generator, CML — Project basic information

11 kg CO_2e

527 € Social cost of carbon

Results

+ Environmental impacts - EN 15804+A1, CML / ISO 21930

− Core environmental impact indicators - EN 15804+A2, PEF

	Result category	Global Warming Potential total kg CO_2e	Global Warming Potential fossil kg CO_2e	Global Warming Potential biogenic kg CO_2e	Global Warming Potential, LULUC kg CO_2e	Depletion potential of the stratospheric ozone layer kg CFC11e	Acidification potential, Accumulated Exceedance mol H+ eq.	Eutrophication aquatic freshwater kg Pe	Eutrophication aquatic marine kg N eq.	Eutrophication terrestrial mol N eq.	Formation potential of tropospheric ozone kg NMVOC eq.	Abiotic depletion potential (ADP-elements) for non fossil resources (+A2) kg Sbe	Abiotic depletion potential (ADP-fossil fuels) for fossil resources (+A2) MJ	Water use m³ deprived
A1	Raw material extraction and processing	5,839E-3	6,247E-3	-4,177E-4	1,056E-5	4,391E-10	8,105E-5	5,346E-7	9,05E-6	1,562E-4	3,309E-5	2,247E-6	6,52E-2	2,624E-3
A2	Transport to the manufacturer	1,31E-3	1,31E-3	3,249E-8	6,94E-7	2,749E-10	3,058E-5	7,306E-9	7,706E-6	8,562E-5	2,237E-5	1,754E-8	1,774E-2	4,238E-5
A3	Manufacturing	-4,167E1	7,167E0	-4,887E1	2,669E-2	8,005E-7	4,333E-2	4,029E-4	1,151E-2	1,301E-1	5,271E-2	1,244E-4	1,276E2	2,36E0
A1-A3	Product stage	-4,167E1	7,174E0	-4,887E1	2,67E-2	8,012E-7	4,344E-2	4,034E-4	1,152E-2	1,303E-1	5,277E-2	1,266E-4	1,277E2	2,363E0
A4	Transport to the building site	1,083E-2	1,082E-2	7,861E-6	3,257E-6	2,545E-9	4,546E-5	8,805E-8	1,37E-5	1,513E-4	4,865E-5	1,847E-7	1,684E-1	6,263E-4
A5	Installation into the building	2,761E0	2,907E0	-1,499E-1	4,045E-3	4,61E-7	1,967E-2	1,281E-4	3,027E-3	5,334E-2	9,475E-3	5,455E-5	5,328E1	3,924E0
B1	Use or application of the product	-2,593E-2	-2,593E-2											
C2	Waste transportation	1,077E-2	1,076E-2	5,321E-6	4,674E-6	2,374E-9	4,313E-5	1,039E-7	1,235E-5	1,366E-4	4,198E-5	3,857E-7	1,601E-1	5,685E-4
C3	Waste processing	7,108E-1	7,108E-1	3,898E-5	9,141E-6	3,479E-9	2,642E-4	3,339E-7	6,925E-5	7,328E-4	1,88E-4	3,892E-7	1,755E-1	1,291E-2
C4	Waste disposal	8,991E-2	8,985E-2	5,693E-5	3,487E-6	1,978E-9	9,685E-5	1,323E-7	7,799E-5	2,07E-4	8,128E-5	6,935E-8	1,527E-1	6,704E-3
D	External impacts (excluded from totals)	-2,952E-1	-2,949E-1	-2,358E-4	-2,116E-5	-1,275E-7	-2,796E-3	-9,773E-7	-2,762E-4	-2,769E-3	-9,789E-4	-2,495E-7	-7,848E0	-4,77E-2
	Total	**-3,81E1**	**1,089E1**	**-4,902E1**	**3,077E-2**	**1,275E-6**	**6,361E-2**	**5,323E-4**	**1,474E-2**	**1,85E-1**	**6,264E-2**	**1,826E-4**	**1,818E2**	**6,308E0**

Figure 6. Screen capture of the OCL Environmental impact results tab. (One Click LCA Ltd, 2021c).

A major part of the tool functionality is the ability to print out pre-made EPD documents necessary for the verification and publishing. The tool allows the user to generate EPD- and background report documents. The generated documents have a pre-set structure with the format done according to the LCA and EPD standards (ISO 14044, ISO 14025, and EN 150804+A2). The feature is presented in Figure 7.

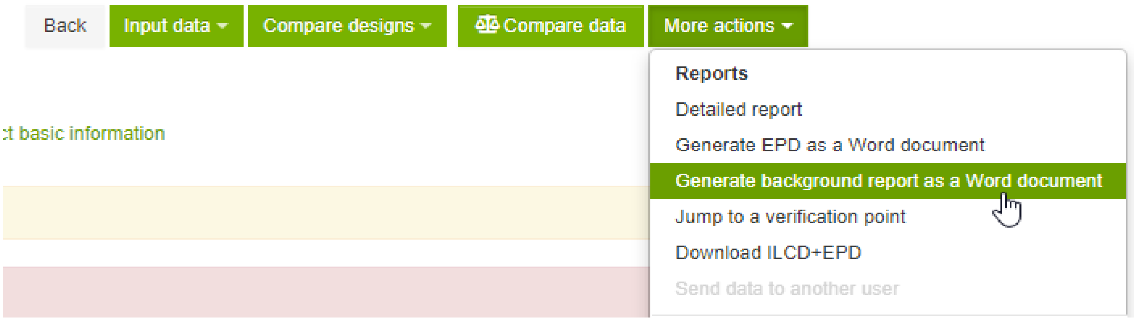


Figure 7. Screen capture of the OCL results page feature allowing the user to print out the EPD-documents required for the verification. (One Click LCA Ltd, 2021c).

The documents are populated with the inputs the user makes in the software, including the textual content, and the automatic documentation of the used LCA datasets and the impact assessment results. The textual content consists of, among other LCA documentation, the product and manufacturing descriptions, descriptions about the content and modelling of the various life cycle stages, and the assumptions made and interpretation of the results.

The documentation of the used LCA data inventory is done through automatically generated tables which include the names of the datapoints, their representativeness, and their reference unit quantity used in the calculation. Result of the study are also automatically documented on the reports and appear in a table format. The reports are also partially populated by static texts and tables which contain mandatory statements and data presentation which do not need to be changed by the user.

5.1 The Pre-Verification

The verification process is a time intensive, yet an integral part of the type III environmental product declaration. The most robust of these being a third-party verification, which makes the resulting EPD an environmental label of a very high standard. This however, combined with the difficult process of collecting data and putting together an LCA model, also makes it very expensive.

Returning on the EPD verification types we can reflect on their relationship with the strictly external third-party verification. The verification process can be evaluated for example by its speed, quality, and price. To get perspective of how the different methods can be compared, the different methods are assigned grades (Low, Medium, High). The grades are not definite, and instead their purpose is to be indicative of the approximate performance of each method in comparison not one another. The grades are also not based on any quantitative studies and have been made by qualitative evaluation of the previously defined verification types. The verification types and their characteristics are presented in Table 4.

Table 4. EPD Verification types (Adapted from One Click LCA Ltd, 2021d)

	No verification (ISO 14024)	**Internal verification (ISO 14025)**	**Third party verification (ISO 14025)**	**Computer verification**
Speed	Varies	Low	Low	High
Quality	Varies	Low/Medium	High	Low
Price	Varies	Medium	High	Low

The One Click LCA Pre-Verified tool attempts to combine the advantages of the highly efficient computer verification, while attaining the robustness of an actual third-party verification and retain strong compliance with ISO 14025. The pre-verification thus works to decrease the documentation and modelling load of the user. The software structure and features, database, and premade content set up a partly closed framework in which the user must operate. The database relying on Ecoinvent, forces an uniform application of allocation on the background LCA data which the user cannot change. The structure of the queries, and therefore the inputs and outputs, enforce the modular life cycle stage structure according to EN15804:A2.

In order to understand how the premade content functions, it is necessary to go through the pre-verification process itself. The pre-verification of the OCL Pre-Verified tool is generally done for specific product category and for a specific PO. Currently the tool has a pre-verified status for two program operators RTS and the IES. For IES, the tool has only category, which covers the entirety of the construction sector (EPD International AB, 2021e). RTS on the other hand has demanded the pre-verification to be done for more specific categories, such as cementitious products, steel products and wood products (The Building Information Foundation RTS sr, 2021).

During the pre-verification, the tool is used to produce several designs which are sent alongside other required documentation to the PO. The purpose of this sample of EPD designs is to act as a showcasing of the tools capability to handle the modelling of that product category. This is where the name pre-verification comes form, the tools competency for modelling a certain product has been demonstrated before any EPDs have been made. In addition to allowing for a lighter form of verification conducted for EPDs made with the tool, lowering the process for verification, the POs also demand lower prices for publishing these EPDs. Going through further specifications on how the software is reviewed during the pre-verification is outside the scope of this study, but the actions taken to showcase tool functionality and the set up for a specific category will be explained.

To make sure that the demonstrated modelling and data are used in the subsequent EPDs made with the tool, the sample EPDs made for the pre-verification are used to create product category specific templates and datalists. For IES this does not need to be done as the category covers the entire construction product category, but for RTS this is always the case. For RTS each new category requires another pre-verification, and new templates made, but for IES new category templates can be created as needed without additional verification.

Regardless of PO, the new templates and datalists are created either as a project from a client, who wishes that their products would be available for the pre-verified tool, or as an internal project initiated by OCL. In the former case, the models made are based on a customer's product, and in the latter on OCL own research and data. The templates and datalists act as a guidance document and a ruleset for authors using the tool for that product category, aiming to ensure that the accepted modelling practises are followed.

Currently there are 17 pre-verified product categories. Some of the categories also have multiple templates when the created category is too large to be covered with a single template. As of now, there exists templates for 23 different product types, with more under development. A non-exhaustive list of product category templates is presented as they appear in the software page in Figure 8.

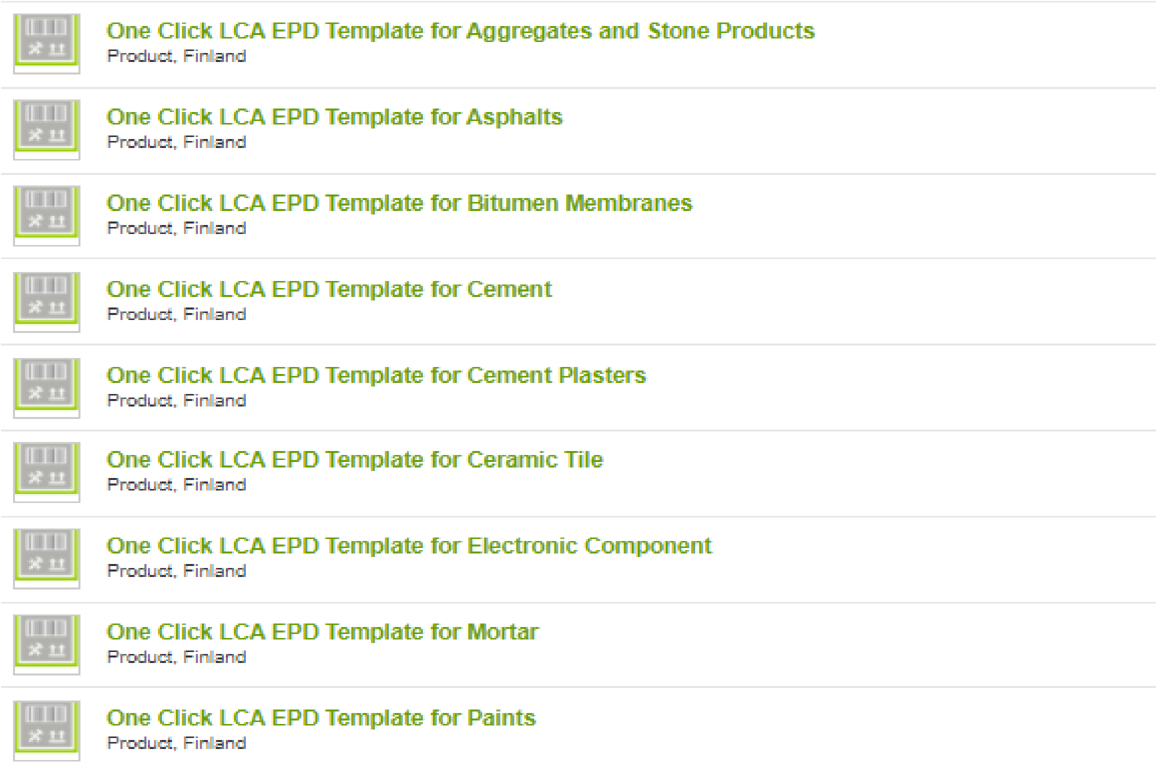


Figure 8. Screen capture of the One Click LCA EPD Templates for various product categories.(One Click LCA Ltd, 2021e).

The template itself is a design in the OCL software which has most of its questionnaires pre-filled. The design is the same kind that a user would make themselves but includes a premade LCA model, which acts as a guide for the user of the pre-verified tool. This includes both the textual content and the LCA datapoints which are used to calculate the impacts. Each user gets a template to match their product category (i.e., steel, concrete, plastic) the purpose of which is to allow for faster adoption of the correct modelling and reporting principles. The user can copy the model and use it as a basis for their own product LCA project which, alongside the premade data list, should give them the ability go through the EPD creation without major issues.

The templates datalists made in conjunction with the templates offer product group specific and relevant data. The data includes, for example, raw material, manufacturing, and end-of-life data specific to the product groups, i.e., cement and aggregate data for cementitious products and plastic constituent data for plastic pipes. The pre-verified generator also includes product group templates which are premade LCA models made with the software.

These datasets are chosen both because of the pre-verification process where the tools capability to handle a certain product category is reviewed, and as an extrapolation of this review by expert opinion. The data lists are primarily applicable to the specific products modelled for the pre-verification However, through the additional extrapolation, can made applicable to the wider product category the tool is receiving the pre-verification for. A non-exhaustive sample list of the available datasets is shown in Figure 9.

Reference Lists	Data list type
Steel products One Click LCA core raw materials	Ecoinvent
PEX pipes One Click LCA core raw materials	Ecoinvent
Asphalt and aggregate One Click LCA core raw materials	Ecoinvent
Ready-mix concrete One Click LCA core raw materials	Ecoinvent
European waste treatment One Click LCA core waste datasets	Ecoinvent
Europe and world fuel datasets	Ecoinvent
Cementitious products One Click LCA core raw materials	Ecoinvent

Figure 9. Screen capture of the One Click LCA EPD Data lists for various product categories. (One Click LCA Ltd, 2021f).

The final part of the pre-verification is the process set up by One Click LCA to audit the inputs made by the tool user. The audit is done by the Appointed Data Controller (ADC). This data controller check is part of the pre-verified process that attempts minimize the number of mistakes in the documents going to the actual verification. The ADC goes through the model to make sure that the user has used the software correctly, and also checks that no outrageous errors have been made in the data selection. They also check that all the basic requirements in reporting are met and the background report and EPD do not have places that do not have anything reported in them. The ADC does not conduct a full verification and so does not promise a instant pass on the actual verification.

In conclusion, the pre-verification aims to decrease the total time spent in the EPD project by doing large parts of it beforehand. This is done by demonstrating to the PO beforehand that the software is capable in handling specific products, giving the user access to pre-selected data and LCA modelling templates, as well as providing partly prepopulated reports. In theory, this should be extremely helpful for EPD creators, especially for people and companies who have no previous experience with EPDs. For them, the time used in creating the first EPD studies should decrease considerably in comparison of starting from scratch.

5.1.1 Customer satisfaction and verification success

Even though the tool currently answers many of the demands of an EPD verification by the way of pre-verification, there are still issues. One Click LCA Ltd has conducted a customer satisfaction survey which indicates how the customers view their user experience both with the tool itself and the associated customer support. It is aimed at gaining a net promoter score which measures the willingness of the user to recommend the tool to a colleague.

Looking at the users who answered in the product level tool category, the result is generally quite positive with a total score above 8 (score range is 1-10), with the number of users taking part in the survey being 34 (One Click LCA Ltd, 2021g). This category covers all product level tools and not only the pre-verified tool but they are similar enough so the score can be used to represent the category in general. Despite the generally favourable outlook of the results, a few issues are pointed out.

Those users who have given a rating of 7 or lower, meaning it being less likely that they will recommend the program, point towards a few distinct issues. One of these is a lack of clarity on how some of the inputs in the software translate to content on the generated documents. Another issue is that software still has points in which the user must manually include some things into the final documents, and the difficulty of knowing what to include. Finally, and perhaps most importantly there seems to be a general lack of visibility on the correct application of the tool to answer the verifiers demands pre-emptively. Most of these issues tend to only appear after the verification has begun. This causes unforeseen delays in the final approval of the EPD and therefore dissatisfaction with the entire process. A more robust system where the tools, and therefore the verifications, demands are more transparently presented and communicated would likely solve many of these issues.

One Click CLA has also followed the success rate of the verifications done for the EPDs made with their software. One such indicator is the average of rounds in an average verification of a single EPD. The sample size is quite small for the actual data gathered due to this not being documented previously, but it still gives some information how verifications go in this environment, according to the data, the average number of rounds in a given verification is two, meaning that the user has sent their documents to the verifier for review two times before acceptance. (One Click LCA Ltd, 2021h).

The reasons for the verification returns are varied. There are a lot of compliance, data handling and documentation related issues that need to be covered in the EPD, and the LCA study required for it. The number of returns depend heavily on the authors previous experience in both LCA, scientific reporting, and even office software use.

Looking at the amount of checks the number does not seem high. However, this is after the checks done by the One Click LCA Appointed Data Controller (ADC) assigned to the EPD project. The number of bounces here can be as high as three but in general the amount is only one. Although these checks are much faster than the verifiers and decrease the time in actual verification, this still creates additional workload and therefore also consumes time.

Often the program operators also check the documents before the final approval and can ask additional questions about the LCA. Here the number of bounces are also range from 0 to 3. In total the number of rounds in the verification of an EPD using the pre-verified tool can, depending on the experience of the EPD author, ADC, verifier, and the PO, range from just a few to six. This indicates some systematic issues either in the software itself or in the way it is being used.

5.2 Verification demands and issues in the tool

A few main categories can be identified that the EPD verification aims to achieve. First is to ensure the formal correctness of the delivered documentation, the EPD document that the author wishes to publish, and the LCA Background report that documents the LCA study. These include the structure of the documents, naming conventions, and reporting of necessary contact and validity related details.

The second is the assessment of completeness, i.e., does the LCA study behind the EPD take all the necessary factors into consideration in both data collection, handling and result calculation, and are any deviations properly and transparently presented. This includes for example, if all the processes one could expect of the product system in question are considered in the study.

The third is the documentation comprehensibility. Here the targets of scrutiny are the reporting and presentation methods of the author. The checks here include evaluation of the understandability of the documents, especially the EPD document. The information being offered must be in a format where the reader can understand what type of product is being studied. Especially the verifier must be able to understand what each piece of information represents and what effects it has on the study as a whole.

The fourth and final category is the mathematical plausibility of the data and calculations that form the core of the study. Here the verifier goes through the inputs and outputs and checks if the make sense. The study data and results must be consistent and sensible both internally and compared to other similar studies made previously.

