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Brisson Stapel, Emilie; Balouktsi, Maria; Grau Sørensen, Christian; Birgisdottir, Harpa

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Type III Environmental Product Declarations – The perils and pitfalls of digitalization

Emilie Brisson Stapel[1*], Maria Balouktsi[1], Christian Grau Sørensen[1], Harpa Birgisdottir[1]

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

*Emilie Brisson Stapel: eebj@build.aau.dk

Abstract. Recent research highlights buildings as significant contributors to greenhouse gas (GHG) emissions, entailing the implementation of legally binding CO2 limits for several countries and a widespread adoption of environmental product declarations (EPDs). While PDF remains the common EPD format, the emergence of the digital ILCD+EPD format introduces start to play a more significant role. The format introduces complexities, posing uncertainties and challenges in effectively managing product data and integrating them into LCA software applications. Despite this, persistent challenges in transparency and comparability underscore the need for robust methodologies to ensure reliable material assessments. Limited literature exists on the applicability and comprehension of the ILCD+EPD format, prompting this study's exploration, using the Web API from the European umbrella organization, the ECO Platform Portal. By compiling digital EPD files into a standard schema, the study aims to scrutinize the format for enhanced reliability and usability. The study assesses a total of 12,962 datasets from the ECO Platform Portal, revealing discrepancies in compliance and documentation, with adjustments made to ensure accuracy. Notably, 17 datasets were removed due to unknown compliance with EN15804, 2097 datasets were expired, 330 datasets were lacking important information of expiration and functional unit, and 66 datasets were removed due to invalid units unsuitable for building-LCAs This resulted in a total of 10,452 datasets, with 29% allocated to EN15804+A1 and 71% to EN15804+A2. Embracing the ILCD+EPD format enhances EPD effectiveness and improves sustainability practices but requires efforts to address data extraction challenges and inconsistencies.

Keywords: Type III Environmental Product Declarations (EPD), Digitalization, Machine-readability, Availability

1. Introduction

The construction industry faces significant challenges in understanding the embodied carbon coefficients of materials, with Environmental Product Declarations (EPDs) being pivotal yet plagued with transparency and comparability issues, undermining their credibility. Nevertheless, the use of EPDs is recognized as a growing and widely acknowledged source of environmental data [1], and are increasingly utilized for conducting environmental performance assessments of buildings and facilitating product comparisons [2]. However, the current discourse surrounding EPDs, and their comparisons is a subject of considerable debate among various studies. These discussions highlight pervasive inconsistencies in documentation, substantial variations in data quality, transparency, and specificity, often resulting in misleading comparisons [3,4]. A key concern is the deterministic approach often employed in comparisons, which yields single-point estimates and fails to account for potential variability [5]. Consequently, there is a pressing need for the industry to adopt robust methodologies that ensure consistent and reliable assessments of materials [6], given that comparability and methodological issues rank among the top concerns for LCA practitioners when utilizing EPD data [7].

EPDs, categorized as Type III environmental declarations in accordance with ISO 14025 [8], serve as essential tools for communicating environmental impacts in the construction industry, predominantly facilitating business-to-business (B2B) communication. They have gained traction due to initiatives like the US Green Building Council's LEED program, BREEAM and DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen), which incentivizes their use. Although B2B communication is the primary target, these declarations also provide data for building-scale environmental performance assessments [1,9]. ISO 14025 is the primary standard governing EPDs, setting forth guidelines for the development of Product Category Rules (PCRs) to ensure comparability. However, the proliferation of diverse PCRs, such as EN 15804 and ISO 21930, has led to concerns about harmonization and comparability [10]. Efforts to address these issues, like EN 15804+A1 and EN 15804+A2, have shown some success in aligning PCRs, improving comparability, and enhancing the credibility of EPDs [11].

Despite facing challenges like methodological heterogeneity and lack of harmonization, EPDs maintain their value as third-party verified sources of environmental information supporting informed decision-making in the construction industry [1,5,9].

Furthermore, given the complexity of EPDs, manually extracting data from PDFs is a persistent and resource-intensive task, prone to human error, potential leading to misinterpretations of buildings' environmental impact and emissions. In recent years, a notable shift has occurred from individual EPD Programme Operators (POs) towards collaborative databases such as ECO Platform and the InData network, highlighting the ongoing digital transformation [12]. Despite PDFs remaining a prevalent EPD format, there has been a noticeable increase in the adoption of machine-readable formats, fuelled by the need for standardization, exchange, and comparison. Nevertheless, this rapid growth has introduced challenges, including evolving policy landscapes and the proliferation of concurrent initiatives, which complicate the establishment of robust schemas [13].

