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BIM-LCA data fidelity for building-passport workflows: IFC export vs drawing take-off

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Abstract. While BIM-LCA plugins allow faster life cycle assessment (LCA) workflows, 2024 Energy Performance of Buildings Directive (EPBD) and upcoming assurance frameworks begin demanding auditable workflows - here - Digital Building Logbooks (DBLs), leading to potential gap between speed and accuracy. This study benchmarks two BIM-to-LCA routes on a 3794 m^2 science building in Kaunas, Lithuania: IFC → OneClickLCA and drawing take-off (PDF → LCAbyg) workflows. Both use sector-average datasets and cover modules A1-D over a reference study period, here, 50 years. The IFC export dropped curtain-wall and HVAC objects, resulting in 30% greater whole-life $kgCO_2eq$; restoring elements cut the gap to 8 %. Changing only the electricity grid setting in LCAbyg from static mix to progressive mix shifted the GWP by 46 %. Module D credits ranged from -600 t to -146 t CO_2e because OneClick defaults to downcycling, whereas LCAbyg passes the EPD module D value and rescales it with the grid factor. These swings exposed the impact of the lack of metadata from exported BIM model into IFC. Geometry checks at export/import and additional DBL tags (electricity factor and scenario type, for module D transparency) could let plugin workflows reach 10 % deviation with manual take-off at LOD 300 - meeting EPBD 2024 upcoming requirements - while avoiding rework.

1 Introduction

Building Information Modelling integration with Life Cycle Assessment (**BIM-LCA**) represents critical progress in sustainable construction practices, combining digital modelling of building geometry and materials with environmental impact evaluation across the buildings' lifecycle [1, 2, 3, 4]. This enables quantification of embodied and operational (carbon) emissions throughout the design processes, which is increasingly necessary amid global push to reduce the construction sector $\mathbf{CO_2}$ emissions, as it supports data-driven decisions for low-carbon design choices and efficient operational energy and resource management.

The 2024 recast of **Energy Performance of Buildings Directive (EPBD)** introduces two legally binding data duties for building in EU [3]: each asset should be accompanied by **Digital Building Logbook (DBL)** that travels with the building for its full life-cycle, and **whole-life-carbon (WLC)** information must be **machine-readable** and **accessible via a digital interface**. At the same time, Corporate Sustainability Reporting Directive (CSRD) will subject Scope 1-3 disclosures (scope 3 optional) from 2026, turning data fidelity - **completeness, traceability, auditability** - into a **legal deliverable** [5]. Static PDF reports are therefore slowly switching to linked, queryable datasets.

1.1 Digital Building Logbooks and minimum viable dataset

The Commission 2020 definition study describes DBL as "common repository for all relevant building data, recorded and enriched over the asset life-cycle" [6]. Digital Building Logbook is not a bureaucratic addition, but **the missing link** for credible carbon accounting, as progress on circularity stagnates due to inconsistent data formats, absent material passports and lack of a shared demolition-waste repository [7].

The 2024 EPBD indicated a **minimum viable dataset (MVD)** of **four blocks** [8]: geometry, material composition, operational energy performance, cradle-to-grave carbon footprint. Cradle-to-grave footprint, also known **whole-life carbon (WLC)**, follow **EN 15978** modules: A1-A3 (raw material supply to manufacturing), A4-A5 (transport and construction), B1-B7 (use phase, including maintenances B4/B5 and operational energy B6/B7), C1-C4 (end of life deconstruction to disposal), and D (benefits from beyond the system boundary from reuse/recycling). The WLC block is the hardest to automate because it relies on quantities exported from Building Information Models (BIM) and product impacts from LCA/EPD databases. Within this, loss of data quality can occur at **two points**: structure loss when geometry fails IFC export [1, 9], or when specific EPDs are replaced by generic datasets because material codes or performance classes are missing [10, 1, 11]. Either loss could propagate into DBL and be either visible during CSRD audit, or **lead to uncertainty** during demolition. A workflow that is **fast yet omits facade systems**, or one that is **complete yet filled with generic factors**, will fail passport-ready test. Quantifying both kinds of loss and the combined impact on cradle-to-grave GWP is therefore critical for evaluating BIM-linked LCA software.

1.2 State of research

Deriving from 2024 EPBD recast and CSRD, **BIM-LCA workflows** can be attributed to have evolved along **three technological generations**.

