Environmental Product Declarations – an extensive collection of availability, EN15804 revision and the ILCD+EPD format

Brisson Stapel, Emilie; Tozan, Buket; Sørensen, Christian Grau; Birgisdottir, Harpa

Published in:
IOP Conference Series: Earth and Environmental Science

DOI (link to publication from Publisher):
10.1088/1755-1315/1078/1/012108

Publication date:
2022

Document Version
Publisher's PDF, also known as Version of record

Environmental Product Declarations – an extensive collection of availability, EN15804 revision and the ILCD+EPD format

Environmental Product Declarations – an extensive collection of availability, EN15804 revision and the ILCD+EPD format

E Stapel[1], B Tozan[1], C Sørensen[1] and H Birgisdóttir[1]

[1]Department of the Built Environment, Copenhagen Campus, Aalborg University, 2450 Copenhagen, Denmark

eebj@build.aau.dk

Abstract. The increasing awareness on climate issues in the built environment places a greater responsibility on the different actors to map the building emissions, reduce and optimise the use of materials, and thereby lower the environmental footprint. With several countries enforcing legally binding CO_2 limits to assess and benchmark the negative environmental side effects from buildings using the LCA method, it is presumable that practitioners from the industry will look for higher availability of data found from Environmental Product Declarations (EPDs). As the availability of data more than likely will increase drastically over the years, the study provides an extensive look into the world of digitalised EPDs, and how to use the format to extract a comprehensive number of EPD data. The extraction of data from the ECO Platform leads to a total of 1478 entities, and when adding EPDs from EPD Denmark this study scrutinises 1644 EPDs in total, from 4 EPD Program Operators (EPD-POs). The extraction process highlights the need for transparency and more mutual agreements in the documentation methods. Further, the study scratches the surface of the revised European EPD Standard EN15804, and what the changes and the transition will mean for the applicability and transparency in the building sector and for LCA models when the majority of emissions from GWP will increase.

Keywords: Environmental Product Declarations (EPDs); EN15804, Digitalisation; EPD Program Operator (EPD-PO); Data Availability, ILCD+EPD; ECO Platform; In Data

1. Introduction

Throughout history, humanity has faced rapid environmental changes and thereby the change of natural phenomena from local to global levels. Today is no different, as changes are an inevitable phenomenon in the globalised world and as humankind has entered a new geological epoch, known as the Anthropocene, human activities now threaten the resilience of the ecosystem and nature's natural cycle to persist and to provide for future generations [1], [2]. Due to this, the sustainability agenda continues to evolve, and the awareness among decision-makers, consumers, and industries is now more present than ever [3].

The increasing awareness creates increasing demands in the building industries' sustainability agenda, as one of the largest anthropogenic culprits and largest contributors to the increasing Greenhouse Gas (GHG) emissions, comes from buildings. With almost one-third of the emissions emerging from the production of materials, buildings play an important role in reducing GHG emissions and in the transformation toward CO_2 neutral societies [4]. While the building industry is actively

seeking sustainable solutions, the lack of documentation strategies and transparency from authorities and regulatory systems has been critically missing from the agenda for decades, thereby failing to provide holistic and structural guidelines. Until recently, embodied carbon emission in buildings has thereby only been addressed on various voluntary levels, through multiple certification systems and guidelines. However, the landscape of European policy is set to change, and while a common based EU policy on whole-life carbon is under preparation, several national initiatives have already been introduced, such as Denmark, France, and the Netherlands which have enforced legally binding CO_2 limits to assess and benchmark the negative environmental side effects from buildings using the LCA methodology [5]–[7]. Accordingly, with the growing awareness on the environmental performance of buildings and the utilization of materials, it is predicted that the requirements and limits will induce manufacturers of building materials to publish LCA-based data on their products in the form of Environmental Product Declarations (EPD) and other formats [8].

An EPD is an international standardised method documenting the environmental performance of a product or a service, i.e., the related emissions. The data are third-party verified based on the ISO 14025 standard [9] since 2006, governed by several Product Category Rules (PCRs) elaborated by the numerous EPD Program Operators (EPD-POs) responsible for the rule creation and the third-part verification [10]–[12]. In comparison the European standard, EN 15804 from 2012, introduces limited guidance by dealing only with construction products, establishing the scope, allocation, as well as covering the impact categories. In 2019 the standard was revised, entailing a completely new form of reporting, making the two standards incomparable. The "old" standard is defined as EN15804:2012 + A1:2013 (EN15804+A1) [13], and the "new" standard is defined as EN15804:2012 + A2:2019 (EN15804+A2) [14].