These initiatives aim to boost LCA adoption within the construction sector and streamline the exchange of EPD data. However, despite these strides, obstacles persist, such as crucial information omissions in digital schemas and the limited widespread utilization of standardized datasets among industry professionals. Additionally, the integration of EPDs into Building Information Modelling (BIM) poses additional challenges, particularly regarding ensuring data granularity consistency and effectively integrating impact modules. Although efforts like ISO 22057:2022 [14] strive to tackle these hurdles by offering data templates for seamless BIM model integration, issues related to data quality and product comparability persist. Discrepancies in data granularity levels, further complicate LCA assessments based on BIM, underscoring the necessity for standardized methodologies and continuous enhancement of digital formats [13].

This study is a segment of a bigger picture, meant to understand the embodied environmental impact coefficient in the built environment by focusing on the role of digital Type III Environmental Product Declarations. It has a twofold aim: on one hand, to pinpoint inconsistencies within digitalized EPDs by demonstrating how to identify and recognize potential perils and pitfalls that could complicate their utilization in whole life cycle assessments for buildings; on the other hand, to highlight the practical importance of digitalized EPDs, and particularly of the ILCD+EPD format.

2. Materials and Methods

The primary emphasis of this paper is to highlight the accessibility of EPDs from a digital perspective, particularly in their later application for whole life cycle assessments of buildings. Thereby enhancing comparability, enabling informed decision-making, and standardizing protocols to evaluate products using a consistent set of criteria. Which is why the collection of data was first and foremost limited to third-party verified EPDs following the European Standard EN15804.

The workflow of this study is illustrated in Figure 1, where the initial phase involves acquiring digital EPDs, also referred to as datasets, which are accessible through the ECO Platform Portals Web API (Web Application Programming Interface). This platform serves as an aggregator for EPD data in

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various digital formats, aiming to maintain consistent quality through verification criteria and regular audits. The ECO Platform functions as a central umbrella organization comprising 93 members, including 22 *Established ECO EPD POs* and 46 members encompassing *LCA Consultants, Verifiers, Software & Tool Providers, Other Stakeholders.* The remainder consists of non-profit organizations, manufacturers, industry associations, and individual companies [15].

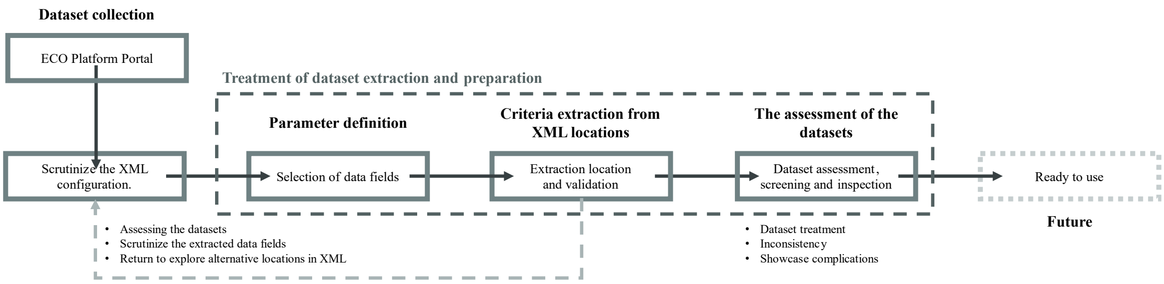

Figure 1. Process of dataset collection, preparation and filtering the digital files obtained through the Web API of the ECO Platform Portal.

The assessment of the data from ECO Platform Portal was conducted on April 12, 2024. An overview from the webpage shows that 11,026 datasets are fully accessible for digital download, with an additional 13,140 datasets that include expired entries. Among these, 10,866 out of 11,026 (valid), and 12,959 out of 13,140 (expired) datasets, were accessible in a fully digital format and adhered to the EN15804 standards. The valid datasets compliant with either EN15804+A1:2023 or EN15804+A2:2019, represent approximately 60% of the EPDs from Programme Operators (POs) under an agreement with the ECO Platform.