The tool has been pre-verified to meet some these demands on behalf of the user. However, that doesn’t mean that the actual third-party verification can be overlooked. The pre-verification means that there is less work for both the user and the verifier during the procedure, but the verifier is still required to go through roughly the same checks as during normal verification. The pre-verification helps the verifier get assurance that the process and background data with which the EPD is conceived are valid but does not entirely prevent wrong modelling choices for example. This means that there is still room for error. In order to get better information about the possible issues, the tools users' performance in verification needs to be evaluated.

As mentioned before, the tool has pre-verification status for both RTS and IES. In terms of verification both program operators follow the ISO 14025 standard but have slightly different interpretations of the same rules. Also, they both are compliant with EN 15804+A2:2019 and any differences in their compliance are mostly to do with different scales of adoption of this new amendment. For example, the RTS verification checklist has not been updated to the new standard. However, this divergency in their compliancy is only superficial as the demands during verification and in their work group meetings are set according to the new amendment, as is the latest version of their PCR. Therefore, as the differences in the demands of the program operator are not very large, and the vast majority of EPDs made with OCL-software have been and are still published by RTS (as of now, none have been published by IES and just a few with other operators), the demands of verification are handled from that perspective.

To get a better look at where the actual issues arise, there is a need for more specific information on the problems uncovered by the verifier. A review is needed on the issues found by the ADC, Verifier, and the PO. However, there is a lack of available information on the ADC and PO checks. The checks performed by the ADC have been very consultative and therefore have not followed the same documented communication as in the official verification stage. Instead, they have been very informal in nature. The same issues affect the last round of reviews done by the program operators technical committee themselves, and as such the results of those studies are mostly lost in different email inboxes, making data gathering very time difficult and time consuming. Therefore, as the only properly documented sources for this information come from the verifier, only those are used as material for this review.

5.2.1 Time spent in verification

Before going into further detail with the communication log review, some important information about the duration of the verification can be gained. Looking at the logged creation and finalization dates of the communication log, the time between the first round of verification and the last can be measured. This is the approximate gross time spent in verification. It includes the time spent by the verifier in the performing and documenting of the checks, time spent by the author in application of the necessary fixes and answering the verifiers questions, as well as the time lag in between. Looking at the overall sample, there is a huge difference between the minimum and maximum in sample group.

Taking a closer look at the EPD project documentation of the EPDs in verification, it can be found that the reason for this is both in the experience of the author and the verifier in using the and checking the documents in the software. At the higher end the users tend to be new to LCA in general and not just to EPDs, and in the lower end they are often LCA experts. On the verifiers side, after they get familiar with the software and the pre-verified process, the time spent in verification drops tremendously, especially if the author has previously submitted EPDs to the same verifier. This increase in efficiency adds up the more EPDs the author produces.

Another factor also affecting this is the amount of resources allocated to the project by the author's company. At the extreme high end of the timescale the author of the LCA seems to often be simultaneously working with other projects, sometimes dropping it for extended periods of time. In the lower end there is often a dedicated person doing the study, with stricter deadlines. Simple statistics for the time spent in verification are presented in Table 5.

Table 5. Verification time statistics.

Value	**Days in verification**
Min	0
Max	142
Average	13,8
Median	6

5.2.2 Verification communication log review

The review is done by collecting and reviewing verification communication logs made by third-party verifiers checking EPDs made by the OCL EPD tool. The method for this review is as follows. An amount of 75 logs is extracted from the project archives of One Click LCA. Those verification logs older than 2 years are immediately excluded as they are deemed to not represent a recent enough version of the software. Some logs were also excluded if they did not contain valuable data i.e., just a comment that no issues were identified, or only notes about grammar.

The verification logs gathered for the review come from EPDs made for 32 different manufacturers and are made by 10 different verifiers. A vast majority of these represent verification done for RTS. The sample gathered for this review covers a large portion of the verifications ever done using the One Click LCA Pre-Verified tool and as such can be deemed to be representable of the average verification process done for an EPD made with the software. The total amounts of gathered, accepted, and excluded logs are shown in Table 6.

Table 6. EPD verification log review

EPD verification log review	Included in review	Excluded from review	Total logs checked
EPD verification logs	35	40	75
Manufacturers	20	12	32
Verifiers	6	4	10

All the comments given by the verifier are documented in an excel file list adapted from the verification checklist available at the RTS website. The list of demands from RTS chosen as the basis as most of the verifications included in this review were done for EPDs published by RTS and therefore any comments from the verifier reference the RTS checklist.

Both the data about the comments quantity and quality are collected. These include simply counting the number of instances a certain check finds an issue in the EPD authors methodology and documentation, as well as documenting the underlying issue presented by the verifier and the consequent answer by the author. Using these it is possible to assess the number of times certain issues have popped up during verification and the gain perspective on the level of complexity these issues generally have.

Some of the comments have been reassigned to different issue topics than what the verifier had marked them as, as there was some variance between them in the way they marked issues. There was also variance in the issue logging within the different EPDs checked by the same verifier, and in the comments within the same verification. The reassignments were done to make the comment assignment methodology more consistent across the entire log sample.

The comments are first presented in categories to provide an overview of the whole sample. The presented categorization is done partly in line with the RTS checklist but heavily adapted for visual and contextual clarity purposes. The categories are also further divided according to the ISO 14040 to showcase how the issues align with the LCA methodology. The background report, designated as part B in the checklist, is reviewed first. The resulting data is presented in

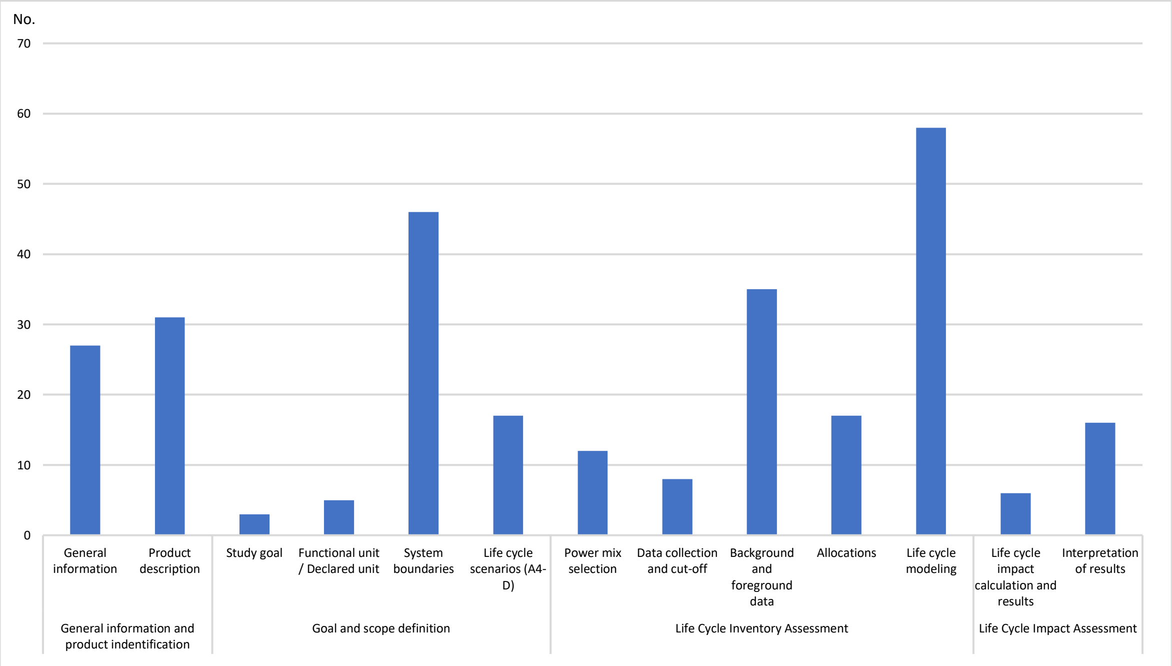


Figure 10.

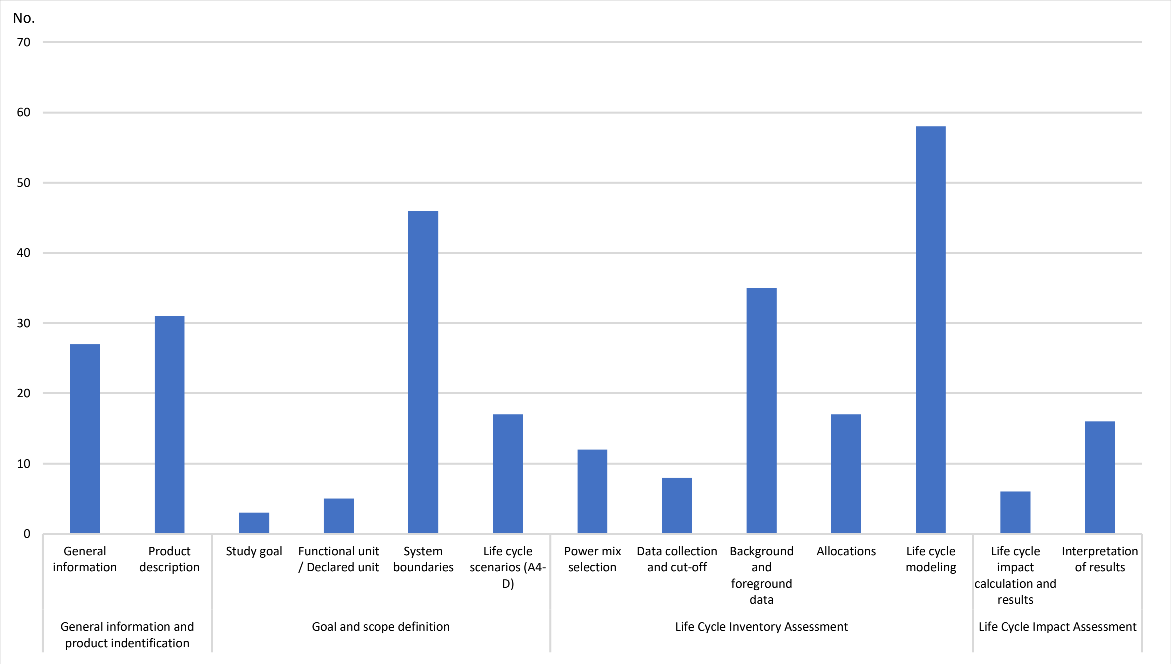


Figure 10. Number of verifier comments from LCA report section (Part A) of the RTS checklist.

The distribution of the issues picked up are quite heavily situated in the part A of the checklist, i.e., the background LCA project report. In part A, most of the comments are given about two check categories, System boundaries, and Life cycle modelling. These categories are wide and encompass many subjects so a large number of errors is somewhat natural, though this high a number does point towards some specific issues. Many issues have also been noticed by the verifier in the General information, Product description, Background and foreground data, Life cycle scenarios, Allocations, and Interpretation sections

Looking only at the broad categories and their number of comments does not yield much information about what errors the users are making. To get a more accurate look at the individual checks, the categories need to be analysed in greater detail. The background report comments are given a closer look by checking the specific verification check topics the comments have been given on. Much like the categories, the nomenclature of the presented topics is not fully aligned with the checks present in the RTS checklist. They have been modified to allow for easier understanding and clearer presentation. The issues are presented along the lines of the LCA framework. The shares of issues found by the verifier in the General information and product identification are presented in Figure 11.

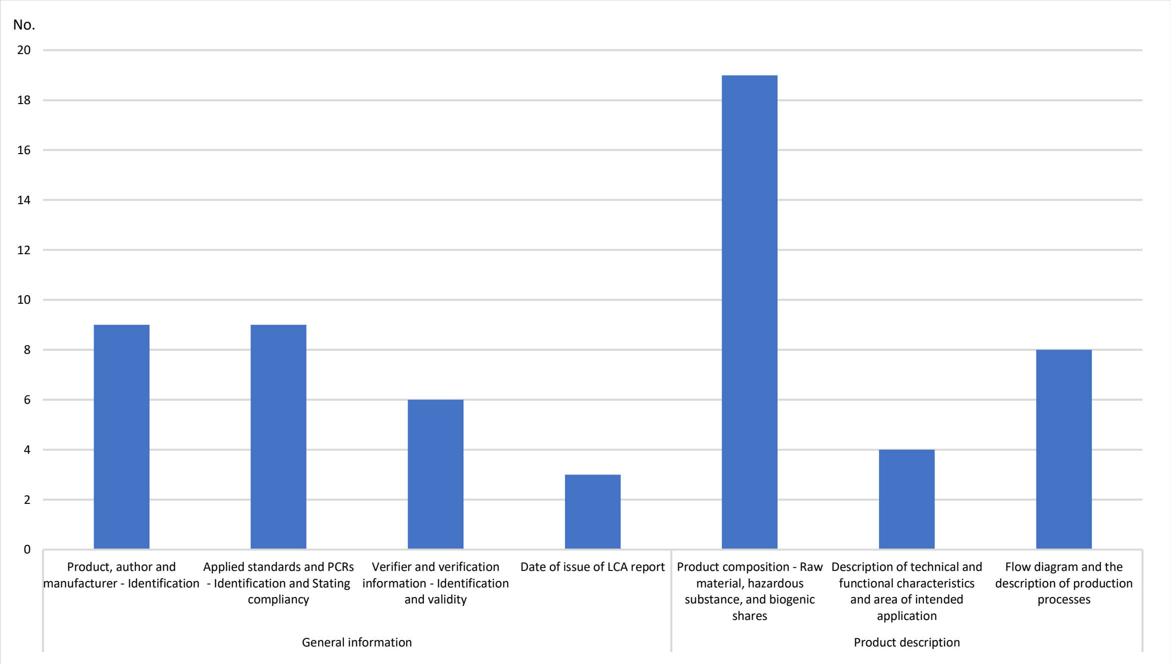


Figure 11. Number of verifier comments for issues related to general information and product description.

Mistakes in the disclosure of the product composition seems to be the largest source of mistakes in these categories. The most common issue with the product composition is the reporting of biogenic carbon in the product's raw materials. The users often either leave it out when it should have been reported or there are inconsistencies in the written parts of the report and with the state of disclosing the numerical values of the biogenic carbon.

Looking at the problems with the raw material composition reporting itself, the verifier has found inconsistencies between the written descriptions of the product or identified clear deficiencies in the reported composition itself. The composition is often simply miscalculated resulting in too high or low in total percentage (e.g., 100,1 %). The comments also point to a lack of accuracy in the material shares, which are in many cases reported as ranges. This is allowed, but sometimes the ranges are so high that no meaningful information can be gotten from them. Looking at the author answers to this, there seems to be some hesitancy in giving away information about the accurate product formulation, and because of this, getting this information often requires direct prompting from the verifier.

A significant portion of the verifier's comments are also centred around the identification of the product, manufacturer and on the correct documentation of the used PCR. Here many issues arise from the incorrect or insufficient reporting of the product name and the manufacturer location. The verifier often has to point out missing contact or personnel details. Also, the location of the manufacturer is often left out from all the required places. Recurring issue with these seems to be that the author gets confused about all the places the general information needs to be reported.

Other issues worth discussing include problems with the visual presentation of the product system and the disclosure of the product material composition. Looking at the comments, the issue is often that the flow charts presented of the products manufacturing are not clear enough to be understood by the verifier. Related to this, it seems that these diagrams are often in conflict with the rest of the report, either due to a lack of visibility of the EPD author on the actual process, possibly due to difficulty of obtaining such information, or due to honest errors made during the drawing of said charts. The shares of major issues within the system boundary category are shown in in Figure 12,

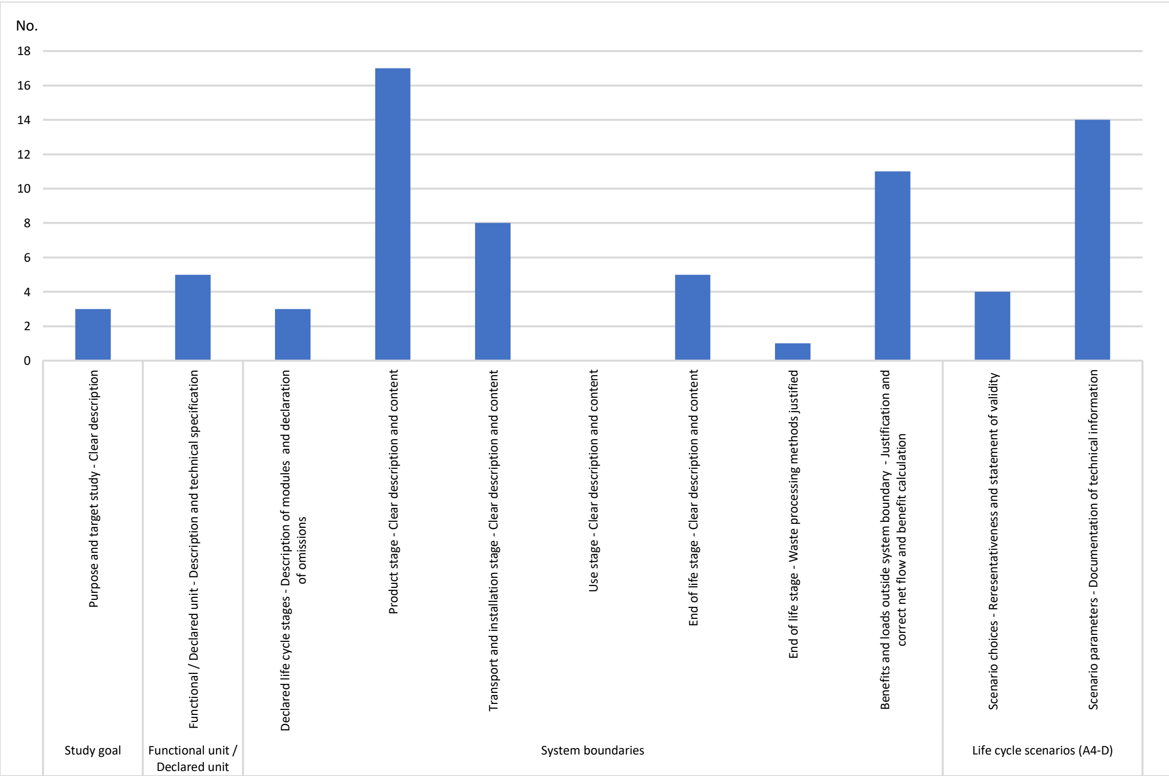


Figure 12. Number of verifier comments for the goal and scope of the study.

The two largest sources for issues here are the System boundaries and the Life cycle scenarios categories. Looking at the verifier comments and author answers on these categories, there seems to be a general difficulty in properly describing the processes within the various modules of the LCA. More specifically the issues come from three places, the description of the product stage, the benefits and loads beyond the system boundary, and the documentation of technical parameters related to life cycle stages outside product stage.

Taking a look at the issues surrounding Product description, the verifier is often not able to get a good picture of the processes being described in the level of detail given by the EPD author. The descriptions of the raw materials, their transport, and the manufacturing processes are commonly written too ambiguously to be perfectly understood by the verifier. One of the themes that stand out is the reporting of secondary materials in the product seems to cause confusion among the authors.