Current trends and regulations on CO_2 limits and documentation of emissions push the industry and the various actors to evolve and think beyond business-as-usual, by incorporating Life Cycle Assessments (LCAs) to strengthen design ideas and processes. Simultaneously, it is expected that the level of product data, unfolded as EPDs will increase even more rapidly over the next few years, to support the sustainability agenda. For a long period of time, EPDs were often found through the individual EPD-POs, however, with the growing digital world, joint databases such as ECO Platform and the InData network have evolved. ECO Platform and InData stores EPDs in different file formats, the most common is the pdf format, however the digital format ILCD+EPD is intensively increasing. The digital format is based on the European Commission's International Reference Life Cycle Data System (ILCD), as an object-oriented data format. The ILCD format was extended to ILCD+EPD format with the publication of EN15804 to explicit allow the linking of data sources [15], [16]. Even with a joint database and the ILCD+EPD format, the search for specific EPDs can be rather time-consuming, as designers are often met with an extensive amount of data, with few possibilities for filtrations.

The aim of this paper is to quantify the comprehensive ILCD+EPD format, followed by extensive research on EPD availability, accessibility, and the coming challenges, the revision of EN15804+A1 to EN15804+A2 encloses.

2. Method

The work encompasses a look into the extensive increase in the availability of EPDs and the rapidly growing digitalisation as a new era related to the growing use of LCA tools. The collection of data was therefore limited to focus on third-party verified EPDs published on the digital ILCD+EPD format, following both European Standards, EN15804+A and EN15804+A2. A study by Jane Anderson, from February 12, 2022, [17] identifies a comprehensive overview of published EPDs, following EN15804, from international EPD-POs, accessible on the digital format. This study thereby takes its point of reference in the list of EPD program operators identified by Anderson.

An assessment of each of the EPD-POs was thereby conducted to identify the accessibility of digital files, as Anderson states, that more than half of all EPDs available on EN15804 should be accessible on a digital format. From the assessment, both InData and ECO Platform were identified as interesting online and open-access databases for EPDs from around the world, and as a gathering point for the

ILCD+EPD format. The search through the InData network resulted in a list of 1611 entries from EPD Norway Digi, ENVIRONDEC, EPD Italy, IBU and Ökobau.dat respectively. As Ökobu.dat is no recognised EPD-PO, 592 files were excluded. From the ECO Platform 3210 entries were identified from BRE, ECOSMDP (EPD Denmark, Bau EPD GmbH, Programa DAPconstrución, and DAPHabitatSystem), ENVIRONDEC, EPD Norway Digi, EPD Italy, IBU, ITB-EPD Poland, and MRPI. The numbers from the databases are from the 22nd of February 2022.

2.1. Extraction Rules from ILCD+EPD

The data process collection is conducted based on the simplicity of gathering EPDs and the subsequent process of data extraction. The study is thereby limited to EPDs published through the ILCD+EPD format (XML files), as a tool to analyse a greater amount of data for quick and more accurate comparisons. As the extraction of data is based on digital files with a possibility of flaws, meaning that needed data might be missing, a few extraction rules were generated to create some navigation points.

The main rule used through the extraction was that if the module A1-3 and GWP were missing, as well as an empty or invalid GWP value, the dataset was removed from the analysis and assembled in a blacklist, just in case, if needed for further analysis. This process presented an issue, as data published on EN15804+A2 has a GWP-total, however from some EPD-POs this is translated to e.g., GWP-gesamt, making the value invalid and thereby collected in the blacklist. When discovered, the extraction rules were changed to feature the different languages as well. Further, a list of data extraction points was defined in Table 1, creating a more solid foundation for further validation of the data, and making it possible to analyse and compare.

Table 1. Data extraction points used in the process of data extraction.

Data Extraction Points	Description
EPD uuid	A unique id for every EPD found in the ILCD+EPD format.
EPD owner	The owner of the EPD.
Validation from/to	Dates or years from which the EPD is valid from and to.
European Standard	The type of standard the EPD was reported from, EN15804+A1 or EN15804+A2.
System boundaries	The included life cycle modules from the EPD. These boundaries are defined according to the standards, concerning the production stage (A1-A3), the construction stage (A4-A5), the use stage (B1-B7), the end-of-life (EoL) stage (C1-C4), and last the benefits beyond the system boundary (D) [12], [13], [18].
Data type	The data type describes the data used to model the EPD. The types are defined in Table 3.
Environmental impact categories	The environmental impacts per functional unit.