From the extraction of the digital datasets through the ECO Platform Portals Web API, a total of 13,053 datasets were extracted. However, during the initial filtering process, 91 datasets were excluded due to missing data files, as per the documentation criteria outlined by InData [16]. When obtaining an EPD in digital format, the dataset is packaged as a zip-file[1], containing multiple XML files. This compilation is known as the ILCD+EPD format. Extensible Markup Language (XML) serves as a versatile file format, enabling structured data sharing in a manner that is both machine-readable and human-readable. XML is widely used in various applications, including web development, data interchange, and configuration files for software applications, due to its flexibility and readability [17]. The assessment hereby proceeds within the EPD datasets themselves, utilizing the XML files.

The ILCD+EPD format encompasses an extensive array of data fields distributed across numerous XML files, and the verification process is an ongoing continuous task, akin to manual processing a PDF. Thus, this study concentrates on presenting an overview of the digital dataset by addressing associated complexities to extraction process. The aim is to demonstrate methods for enhancing the utilization of a comprehensive collection of datasets, by showcasing the validation process in two steps, followed by the complexity of extracting the Functional Unit.

3. Results

The findings are segmented into smaller sections, each elucidating a dimension of the validation process along with its corresponding challenges. The verification process is broken down into compliance and validity (day, month, year), concluding with an examination of the extraction of the Functional Unit, which involves navigating through multiple XML files.

[1] A zip file is a compressed archive that contains one or more files or folders. It is a common method for packaging and transferring multiple files or directories efficiently.

3.1. Compliance to EN15804
The primary condition is to ensure compliance with either EN15804+A1 or EN1580+A2. In the ILCD+EPD format, compliance information is often conveyed as text strings, which aren't conducive to machine interpretation, however, InData's documentation assigns a specific UUID (Universal Unique Identifier) to each standard, offering a uniform method for determining compliance. If a UUID is absent, compliance details are extracted from text strings. Out of 12,962 datasets analyzed, 12,945 were initially deemed compliant, with approximately 46% adhering to EN15804+A1 and 54% to EN15804+A2. Closer scrutiny revealed discrepancies, where datasets labelled as EN15804+A1 compliant were, in fact, aligned with EN15804+A2. This discrepancy was rectified by looking into GWP documentation, resulting in a revised distribution depicted in Figure 2, showing EN15804+A1 at 41% and EN15804+A2 at 59%. The remaining 17 datasets lacked information regarding compliance and were removed from the assessment.

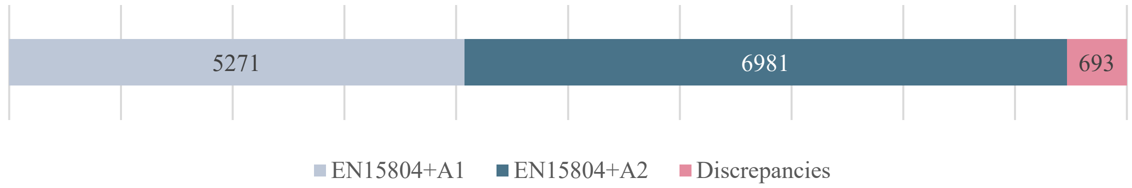

Figure 2. The distribution of datasets: EN15804+A1 and EN15804+A2. The pink bar highlights compliance discrepancies, indicating data originally categorized under +A1 but later moved to +A2.

3.2. Validity screening
The ILCD+EPD format provides four different data fields to define the temporal validity of a dataset: *ReleaseDate*, *TimeRepresentativeness* (TR), *ValidFrom, and ValidUntil.* Among the 12,945 with known compliance, only around 40% had documented full release dates (day, month, year). Only 30% of these were related to EN15804+A2, which is notably low considering that it is a mandatory field according to ILCD+EPD documentation predating the revised EN15084 standard.

In addition to the field of release date, the data format includes a *TimeRepresentativeness* (TR) field, which sometimes encompasses both the release date and the expiration date, allowing for determination of datasets temporal validity. However, the TR field, being a text field, presents challenges due to diverse date documentation styles and language use, making machine-readability difficult. Approximately 39% contained potential information in the TR field, of which close to 62% yielded useful data. When merging the data from the *TR* and the documented release dates, 2,140 additional datasets acquired release date information, with only a small portion related to EN15804+A2. Consequently, 56% of the datasets now possess a release date, which is prospectively mentioned as a combined date.