The same theme gets repeated on the other side of the life cycle. When reporting the benefits and loads happening outside the defined system boundary, the users often miscalculate the net flows of recovered materials and therefore also the net benefits of recycling. Concepts like point of substitution, end-of-waste (the state at which the material undergoing end of life processes stops being waste), and the consideration of input recycled material in the benefits are seen as hard difficult to understand.

The issues of documentation of technical information about the life cycle scenarios is mostly concentrated around reporting information about the transport to the construction site. The users are repeatedly failing to provide the necessary technical scenario information about the transportation, such as bulk density and transport capacity that the verifier demands. Users seldom know where or how to get these values from the manufacturer data and are very uncertain about how to estimate them by calculation.

The next LCA stage, Life cycle inventory assessment, has a lot of content to cover in the log review. For this reason, its presentation is divided in two to make it more legible. The first part of the graphic visualization of the comment distribution is presented in Figure 13.

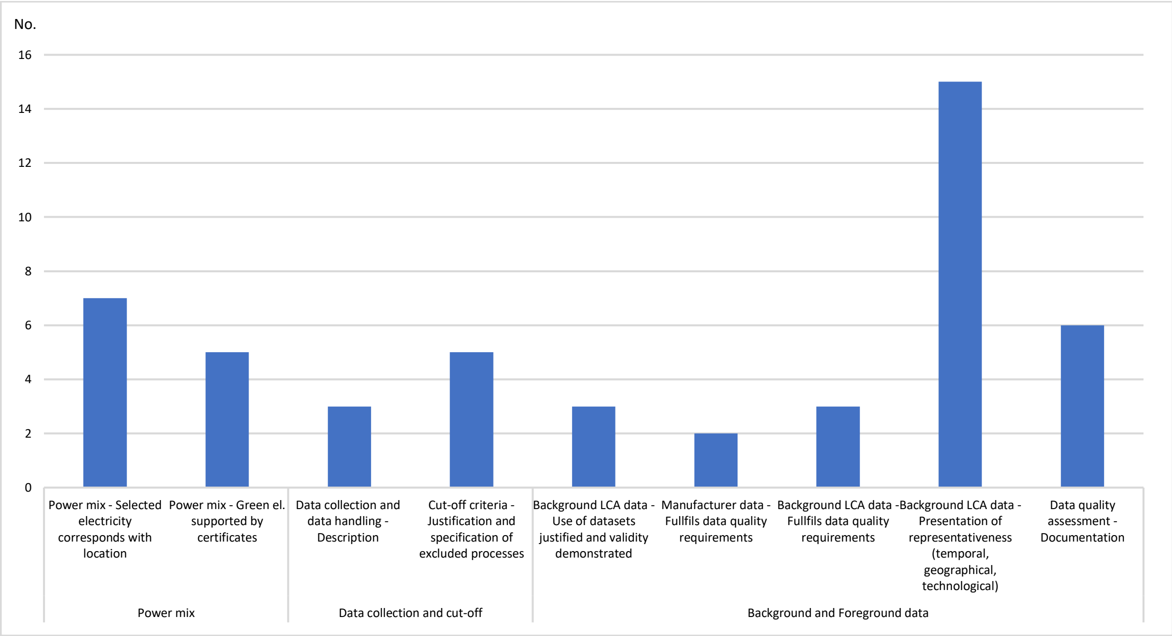


Figure 13. Number of verifier comments for issues related to the Life cycle inventory assessment (Part 1).

In this part of the inventory assessment stage the most commented category is the Background LCA data presentation. Here the issues lie in the correct way of presenting the data tables which need to be reported to satisfy the checklist demand for presenting the representativeness of used data. Not knowing how to report the proper information about the background data like the source database, year of data, and the geographical and technological representativeness has caused a high number of mistakes which have been picked up by the verifier. The reason for the comments is that the reporting methods employed by the authors have not allowed the verifier to properly see the actual data records, resulting in a lack of mandatory transparency. Also causing comments here is the lack of proper referencing of other used sources of information that have been used such as scientific papers, industry standards etc. The second part of the comment data presentation for Life cycle inventory assessment part of the checks is shown in Figure 14.

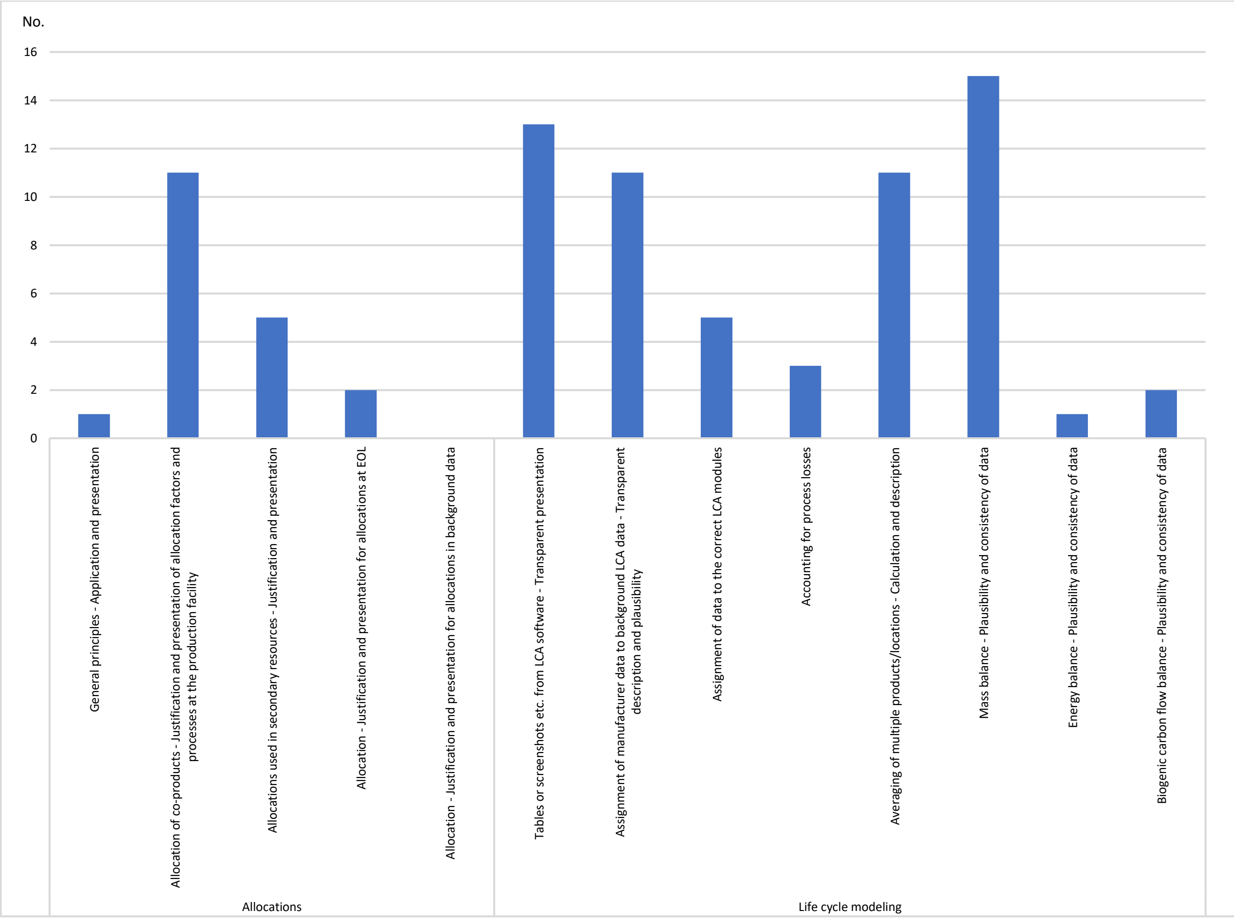


Figure 14. Number of verifier comments for issues related to the Life cycle inventory assessment (Part 2).

The second part of inventory related demands focuses on the reporting of the LCA modelling and is therefore quite susceptible to errors. The errors here can come from either the bad quality of the data itself, pointing towards issues with data collection, or from problems with how the author has handled the data. The largest number of comments here are about the plausibility of data which covers the mass and energy, biogenic carbon balance of the LCA model. Most often the issue lies with an unbalanced mass flows i.e., there are different amounts of inputs and outputs, which also means that there are flows missing from the LCA calculation. As can be seen from the high number of comments the verifier places a lot of weight to the correct mass balance, and therefore demands a high standard from the author in their LCA material accounting.

Allocation and averaging are also some of the more commented categories in the inventory stage. In these categories the users tend to not give adequate explanation on how they have allocated or averaged data. They also often leave out the reporting of relevant calculation factors. A common issue seems to be that the authors are uncertain about the level of disclosure that is required form them in these areas. This is in addition that they seem to be very uncertain about the calculation procedures results in poor quality of reporting, which is picked up by the verifier.

Also, significant sources of errors in these categories are the transparent presentation and clear descriptions on how foreground company inventory data like raw materials and manufacturing process fuel and energy use are assigned to the background LCA datapoints. This is the phase of the LCA where the author takes the data gathered form the manufacturing facility and finds corresponding LCA datapoints in order to model the products impact profile as accurately as possible. Often perfect matches are not found, and proxies have to be used. Here the comments come when the verifier checks the plausibility chosen LCA datapoints and does not fully understand how the model has been conceived. The EPD authors often leave their modelling choices without sufficient explanation or simply model their product wrong, causing the verifier to question their approach.

The reporting of the used datapoints itself causes issues as the users often leave the necessary representativeness related information out of their documents. This is simply a compliancy issue as the representativeness needs to be reported. The problem for user is that they do not seem to have appropriate knowledge on how to report this.

The last stages of the LCA, Life cycle impact assessment and Interpretation are handled together as the issues here aren’t as numerous as in the previous stages. Alongside these is the small Additional information category, which doesn’t have much valuable data for this review but is included for the sake of comprehensiveness. The comments statistics for these stages are presented in Figure 15.

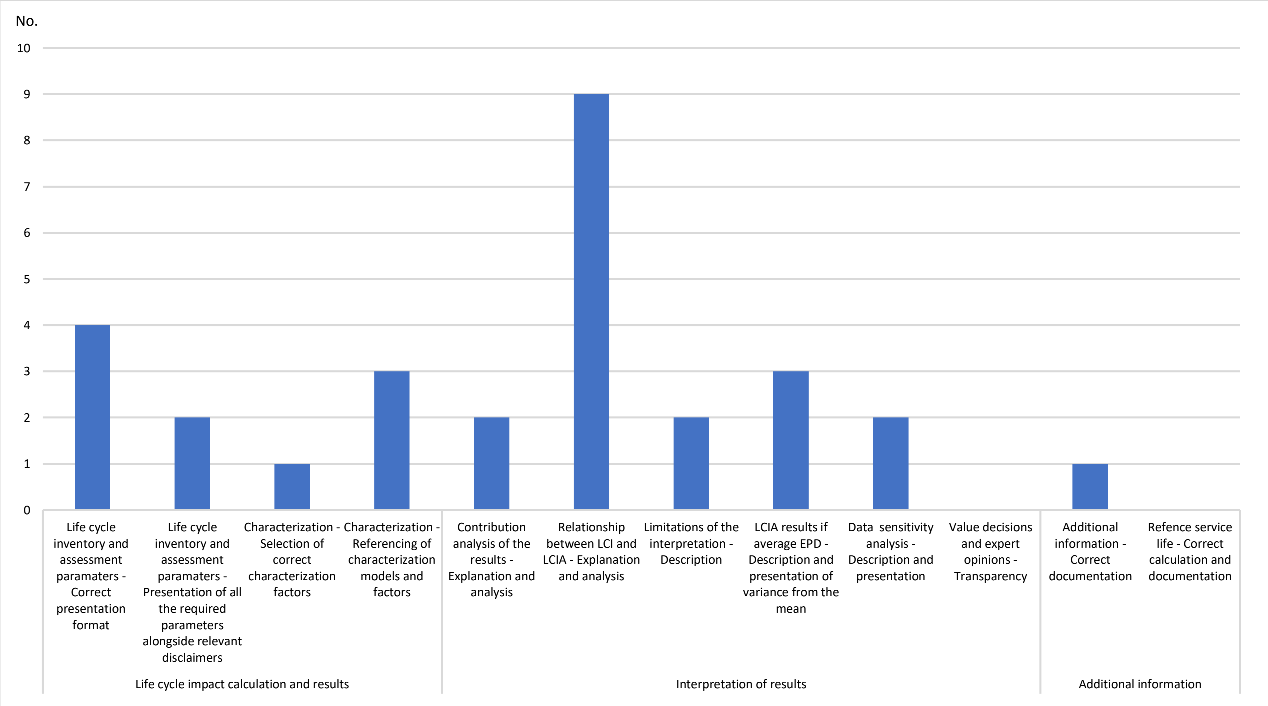


Figure 15. Number of verifier comments for issues related to the Life cycle impact assessment, Interpretation, and additional information.

The number of comments given in these stages is much smaller than the previous, which is likely due to the automatic generation of results on the documents by the OCL LCA tool, which automatically gives the required impact calculation results in the correct format. The issues which due arise are due to issues with users manipulating the resulting documents afterwards or in some rare instances where the verifier picks up a deviant impact result. Because of the impact calculation being done by the software, most of the verifier's comments come from the interpretation stage, which is more reliant on the users own input and analysis.

In the interpretation the issues are mainly in the comprehensiveness and the quality of analysis on the relationships between the manufacturer material and energy inventory, and the chosen LCA data. This is a part that the authors often forget completely as it is not seen as mandatory. Also, the verifier commonly requests for better visual presentation and with more of the indicators covered, meaning that the charts provided by the authors lack clarity and comprehensiveness.

Sometimes the verifier also requests sensitivity analyses and comparisons of the project results to other similar previously published EPDs. The verifier needs these to better check the plausibility of the results. The authors almost always leave this out if not prompted by the verifier. These are not explicitly demanded by the checklist and instead heavily recommended by the verifier.

Alongside the issues that can be attached to certain checks in the verification checklist, there are many comments on the text formatting or spelling. For example, the user inputted text that gets injected on the documents often includes misspelled words, and difficult to understand sentence structures. The text often is missing structures that were clearly intended by the author, like bulleted listing, but did not appear on the final texts.

The next part of the review focuses on the issues coming up on the EPD itself. The comments related to the EPD (Part B of the checklist) are presented in Figure 16. Because of its simplicity Part B is shown as it appears in the checklist and no changes to its category nomenclature have been made.

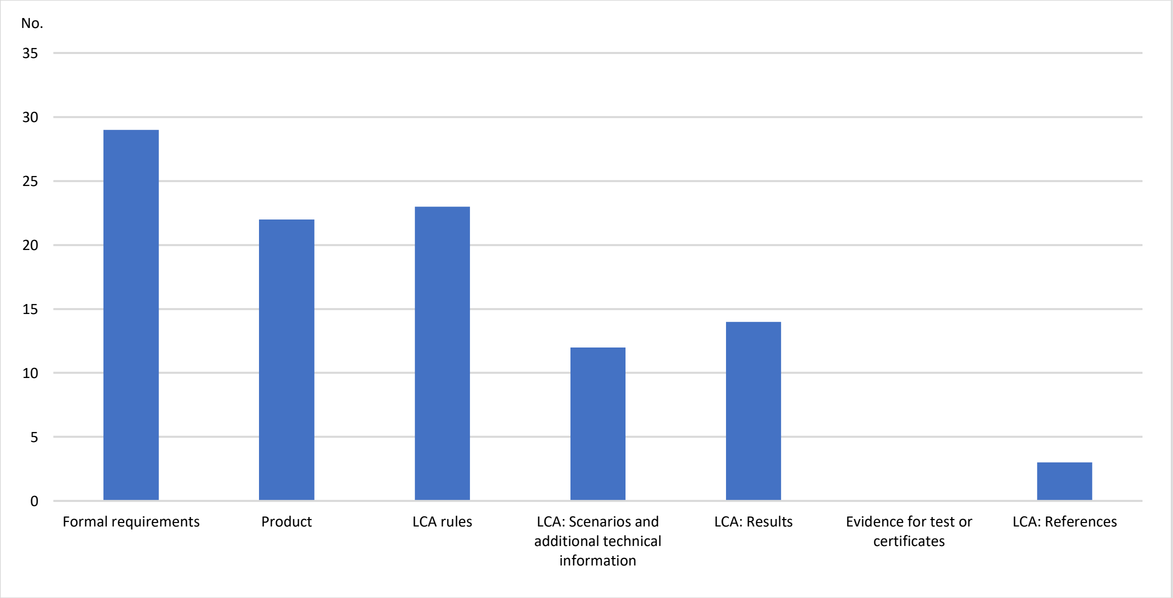


Figure 16. Number of verifier comments from EPD section (Part B) of the RTS checklist.

The part B has most of its comments placed in the Formal requirements, Product, and LCA Rules categories. This is unsurprising as the EPD should have much of the same content as the background report, but in a more concise format. Most differences come from the formal requirements section as there are some publishing related documentation like the time of validity, EPD number, publisher contact information etc., which are not required in the background report. Many of these are also irrelevant to this study as they are put into the EPD after the verifier has accepted the EPD.

A large portion of the comments directed at the EPD refer to of the comments made previously in part A and provide no new insights. Many comments also just reiterate the same issues already mentioned in part A, with perhaps slight variation in the fix suggestions given by the verifiers. Therefore, the part B is not given as close a review as part A, and is only given a short overview.

Some valuable information is available in the comments which point deviations between the background report and the EPD. In the Product category, differences in the descriptions of the product and its technical information between the background report and the EPD have been pointed out by the verifier. These range from reporting different names for the products the EPD represent to giving different product compositions.

In the LCA rule’s part, the issues are also due to inconsistencies with the background report. The verifiers comments indicate that in many cases, the system boundaries reported in the EPD are inconsistent with the background report. The visualization of the system boundaries is often different in the documents, and often the wrong one is the EPD. The same issue covers most of the comments in the LCA Scenarios as well.

Many issues present in almost all the categories are often caused by the verifier not easily finding the right information from the documentation. In addition to this, there is a lack of clarity in reporting practise on the side of the EPD author, who does not fully understand where or what exactly he needs to report the appropriate information. Very often the author has never seen a verification checklist, especially if they are relatively new to the EPD scene. Many times, the issues coming up in verification could have been prevented if the user had better knowledge where the required information needs to go and more importantly, where the verifier seeks to find it.

Taking into consideration all the issues that have come up in the verification log review, the software in its current state can be found somewhat lacking in certain areas. It has been set up to accommodate for easier verification, but the current version still presents some key issues that prevent this from being fully realized. Solutions for some of these issues are presented in chapter 6.

6 EPD-TOOL DEVELOPMENT SUGGESTIONS

As detailed in the verification log review of the previous chapter, there is difficulty in creating a one-way verification process where there are no issues found by the verifier. The current situation of the tool is that the verification process still often still results in back-and-forth exchanges between the EPD author and the verifier. To improve the tools performance in attaining its goal of the efficient third-party verification, certain improvements still must be made.

A great part of the verification is mostly a matter of being concise and clear about what verification demands are answered in which part of the EPD documentation. As was pointed out in the verification log review, many of the questions asked by the verifier come up due to the difficulty of matching the PO checklist demands to the documentation provided by the author. The documentation styles and formats may change a lot depending on the author and as such, the verifier cannot be certain how and if certain required information is presented. In many cases, all the author has to do to answer these questions is to point out where they wrote a specific piece of information. This issue was also highlighted in the customer satisfaction survey where some of the users gave critique on the fact that there is a lack of visibility on how use the tool to answer the verifiers demands before going to the verification. Therefore, the simplest way start improving the tools performance is to make the links between the checks and their intended targets explicit and more easily followable.