2.2. The Process of Extracting EPDs

Based on the 9 EPD-POs, with data available on a digital format, identified by Anderson, and the immediate coincidence in members between InData and the ECO Platform, a thorough assessment was conducted to determine where to find digital data, as well as the consistency of data quantities between the databases. The assessment of the databases shows that ECO Platform has a greater amount of data assembled, as well as a more accurate reproduction of the EPD-POs own webpages, as presented in Table 2. Further, ECO Platform has established a Web Application Programming Interface (API) [19], meaning that all their digital data are available in a bundle, from where the data can be extracted and evaluated in one go. Data extraction from InData and the EPD-POs own webpages is done individually,

based on the precise EPD you want to use, which is why the Web API is chosen as preferable for this analysis.

From the table, the EPD-PO named ECOSMDP was found, featuring 3 individually EPD-POs, Bau EPD, DapHabitat, and EPD Denmark, though only EPD Denmark seems to have files at their own webpage.

Table 2. ILCD+EPD available data from the 9 EPD Program Operators identified by Anderson [17].

EPD-POs	Quantity of digital files found		
	ECO Platform	InData	EPD-PO
FDES	-	-	-
EPD Norge	1155	746	1155
PEPecopassport	-	-	-
IBU	534	26	534
ECOSMDP [a]	482	-	- / - / 166
BRE Global	277	-	-
ENVIRONDEC	236	3	270
EPD Italy	269	269	269
MRPI	167	-	-

[a] Bau EPD / DapHabitat / EPD Danmark.

At the ECO Platform, 3210 entries were identified on the 22nd of February 2022, from where 2930 files were identified as the digital ILCD+EPD format. 7 EPD-POs were found from the extraction, however only 3 could be identified as actual operators related to the ECO Platform, namely Environdec, IBU, and EPD Norway, why those 3 have been chosen to investigate further. Based on the extraction rules, 1478 EPDs were identified.

As this study is conducted based on the interest from a Danish context, the Danish operator, EPD Denmark, was added to the study. EPD Denmark has 166 EPDs on their webpage on the 22nd of February 2022, however, only some of the EPDs are on a digital format, related to the Danish LCA-tool LCAbyg and not the "officially" ILCD+EPD, which is why this data has been manually analysed. A total of 1644 EPDs were thereby collected.

3. **Results**

3.1. The Availability and Distribution of Datatypes for EPDs

Based on the scope of this paper, 1644 EPDs were found, qualifying as representative for the Danish context. The EPDs were extracted from 4 EPD-POs, and as illustrated in Figure 1, EPD Norway holds most of the EPDs with 834 entities equal to 51% of the total number of EPDs and EPD Denmark is responsible for around 10%. The figure further illustrates the distribution of data types i.e., how specific the data is related to the background data used in the EPD, see specifications in Table 3 [20], based on the ILCD+EPD format. From the total of 1644 EPD's, 1266 entities are validated as specific data, and 370 as average data, the last EPD's are validated as generic (3), representative (5) and template (0), allocated between IBU and EPD Norway. EPD Norway accounts for the majority of the specific EPDs and IBU holds the majority of the average EPDs.

Table 3. EPD Data Type Specifications based on the ILCD+EPD format [20].

Data Type	Explanation
Generic	Datasets modelled in accordance with EN15804, based on literature, expert knowledge, etc.

Template	Unspecific datasets are created based on specific products from a "templated EPD".
Representative	Datasets representative for a specific country or region, e.g., average for DK.
Average	An average dataset is provided by the industry associations or several product companies.
Specific	Datasets based on a company-specific product.