Given that nearly half of the datasets lack a combined date for validity check, attention is directed towards the data fields *ValidFrom,* and *ValidUntil*, indicating release and expiration years, respectively. Among the 5,632 datasets containing release or expiration years but lacking combined dates, 1,476 expire before or in 2023, plus 469 from the combined date, and thus 1945 datasets were excluded from the assessment. Notably, 146 datasets are valid until 2024, presenting a challenge due to ambiguity regarding exact dates, which is why these would have to be investigated further, but for now they will apart of further assessment. The remaining 4,010 dataset have expiration dates from 2025 onwards. The distribution of datasets based on the four different data fields, inclusive datasets with an empty validity are illustrated in Figure 3A. After removing expired datasets and those lacking validity indicators, a total of 10,913 datasets were identified. Their distribution between EN15804+A1 and EN15804+A2 is depicted in Figure 3B.

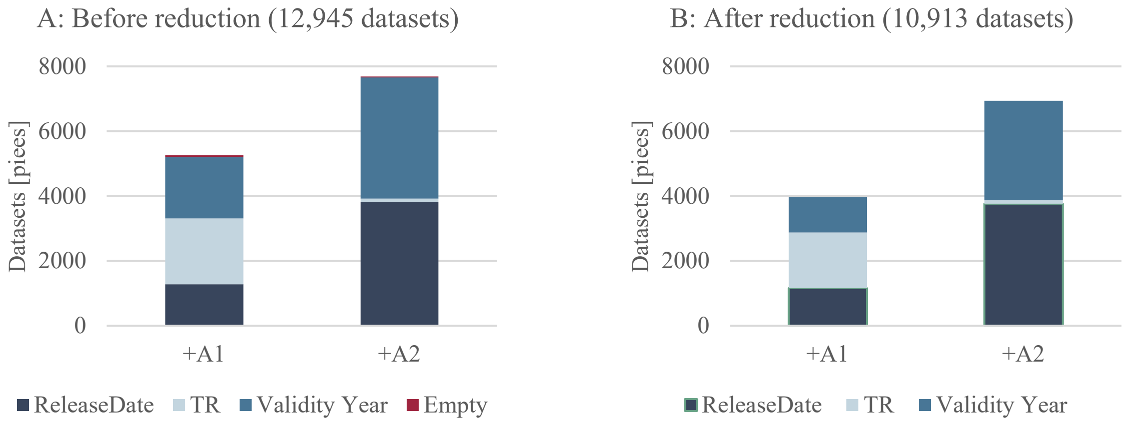

Figure 3. The distribution of the four data fields defining temporal validity in the XML. "Validity Year" serves as both "From" and "Until". A: shows the distribution before the reduction related to unknown validity and expired datasets are removed. B: Shows the distribution after the removal.

Figure 4A, and Figure 4B depict the validity over time, considering both release and expiration year. From Figure 4A, it is apparent that some datasets are released between 2025 and 2028, which is unlikely given the present year. Upon closer examination, it is found that only four datasets fall within this timeframe. Three of these datasets have expiration dates that also seem inaccurate, as indicated in Figure 4B, however, one dataset has an expiration date of 2028, which may be correct. Since there is no additional information available for these datasets, further assessment is necessary, similar to the datasets expiring in the present year.