6.1 Verification point definition

In this study the issue of unclear requirements and their answers is tackled by the definition of verification points. These verification points are meant to allow for easier identification of the answers for verifiers questions by matching program operator checklists to their corresponding answers in the software tool and the documents it generates. This will also serve the needs of the pre-verified tool as by linking the verification questions to their answers, the questions already answered by the tool can be marked and instantly communicated to the person conducting the verification. The result should be that there will be a reduced number of checks that need to be done by the verifier.

6.1.1 Methodology

The starting point for the verification point development is the verification checklist. This checklist is used as a basis for the definition of the verification points which are used to better associate particular checks with sections in both the documents and the software. In order to do this, a number of questions needs to be answered. First the program operator whose verification checklist is going to be used as a basis is chosen as the template for the verification point list. In this study the program operator chosen is RTS, for reasons outlined in chapter 5.2.

These lists are usually available on the program operator website but often they are also provided directly by the program operator on request by the verifier. With RTS the list was directly available on their website. The points are then documented on a separate file, and they can start to be crosschecked.

The next phase is to crosscheck the verification points with the structure of the software. This is done by picking a specific verification point and checking its referenced source standard or PCR (i.e., ISO 14044, EN 15804 etc.). In cases where there is uncertainty with the real purpose of the check, the sources are checked to confirm the nature and actual content of the often heavily shortened verification checklist description. This is done to get better information how the requirement can be fulfilled.

Once all the checks have been reviewed, and the requirements are clear, the software is then gone through to find where or if the requirement is answered. The software is checked question by question to see which of the questions best answers the checklists questions. The confirmed connections are documented in an excel list with unclear ones left for further review.

After the checks have connected with the software questions, they are also compared to the software generated documents. This is done in the same way as the comparison to the software. Both the EPD report and the background LCA report are covered and checked for matches.

Sometimes the checks cannot be directly matched with its counterparts. This happens in both the software and the documents. The reason for this can be that the check is too large to fit into a single part in the software for example. In this situation the check is split into parts, while keeping the original wording of the requirement intact, and matching the now simpler checks into their counterparts. In other cases, multiple checks can be combined into one if their answer is found in the same location in the software or the documents

When the checks are done, there is a possibility to mark some of the points as pre-verified. As these checklists have been made by following the standards there is a large amount of redundancy, especially in the form of default statements and very similar checks, which can be easily dealt with by simple software changes. Especially, the redundancies between the generated background report and the EPD are looked for. These are detailed in the results chapter.

6.1.2 Difficulties in point creation

Many problems arise from attempting to create a comprehensive list of verification points connecting the different standard and/or program mandated checks, software inputs and the documents generated by the software. The checks to be included in the list of verification points sometimes cover multiple topics, the answer for which cannot be given in just one software question. Also, the questions and their respective locations in the EPD and background LCA report documents are often in many places, the locations of which cannot be defined in a simple way, which makes the organisation of the points somewhat difficult.

In general, the issue is that the documents and the software, in the format they are at the time of writing this paper, do not make it possible to make perfect matches. This means that the verification points related checks have their answers in multiple software locations or that many software locations have multiple verification points attached to them. This is counterproductive when the purpose of the verification points is to make the checking of those questions quick and simple for the verifier.

Another issue is that some of the checks are very complex, requiring for example calculation of the input and output flows of the process under study to balance the mass flows of the product system. This is difficult and time consuming for both the verifier and the user of the software to answer and check. This kind of a verification point does not have a simple input and therefore cannot be included in the checklist in the way the software currently handles it.

The issue with uncertain and sometimes complex matches between the software, verifier and the documents, is also shown in the communication log review as an inconsistency in the documentation of checklist references. Depending on the verifier and the EPD being verified, the comments can refer to multiple different places in the checklist if the issue concerns for example the reporting of issues in LCA modelling. Of course, the issue itself can be multidimensional, but often issues that look simple at first can have their reference taken from a sizable pool of similar overlapping demands.

As an example the aforementioned issue with LCA modelling can have a comment by the verifier the reference of which can point towards checklist compliancy demands such as ”Clear description how company data are used in which data records in Life Cycle Assessment software programs” and ”A1 to A3: System boundary, Clear description of what the modules cover”. The difference between the chosen reference is in the nuance of the issue. Is it a strictly a problem with a lack of textual explanation on the inclusion of certain processes or an issue with how the inventory data is assigned to LCA data? Because of the way many of the demands in the list of checks are worded, both verifier and the user can get confused. For the verifier, especially if they are not very experienced, the convoluted presentation of these demands can cause loss in efficiency during verification.

The tool also has many features in the current version, which do not have a proper output in the documents. For example, the allocation factors and the transportation distances do not get printed on the generated documents at the time of writing this paper. Some of these directly answer some of the verifier’s questions at least partly so to not have them included in the documentation that is sent to the verifier ensures that the verification will take at a minimum couple of rounds.

This issue also makes it necessary to manually modify the generated documents, which again increases the number of possible errors made by the user. If the documents are sent back for another round by the verifier, and due to the user having to manually add some things in the documents, they end up in a very uncomfortable situation documentation wise. If there are changes required in the calculations, they will need to fix their calculations in the software, print out the documents, copy the new results onto the previous generated documents, and then fix any issues the verifier has pointed out in the texts.

The need for the manipulation of the documents, due to a lack of sufficient software input options, results in the user changing calculation parameters and textual content in many different places. This often causes versioning differences meaning that, for example the background LCA report gets updated with something which has not been updated to the EPD document. It is very difficult to keep up with where changes were made in this kind of a situation and very easy to make mistakes here and there, or even leave something out altogether. It is also very possible to simply send wrong documentation to the verifier and vice versa when the amount of document versions increases.

In addition to these issues which can be fixed with a better tailored software user interface and a more concise documentation format with the documents and verification points, there is a more difficult issue, namely the human factor. As a necessity, because of the wide array of very different product categories the tool must support, it is very free form in some of its questionnaires. The scope and goal defined in the previous chapters are successfully fixed and the checks related to them in the verification can be very efficiently answered with fixed content. The textual inputs, however, are very dependent on the ability of the user to properly report and articulate the processes and modelling of the production process of their product. This issue is being solved with the LCA model templates available to the users of the tool, but the content of these templates is freely editable, and therefore cannot be guaranteed to be appropriate when the results are sent to the verifier.

6.1.3 Point definition results

During this study, a set of verification points were defined to act as another layer of improvement in the verification process for EPDs made with the OCL Pre-verified tool. The purpose of the verification points is to allow for easy identification of verifiable items in the OCL LCA software tool and the EPD documentation it can generate. The points can be used to efficiently check the EPD documents for issues related to formal compliance, correctness of LCA methodology, and plausibility of results. The verification points created are currently under software development to be added to the user interface of the tool. The points as they currently appear in the development environment of the tool are presented in Figure 17.

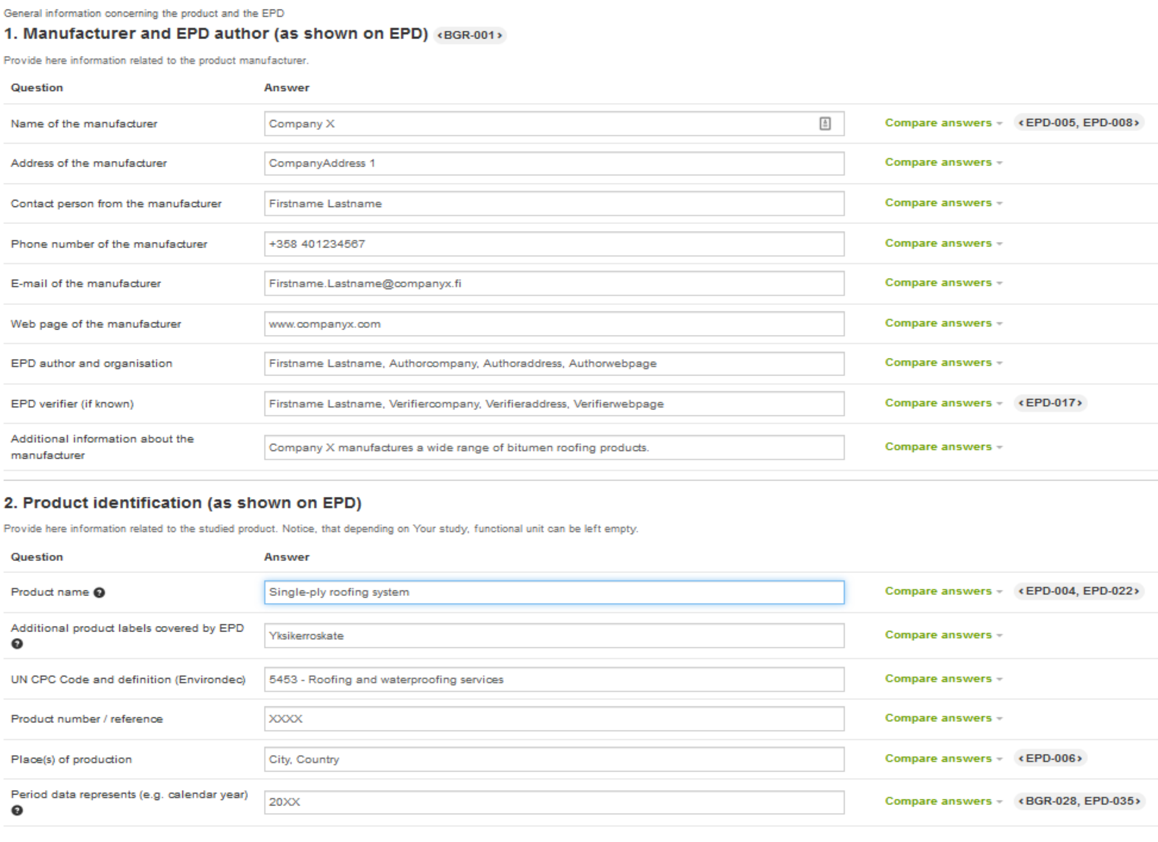


Figure 17. Verification points shown in the "Product description" tab of the EPD-tool. (One Click LCA Ltd, 2021b).

As a result of the study verification point connections were identified for 108 checks in the RTS checklist. The verification points cover the entirety of the RTS checklist and connect these checks to the answers the software and its generated documents. However, as of now the verification points are not yet in use, so they cannot be proven to be able to decrease time spent in verification. Further elaboration needs to be done in cooperation with the verifiers themselves on what are the actual improvements, if any, that these points provide for the verification process.

The verification points still also need feature that would add them as a separate query, where they can be viewed as list. The feature would function as a list of links whereby clicking them the verifier would be able to see where in the model the answers are located. This verification point query should also be made available to not only the verifier, but to the user as well. As the problem is that while conducting the EPD project, the user does not have a full view or knowledge of the requirements put on their model by the verifier or the program operator. For this use the list needs to have a function where the viewer can see the description of the demand associated with a specific verification point. Seeing what part of their input corresponds to what part of the verification, would greatly enhance the customers' ability to prevent verification related issues without the need for intervention from customer support or a comment from the verifier. Verification points as they appear in RTS checklist is presented in Table 7. Full list of the verification points is available in Appendix 3.

Table 7. Excerpt of the RTS checklist with the verification points (Adapted from The Building Information Foundation RTS Sr, 2017).

1	**General information - availability**	**Mandatory / optional**	**Reference**	**Deviations from requirements**	**Done**	**Pre-verification justification**	**Verification point**
1.1	Commissioner of LCA study, LCA practitioner	M	EN15804 ch.8.2				BGR-001
1.2	Date of issue of LCA report	M	EN15804 ch.8.2		☒	Automatically generated	BGR-002
1.3	Statement that the Life Cycle Assessment study has been performed in accordance with the requirements of EN 15804 and. applicable PCRs	M	EN15804 ch.8.2 + applicable PCR		☒	Fixed statement	BGR-003
1.4	Any other independent verification of the data given in the LCI/LCA documentation?	O			☒	Database reviewed	BGR-004
2	**Study goal – availability of info**	**Mandatory / optional**	**Reference**	**Deviations from requirements**	**Done**		
2.1	Reasons for performing the Life Cycle Assessment	M	EN15804 ch.8.2		☒	Fixed statement	BGR-005
2.2	Intended application – (e.g. for EPD, databases, publication etc.) Is the LCA designed in such a way that it allows B2B communication for	M	EN15804 ch.8.2		☒	Fixed statement	BGR-006

	environmental assessments of buildings?						
2.3	Target group (B2B, B2C, …)	M	EN15804 ch.8.2		☒	Fixed statement	

As can be seen from the checklist excerpt another result of the verification point development is the identification of the places in the checklist that can be directly marked as solved by the pre-verified tool. In the checklist table, this is shown as highlighted rows and being marked as done. Many of the checks ask for information that is automatically documented, or otherwise made irrelevant by the tools feature or the pre-verification process. The reason for each pre-verification is given in the column for pre-verification justification. Numbers of the verification points as well as their pre-verification status are presented in Table 8.

Table 8. Pre-verification status of the verification points for RTS.

Checklist part	**Checks**	**Verification points**	**Pre-verified verification points**	**Pre-verifiable with identified software improvements**
Part A: Background report	65	58	19	9
Part B: EPD	34	42	24	6
Part C: PCR Specific	10	10	7	3
Total	109	110	50	18

From the total number of defined verification points, approximately half could be instantly pre-verified. The answers for these checks are provided by the pre-verified tool through the set tool query structure, pre-made reports, fixed textual content, as well as the background LCA database control, and the automatic documentation of answers in the software generated documentation. Many of the checks are also redundant with each other, often asking of the exact same information but form different documents, either the background report or the EPD. For this reason, many of the EPD related points could be pre-verified as the answers for most of the questions in the software go into both documents, so only the background report needs to be checked.

In addition to the currently pre-verified content, there are many points which have been identified as possible to pre-verify with certain software and template fixes. If these improvements are realized, another 10 % of the verification points could be marked as resolved by the pre-verified tool.

6.2 Tool improvement suggestions

During the review of the verification logs several issues coming up in the verification of EPDs made with the software have been identified. However, as the logs included are form a period of a couple of years, there is some mismatch between the issues found and the required improvements. This is due to continuous software development being done for the tool. Thus, several of the issues generating comments from the verifiers have since been resolved.

This resulting overlap was resolved after going through the defined verification points and checking which of them are already answered by the pre-verified tool. A list of the identified improvement suggestions is presented in Table 9. The table presents the improvement suggestions in the types of documentation related and calculation related. Both the issue and its solution are shortly described. Also detailed are the related verification points, which are either solved or helped by the solutions. It should not therefore be expected that implementing the solution completely solves the underlying issue.

Table 9. Software improvement suggestions.

No.	Issue type	Issue description	Solution description	Related verification point(s)
1	Documentation	The Programme operator and PCR details need to be reported with free text in the software	A drop-down menu selection for PO and PCR	BGR-003, EPD-008, EPD-009
2	Documentation	Product composition is often calculated wrong and not restricted to the raw materials in the LCA or the product	Automatic calculation of percentages from reported masses and limitations on the reportable components according to product category	BGR-009
3	Documentation	The standard flow diagram generated by the software is not accurate enough to be used and cannot be modified	A standard editable flowchart/flowchart editing feature	BGR-011
4	Documentation	The scope has to be modified in the manually in the documents	Automatic scope reporting and limitations on the tool queries depending on the selected scopes	BGR-012, EPD-014, EPD-RTS-003,

5	Documentation	Reporting of all the used transport datasets (A2, A3, A4, C2) has to be done manually	Automatic documentation of transport LCA datasets	BGR-038, BGR-016
6	Documentation	Description of company data assignment has to be done separately from the inventory tables	Allowing more direct presentation on how manufacturer data is assigned to LCA datapoints	BGR-043
7	Documentation	Documenting the required additional transport scenario information is done manually	Better template documentation about Transport technical information	BGR-016, BGR-038, EPD-RTS-008
8	Documentation	The reporting of energy scenario has to be done manually	Automatic energy scenario documentation	BGR-025
9	Documentation	Data quality assessment has to be done manually	Automatic data quality assessment	BGR-035, BGR-055
10	Documentation	Result visualization charts are not clear enough to be understood	Better material/energy flow contribution charts. Allowing the user to choose the LCA stages and impact indicators shown in the chart	BGR-051, BGR-052
11	Calculation	Averaging of inputs and reporting of the resulting variance has to be done manually	Automatic averaging of software designs, reporting of weighting factors and calculation of the resulting variance	BGR-008, BGR-044, BGR-054
12	Calculation	The net flow calculation for module D has to be done manually	Automatic net flow calculation for module D	BGR-023
13	Calculation	Mass balancing has to be done manually	Automatic mass balance feature	BGR-045
14	Calculation	Calculating the biogenic carbon content has to be done manually	Biogenic carbon calculator	BGR-009, EPD-RTS-004

The full specifications for the development of the software are not included in this report and will be separately documented in OCL:s own product development environment. However, the overall nature of the underlying issue and the suggested improvements is explained in more detail in the following sub-chapters.

6.2.1 Documentation improvements

Currently the software does not support adequately automatic reporting. This causes problems on issues that are not difficult to fix but take a lot of time, especially if issues are found during multiple rounds of verification. To improve on this, changes are needed on how the software populates the generated background report and EPD. The issues related to documentation reported in Table 9 are explained below.

First issue requiring solution is the free text reporting of the PO and PCR information. This is a problem because as the largest audience of the pre-verified tool is manufacturers, the users cannot be expected to have in depth knowledge of EPDs. This means that the more restricted the options are the better. The solution suggested here would then be to replace the free text input fields with simple drop-down menus. This applies both for the question asking for the PO and the one asking for the PCR. The selection made in the menu affects how information like the contact details of the PO and the date and version number of the PCR are reported on the generated documents.

Next issue is about the reporting of the product composition. The composition is reported completely separately from the raw material emissions calculation. This creates a requirement for crosschecking from the side of the verifier. The composition is currently also reported in a free text format, enabling the user to make any kind of inputs the want to, increasing the risk of mistakes. The idea here is the same as with the first issue, to decrease the users' options for their product composition. As one of the pre-verified tools features is the possibility to use templates, which are product group or type dependent, the composition is to be limited to certain materials that correspond to the product category of the project.

Therefore, a feature is also needed where the project can be assigned a product category, which impacts the user's ability to access options in their LCA models. In this case the choice would impact the options of what can be picked as the products constituent materials. The question in the tool for choosing constituent materials is made with a drop-down menu.

Continuing down the list of improvements, the third item is the system boundary and manufacturing process visualization with a flow chart. Currently the flow chart provided by default in the software, is wholly inadequate to represent the wide array of different products it is required to represent. This has resulted in users having to make their own chart by hand. This is slow, and often done by users not completely sure what kind of a chart is enough. Especially the system boundaries are often completely left out of the chart, and even the manufacturing process is commonly presented in a very simplistic way. There are two option to solving this issue. The easier one is to simply provide a downloadable and editable flow chart that the user can then add to their document. The harder but more user-friendly way would be to develop a simple chart editing feature where the user would edit a simple standard chart and then have it show up in the generated reports.