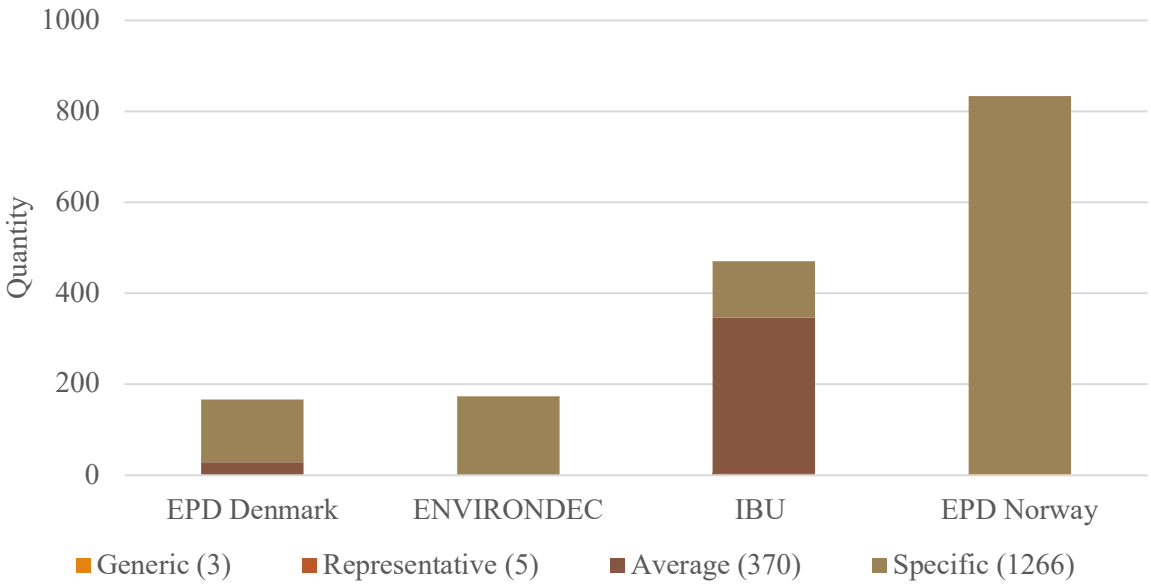

Figure 1: Total number of EPDs distributed on 4 EPD Program Operators, based on the extracted data types specified in Table 3.

3.2. The +A1 and +A2 Standards and Validity

As stated, the availability of EPDs has increased rapidly over the years, however, the data extracted from the ILCD+EPD format including the validation date, is insufficient and with flaws, as some EPDs are approved in 2001 with no revision, and others are approved in 2024. However, the expiration date of the EPDs seems, by a random qualification check with the pdf files, to be updated, illustrating that the 1644 EPDs were approved in a period from 2017 to 2022.

The datasets were extracted based on how they were issued regarding the two standards i.e., EN15804+A1 and EN15804+A2, as it is an important factor, for availability and future LCA models. The EN15804 was significantly revised in June 2019 making it more compatible with the European Commission Product Environmental Footprint (PEF) [21]. One of the main modifications is the background method, which changed from the CML method to the ILCD method, entailing several more environmental indicators to the report, for instance, the GWP reporting is divided into GWP_{fossil}, $GWP_{biogenic}$, and GWP_{LULUC}. The publications format on EN15804+A2 is shown in the EPDs published after 2019, as seen in Figure 2.

The validation period of an EPD published on EN15804, is 5 years, although it is known that EPDs get their validation period extended based on a revision and until October 2022 it is possible to publish EPDs based on both EN15804 standards. Hence, 5 years from October 2022, available EPD data will contain different reporting formats e.g., GWP and other environmental indicators, such as EP and AP. As the two standards are based on different background calculations methods, meaning different characterisation factors and environmental indicators, the data is incomparable, making the next couple of years quite interesting in the growing availability of EPDs, as 93% of the available data are based on EN15804+A1, and new data continues to be published on the EN15804+A1 standard per February 2022.

Figure 2 shows that 334 EPDs expire by the end of this year (2022), it is however likely that they will be replaced with new data, either on EN15804+A2 or revised on EN15804+A1. The data further shows an extensive increase in data in 2020, meaning that a rather large amount (31%) of data will expire in 2025.