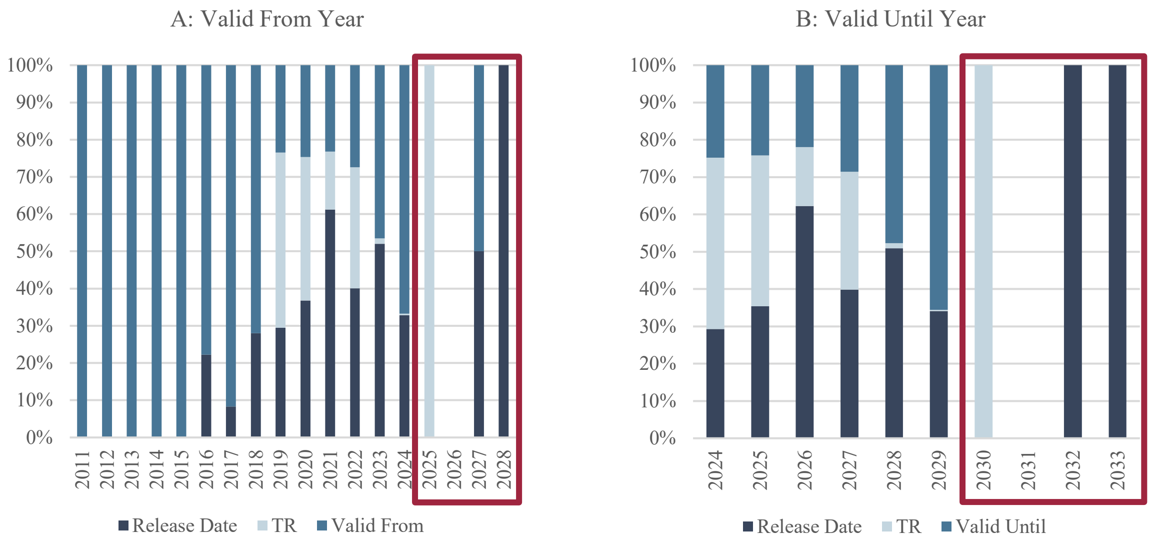

Figure 4. A, illustrates the ValidFrom data field, signifying the initiation of validity. B showcases the ValidUntil data field, denoting the termination of validity. The red box highlights discrepancies in release and expiration years concerning EN15804.

Considering the expiration in 2024, a total of 588 datasets were identified, as illustrated in Figure 5. Among them, 442 have a complete date, of which 152, inclusive April 2024, are expired. This leaves 290 datasets categorized as valid, while 146 remain challenging due to ambiguity surrounding the lack of complete date. Among the 146 datasets lacking combined date and with an expiration date in 2024, 3% is related to EN15804+A2, and 97% is related to EN15804+A1, corresponding to 142 datasets. A total of 298 datasets are then further removed, leaving a total of 10,615 datasets to assess.

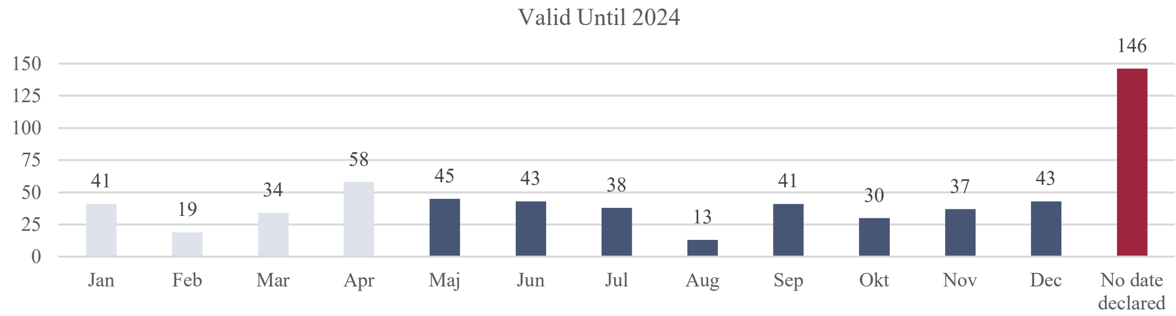

Figure 5. The figure displays the 588 datasets set to expire in 2024, categorized by month, with undated entries highlighted in red. Light blue denotes the 152 datasets that have already expired, including those up to April.

3.3. Screening of the Functional Unit

Another crucial parameter for extraction and verification is the Declared Unit (DU) or Functional Unit (FU). Currently, these units are not distinct in the digital datasets, hence they are referred to as FU onwards. Extracting FU poses a complex challenge, as it involves consolidating multiple data fields stored across different folders and XML files, mirroring the structure observed in web-based EPDs. This entails combining two fields denoting the value and potential conversion factor, a unit field, and two fields describing the unit, typically represented as a single description field in the web EPD viewer, known as *ReferenceFlow (RF)*. Among the remaining datasets, 358 lacked a unit. However, nearly 50% of these were populated based on the unit description, leaving 176 units unidentified. Of these, 13 were deciphered as "Item(s)", equated to pieces. Furthermore, 66 datasets comprised lengthy text strings describing products such as photovoltaic systems [Wp], LED luminaires [lumen], and heating systems [kW], units not commonly used in building LCAs. Finally, the last 97 datasets still lack a unit, resulting in the removal of 163 datasets. This leaves 10,452 datasets with 29% allocated to EN15804+A1 and 71% to EN15804+A2 for further assessment. Among the remaining datasets, six distinct flow units are identified. Mass [kg] and area [m2] collectively account for 72% of the total datasets, making them the most prevalent. In contrast, volume, number of pieces, and length are the least represented units with a total of 28%.