The fourth issue is the reporting of the project scope. The scope does not have presence in the tool queries at all, and instead its documentation is entirely manual. In the generated documents, both the EPD and the background report, the scope is reported as a short textual description of the included modules and a table listing and marking them as either declared or not declared according to the format given in EN 15804+A2:2019. Currently these are static object in the reports and must be modified by hand.

The fix for this issue requires a set of allowed scopes, one of which is chosen by the user. This decision could be done through a software question with a drop-down menu, which allows the user to pick the most appropriate scope for their project. The available scopes should be dependent on the type of product, chosen with a separate feature before creating before the project. The texts and the table in the generated reports documenting the scope should change according to the selections made in the software.

A couple additional changes related to the automatization of the scope definition are needed. One is a visual representation of the scope in the software. This would allow the user to see a life-cycle stages visualization table, where the appropriate modules would be marked either as modules not declared (MND) or modules declared (X). The second is the conditional removal of available life cycle stages in the software. Removal of usable stages in the software when they are outside the scope would prevent the user from utilizing them when they are not supposed to. Similarly, the corresponding sections would be removed from the generated documents automatically to decrease the amount of manual work on the documents.

In the fifth issue, the problem lies in the reporting of inventory data. Currently this helps the user to answer the verifiers demand of transparency by showing all the LCA datapoints used in the software, alongside their representativeness. This is still missing some features that are needed to allow for full transparency, namely full reporting of the transportation datapoints. These are handled in the software as attached additional questions of the chosen LCA datapoints, for example raw materials. This results in them being left out from the generated data tables as they are not considered full datapoints. To rectify this, the transportation data should be reported in full as their own data tables. These table should show all the necessary information, such as name of the datapoint, mass of the transported material, distance, as well as the year, of data, database, and its geographical representativeness.

The sixth issue is another problem with the inventory reporting. There is currently no way to directly present how the manufacturers material and energy flows are assigned to the LCA datapoints. The user can report this information in the life cycle stage process descriptions but as the LCA datapoint inventory is presented in table, the connections between the collected manufacturer data and the chosen LCA datapoints is much harder to see directly.

The solution for this issue is to use a comment section available in the tool. The comment section is implemented in the software as an additional question attached to the datapoint in the same way as the transportation mentioned previously, but here the user inputs are freeform text. Currently, this comment section is not included into the inventory data tables. The solution therefore is simple, to add the comment to the inventory data tables as an additional column and have automatically reported there. This way the comment can be used as a link between the manufacturer data and the LCA datapoint.

Seventh and eight issues concern the reporting of additional scenario information. The scenarios affected are the manufacturing energy scenario (not really a scenario per se as it is part of the A1-A3 product stage), and the A4 transportation to the building site scenario. All the additional information required for these scenarios can be added through the software, but it needs to be written by hand into freeform textbox questions. The issue with this is that a large part of the required information is already available within the datapoints used to model the scenario, and only needs to be reported in a certain form to a separate table. Currently this is done by checking the datapoints' datacard, which shows its background in the software, and copying its name and emission factor to the scenario documentation question.

This is a very inefficient way to handle the documentation of these scenarios. There is some information required that must be added separately but the rest should be changed to a mostly automated alternative. More specifically for the manufacturing scenario, which only needs to have the datapoint name, its representativeness, and its emissions factors reported, the automatization can be fully implemented. All of the mentioned pieces of information can be gotten directly from the software and are already reported in the life cycle inventory data tables automatically generated to the background report. The only different thing would be the format that they are presented in.

Ninth issue concerns the way data quality assessment is currently done in the documents. The current method has no inputs form the software and the documents must be edited by manually editing the generated documents. There is a table in the documents assigning default overall quality values to the data. This is complemented by an excess column on the inventory data table, which the instructions on the document state should be filled in case quality differs from actual data. The problem is that, generally the users do nothing at this point regardless of what their actual data quality is. This seems to be overlooked often by the verifiers as they have not made many comments, but in the cases they have, this has bee the issue.

A solution to this would be to add additional question into the added resource rows, where the user must document their data quality. The questions would have three dimensions, geographical, temporal, and technological, which all would have to be answered. The questions would be handled by drop down menus where the answer choices would range from poor to very good, according to EN 15804+A2:2019. The answers to these would then appear on either the inventory data table, or on a separate table in annex of the background report if the new answer does not fit on the first table. The software questions would also have default values according to the current default data quality table in the background report.

Each option in the drop down list would be assigned a numerical value from 1 to 5, and averages would be calculated form these based on weighting. The weighting could be with the emission factors of each assessed resource, the most emitting having the highest weight. These averaged numbers would then be used to convert back to the string values (poor, good etc.), and placed on the original default data quality table.

The tenth and final issue in the documentation category is the visualization of the impact results. Currently the results are visualized by two charts. One that presents the impact results divided by the contributions of the life cycle modules (A1-D), and another one that presents the impacts divided by the material and energy flows in the product system. Both are implemented as stacked column charts, where the horizontal axis shoes the different impact indicators separate columns, and the vertical axis shows the columns divided into shares of the constituent parts, either LCA stages or flows depending on the chart. The charts are shown in the software results page, and are generated on the background report.

The issue here is that the charts are currently very unclear to the viewer. There user can hover their cursor over the parts to see the actual amounts in the software, but this cannot be done in the background report. The charts are meant to act as part of the interpretation stage and showcase the verifier how the impacts are divided. The main issue is with the chart that shows the impacts divided into material and energy flows. The chart tends to get generated in very unclear ways, especially in cases where the product has many different flows used in its modelling. One cannot always discern the different divisions from the columns in the graphs, and sometimes the list of materials overwhelms the actual visualization and makes it completely unreadable. This problem is not only created by the number of flows, but also by the large amount of impact indicators shown. At the moment, all the available indicators are shown in each chart.

The user currently can choose what flows appear on the software charts. This also affects the documents. However, the list marking the flows present on the chart legend only gets turned grey and does not remove them from the charts. Therefore, this functionality does little to make the chart clearer.

To improve the situation there is a need for a feature that allows the user to modify the chart more thoroughly in the software. These modifications must also transfer to the generated documents in such a way that the chart can be made clear in case the model contains a large number of flows. This can be by utilizing the present feature but expanding it, so the user has ability to choose both the flows and the indicators present on the documentation. The ability to choose would need to be limited so that all the core indicators as defined by EN 15804+A2:2019 would remain in all cases but all the others would be optional. The way the charts appear on the documents would also need to be changed so that the charts list of the flows would have items completely removed when turned off in the software view, and not only change colour.

6.2.2 Calculation feature improvements

Many of the issues the user encounters involve some form of calculation that they must do outside the software. This is likely to feel counterintuitive for the user as the general expectation is that the software will do this automatically, and when it does not, they are likely to get frustrated. To avoid this, as many of these outside the software functions should be eliminated and replaced with features requiring simple to understand inputs, and requiring no calculations done beforehand.

The first calculation issue, numbered as issue 11 in the improvement suggestion table, is the manually done averaging when making average EPDs. As it is now, the software performs at its best when the user is making a single product EPD using a single data collection form. However, there are many users who wish to create EPDs that are averages of different products or manufacturing sites. Currently any averaging that the users want to conduct has to be performed separately from OCL by spreadsheet programs for example. However, this causes issues because many POs, including RTS, demand certain limits to the allowed variance of impacts that result from the averaging. This means that the user has to model the products separately to know the variance and, if the variance is within the allowed limits, create another model using averaged inputs. This creates a huge amount of modelling and calculation work for the users.

A solution to this would be to allow for the automatic averaging of software designs. This can be done with an averaging feature where the user chooses the weighting factors for two or more LCA designs, and the software uses those to create a new LCA model. This should allow for easy assignment of allocation factors for different products/manufacturing plants. The new design should have the inputs and outputs of the previous designs with the weighting factors presented. The complied resource rows form the software queries alongside the weighting factors should also be generated on the inventory data tables in the background report to allow the verifier to see how the averaging has been done. The variance of results should also be calculated from the designs used in the averaging and presented on the generated documents.

Issue number 12 is the manual calculation of the net virgin material flows for the assessment of benefits and loads beyond the system boundary (module D). The material and energy flows accounted for in the calculation of module D, cannot be directly taken from the flows coming from the other end of life modules. Instead, the secondary material content already in the materials, i.e., materials that were recovered in the previous product system, and received in the current system without impacts, must be accounted for and removed from the flows recovered in the EOL of this system before going to module D. Currently this calculation needs to be done by hand and reported manually to a table in the background report.

This manual calculation should be replaced with a feature that automatically calculates the net flows in the software. This could be done according to the in the instructions in EN 15804 "6.4.3.3 Allocation procedure of reuse, recycling and recovery". A formula for this can checked for example from RTS PCR. The user would input the amount of recovered material received as raw material and the amount of material that is recovered in the current system into a software question. The user would also designate the Ecoinvent resources which would be used to model their emission values of these inputs. These values would represent the benefits of the avoided production of virgin material being substituted, and the loads of producing the recycled material respectively. The software inputs of the material flows, their designated emission factors as well as the result of the calculation should be reported in the background report table. This feature would also replace the resource input query currently in use.

Perhaps the most important calculation related issue is issue number 13, the manual mass balancing. This mass balance does not have the highest comment rate, though it has a high one, but is integrally connected to the correctness of the entire LCA. If the mass balancing is not done correctly, the results will be off, and even though the verifier check of the mass balance is voluntary, many verifiers still do it in order ensure the proper calculation of emissions. The mass balance is also quite prone to errors when done by hand. Also, having the verifier find an issue in the mass balance often results in the user having to redo much of the quantities in the model at a very late stage in the project. This could be due to it uncovering material flows overlooked in the original data collection. Together with the other manual documentation related issues it can mean a high amount of work for the user at a point in the EPD project where it was thought to be almost done.

A solution to this would be the automatic calculation of a mass balance from material flows in the software. By automating the calculation of the mass balance, the plausibility of the study inventory becomes much faster to check. With the software both calculating and documenting the mass balance neither the user or the verifier needs to calculate it from the separate inputs or separately report it in the software generated reports. This feature would allow the user to immediately see any errors in the balance after putting their input and output data into the software.

The last issue in the list is the manual calculation of the biogenic content of the product and packaging. According to EN 15804+A2:2019, reporting biogenic carbon of the product and packaging is a mandatory part of the EPD, if the mass of the biogenic carbon constituent is over 5 % of the total mass of the product or the packaging respectively. The product biogenic carbon seldom has to be reported as the limit is usually only crossed by wooden products. The packaging biogenic carbon on the other hand is quite often required, due to the use of pallets. This means additional work for a large part of users as pallets are very common. Currently the biogenic carbon content has to be manually calculated, which is creating issues as the right way to do this is not known to many.

Here the improvement suggestion is a biogenic carbon content question, which automatically calculates the biogenic carbon content for the product and packaging, with inputs from the wood volume, density, and moisture contents. The calculation should be done according to EN 16449 with default values for moisture content and density. The values would need to have default values, but changeable by the user. Also, due to the recurring problem of leaving out the reporting of the biogenic, an alert should be given by the software if there are biogenic materials like wood reported in the raw materials or packaging.

7 CONCLUSIONS

In conclusion, if the verification points can be successfully taken in to use and the suggested tool improvements implemented, approximately 60 % of the tool verification points can be pre-verified. No accurate direct time saving can be assumed from this in advance, as the checks are very heterogenous with some of them being very simple (i.e., a check for the presence of author name) or complex (i.e., mass balance). However, rough some rough estimations can be made.

As it was mentioned in chapter 5.2.1, the current average time it takes to complete a verification process is around two weeks (13,8 days), and around a week (6 days) when looking at the median duration. If we assume that the percentage of checks not having to be reviewed by the verifier affect linearly and homogenously to the verification time savings, then these times are cut roughly in half. In numbers, 60 % decrease in time spent in verification means 8.3 days for the average time and 3,6 for the median.

If assuming a standard hourly rate for the pricing of verification and a reasonably experienced verifier with consistent verification times, the price is also decreased by over a half. Looking at the numbers for pricing of an EPD from Tasaki et al. (2017) presented in this study in chapter 3.1.1, the total cost of an EPD varies between the between 10 000 - 30 000 €, with a median of around 13 000 €. A 60 % cut form this number means a cost saving of 7800 €, not accounting of course any special pricing such as bulk verification of multiple similar EPDs or other pricing convention apart from a standard rate for a single EPD verification.

Apart from time decreases due to pre-verification, the points are also meant to make it very clear for both the verifier and the EPD author where certain demands are answered. This can possibly to reduce the number of bounces and further shorten verification times. If the demands can be made absolutely clear to both sides of the verification with the verification points, then assuming all other issues are dealt with, the number of bounces could be reduced to just one. As it was found from the verification log review, many of the issues spotted by the verifier have to do with them just not finding correct answers from the documents supplied to them by the EPD author. This reduction in the number of bounces is of course dependent on the software itself working without issues, and the user following the verification points as well.

In addition to the verification points, the improvement suggestions themselves are required to achieve any of these time savings. They are both required to achieve pre-verification in many of the defined points, as well as generally improving the functionality of the tool. Certain fixes, namely the ones related to calculation, stand out as large sources of trouble for the EPD authors in the log review, but their difficulty makes them much harder to address through pre-verification than many of the documentation related fixes. These are the averaging of LCA models, mass balancing, module D net benefits outside system boundary, and biogenic carbon calculation.

These issues likely have a much heavier effect on the time consumption of verification which is not directly shown in the quantitative log review. While directly measuring their time intensity during verification consumption is outside the scope of this study, it can be assumed from the present data, that they are both difficult to answer from the user’s side and slower to check from the verifiers side, especially when they are not sufficiently addressed by the software. It is therefore very important for the achievement of a smooth verification process that these improvements in particular are implemented at least partially. It is highly likely that solving these has a much higher effect to the verification duration than could be assumed just looking at the number of verifications points they solve.

As for next topics to be studied in the future to further develop the tool and the verification process itself, a recommendation would be to do a follow up study after the implementation of the improvements suggested in this paper. This should be done in order to see if the improvements had their intended effects and if there still remain any significant shortcomings which affect the verification of EPDs made with the tool. A separate study should also be made on the practises of actual verifiers. Currently the verification process somewhat lacks comprehensive guidelines and any steps toward documenting the current best practises would make it easier to prepare EPD software as well as authors to answer its demands.

8 DISCUSSION ON THE FUTURE OF THE VERIFICATION PROCESS

The results are very specific to the software under examination and should not be used to make direct assumptions about any other LCA software. However, they can be used to reflect on what kind of development could be advantageous for the future of the EPD verification process. In this chapter, the results of this study are reviewed and their possible implications of the findings to the EPD market at large are discussed.

The LCA and EPD standards, and through them the practises of most POs have been created to provide a framework for primarily artisanal manually written reports and have somewhat neglected the possibility for more streamlined solutions. In many cases this has resulted in a situation where the EPDs require a lot of information from different sources, as well as figures, tables, written text etc., that serves no other purpose than to achieve compliancy. This has made creating a streamlined EPD creation process somewhat challenging.

This documentation and bureaucracy heavy approach have created a hard to approach environment. A first step in improving this situation would be to stop requiring both a background report and an EPD in the same sense as they are now. Currently the background report serves practically as a standalone document documenting every part of the LCA study and containing everything the EPD does but in more detail. This is of course somewhat dependent on the PO, but generally the EPD is essentially an abbreviated version of the backgrounds report. This means that in order to make an EPD the author has to document many of the study’s aspects twice, sometimes even more times. This is further exacerbated if the PO requires, for example the front page of the EPD to contain a summary of some of the EPD information, and then in more detail in the rest of the EPD, which is the case with IES.

Even when not considering the similarity between the background report and the EPD, there is still a high level of redundancy in general in the checks demanded by the POs and documented in their checklists. In multiple cases, the difference in the checked content is marginal and in others exactly the same, only difference being the location where the information had to be documented.

This could be partially solved simply by POs accepting documents in a form where they do not require information on the EPD to be placed also to the background report. A clear reference to the information only on one document would of course be needed. Some identification information like author, verifier, product name etc., would still need to go on both documentation but apart from that, any other redundant information should be allowed to be left out. Also, in reference to the general redundancy in demands present in the checklist, a re-evaluation on what checks are actually needed, could make the process clearer for the verifier and thus faster.

This would make it easier to develop EPD generator tools looking for higher automation but wishing to retain true third-party verification, like OCL. The removal of redundant demands would allow for shorter more concise documents, and therefore make them both easier to generate through software and faster to verify. This would make it an easier choice to opt for an actual third-party verification.

Continuing from redundancy, a general clean-up is needed for the checklists of POs. If the clarity and understandability of the checks could be greatly improved, then similarly to the purpose of the verification points, the checklists could be more widely spread to the authors of EPDs. Currently this is often not the case, and the checklist is strictly the domain of the verifier. This would require some change in the method of operation for program operators, as in some cases the checklist is freely available but there is no practise of making it easily available to the EPD authors. Were this to be changed than it would also somewhat answer the issue of prospective EPD authors and users lacking sufficient information.

The external third-party verification is undoubtedly the most transparent and extensive verification of the various alternatives, providing the most robust method of verification when done by an expert. However, currently there are many EPD tools and POs offering alternative methods for external third-party verification due to the great amount of time and money going into the process. If the documentation requirements could be made more efficient and streamlined, the third-party verification could make itself more appealing, and thus have more EPD authors choose it. This would ensure that more the EPDs coming to the market could be trusted to have been properly verified, improving their acceptance and therefore also their usability in various applications requiring transparent environmental data.

However, the very-long-term vision for the verification process as a whole would be to proceed towards to nearly full automatization of the verification and publication processes. Currently any attempts to automatize the verification process leave much to be desired as a lot of the EPD content is difficult to automatically test, for example, no free text inputs, common in EPDs, can be checked by computer unless highly standard texts are used. Because of this, achieving such a scenario could possibly rest in the hands of AI utilization. An AI-based solution could possibly replace the human verification entirely, or at the very least render is so short that it would not impact the price or duration of the publishing procedure. If implemented this would massively decrease the issues of time and cost in the whole EPD process.

9 SUMMARY

The LCA methodology, as defined by ISO 14040 and ISO 14044, consists of four distinct stages: Goal and Scope definition, Inventory analysis, Impact assessment and Interpretation. This methodology provides a framework to conduct a comprehensive assessment of the environmental performance of a systems life cycle. The LCA can be used as is to evaluate the impacts of different systems, but in order to better utilize this information in a business context, a number of environmental labels and declarations have been created.

There are three main types of labels standardized by ISO, type I ecolabel, type II self-declaration, and type III environmental declaration, governed by ISO 14024, ISO 14021, and ISO 14025 respectively. The type III product declaration, better known as the EPD, provides quantified, transparent, and verified information about the life cycle impacts of products and services. Currently the main reasons for using EPDs are regulatory compliance and the advantage they provide when applying for building certifications. Their main issues on the other hand include a general lack of information about EPDs, uncertainty about their comparability, and costs associated with their creation.