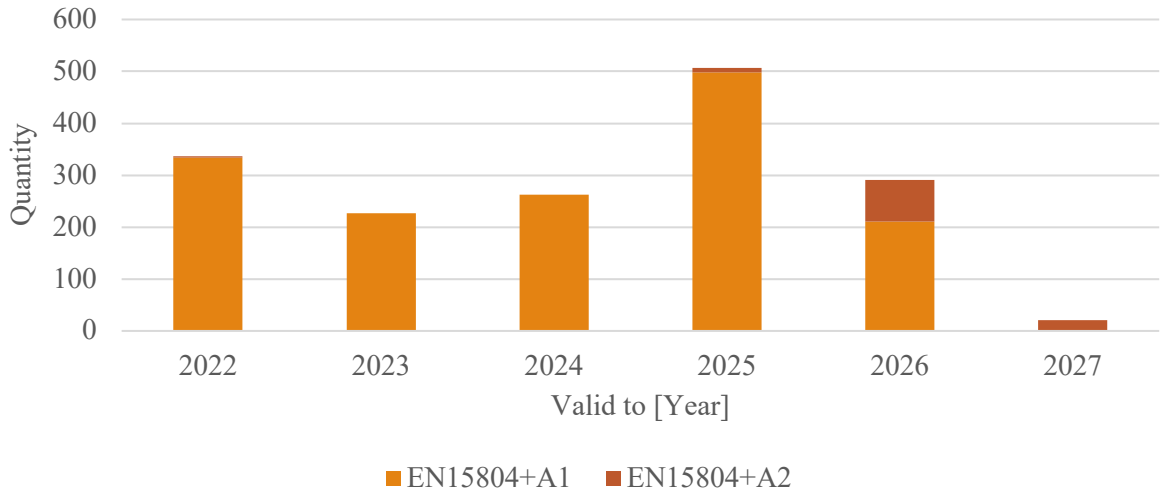

Figure 2. The quantity of EN15804 EPDs and their year of expiration.

3.3. Included Modules (EPD Scope)

The included modules in the EPDs vary significantly across the extracted data. A total of 81 different combinations of the defined scope were found, however, the 10 combinations with the highest repetitions were picked and visualised in Figure 3. As seen in the figure, 538 of the EPDs only include the modules A1-3 and additionally, 76 further contain A4, 124 of the EPDs include all the life cycle modules, and 43 contain A1-3, C1-4 and D.

The immense different combinations of data have the potential of leading to misinterpretations, especially if the user of the EPDs are matching data from an EPD with only A1-3 with EPDs containing EoL and fail to choose another EoL as the best case. Further, the overwhelming number of combinations shows the lack of a mutual way of reporting the life cycle modules, bringing yet another confusing subject to the table when comparing. However according to EN15804+A2, A1-3, C1-3 and D shall be reported, which leads to some degree of a mutual reporting model, but the different manufacturers still have the possibility to add more modules to the reporting.

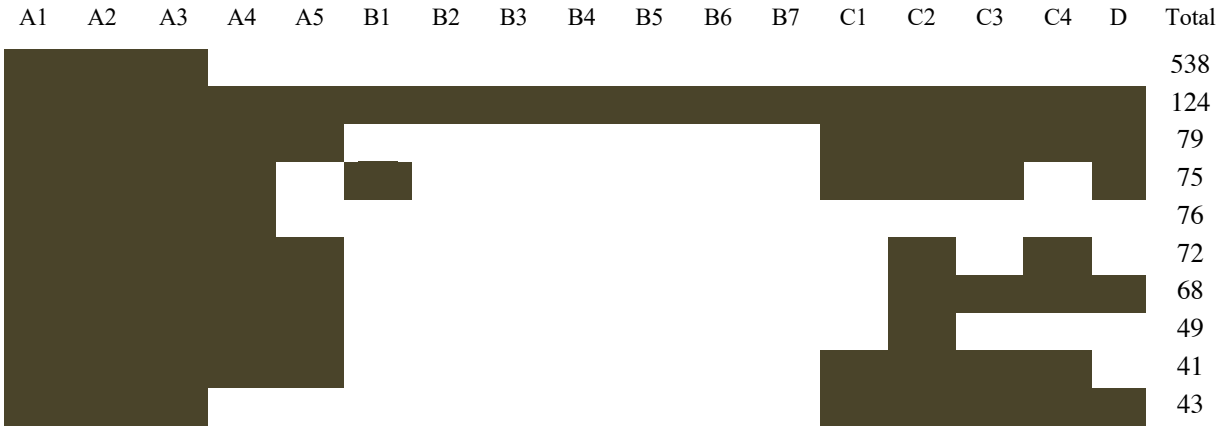

Figure 3. 5 out of the 81 different combinations found of the included life cycle stages in the sample of EPD data.

3.4. Data Deviation, EN15804

The extraction of data lead to 113 EPDs published based on EN15804+A2, with 77 entities issued from IBU and 36 issued from EPD Denmark. As far as this work goes, it was discovered that EPD Denmark is the only EPD-PO that has EPDs published on both EN15840+A1 and EN15804+A2 for the same products, why an extensive scrutiny based on the different GWP values was utilised, to document the changes and possible issues in the sustainable agenda. As an EPD reported on EN15804+A2 has additional indicators compared to EN15804+A1, the GWP-total from EN15804+A2 was used to "compare" with GWP from EN15804+A1.