Each dataset has a combination of two values which together determine the value of FU of the EPD, e.g. 1 kg, or indicate the presence of a scaling factor related to another aspect of the product's function. When considering these factors together, 81% of the datasets have an FU of 1, while 16% present an FU of 1000. The remaining datasets (3%) require further verification; however, they appear to represent scaling factors for another function rather than FUs equating to 1 or 1000. This suggests that they may lack the necessary value for use in a building-LCA.

When combining the *Flow Unit* with the scaling factors, as depicted in Figure 6, 160 different combinations were observed. The most common combinations include 1 m^2, 1 kg, 1000 kg, 1 m^3, 1 pcs., and 1 m, in descending order, accounting for 97% of the total datasets. The remaining 3%, highlighted in grey in the figure, represent the remaining datasets, as described previously.

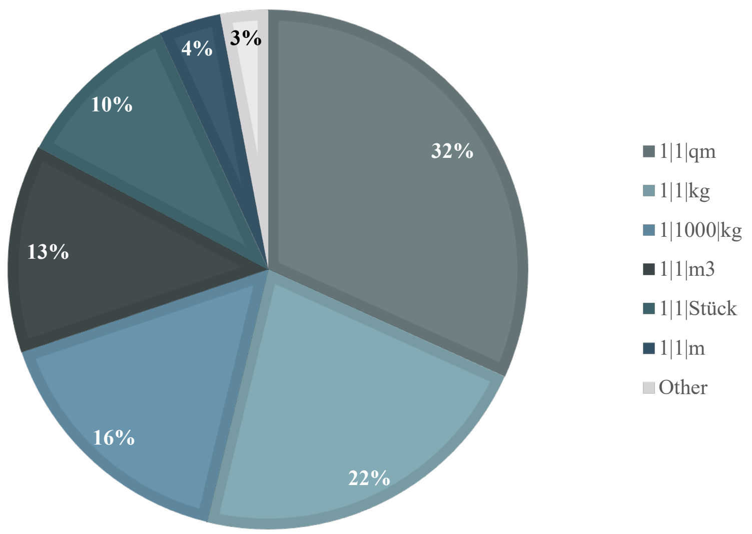

Figure 6. The figure shows 160 different functional unit distributions, with 97% attributed to the top six combinations and the remaining 3% to others.

4. Discussion

Issues and challenges surrounding the harmonization of EPDs have been extensively discussed in literature. Despite the development of various standards like PCRS and sub-PCRs, discrepancies in reporting and calculation methods remain a significant limitation for comparative assessments. While previous challenges persist in the digitalization of EPDs, the digital format introduces additional layers of uncertainty. Extracting data from human-readable PDF files relies heavily on analysts' interpretation and comprehension of the reported information, introducing the potential for significant errors. However, digitalization unveils new sources of errors, such as translations into local languages and important information being presented in non-machine-readable formats and locations compounding the risk of errors. This underscores the transparency challenges and intricacies of digitalization overall, particularly in the unquestioning adoption of digital processes within the construction industry.

Nevertheless, digitalization is increasingly becoming a central component of sustainability agendas, offering the potential for faster and more precise data extraction, utilization, and comparisons. Yet, its implementation requires careful and precise handling, both during the development phase, and its utilization. While no digital format is flawless, the ILCD+EPD format benefits from a network of experts from diverse areas within the EPD market, contributing extensive knowledge to refine the format's overall framework.

4.1. Dataset assessment and screening

Previous assessments of the challenges related to EPDs have typically been focused on individual product types, smaller product categories, or presenting an overarching framework illustrating patterns of inconsistency [3,18,19]. This is due to the time-consuming nature of the data extraction process from PDF files, which heavily relies on the analyst’s verification process for accuracy. Nevertheless, this study demonstrates that with adequate preparation, previous assessments of smaller datasets can be expanded to encompass more extensive evaluations.

The study encompasses a substantial extraction involving 12,945 datasets compliant with EN15804. However, it was discovered that 5% of these datasets had incorrect compliance, altering the distribution between EN15804+A1 and EN15804+A2. While detecting or rectifying this discrepancy may not be overly challenging through simple tests with emission categories, it highlights a significant concern regarding the creation of each digital dataset, as the documentation clearly states a unique UUID related to each standard.