EPDs are published by Program Operators (PO). Their responsibilities, as defined in the ISO 14025, are to administer and develop an EPD program. The EPD program is a system governing the verification and publishing process of EPDs. Authors must adhere to the rules of the PO with whom they wish to publish their EPD. This paper introduces three Nordic EPD program operators, the Swedish EPD International AB (IES), Norwegian EPD Foundation (EPD Norge), and the Finnish Building Information Foundation RTS sr (RTS). There are also international and regional EPD organizations, the most important in Europe being ECO platform, an umbrella organization set up together by many of the European POs to advance sustainability requirements and standardization.

One Click LCA Pre-Verified EPD tool is an LCA software tool, which aims to achieve a highly efficient EPD process flow by extensively utilizing the straightforward OCL tool structure, pre-made content, document generation and extensive database. The tool is pre-verified in two EPD programs, RTS and IES. This pre-verification has been achieved through demonstration of the tools ability to model construction products by the way of review of the tools database, queries, and calculation results. The verifiers of the tool were provided sample EPDs, which were utilized after the verification as EPD templates and datalists. These pre-made materials are then used to give users of the tool product category specific rules and guidance on modelling and reporting. To gain more insight of its success on this matter, its performance is reviewed by going through One Click LCA own measurements and materials on this matter. The tool has received praise in a customer satisfaction survey conducted by One Click LCA Ltd, however there are still issues. The measured verification process is also somewhat slower than intended. To get more accurate information about the specific issues in the tool, verification logs of EPDs verified with the tool are reviewed. The results of this review indicate that the highest incidence rate is in the implementation and documentation of system boundaries and inventory data, as well as in the quality of modelling

The verification point definition is done to better demonstrate the links between the software, its generated documents, and the POs. The methodology of the point definition included taking a PO verification checklist, reviewing its referenced standards, and crosschecking its demands with the questions in the OCL software structure and the generated documents. As a result, 110 verification points were defined. The checks in the list were also occasionally either combined or divided when assigning the verification points to find the best match.

After definition the points were given a second look to see which of them could be marked as ready and pre-verified if their demand were met with the software or document content by default. Of the defined points, 50 (45 %) could be pre-verified. Any Issues identified during the log review and the verification point definition were listed and evaluated to figure out possible solutions. Improvement suggestions were identified for 14 items, whose completion could pre-verify further 18 (16 %) of the verification points.

As a conclusion to the study, if the verification points can be successfully taken in to use and the suggested tool improvements implemented, approximately 60 % of the tool verification points can be pre-verified. This roughly translates to 8.3 days saved when looking at the average verification duration and 3,6 days when looking at the median duration if assuming a linear causality between the verification points and time. In costs the 60 % decrease means saved 7800 €, if assuming both that the pre-verification of the verification points linealry affects the time, and that a standard hourly rate is applied for the EPD verification without any special pricing conventions.

In addition to the conclusions of the study, a general proposition is made that if POs could work towards a lighter load in documentation, decrease redundancies in their documentation demands and update their operations to suit more automated solutions, the rate at which markets adopt EPDs as a method for communicating environmental information could increase.

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OCL Pre-Verified EPD Generator tool structure (One Click LCA Ltd. 2021b)

Product description	**Declared unit**	**Materials (A1-A3)**	**Manufacturing (A3)**	**Construction (A4-A5)**	**Use stage (B1-B7)**	**End-of-life**	**EPD Description**	**Background report**	**EPD generation**
1. Manufacturer and EPD author (as shown on EPD)	1. Declared unit and unit for all inputted data	1. Manufacturing materials - A1	1. Manufacturing energy use - A3	1. Transport to the building site - A4	1. Use or application of the installed product - B1	1. De-construction, demolition - C1	1. Product Life - Cycle (as shown on EPD)	1. Life cycle interpretation	1. EPD Program and PCR
2. Product identification (as shown on EPD)		2. Ancillary and packaging materials - A3	2. Manufacturing waste and wastewater - A3	2. Installation into the building - A5	2. Maintenance - B2	2. Transport to waste processing - C2	2. Life-Cycle Assessment information (shown on EPD)	2. Supplementary description of Materials (A1-A3) and Manufacturing (A3)	2. EPD visuals
3. Product information (as shown on EPD)		3. Additional transport - A1 & A2	3. Process direct emissions - A3		3. Repair - B3	3. Waste processing for reuse, recovery and/or recycling - C3	3. Manufacturing energy scenario documentation (as shown on EPD)	3. Supplementary description of Construction (A4-A5)	
4. Product raw material composition (as shown on EPD, RTS only)					4. Replacement - B4	4. Disposal - C4		4. Supplementary description of End of Life (C-D)	
5. Material composition (International EPD System, as shown on EPD)					5. Refurbishment - B5	5. Benefits and loads beyond the system boundary - D			
6. Biogenic carbon content of product and packaging (as shown on EPD)					6. Operational energy use - B6				
7. REACH materials (as shown on EPD)					7. Operational water use - B7				

OCL Pre-Verified EPD Generator questionnaire connections with the generated documents (One Click LCA Ltd. 2021b)

No.	Description in Software	Which section in Software	UI Query tab	Answer's location in the EPD	Answer's location in the BG-report
1	Name of the manufacturer	Manufacturer and EPD author (as shown on EPD)	Product Description	MANUFACTURER INFORMATION - Manufacturer	Front page - Manufacturer
2	Address of the manufacturer	Manufacturer and EPD author (as shown on EPD)	Product Description	MANUFACTURER INFORMATION - Address	-
3	Contact person from the manufacturer	Manufacturer and EPD author (as shown on EPD)	Product Description	-	-
4	Phone number of the manufacturer	Manufacturer and EPD author (as shown on EPD)	Product Description	-	-
5	E-mail of the manufacturer	Manufacturer and EPD author (as shown on EPD)	Product Description	MANUFACTURER INFORMATION - Contact details	-
6	Web page of the manufacturer	Manufacturer and EPD author (as shown on EPD)	Product Description	MANUFACTURER INFORMATION - Website	-
7	EPD author and organisation	Manufacturer and EPD author (as shown on EPD)	Product Description	EPD INFORMATION - EPD Author	Front page - EPD Author
8	EPD verifier (if known)	Manufacturer and EPD author (as shown on EPD)	Product Description	EPD INFORMATION - EPD Verifier	Front page - EPD Verifier
9	Additional information about the manufacturer	Manufacturer and EPD author (as shown on EPD)	Product Description	ABOUT THE MANUFACTURER	-
10	Product name	Product identification (as shown on EPD)	Product Description	Cover page, PRODUCT IDENTIFICATION - Product name	Front page - Products
11	Additional product labels covered by EPD	Product identification (as shown on EPD)	Product Description	PRODUCT IDENTIFICATION - Additional label(s)	1.1. GENERAL INFORMATION - Additional label(s)
12	UN CPC Code and definition (Environdec)	Product identification (as shown on EPD)	Product Description	MANUFACTURER INFORMATION - CPC code	-
13	Product number / reference	Product identification (as shown on EPD)	Product Description	PRODUCT IDENTIFICATION - Product number / reference	1.1. GENERAL INFORMATION - Product number / reference
14	Place(s) of production	Product identification (as shown on EPD)	Product Description	PRODUCT IDENTIFICATION - Place(s) of production	Front page - Production Site
15	Period for LCA data	Product identification (as shown on EPD)	Product Description	LIFE-CYCLE ASSESSMENT INFORMATION - Period for data	Front page - Data Period
16	Product description	Product information (as shown on EPD)	Product Description	PRODUCT DESCRIPTION	2.2. DESCRIPTION OF THE PRODUCT AND TECHNICAL PARAMETERS - Description of the Products
17	Product application	Product information (as shown on EPD)	Product Description	PRODUCT APPLICATION	2.2. DESCRIPTION OF THE PRODUCT AND TECHNICAL PARAMETERS - Products application
18	Technical specifications	Product information (as shown on EPD)	Product Description	TECHNICAL SPECIFICATIONS	2.2. DESCRIPTION OF THE PRODUCT AND TECHNICAL PARAMETERS - Technical specification
19	Product standards	Product information (as shown on EPD)	Product Description	PRODUCT STANDARDS	2.2. DESCRIPTION OF THE PRODUCT AND TECHNICAL PARAMETERS - Product Standards
20	Physical properties of the product	Product information (as shown on EPD)	Product Description	PHYSICAL PROPERTIES OF THE PRODUCT	2.2. DESCRIPTION OF THE PRODUCT AND TECHNICAL PARAMETERS - Physical properties of the product
21	Product raw material composition (as shown on EPD, RTS only)	Product raw material composition (as shown on EPD, RTS only)	Product Description	PRODUCT RAW MATERIAL MAIN COMPOSITION	2.2. DESCRIPTION OF THE PRODUCT AND TECHNICAL PARAMETERS - Table. Raw material summary (RTS only)
22	Material composition (as shown on EPD)	Material composition (as shown on EPD)	Product Description	PRODUCT RAW MATERIAL COMPOSITION	2.2. DESCRIPTION OF THE PRODUCT AND TECHNICAL PARAMETERS - Table. Materials of Products
23	Biogenic carbon content in product	Biogenic carbon content of product and packaging (as shown on EPD)	Product Description	BIOGENIC CARBON CONTENT - Biogenic carbon content in product, kg C	-
24	Biogenic carbon content in accompanying packaging	Biogenic carbon content of product and packaging (as shown on EPD)	Product Description	BIOGENIC CARBON CONTENT - Biogenic carbon content in packaging, kg C	-
25	REACH materials (as shown on EPD)	REACH materials (as shown on EPD)	Product Description	SUBSTANCES, REACH - VERY HIGH CONCERN	2.2. DESCRIPTION OF THE PRODUCT AND TECHNICAL PARAMETERS - Table. Materials of Products
26	Declared Unit (mandatory)	Declared unit and unit for all inputted data	Declared unit	DECLARED AND FUNCTIONAL UNIT - Declared unit	2.1 FUNCTIONAL UNIT AND DECLARED UNIT
27	Mass per declared unit kg	Declared unit and unit for all inputted data	Declared unit	DECLARED AND FUNCTIONAL UNIT - Mass per declared unit	2.1 FUNCTIONAL UNIT AND DECLARED UNIT
28	Functional Unit	Declared unit and unit for all inputted data	Declared unit	DECLARED AND FUNCTIONAL UNIT - Functional unit	-
29	Product Reference Service Life	Declared unit and unit for all inputted data	Declared unit	-	-
30	Manufacturing and packaging (A1-A3)	Product Life-Cycle (as shown on EPD)	EPD Description	MANUFACTURING AND PACKAGING (A1-A3)	2.3. SYSTEM BOUNDARIES - 2.3.2. Technical flowchart
31	Transport and installation (A4-A5)	Product Life-Cycle (as shown on EPD)	EPD Description	TRANSPORT AND INSTALLATION (A4-A5)	-
32	Product End of Life (C1-C4, D)	Product Life-Cycle (as shown on EPD)	EPD Description	PRODUCT END OF LIFE (C1-C4, D)	-
33	Cut-Off Criteria	Life-Cycle Assessment information (shown on EPD	EPD Description	CUT-OFF CRITERIA	-
34	Allocation, Estimates and Assumptions	Life-Cycle Assessment information (shown on EPD	EPD Description	ALLOCATION, ESTIMATES AND ASSUMPTIONS	3.3. ALLOCATION PRINCIPLES AND PROCEDURES
35	Averages and Variability	Life-Cycle Assessment information (shown on EPD	EPD Description	AVERAGES AND VARIABILITY	2.2.1. Calculation rules for averaging data
36	Supply-chain specific data for GWP-GHG	Data specificity and GWP-GHG variability for modules A1-A3 - Environdec only (as shown on EPD)	EPD Description	Data specificity and GWP-GHG variability for GWP-GHG for A1-A3 - Supply-chain specific data for GWP-GHG	-
37	Variation in GWP-GHG between products	Data specificity and GWP-GHG variability for modules A1-A3 - Environdec only (as shown on EPD)	EPD Description	Data specificity and GWP-GHG variability for GWP-GHG for A1-A3 - Variation in GWP-GHG between products	-

38	Variation in GWP-GHG between sites	Data specificity and GWP-GHG variability for modules A1-A3 - Environdec only (as shown on EPD)	EPD Description	Data specificity and GWP-GHG variability for GWP-GHG for A1-A3 - Variation in GWP-GHG between sites	-
39	Electricity data source and quality	Manufacturing energy scenario documentation (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - Manufacturing energy scenario documentation - Electricity data source and quality	2.3.4. Assumptions about electricity consumption and other relevant background data - Table. Manufacturing energy scenario - Electricity data source and quality
40	Electricity CO2e emissions	Manufacturing energy scenario documentation (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - Manufacturing energy scenario documentation - Electricity CO2e / kWh	2.3.4. Assumptions about electricity consumption and other relevant background data - Table. Manufacturing energy scenario - Electricity CO2e / kWh
41	District heating/cooling data source and quality	Manufacturing energy scenario documentation (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - Manufacturing energy scenario documentation - District heating data source and quality	2.3.4. Assumptions about electricity consumption and other relevant background data - Table. Manufacturing energy scenario - District heating data source and quality
42	District heating/cooling data source CO2e emissions	Manufacturing energy scenario documentation (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - Manufacturing energy scenario documentation - District heating CO2e / kWh	2.3.4. Assumptions about electricity consumption and other relevant background data - Table. Manufacturing energy scenario - District heating CO2e / kWh
43	A4 Specific transport CO2 emissions	Transport scenario documentation A4 - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - Transport scenario documentation (A4) - Specific transport CO2e emissions, kg CO2e / tkm	3.5.1. Transportation to construction site - A4 - Table: Transport scenario documentation A4 RTS only - A4 specific transport CO2e emissions, kg CO2e / tkm
44	A4 Average transport distance	Transport scenario documentation A4 - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - Transport scenario documentation (A4) - Average transport distance, km	3.5.1. Transportation to construction site - A4 - Table: Transport scenario documentation A4 RTS only - A4 average transport distance, km
45	A4 Capacity utilization (including empty returns)	Transport scenario documentation A4 - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - Transport scenario documentation (A4) - Capacity utilization (including empty return) %	3.5.1. Transportation to construction site - A4 - Table: Transport scenario documentation A4 RTS only - A4 Capacity utilization (including empty return) %
46	A4 Bulk density of transported products	Transport scenario documentation A4 - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - Transport scenario documentation (A4) - Bulk density of transported products	3.5.1. Transportation to construction site - A4 - Table: Transport scenario documentation A4 RTS only - A4 Bulk density of transported products
47	A4 Volume capacity utilization factor	Transport scenario documentation A4 - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - Transport scenario documentation (A4) - Volume capacity utilization factor	3.5.1. Transportation to construction site - A4 - Table: Transport scenario documentation A4 RTS only - A4 Volume capacity utilization factor
48	Collection process by type - kg collected separately	End of life scenario documentation - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - End of life scenario documentation - Collection process – kg collected separately	3.7. DESCRIPTION OF END OF LIFE (C-D) - Table: End of life scenario documentation RTS only - Collection process – kg collected separately
49	Collection process by type - kg collected with mixed construction waste	End of life scenario documentation - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - End of life scenario documentation - Collection process – Collection process – kg collected with mixed waste	3.7. DESCRIPTION OF END OF LIFE (C-D) - Table: End of life scenario documentation RTS only - Collection process – kg collected with mixed waste
50	Recovery process by type - kg for re-use	End of life scenario documentation - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - End of life scenario documentation - Collection process – Recovery process – kg for re-use	3.7. DESCRIPTION OF END OF LIFE (C-D) - Table: End of life scenario documentation RTS only - Recovery process – kg for re-use
51	Recovery process by type - kg for recycling	End of life scenario documentation - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - End of life scenario documentation - Collection process – Recovery process – kg for recycling	3.7. DESCRIPTION OF END OF LIFE (C-D) - Table: End of life scenario documentation RTS only - Recovery process – kg for recycling
52	Recovery process by type - kg for energy recovery	End of life scenario documentation - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - End of life scenario documentation - Collection process – Recovery process – kg for energy recovery	3.7. DESCRIPTION OF END OF LIFE (C-D) - Table: End of life scenario documentation RTS only - Recovery process – kg for energy recovery
53	Disposal (total) - kg for final deposition	End of life scenario documentation - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - End of life scenario documentation - Collection process – kg for final deposition	3.7. DESCRIPTION OF END OF LIFE (C-D) - Table: End of life scenario documentation RTS only - Disposal (total) – kg for final deposition
54	Scenario assumptions, e.g. transportation	End of life scenario documentation - RTS only (as shown on EPD)	EPD Description	SCENARIO DOCUMENTATION - End of life scenario documentation - Disposal (total) – Scenario assumptions e.g. transportation	3.7. DESCRIPTION OF END OF LIFE (C-D) - Table: End of life scenario documentation RTS only - Scenario assumptions e.g. transportation
55	Assess the quality of the collected activity data	Life cycle interpretation	Background report	-	5.3. DATA QUALITY ASSESSMENT
56	Interpretation of the results	Life cycle interpretation	Background report	-	5.1. INTERPRETATION OF RESULTS
57	Assumptions and limitations associated with the interpretation	Life cycle interpretation	Background report	-	5.2. ASSUMPTIONS AND LIMITATIONS ASSOCIATED WITH THE INTERPRETATION
58	Conclusions and recommendations	Life cycle interpretation	Background report	-	5.4. CONCLUSIONS AND RECOMMENDATIONS
59	Detailed cut-off documentation	Life cycle interpretation	Background report	-	2.3.5. Cut-off criteria for initial inclusion of inputs and output
60	Manufacturing materials - A1	Supplementary description of Materials (A1-A3) and Manufacturing (A3)	Background report	-	3.4.1. Raw material supply A1
61	Transport of materials - A2	Supplementary description of Materials (A1-A3) and Manufacturing (A3)	Background report	-	3.4.2. Transportation A2
62	Manufacturing energy use - A3	Supplementary description of Materials (A1-A3) and Manufacturing (A3)	Background report	-	3.4.3. Manufacturing A3
63	Manufacturing waste and wastewater - A3	Supplementary description of Materials (A1-A3) and Manufacturing (A3)	Background report	-	3.4.3. Manufacturing A4
64	Ancillary and packaging materials and process direct emissions - A3	Supplementary description of Materials (A1-A3) and Manufacturing (A3)	Background report	-	3.4.3. Manufacturing A5
65	Transport to the building site - A4	Supplementary description of Construction (A4-A5) -	Background report	-	3.5.1. Transportation to construction site - A4
66	Installation into the building - A5	Supplementary description of Construction (A4-A5) -	Background report	-	3.5.2. Installation into the building - A5
67	De-construction, demolition - C1	Supplementary description of End of Life (C-D	Background report	-	3.7.1. Disassembly - C1
68	Transport to waste processing - C2	Supplementary description of End of Life (C-D	Background report	-	3.7.2. Transportation to treatment - C2
69	Waste processing for reuse, recovery and/or recycling - C3	Supplementary description of End of Life (C-D	Background report	-	3.7.3. Waste processing C3
70	Disposal - C4	Supplementary description of End of Life (C-D	Background report	-	3.7.4. Disposal - C4
71	Benefits and loads beyond the system boundary - D	Supplementary description of End of Life (C-D	Background report	-	3.7.5. Benefits of recycling - D