EPD Denmark has 36 EPDs reported on EN15804+A2, from where 29 additionally contain a reporting from EN15804+A1. 11 of the EPDs further contain documentation on more than one product, meaning that a total of 66 products are documented from the 29 EPDs. Based on the 66 products, a segment is illustrated in Figure 4, presenting how the majority of data evolves between the two standards. The figure shows the sum of A1-3 and C3-4, based on the GWP-total.

The data reported from EN15804+A2 has a higher level of emission, which is consistent with the methods used, as the ILCD format has a larger characterisation factor than the CML method. Even though the emissions are higher it is a minimal change e.g., the facade tiles *Peat Black* increases by around 13 kg/CO_2-eq pr. FU, equal to around 3% change. This is the same case for most of the data, with an increase of around 3-5% on average.

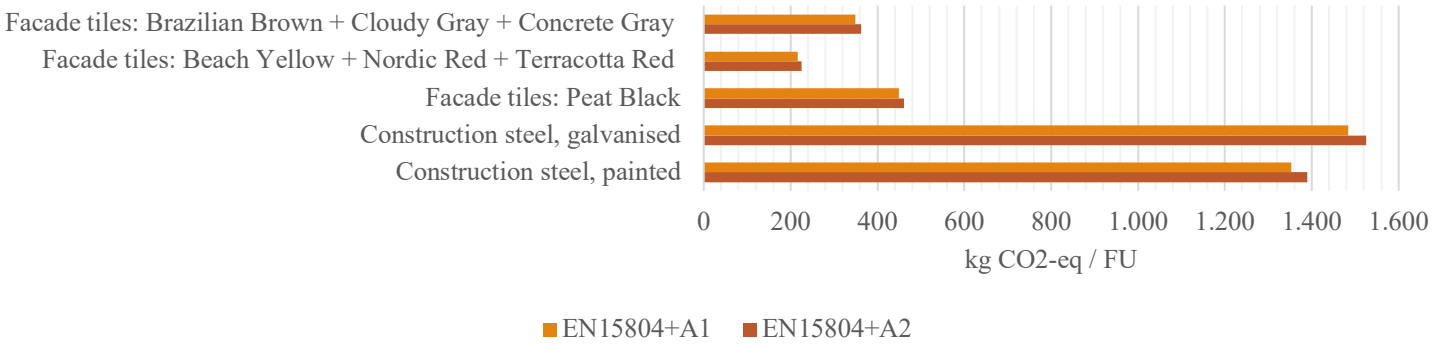

Figure 4. A segment of the 29 EPDs from EPD Denmark, containing data from both EN15804+A1 and EN15804+A2. The data is a sum of A1-3 and C3-4 from GWP-total.

4. **Discussion**

4.1. The Significance of the ILCD+EPD format

Throughout the years, a highly discussed matter is the diverging approaches in the reporting and calculation methods of EPDs, as it is an extensive part of the limitations when making a comparative analysis for a better understanding of products [12], [22], [23]. Even though the EPDs are in line with EN15804, the changing program-specific PCRs lead to results which can be different to compare. These issues are transferred directly to the digital format, with an even extra layer of possible errors, as some digital formats are translated from a common language to the country's own language, and with the information highlighted in different places from one EPD-PO to another. Thus, making the digital format less transparent and with higher risks of fallible comparisons, as the information is complicated to find.

Even when digital files are imperfect and with flaws, the ILCD+EPD format supports the future of digitalised working processes, contemporary to a quick overview of availability and big data searches, making it the new future format in the sustainability agenda.

4.2. Data Availability and Representativeness

EPDs are an important factor in the decision-making process concerning material choices in the building design and based on this work, the availability of EPDs from the ILCD+EPD format was mapped, leading to an extensive overview of published EPDs based on EN15804. The outcome of the extraction ended with an extensive number of data, as 1644 EPDs were found to be representative in a European context from 4 different EPD-POs. The allocation of data between the EPD-POs shows a significant difference in EPDs published, as more than half of the entities were found from EPD Norway, and around 10% from EPD Denmark, making EPD Denmark in the low end of published EPDs compared to other EPD-POs [17], [24], [25], which is interesting, compared to the fact that Denmark marks a new era in the sustainable agenda by implementing regulations on CO_2-levels and LCA documentation from 2023.