Another significant parameter pertains to the temporal validation of the dataset, indicating whether the dataset is still valid for use or has expired. This aspect poses a greater challenge in terms of identification and authentication, as there are four potential fields for the necessary information, with only two offering a complete date of release and expiration. Merely 40% of the datasets include information in the designated field for extracting full release and expiration dates. However, by utilizing the *TimeRepresentativeness* field, an additional 16% of the datasets could be supplemented with this information. For the remaining datasets, investigation into fields providing only the year of release and expiration was necessary. Although these fields authenticate the dataset with a year, discerning the precise expiration date within a given year becomes problematic, introducing ambiguity regarding exact dates. Despite the extracted information, this field still yields errors, as a small number of datasets were documented as released after 2024, contravening the rules of EN15804. This necessitates further investigation and potentially manual intervention.

The inability to ascertain temporal validity has profound implications. Environmental performance assessment results are no longer merely voluntary but have evolved into binding assessment statements, even influencing financing decisions as part of Taxonomy criteria. This transformation necessitates that results are traceable and devoid of any ambiguity. Achieving court-proof results without room for interpretation requires that the period of validity of the information is clearly declared, which is lacking in more than 40% of the datasets.

The final parameter, which is crucial for integrating the data into a building-LCA, is the extraction of the Functional Unit (FU). However, obtaining this information is even more challenging, as the unit and related values are scattered across four different folders and XML files, complicating the comprehensive understanding. Initially extracting the actual unit is relatively straightforward, and only 97 datasets out of the remaining 10,615 lacked the necessary information. However, defining the value presents a challenge, with 3% of datasets not compliant with a value of 1 or 1000. This complication significantly hampers the use of digital formats for building LCAs and comparisons, as the FU is the primary indicator for evaluating product function within the document and determining the basis for emissions calculations.

Another issue, prevalent in both PDF and the ILCD+EPD format, concerns the documentation of photovoltaic systems. These systems are often designated with a functional unit of Wp, an energy production unit unsuitable for building-LCAs. The major problem arises when PDFs fail to convert this to a declared unit such as m2. Even a cursory examination of the few datasets in digital format documenting Wp as a FU reveals a lack of conversion to m2, despite potentially containing this information in the PDFs. This issue underscores a broader problem present in PDFs: when both a Functional Unit and a Declared Unit are documented, analysts must exercise extra caution in utilizing the EPD.

4.2. The importance of the ILCD+EPD format

EPDs play a pivotal role in decision-making regarding material choices in building design, and even more so as Environmental performance assessment are no longer just voluntary in most countries, thus speeding up the process of the availability. If disregarding the overall complications of EPD comprehension, and the lack of more consistency within the ILCD+EPD format as well, the digitalization offers several notable advantages over traditional formats, as the digital format enhances accessibility and ease of dissemination. Unlike printed documents, digital EPDs can be easily shared, accessed, and updated across various platforms, facilitating broader dissemination, and ensuring up-to-date information availability. Additionally, digital EPDs support interoperability with other tools and systems, enabling seamless integration into building design processes, as well as dynamic updates and version control enabling manufacturers to provide current information efficiently, supporting informed decision-making throughout the product life cycle.

By shedding light on the shortcomings of the format, scrutinizing its flaws and improper usage in digital file development, identifying the essential information to rectify these issues, and pinpointing specific problems related to each Program Operators, we can pave the way for future use and validation of the data.

5. Conclusion

The study offers a thorough assessment of datasets extracted from the ECO Platform Portal, equal to 12,962. Through meticulous scrutiny of three key parameters, two of which pertain to validation, 3% were excluded due to missing information scattered across various sources, and 17% were removed due to expiration or invalid units unsuitable for building-LCAs. This leaves 10,452 datasets, with 29% allocated to EN15804+A1 and 71% to EN15804+A2 for further assessment highlighting the substantial growth in EPD releases throughout the years, following the enforcement of legally binding CO2 limits and environmental performance assessments.

In conclusion, embracing the ILCD+EPD format not only enhances EPD effectiveness but also brings significant advantages in terms of accessibility, data integrity, and interoperability into the sustainability practices in the building industry. However, the format also presents several perils and pitfalls. These challenges include difficulties in extracting and interpreting data, particularly for individuals lacking extensive programming knowledge. Moreover, inconsistencies in reporting and language differences within the format can result in data gaps and inaccuracies. Addressing these issues requires concerted efforts to enhance transparency, standardize guidelines for data publication, and improve user accessibility to ensure the effective and reliable use of EPDs in supporting sustainability practices and life cycle assessments in the building industry.

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