A	EPD program operator	EPD Program and PCR	EPD generation	EPD INFORMATION - EPD program operator	Front page - Program Operator
B	Product Category Rules	EPD Program and PCR	EPD generation	EPD INFORMATION - Product category rules	Front page - PCR
C	Pre-Verified EPD generator	EPD Program and PCR	EPD generation	EPD AUTHOR AND CONTRIBUTORS - LCA software	-
D	Brand	EPD visuals	EPD generation	Header - right side	-
E	Product image	EPD visuals	EPD generation	Front page	-
F	Manufacturing diagram	EPD visuals	EPD generation	MANUFACTURING PROCESS	2.3.2. Technical flowchart
n/a	Date	-	-	-	1.1. GENERAL INFORMATION

Verification points matched with a program operator checklist (Adapted from The Building Information Foundation RT sr. 2017)

Verification point	Standard references	Check number	Description in checklist	Reference to OCL	Reference to the Background report/EPD	Pre-verified	Pre-verification justification
BGR-001	EN15804 ch.8.2	1.1	Commissioner of LCA study, LCA practitioner	Product description - 1. Manufacturer and EPD author	1.2. - COMMISSIONER AND PRACTITIONER OF LCA STUDY		
BGR-002	EN15804 ch.8.2	1.2	Date of issue of LCA report	-	1.1. GENERAL INFORMATION	☒	Automatically generated
BGR-003	EN15804 ch.8.2 + applicable PCR	1.3	Statement that the Life Cycle Assessment study has been performed in accordance with the requirements of EN 15804 and. applicable PCRs	-	1.3. STATEMENT OF ASSESSMENT STANDARDS	☒	Fixed statement
BGR-004		1.4	Any other independent verification of the data given in the LCI/LCA documentation?	-	-	☒	Database reviewed
BGR-005	EN15804 ch.8.2	2.1	Reasons for performing the Life Cycle Assessment	-	1.4. REASONS FOR PERFORMING THE LCA	☒	Fixed statement
BGR-006	EN15804 ch.8.2	2.2	Intended application – (e.g. for EPD, databases, publication etc.) Is the LCA designed in such a way that it allows B2B communication for environmental assessments of buildings?	-	1.5. INTENDED APPLICATION AND TARGET AUDIENCE	☒	Fixed statement
BGR-006	EN15804 ch.8.2	2.3	Target group (B2B, B2C, …)	-	1.5. INTENDED APPLICATION AND TARGET AUDIENCE	☒	Fixed statement
BGR-007	EN 15804 ch.6.3.1/6.3.2 and/or applicable PCR or additional specific requirements for certain product groups	3.1	Functional / Declared unit, including relevant technical specification	Declared unit - 1. Declared unit and unit for all inputted data	2.1. FUNCTIONAL AND DECLARED UNIT		
BGR-008	EN15804 ch.8.2	3.2	If product groups (similar products from one manufacturer and/or from different production plants) are formed as averages: · Calculation rules for the formation of averages · Representativeness of averages	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Averages and Variability	2.2.1. Calculation rules for averaging data		

BGR-009	ISO 14025	4.1	Composition of the product	Product description - 5. Material Composition	2.2. DESCRIPTION OF THE PRODUCT AND TECHNICAL CHARACTERISTICS - Table. Materials of Products		
BGR-010	EN15804 ch.8.2, Applicable PCR	4.2	Description of technical and functional characteristics and area of intended application in the building	Product description - 3. Product information (as shown on EPD)	2.2. DESCRIPTION OF THE PRODUCT AND TECHNICAL CHARACTERISTICS		
BGR-011	ISO 14025	4.3	Flow diagram of main production processes and visualization of system boundaries	EPD generation - 2. EPD visuals - Manufacturing diagram	2.3.2. Technical flowchart - Figure 2. The process diagram		
BGR-012	EN15804 ch. 6.3.4	5.1	Comprehensive declaration of modules A1 to A3 as a minimum requirement, if necessary as an aggregated module A1-A3	-	2.3.1. System Boundaries		
BGR-012	EN15804 ch. 8.3	8.1	· Omissions of life cycle stages, processes and data requests	-	2.3.1. System Boundaries		
BGR-012				-	2.3.1. System Boundaries		
BGR-013	EN15804 ch. 6.3.4.2 and applicable PCR	5.2	A1 to A3: System boundary · Clear description of what the modules cover · System boundary to nature (eg forest in wood production) · Use of secondary materials and secondary fuels and waste produced (check end-of-waste state)	Background report - 2. Supplementary description of Materials (A1-A3) and Manufacturing (A3)	3.4. DESCRIPTION OF MANUFACTURING (A1-A3/D)		
BGR-014	EN15804 ch. 6.3.4.2 and applicable PCR	5.2	· If applicable: Reference to the certificate of the offsetting of CO2	-	-	☒	Never part of study
BGR-014	Applicable PCR	7.1	If applicable: Selecting allowable certificates in accordance with the PCR	-	-	☒	Never part of study
BGR-014	Applicable PCR	7.2	If applicable: Offsetting in accordance with the requirements from the individual program operators	-	-	☒	Never part of study

BGR-015	EN15804 ch. 6.4.3.2 + annex B.1	5.3	A1 to A3: Allocation of co-products: · Specification of the "end-of-waste state" · Selection of the allocation factors for co-product allocation · Justification of specific allocation processes (e.g. if data are not available to allocate according to the EN15804 rules) · Presentation of the energy and material flows as a result of deviating allocation processes · No declaration of loads and benefits in Module D from allocation in A1-A3	Background report - 2. Life-Cycle Assessment information (shown on EPD) - Allocation, Estimates and Assumptions	3.3.1. Documentation and justification of allocation procedures		
BGR-015		13.3	Presentation and justification of allocations in the plant (delineation from other products in a plant)	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Allocation, Estimates and Assumptions	3.3.1. Documentation and justification of allocation procedures		
BGR-015		13.4	If applicable: Presentation and justification of allocation of multi-input processes (e.g. landfilling or incineration)	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Allocation, Estimates and Assumptions	3.3.1. Documentation and justification of allocation procedures		
BGR-015	EN15804 ch. 6.4.3.2	13.5	Co-product allocation correctly applied, see also 5.3	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Allocation, Estimates and Assumptions	3.3.1. Documentation and justification of allocation procedures		
BGR-015		13.6	Documentation of allocation factors used and their (independent) sources	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Allocation, Estimates and Assumptions	3.3.1. Documentation and justification of allocation procedures		

BGR-016	EN15804 ch. 6.3.4.3 and applicable PCR	5.4	A4 to A5 (optional module): Clear description and content of modules	Background report - 3. Supplementary description of Construction (A4-A5)	3.5. DESCRIPTION OF CONSTRUCTION (A4-A5)		
BGR-017	EN15804 ch. 6.3.4.1	5.5	Accounting losses in the modules in which they arise (e.g. A4, transport to construction site)	Materials (A1-A3), Manufacturing (A3), Construction (A4-A5)	3.4. DESCRIPTION OF MANUFACTURING (A1-A3/D), 3.5. DESCRIPTION OF CONSTRUCTION (A4-A5)		
BGR-018	EN15804 ch. 6.3.4.4 and applicable PCR	5.6	B1 to B5 (optional module): Delineation and content of modules	Background report - 4. Supplementary description of Use stage, whole life-cycle (B1-B7)	3.6. DESCRIPTION OF USE STAGE (B1-B7)	☒	Not part of standard scope
BGR-019	EN15804 ch. 6.3.4.4 and applicable PCR	5.7	B6 and B7 (optional module): Delineation and content of modules	Background report - 4. Supplementary description of Use stage, whole life-cycle (B1-B7)	3.6. DESCRIPTION OF USE STAGE (B1-B7) - 3.6.7. Operational energy use - B6, 3.6.8. Operational water use - B7	☒	Not part of standard scope
BGR-020	EN15804 ch. 6.3.4.5 and applicable PCR	5.8	C1 to C4 (optional module): Delineation and content of modules	Background report - 5. Supplementary description of End of Life (C-D)	3.7. DESCRIPTION OF END OF LIFE (C-D)		
BGR-021	EN15804 ch. 6.3.4.5 + annex B.1 and applicable PCR	5.9	C3 (optional module): Justification of the "end-of-waste state" · Existing purpose · Existing market or demand · Compliance with technical requirements and legal guidelines · Fulfils limit values for Substances of Very High Concern (SVHC)	Background report - 5. Supplementary description of End of Life (C-D) - Waste processing for reuse, recovery and/or recycling - C3	3.7.3. Waste processing C3		
BGR-021	EN15804 ch.6.4.3.3 and applicable PCR	13.7	Allocation process for reuse, recycling and recovery, check specifically: · Consistency with other scenarios of waste management · Conventional average technologies and practices · Specification and justification of end-of-waste state where applicable	Background report - 5. Supplementary description of End of Life (C-D) - Waste processing for reuse, recovery and/or recycling - C3	3.7.3. Waste processing C3		

BGR-021	EN15804 ch.6.4.3.3 and applicable PCR	13.7	· Conservative approach, i.e. choice of those scenarios and calculation rules that reflect the highest environmental impacts in comparison to other choices	Background report - 5. Supplementary description of End of Life (C-D) - Waste processing for reuse, recovery and/or recycling - C3	3.7.3. Waste processing C3		
BGR-022	EN15804 ch. 6.3.4.5 and ch.6.3.4.6	5.1	C4 (optional module): Carefully check the correct allocation	Background report - 5. Supplementary description of End of Life (C-D) - Disposal - C4	3.7.4. Disposal - C4		
BGR-023	EN15804 ch. 6.3.4.6	5.11	D (optional module): System boundary and contents of Module justified	Background report - 5. Supplementary description of End of Life (C-D) - Benefits and loads beyond the system boundary - D	3.7.5. Benefits of recycling - D		
BGR-023	EN15804 ch. 8.5	8.1	It should also be transparent which electricity/energy model is applies as avoided product if energy recovery is included in the optional Module D.	End of life (C-D) - 5. Benefits and loads beyond the system boundary - D	3.7.5. Benefits of recycling - D - Table. List of processes included in D		
BGR-023	EN15804 ch.6.4.3.3 and applicable PCR	13.7	· If applicable (module D): Selecting substituted processes in accordance with the PCR or (if no PCR is available) representative actual processes	Background report - 5. Supplementary description of End of Life (C-D) - Benefits and loads beyond the system boundary - D	3.7.5. Benefits of recycling - D		
BGR-024	EN15804 ch. 6.3.4.6 and 6.4.3.3	5.12	D (optional module): Check if the net flow calculation is done correctly taking into consideration relevant factors, e.g.: · Processing losses · Inputs in Modules A1 to A3 (and A4 to B5 if necessary)	End of life (C-D) - 5. Benefits and loads beyond the system boundary - D	3.7.5. Benefits of recycling - D - Table. List of processes included in D		
BGR-024	EN15804 ch.6.4.3.3	5.13	D (optional module): No benefits or loads of allocated co-products	End of life (C-D) - 5. Benefits and loads beyond the system boundary - D	3.7.5. Benefits of recycling - D - Table. List of processes included in D		

BGR-024	EN15804 ch.6.4.3.3 and applicable PCR	13.7	· If applicable (substitution in Module D): Calculation of net flows	End of life (C-D) - 5. Benefits and loads beyond the system boundary - D	3.7.5. Benefits of recycling - D - Table. List of processes included in D		
BGR-025	CEN TR15941 and applicable PCR	6.1	Selection of the power mix in accordance with the location of the production site(s)	EPD Description - 3. Manufacturing energy scenario documentation (as shown on EPD)	2.3.4. Assumptions about electricity consumption and other relevant background data		
BGR-025	EN15804 ch. 8.4	8.1	· Assumptions with regard to energy and electricity production incl. year of reference.	EPD Description - 3. Manufacturing energy scenario documentation (as shown on EPD)	2.3.4. Assumptions about electricity consumption and other relevant background data		
BGR-026	Applicable PCR	6.2	If applicable: Validity of the certificates for green power	-	Annex X		
BGR-027	EN15804 ch.6.3.5 and ch. 8.2 and applicable PCR	9.1	Selection of the cut-off criteria, description of application of the criteria and assumptions	Background report - 1. Life cycle interpretation - Detailed cut-off documentation	2.3.5. Cut-off criteria for initial inclusion of inputs and output		
BGR-028	EN15804 ch. 8.2	9.2	List of excluded processes available	-	-		
BGR-029	EN15804 ch.6.3.6 EN 15941 and applicable PCR	12.1	Selection and use of generic data and background data justified and validity demonstrated (Commonly used and publicly available databases in Europe are: GaBi database, EcoInvent, Okobau.dat, ILCD, … [to be extended by Program Operators])	-	3.2.2. Criteria for choosing the generic data	☒	Automatically documented
BGR-029	EN15804 ch. 6.3.7 EN15941 and applicable PCR	12.2	· Integrity of generic data records, system limit and cut-off criteria for generic data records validity demonstrated	-	3.2.2. Criteria for choosing the generic data	☒	Automatically documented
BGR-029	EN15941 and applicable PCR	12.3	Documentation on data / background data: · Name of the (background) data record, its source (data base, literary source etc.), year of data collection and its representativeness	-	3.2.2. Criteria for choosing the generic data	☒	Automatically documented

BGR-030	EN15804 ch. 8.2	8.1	· Assessment period for each module considered in the Life Cycle Assessment (eg one year average, etc)	Product description - 2. Product identification (as shown on EPD) - Period data represents (e.g. calendar year)	3.2.1. Procedures for collection process specific data		
BGR-030	ISO 14044:2006, section 4.3.2; Documentation ISO 14040 EN15804 6.3.6	10.1	Data collection, including data quality issues, according to LCA rules	-	3.2.1. Procedures for collection process specific data		
BGR-030	EN15804 ch. 6.3.7 EN15941 and applicable PCR	12.2	· < 5 years for manufacturer's data	-	3.2.1. Procedures for collection process specific data		
BGR-030	EN15804 ch. 6.3.7 EN15941 and applicable PCR	12.2	· Data manufacturer based on 1 year average	-	3.2.1. Procedures for collection process specific data		
BGR-031	ISO 14040	8.1	Transparent description of the system boundaries: · Representativeness (temporal, geographical, technological)	All used resources datacards	3. LIFE CYCLE INVENTORY ANALYSIS - Table: List of processes - columns (Resource name, Geographical representation, Date, Representativeness)		
BGR-032	EN15804 ch. 8.6	8.1	· Assumptions concerning other relevant background data where relevant for the system boundar	-	3.2.3. Treatment of missing data		
BGR-032	EN15941 and applicable PCR	12.3	· Handling missing data	-	3.2.3. Treatment of missing data		
BGR-033	EN15804 ch. 6.3.7 EN15941 and applicable PCR	12.2	· < 10 years for background data	-	3.2.2. Criteria for choosing the generic data	☒	Automatically set through database
BGR-033	EN15804 ch. 6.3.7 EN15941 and applicable PCR	12.2	· Time period of 100 years in case of a landfill scenario, longer if relevant	-	3.2.2. Criteria for choosing the generic data	☒	Automatically set through database
BGR-034	EN15804 ch. 6.3.7 EN15941 and applicable PCR	12.2	· Technical background complies with physical reality	All the resource inputs comment fields	3. LIFE CYCLE INVENTORY ANALYSIS - Table: List of processes - Comment column		
BGR-035	EN15941 and applicable PCR	12.3	· Assessing data quality	-	3.2.4. Data quality assessment	☒	Automatically documented
BGR-036		12.4	Manufacturing data should be reproducible, e.g. by available data management systems. Random checks could be carried out, or	-	-		

			based on importance; some data could be checked in the verification.				
BGR-037	EN15804 ch. 6.3.8 Applicable PCR	11.1	Statement that the scenarios included are currently in use and are representative for one of the most likely scenario alternatives. Check the PCR / program rules if average scenarios are allowed. (preferably no average scenarios for various alternatives)	-	2.3.3. Scenarios for analyses beyond cradle to gate	☒	Fixed statement
BGR-038		11.2	Documentation of the relevant technical information, e.g. recycling or reuse rates, with reference to the literature source	Background report - 2. Supplementary description of Materials (A1-A3) and Manufacturing (A3), 3. Supplementary description of Construction (A4-A5), 4. Supplementary description of Use stage, whole life-cycle (B1-B7), 4. Supplementary description of End of Life (C-D)	3.4. DESCRIPTION OF MANUFACTURING (A1-A3/D), 3.5. DESCRIPTION OF CONSTRUCTION (A4-A5), 3.6. DESCRIPTION OF USE STAGE (B1-B7), 3.7. DESCRIPTION OF END OF LIFE (C-D)		
BGR-039	ISO14044:2006 4.3.4	13.1	General allocation principles applied (avoidance of allocation, no double counting / omissions, uniform application of the allocation rules etc.)	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Allocation, Estimates and Assumptions	3.3.1. Documentation and justification of allocation procedures		
BGR-040	EN15804 ch.6.4.3 and 8.2 and applicable PCR	13.2	Presentation and justification of allocations in the use of secondary materials or secondary fuels as raw materials	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Allocation, Estimates and Assumptions	3.3.1. Documentation and justification of allocation procedures		

BGR-041	Applicable PCR	13.8	Is there any presentation or expert guess of data sets which do not comply with the allocation principles and description of consequences for the LCA results?	-	-	☒	Not applicable
BGR-042	EN 15804 ch.8.4	14.1	Transparent presentation of Life Cycle Assessment modelling (for example by tables, screenshots from Life Cycle Assessment software programs etc.)	All the resource input queries	3. LIFE CYCLE INVENTORY ANALYSIS - Table: List of processes	☒	Automatically generated
BGR-043	EN15804 ch.8.4	14.2	Clear description how company data are used in which data records in Life Cycle Assessment software programs	All the resource inputs comment fields	3. LIFE CYCLE INVENTORY ANALYSIS - Table: List of processes		
BGR-043	EN15804 ch.8.4	14.3	Assignment of process data to the Life Cycle Assessment modules	All the resource input queries	3. LIFE CYCLE INVENTORY ANALYSIS - Table: List of processes		
BGR-044		14.4	For several locations/products: Presentation of modelling of all locations and products as well as weighting thereof	All the resource input queries allocation fields	3. LIFE CYCLE INVENTORY ANALYSIS - Table: List of processes		
BGR-045	EN15804 ch.8.4	14.5	Plausibility and consistency of data (mass balance, energy balance) Balances on company level and in the life cycle. e.g. Mass balance between reference flow and wastes for cradle to grave data / Mass of non-energetic resources used coherent with the reference flow	Results - Mass balance	Annex 1: Table. Mass balance for product stage		
BGR-046	EN15804 ch.8.4	14.5	/ CO and CO2 emissions coherent with the mass of fossil energetic resources	Results - Core environment al impact indicators - EN 15804+A2, PEF - GWP Impact indicators - Details	4.1. LCIA PROCEDURES, CALCULATIONS AND RESULTS OF THE STUDY - Core environmental impact indicators - EN 15804+A2, PEF - GWP Impact indicators		
BGR-047	EN15804 ch.8.4	14.5	/ check of the sum of non-renewable and renewable parts or between feedstock and fuel parts / Is the energy indicators coherent with the	Results - Use of natural resources - Use of energy indicators - Details	4.1. LCIA PROCEDURES, CALCULATIONS AND RESULTS OF THE STUDY - USE OF NATURAL RESOURCES - Use		

			energetic resources used?		of energy indicators		
BGR-048	EN15804 ch..7.2.2 EN15978 ch.12.5	15.1	Presentation of the parameters in tabular form for all modules A1 to D.Marking unassessed modules as "MNA" (= module not assessed) or "MNR" (= module not relevant)	Results	4.1. LCIA PROCEDURES, CALCULATIONS AND RESULTS OF THE STUDY	☒	Automatically generated
BGR-048	EN15804 ch. 6.5, 7.2.3 – 7.2.5	15.2	Presentation of the parameters describing environmental impact (7 parameters), the parameters for describing the use of resources (10 parameters), parameters for describing the waste categories (3 parameters) and parameters concerning output material flows (4 parameters)	Results	4.1. LCIA PROCEDURES, CALCULATIONS AND RESULTS OF THE STUDY	☒	Automatically generated
BGR-049	EN15804 ch.8.2 and annex (amendment) and applicable PCR	15.3	Selection of correct characterisation factors and elimination of long-term emissions (> 100 years)	-	ANNEX 1: CHARACTERIZATI ON METHODS	☒	Automatically documented
BGR-049		15.4	Justification of characterisation factors applied in case of input/output flows that are not on the list of characterisation factors of the EN15804 and applicable PCR	-	-	☒	Not applicable
BGR-050	EN15804 ch.8.2	15.5	Information on the environmental impacts in the project report: · Reference to characterisation models and factors · Statement that the estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks	-	ANNEX 1: CHARACTERIZATI ON METHODS	☒	Fixed statements
BGR-051		16.1	Interpretation of the results based on a dominance/contributio n analysis of selected indicators	Background report- 1. Life cycle interpretatio n - Interpretatio n of the results	5.1. INTERPRETATION OF RESULTS		