The processed data, further shows high accessibility of product representative data (77%) i.e., what is called specific data from the five data types from Table 3, as well as approximately 23% data available as the data type, average. Product specific data is an important factor in the future of building specific LCA models, however, depending on the design stage, it may be difficult to use, why generic data or average data can be more appropriate. The use of representative data is a key factor in building-LCA models, thus requiring that the users of EPDs critically access the data, drastically increasing the workload further. The documentation of EPDs varies quite massive, not only between EPD-POs, but unfortunately also from one EPD to another within the same EPD-PO, which is not getting easier to access with the ILCD+EPD format, as the information can be neglected or found in different places.

4.3. Pitfalls in the Revision of EN15804

The extraction of data further quantified the availability of EPDs on EN15804+A1 and EN15804+A2 respectively, showing that EPDs published based on EN15804+A2 are gradually increasing from 2019, though, with a higher concentration of published EPDs on EN15804+A1. As EN15804+A2 becomes the only effective standard from October 2022, there are still products being published from EN15804+A1, making it difficult to predict how the future building-LCAs will be modelled, as the validity of EPDs is five years. Thus, it is predicted that it will take years before building-LCAs can be conducted based on the EN15804+A2 standard unless an extra rapid increase in the development of EPDs based on EN15804+A2 will take place.

A presumable limitation for future LCA-models is thereby the accessibility of data from both standards, as they are based on complex and different background methods, which is why it is a fairly interesting factor that EPD Denmark, as the only EPD-PO, has EPDs published on both EN15804+A1 and EN15804+A2 for the same product, making it possible to dive into the changes the revision will bring to the framework of building-LCAs and the coming legislations. The analysis based on the changes between the two standards shows that a majority of datasets will increase by around 3-5% in GWP emissions, possible making it difficult to comply with future legislation if they are tightening even further in prolongation to the fact, that the availability of data on the “right” standard might be an issue.

5. **Conclusion**

This study provides an extensive overview of 1644 third-party verified EPDs from 4 EPD program operators. The data extracted were identified as in compliance with EN15804, from the digitalised data format ILCD+EPD. A great share of the EPDs includes a more complete life cycle with EoL options, however, almost 45% of the datasets only include A1-3 stages. This number will change, with the transition from EN15804+A1 to EN15804+A2, as EN15804+A2 includes EoL (C1-4) and D in the reporting standards. It was further found that most of the EPDs background data were based on specific or average data, making the datasets the best possible option in the sustainable agenda.

The extraction of data from the ILCD+EPD format creates a unique opportunity to evaluate a comprehensive amount of data, thus implementing the datasets in LCA models, however to “read” the digital format, great programming knowledge is needed. Further, the format creates certain data-gaps, as the format is as consistent as the current reporting of EPDs, i.e., important data are found in different

places, as well as language differences. The study thereby enhances the importance of transparency and more common guidelines for data publication, in the process of supporting life cycle assessments.

References

[1] C. N. Waters *et al*., "The Anthropocene is functionally and stratigraphically distinct from the Holocene," *Science*, vol. 351, no. 6269, Jan. 2016, doi: 10.1126/SCIENCE.AAD2622.
[2] W. Steffen *et al*., "Planetary boundaries: Guiding human development on a changing planet," *Science*, vol. 347, no. 6223, Feb. 2015, doi: 10.1126/science.1259855.
[3] S. Hildebrandt, *Bæredygtig global udvikling : FN's 17 verdensmål i et dansk perspektiv*. 2016.
[4] International Energy Agency, "Material efficiency in clean energy transitions," 2019.
[5] M. Kuittinen and T. Häkkinen, "Reduced carbon footprints of buildings: new Finnish standards and assessments," *Buildings and Cities*, vol. 1, no. 1, pp. 182–197, Jun. 2020, doi: 10.5334/bc.30.
[6] T. Lützkendorf, "Assessing the environmental performance of buildings: trends, lessons and tensions," *Building Research and Information*, vol. 46, no. 5, pp. 594–614, Jul. 2018, doi: 10.1080/09613218.2017.1356126.
[7] United Nations Environment Programme (2021), "2021 GLOBAL STATUS REPORT FOR BUILDINGS AND CONSTRUCTION Towards a zero-emissions, efficient and resilient buildings and construction sector," 2022. [Online]. Available: www.globalabc.org.
[8] M. Röck *et al*., "Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation," *Applied Energy*, vol. 258, p. 114107, Jan. 2020, DOI: 10.1016/J.APENERGY.2019.114107.
[9] EN ISO 14025, "Environmental labels and declarations -Type III environmental declarations - Principles and procedures," Geneva, Switzerland, 2010.
[10] I. S. Modahl, C. Askham, K. A. Lyng, C. Skjerve-Nielssen, and G. Nereng, "Comparison of two versions of an EPD, using generic and specific data for the foreground system, and some methodological implications," *International Journal of Life Cycle Assessment*, vol. 18, no. 1, pp. 241–251, Jan. 2013, DOI: 10.1007/S11367-012-0449-0/FIGURES/9.
[11] M. D. C. Gelowitz and J. J. McArthur, "Comparison of type III environmental product declarations for construction products: Material sourcing and harmonization evaluation," *Journal of Cleaner Production*, vol. 157, pp. 125–133, Jul. 2017, DOI: 10.1016/J.JCLEPRO.2017.04.133.
[12] F. N. Rasmussen, C. E. Andersen, A. Wittchen, R. N. Hansen, and H. Birgisdóttir, "Environmental product declarations of structural wood: A review of impacts and potential pitfalls for practice," *Buildings*, vol. 11, no. 8. MDPI AG, Aug. 01, 2021. DOI: 10.3390/buildings11080362.
[13] CEN (2013), "EN 15804:2012+A1:2013 - Sustainability of construction works - Environmental product declarations - Core Rules for the Product Category of Construction Products."
[14] CEN (2019), "EN 15804:2012+A2:2019 - Sustainability of construction works - Environmental product declarations - Core Rules for the Product Category of Construction Products." https://standards.iteh.ai/catalog/standards/cen/c98127b4-8dc2-48a4-9338-3e1366b16669/en-15804-2012a2-2019 (accessed Feb. 17, 2022).
[15] European Commission, "International Reference Life Cycle Data System (ILCD) data format and editor.," 2011. https://eplca.jrc.ec.europa.eu/LCDN/developerILCD.xhtml (accessed Feb. 24, 2022).
[16] O. Kusche, C. Düpmeier, A. Braune, T. Brockmann, and S. Rössig, "Extending the ILCD Format to Support Environmental Product Declarations of Construction Products," Shaker, 2013.

[17] J. Anderson, "ConstructionLCA | Almost everything you want to know about EPD, LCA and buildings, embodied energy and the CEN/TC350 standards.," *ConstructionLCA*, 2022. https://constructionlca.co.uk/ (accessed Feb. 22, 2022).
[18] S. Welling and S. O. Ryding, "Distribution of environmental performance in life cycle assessments—implications for environmental benchmarking," *International Journal of Life Cycle Assessment*, vol. 26, no. 2, pp. 275–289, Feb. 2021, DOI: 10.1007/S11367-020-01852-3/FIGURES/10.
[19] ECOPlatform, "ECO Portal API - Register - Eco Platform en." https://www.eco-platform.org/eco-portal-api-register.html (accessed Feb. 24, 2022).
[20] H. Figl and O. Kusche, "ÖKOBAUDAT Manual Technical and formal information and rules for the ÖKOBAUDAT database Version 2.1," 2021.
[21] Directorate-General for Environment, "COMMISSION RECOMMENDATION - on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations," 2021. [Online]. Available: https://www.consilium.europa.eu/media/40928/st12791-en19.pdf
[22] A. Passer *et al*., "Environmental product declarations entering the building sector: critical reflections based on 5 to 10 years experience in different European countries," *International Journal of Life Cycle Assessment*, vol. 20, no. 9, pp. 1199–1212, Sep. 2015, DOI: 10.1007/S11367-015-0926-3/TABLES/3.
[23] W. W. Ingwersen and M. J. Stevenson, "Can we compare the environmental performance of this product to that one? An update on the development of product category rules and future challenges toward alignment," *Journal of Cleaner Production*, vol. 24, pp. 102–108, Mar. 2012, DOI: 10.1016/J.JCLEPRO.2011.10.040.
[24] J. Anderson, "ConstructionLCA's 2021 Guide to Environmental Product Declarations (EPD)," *ECO PLATFORM*. https://www.eco-platform.org/epd-facts-figures.html (accessed Feb. 20, 2022).
[25] S. C. Andersen, H. F. Larsen, L. Raffnsoe, and C. Melvang, "Environmental Product Declarations (EPDs) as a competitive parameter within sustainable buildings and building materials," *IOP Conference Series: Earth and Environmental Science*, vol. 323, no. 1, p. 012145, Aug. 2019, DOI: 10.1088/1755-1315/323/1/012145.