BGR-052	EN15804 ch.8.2	16.2	Relationship between the results of the Life Cycle Inventory Assessment and the results of the Life Cycle Impact Assessment (LCIA)	-	4.2. RELATIONSHIP OF THE LCIA RESULTS TO THE LCI RESULTS	☒	Automatically generated charts
BGR-053	EN15804 ch.8.2	16.3	Assumptions and restrictions as regards the interpretation of results in the EPD, in terms of both methods and data	Background report- 1. Life cycle interpretation - Assumptions and limitations associated with the interpretation	5.2. ASSUMPTIONS AND LIMITATIONS ASSOCIATED WITH THE INTERPRETATION		
BGR-054	EN15804 ch.8.2	16.4	Variance from the means of LCIA results must be presented if generic data is provided from several sources or [the results] refer to a number of similar products.	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Averages and Variability	2.2.1. Calculation rules for averaging data		
BGR-055	EN15804 ch.8.2 ISO 14040 CEN TR15941 Applicable PCR	16.5	Data quality assessment	Background report- 1. Life cycle interpretation - Assess the quality of the collected activity data	5.3. DATA QUALITY ASSESSMENT		
BGR-056	EN15804 ch.8.2	16.6	Comprehensive transparency as regards value decisions, justifications and expert opinions	-	4.3. VALUE BASED CHOICES RELATED TO DECISIONS REGARDING CHARACTERIZATION MODELS, FACTORS AND METHODS		
BGR-057	EN15804 ch.8.3	17.1	Where relevant to check the documentation: · Laboratory results/measurements listed in the content declaration · Laboratory results/measurements listed in the functional/technical performance · Documentation on the declared technical information on individual life cycle stages not taken into consideration in the construction product's Life Cycle Assessment and applied for evaluation of the building (e.g. transport routes, energy	-	3.6. DESCRIPTION OF USE STAGE (B1-B7)	☒	Not part of scope. Exclusion of Indoor air, soil or water measurement is a fixed statement

			consumption during the usage stage, cleaning cycles etc.) · Laboratory results/measurements pertaining to the declared emissions in indoor air, soil or water during the use stage				
BGR-058	EN15804 ch.6.3.3	18.1	Necessary if the entire life cycle A1-C4 is declared: Documentation for calculating the reference service life (RSL), should be representative for the declared product	Background report - 4. Supplementary description of Use stage, whole life-cycle (B1-B7)	3.6. DESCRIPTION OF USE STAGE (B1-B7)		
EPD-001	EN15804 ch.7.1	1.1	General, EPD includes: - Text "Environmental Product Declaration in accordance with ISO 14025 and EN 15804"	-	EPD Front page	☒	Fixed statement
EPD-002	EN15804 ch.7.1	1.1	- Statement that "EPD of construction products may not be comparable if they do not comply with EN15804 and seen in a building context"	-	GENERAL INFORMATION - EPD INFORMATION	☒	Fixed statement
EPD-003	EN15804 ch.7.1	1.1	- Publisher / program operator, name, address	EPD generation - 1. EPD Programme and PCR - EPD program operator	GENERAL INFORMATION - EPD INFORMATION - EPD program operator		
EPD-004	EN15804 ch.7.1	1.1	- Name of declared product	Product description - 2. Product identification (as shown on EPD) - Product name	GENERAL INFORMATION - PRODUCT IDENTIFICATION - Product name		
EPD-005	EN15804 ch.7.1	1.1	- Declaration owner / Name and address of manufacturer/association	Product description - 2. Product identification (as shown on EPD) - Name of the manufacturer, Address of the manufacturer	GENERAL INFORMATION - MANUFACTURER INFORMATION		

EPD-006	EN15804 ch.7.1	1.1	- Representativeness of geographical area	Product description - 2. Product identification (as shown on EPD) - Place(s) of production	GENERAL INFORMATION - PRODUCT IDENTIFICATION - Place(s) of production		
EPD-007	EN15804 ch.7.1	1.1	- Representativeness with regard to which manufacturer(s)	Product description - 3. Product information (as shown on EPD) - Product description	PRODUCT INFORMATION - PRODUCT DESCRIPTION		
EPD-008	EN15804 ch.7.1	1.1	- Program logo	EPD generation - 1. EPD Programme and PCR - EPD program operator	Front page - top left header	☒	Automatically generated
EPD-009	EN15804 ch.7.1	1.1	- Program website	EPD generation - 1. EPD Programme and PCR - EPD program operator	GENERAL INFORMATION - EPD INFORMATION - EPD program operator		
EPD-010	EN15804 ch.7.1	1.1	- Date of issue	-	GENERAL INFORMATION - EPD INFORMATION - Publishing date		
EPD-011	EN15804 ch.7.1	1.1	- Validity (5 years)	-	GENERAL INFORMATION - EPD INFORMATION - EPD valid until		
EPD-012	EN15804 ch.7.1	1.1	- Variability for average declaration	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Averages and Variability	LIFE-CYCLE ASSESSMENT - AVERAGES AND VARIABILITY	☒	Redundant, generated from the same source as Part A 16.4 (RTS), 15.4 (IES)
EPD-013	EN15804 ch.7.1	1.1	- Product composition	Product description - 5. Material composition (as shown on EPD)	PRODUCT INFORMATION - PRODUCT RAW MATERIAL COMPOSITION	☒	Redundant, generated from the same source as Part A 4.1
EPD-014	EN15804 ch.7.1	1.1	- Stages omitted, if not full LCA	-	LIFE-CYCLE ASSESSMENT - SYSTEM BOUNDARY		
EPD-014	EN15804 ch.7.2.2	3.2	Indication of the EPD type (cradle-to-gate, cradle-to-gate with options, cradle-to-grave)	-	SYSTEM BOUNDARY		
EPD-015	Applicable PCR	1.2	PCR name, registration number, version and date	EPD generation - 1. EPD Programme	GENERAL INFORMATION - EPD INFORMATION -		

				and PCR - Product Category Rules	Product category rules		
EPD-016	EN15804 ch.7.1 Table 2	1.3	Demonstration of verification: external independent verification, name of third party verifier	Product description - 1. Manufacturer and EPD author (as shown on EPD) - EPD verifier (if known)	GENERAL INFORMATION - EPD INFORMATION - EPD verifier		
EPD-017		1.4	Information on the validity corresponds with the specifications in the project report	-	-	☒	Validity only marked on EPD
EPD-018		2.1	The product description is in line with the project report and the product studied, and clear enough described in the EPD to understand what product is declared	Product description - 3. Product information (as shown on EPD) - Product description	PRODUCT INFORMATION - PRODUCT DESCRIPTION	☒	Redundant, generated from same source as 4.2
EPD-019	EN15804 ch.7.1	2.2	If applicable: Explanations on calculations of averages within a product group	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Averages and Variability	LIFE-CYCLE ASSESSMENT - AVERAGES AND VARIABILITY	☒	Redundant, generated from same source as Part A 3.2 (RTS), Not relevant (IES)
EPD-020	EN15804 ch.7.1	2.3	Specification / identification (picture, name, model)	EPD Generation - 2. EPD Visuals - Product image	Front page		
EPD-021	EN15804 ch.7.1	2.4	Indication of the intended use	Product description - 3. Product information (as shown on EPD) - Product application	PRODUCT INFORMATION - PRODUCT APPLICATION	☒	Redundant, generated from same source as 4.2
EPD-022		2.5	Relevant technical data (additional information is possible) including RSL if applicable	Product description - 3. Product information (as shown on EPD) - Technical specifications	PRODUCT INFORMATION - TECHNICAL SPECIFICATIONS	☒	Redundant, generated from same source as 4.2
EPD-023		2.6	The test standards to which the technical data are referred to.	Product description - 3. Product information (as shown on EPD) - Product standards	PRODUCT INFORMATION - PRODUCT STANDARDS		

EPD-024	EN15804 ch.7.1	2.7	A description of the main product components and or materials is provided in accordance with the specifications of the PCR (if available) and LCA project report.	Product description - 3. Product information (as shown on EPD) - Physical properties of the product	PRODUCT INFORMATION - PHYSICAL PROPERTIES OF THE PRODUCT	☒	Redundant, generated from same source as 4.1
EPD-025	EN15804 ch.7.1	2.7	As a minimum substances that are listed in the latest "Candidate List of Substances of Very High Concern for authorisation" if their content exceeds the limits for registration	Product description - 7. REACH materials (as shown on EPD)	PRODUCT INFORMATION - SUBSTANCES, REACH - VERY HIGH CONCERN		
EPD-026	EN15804 ch.7.1	2.8	Description of the manufacturing process / all manufacturing processes if several locations are involved	EPD Description - 1. Product Life-Cycle (as shown on EPD) - Manufacturing and packaging (A1-A3)	PRODUCT LIFE-CYCLE - MANUFACTURING AND PACKAGING (A1-A3)		
EPD-027	Applicable PCR	3.1	Information on the declared / functional unit corresponds with the specifications of the PCR (if available)	Declared unit - 1. Declared unit and unit for all inputted data	LIFE-CYCLE ASSESSMENT - DECLARED AND FUNCTIONAL UNIT	☒	Redundant, generated from same source as Part A 3.1
EPD-028	EN15804 ch.7.2.1	3.3	EPD contains a (simple) flow diagram in accordance with the modular approach	EPD generation - 2. EPD visuals - Manufacturing diagram	MANUFACTURING PROCESS	☒	Redundant, generated from same source as Part A 4.3
EPD-028	EN15804 ch.7.2.1	3.4	Description of the system boundary (can be simplified, as a picture or in wording) Presentation of assignment of the analysed processes to the life cycle modules	EPD generation - 2. EPD visuals - Manufacturing diagram	MANUFACTURING PROCESS	☒	Redundant, generated from same source as Part A 4.3
EPD-029		3.5	Indication of the key assumptions and estimates for interpretation which are not depicted elsewhere in the EPD	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Allocation, Estimates and Assumptions	LIFE-CYCLE ASSESSMENT - ALLOCATION, ESTIMATES AND ASSUMPTIONS	☒	Not applicable
EPD-030		3.6	Presentation of the application of cut-off criteria in accordance with the project report	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Cut-Off Criteria	LIFE-CYCLE ASSESSMENT - CUT-OFF CRITERIA	☒	Redundant, generated from same source as Part A 8.1.

EPD-031	Not required by EN 15804 and thus optional in EPD	3.7	Source of background data used	-	BIBLIOGRAPHY	☒	Automatically documented
EPD-031	Not required by EN 15804 and thus optional in EPD	3.8	Indication of the age of background data used	-	BIBLIOGRAPHY	☒	Automatically documented
EPD-032	Not required by EN 15804 and thus optional in EPD	3.9	Information on the data collection period and resulting averages	Product description - 2. Product identification (as shown on EPD) - Period data represents (e.g. calendar year)	LIFE-CYCLE ASSESSMENT - LIFE-CYCLE ASSESSMENT INFORMATION	☒	Redundant, generated from same source as Part A 9.3
EPD-033		3.1	Presentation of the allocations of relevance for calculation in accordance with the minimum requirements of the PCR	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Allocation, Estimates and Assumptions	LIFE-CYCLE ASSESSMENT - ALLOCATION, ESTIMATES AND ASSUMPTIONS	☒	Redundant check with Part A section 12
EPD-034	EN15804 ch.7.3	4.1	Mandatory for all declared modules > A3: Presentation of the assumptions pertaining to the scenarios of the declared modules in accordance with the project report. Information on undeclared modules is optional.	EPD Description - 1. Product Life-Cycle (as shown on EPD)	PRODUCT LIFE-CYCLE		
EPD-035	EN15804 ch.7.3.3.2	4.2	If a reference service life is declared in the EPD, presentation of the scenario on which the RSL is based, in accordance with the project report	-	PRODUCT LIFE-CYCLE - PRODUCT USE AND MAINTENANCE (B1-B7)		
EPD-036		5.1	Description of the declared / functional unit	Declared unit - 1. Declared unit and unit for all inputted data	LIFE-CYCLE ASSESSMENT - DECLARED AND FUNCTIONAL UNIT	☒	Redundant, generated from same source as 3.1
EPD-037		5.2	Identification of the declared/undeclared modules MNA = module not assessed	Results	ENVIRONMENTAL IMPACT DATA	☒	Automatically generated
EPD-037	EN15804 ch.7.2.3, 7.2.4, 7.2.5 and ch.7.5	5.3	Full declaration of all indicators required according to the modular approach INA = indicator not assessed	Results	ENVIRONMENTAL IMPACT DATA	☒	Automatically generated
EPD-037	Program operator rules	5.6	Deletion of module columns which are not declared (permissible	Results	ENVIRONMENTAL IMPACT DATA	☒	Not relevant

			for the Results part) if program allows				
EPD-037		5.7	Formatting the table framework and parameter addressed in accordance with the specifications of the PCR or the Program Operator rules	Results	ENVIRONMENTAL IMPACT DATA	☒	Automatically generated
EPD-039		5.4	Compliance of the declared values with the information in the project report	-	-	☒	Generated from the same source
EPD-040	EN15804 ch.7	5.5	In case of product averages: description of the range / variability of the LCIA results	EPD Description - 2. Life-Cycle Assessment information (shown on EPD) - Averages and Variability	LIFE-CYCLE ASSESSMENT - AVERAGES AND VARIABILITY		
EPD-041	EN15804 ch.7.4	6.1	Additional information is provided to indoor air or soil/water, if applicable	-	-	☒	Not in default scope – fixed statement to the contrary
EPD-041	EN15804 ch.7.2 and applicable PCR, existing program rules	6.2	Declaration of the relevant evidence. Information where to find this evidence	-	-	☒	Not in default scope – fixed statement to the contrary
EPD-042	In the general information sources list the PCR is not listed. List not requires by standard, thus optional in EPD, shown in report.	7.1	Full indication of all referenced sources (excluding standards already quoted in full and standards concerning evidence)	-	BIBLIOGRAPHY		
EPD-RTS-001	RTS PCR 1.	1.1	To be drawn up in accordance with EN 15804 + A1:2014	-	-	☒	Redundant, with Part A and B
EPD-RTS-002	RTS EPD 6.2	2.1	Modules A1–A3 (Acquisition of raw materials, Transport to manufacturing site, Manufacturing) are mandatory under EN Standard SFS-EN 15804 + A1:2014	-	2.3.1. System Boundaries	☒	Redundant, with Part A 5.1
EPD-RTS-003	RTS EPD 6.2	2.2	the protocol (RTS PCR), EPDs (RTS EPDs) must include modules A4, C1, C2, C3, C4 and D in accord-ance with the provisions	-	2.3.1. System Boundaries	☒	Redundant, with Part A 5.1
EPD-RTS-004	RTS EPD 6.4.3	3.1	Information about wood products shall be provided in accordance with the PCR for wood products (EN 16485:2014). This does not apply to the carbon store of wood products, which, based	Product description - 5. Biogenic carbon content of product and packaging (as shown on EPD)	LIFE-CYCLE ASSESSMENT - BIOGENIC CARBON CONTENT		

			on Euro-pean practices, shall be declared as additional information in section 7.3 instead of module B1				
EPD-RTS-005	RTS EPD 6.4.3	3.2	When calculating the environmental profile of construction products, process-specific information shall be used, where available, for the emissions of various forms of energy. For the time being, in all other cases, a possible source is, for example, the information contained in the data banks.	-	3.2.2. Criteria for choosing the generic data	☒	Redundant, with Part A 12.1 and 12.3
EPD-RTS-006	RTS EPD 6.4.3.3	3.3	Waste flows are treated as recoverable material in accordance with EN 15804:2012 + A1:2013. In the calculation, the direct emissions of waste processing shall be taken into account until waste processing has reached the so-called "end of waste" state. When a building is demolished, all materials are, in principle, waste. When the material meets the criteria for "end of waste" state outlined in the standard, the material is no longer waste.	Background report - 5. Supplementary description of End of Life (C-D) - Waste processing for reuse, recovery and/or recycling - C3	3.7.3. Waste processing C3	☒	Redundant, with Part A 5.9 and 13.7
EPD-RTS-007	RTS EPD 7.3.1	4.1	As regards the electricity and district heating used in modules A3, the following additional in-formation shall be included in the declaration: quality of electricity and district heating data and at least CO2 emissions (kg CO2 eq. /kWh).	EPD Description - 3. Manufacturing energy scenario documentation (as shown on EPD)	SCENARIO DOCUMENTATION - Manufacturing energy scenario documentation	☒	Redundant, with Part A 6.1
EPD-RTS-008	RTS EPD 7.3.2.1	4.2	The eco-profile of transport must be declared. In principle, the correct information shall be used. If no information is available, the most common transport method in the sector shall be used in-stead. Technical specifications shall be	EPD Description - 5. Transport scenario documentation A4 - RTS and EPD Norge only (as shown on EPD)	SCENARIO DOCUMENTATION - Transport scenario documentation (A4)		

			provided in accordance with Table 7 of section 7.3.2.1 of the standard.				
EPD-RTS-009	RTS EPD 7.3.3.3	4.3	When calculating the environmental profile of construction products, process-specific infor-mation shall be used, where available, for the emissions of various forms of energy. In all other cases, it is possible to use as source of environmental information, for example, the sources of information referred to in section 6.4.3.	-	-	☒	Not applicable
EPD-RTS-010	RTS EPD 7.4.1	4.4	In RTS EPDs, it is also possible to declare the product's M emission class for construction materials (where applicable) or the emissions measurement results.	-	-	☒	Not applicable