1. **Spreadsheets**. Early pilots exported bills of quantities from CAD/BIM, rebuilt them in Excel and ran LCA in stand-alone tools [2, 12]. This avoided structure loss but produced static outputs that would have to be re-keyed for any Digital Building Logbook (DBL).

2. **Plugins and APIs**. Commercial connectors such as Tally, OneClickLCA and eTool deliver single-click WLC estimates inside Revit or Archicad. Studies on offices, hospitals and universities report 50-70 % faster take-off, yet **10-35 % variance in embodied-carbon results** when geometry or (meta)data disappear on IFC export [9, 13, 10]. A Hong Kong high-rise benchmark cut LCA-model build time by 90 %, but still required hand edits and fell back on generic data [9].

3. **Open-standard pilots**, focus shifts **from tools to data structures**.
   - **ISO 23387/23386** property dictionaries allow key attributes - density, recycled content, GWP A1-3 travel intact across software [14].
   - Facade-industry framework streamed ERP/PLM, BIM and LCA data into a curtain-wall Digital Product Passport; validation on three Basajaun modules proved the concept but still relied on manual ETL setup [11]. Pilot projects embedding Product Data Templates into BIM objects report near-lossless IFC export for core attributes [15], but the facade case above shows that additional circularity fields still need manual tagging.
   - An **IFC-centric** Python workflow (**IFCOpenShell** + Pandas) processed a 7 200 m^2 sports centre in seconds after 75 min of model prep for A1-A3 analysis, staying within 4 % OneClickLCA benchmark while remaining vendor-neutral [16].
   - German BIM Assistant fused OKOBAUDAT LCA data with WECOBIS hazardous-material flags inside a DESITE BIM plugin, offering real-time feedback yet still omitting coatings and sealants unless tagged by hand [13].
   - IEA EBC Annex 72 propose synchronization methods for IFC geometry, EPD datasets and operational sensors for dynamic WLC updates [17].

A 2025 PRISMA review of 115 peer-reviewed BIM-LCA studies (2019-2024) highlights **five** persistent shortcomings [1]. First, **only 2 %** of surveyed workflows achieve full automation, while **77 %** still require analysts to map Environmental Product Declarations (EPDs) to BIM objects **manually**. Second, studies remain heavily skewed toward new-build projects: 83 % of case studies ignore renovation, even though EU Renovation Wave turns existing stock into a carbon priority. Third, roughly two-thirds of papers do not state BIM Level-of-Development (LOD). Fourth, 94 % of studies halt their assessment at modules A1-A3 and nearly half consider global-warming potential (GWP) as the only impact category. Finally, less than 10 % implement decision-support techniques such as multi-criteria decision analysis or multi-objective optimization, leaving design teams without structured guidance when trade-offs arise. No peer-reviewed study found has benchmarked BIM-LCA plugins against a full drawing take-off on the same project while tracing both structure and data-quality loss. This study addresses that gap by quantifying fidelity between a plugin route and manual take-off workflow - using sector-average datasets - to determine which pathway better supports forthcoming EPBD transparency and traceability requirements.

Two full-release, regulation compliant tools were chosen - **OneClickLCA** (for automated plugin workflow) and **LCAbyg** (for the manual take-off workflow). On the plugin/ commercial side, OneClickLCA represents single-click, cloud-database route - it is the larger (in terms of dataset accessibility, as compared to Tally, eTool, designLCA) commercial building-LCA platform in Europe, with native plug-ins for Revit, Archicad, Tekla and Rhino, more than 300k EPDs, including Level(s) and DGNB [18]. The second tool, LCAbyg, is a free desktop program developed for/adopted in Denmark 2023 BR18 climate rules. All new buildings must submit an LCA to obtain a permit, and projects over 1 000 m^2 must stay below a 12 kg CO_2eq/ m^2y cap; the Danish Industry guidance notes that LCAbyg is the reference tool most municipalities expect, even though other EN 15978-compliant software can be used [19, 20]. Other open-source options (e.g. ec3-EU, BIM2LCA scripts) were ruled out because they are research prototypes with no official support; an outlier is eLCA suported by Germany BBSR, but it is in beta stage, thus it was also excluded. Benchmarking OneClickLCA and LCAbyg on the same Kaunas project therefore lets the study test a automated workflow generated by the software against fully curated, manual take-off workflow where every quantity is set **explicitly**.

This study assesses how well speed vs manual curation preserves DBL data quality under forthcoming EPBD transparency rules, focusing on **Lithuanian case building**, but incorporating tools and datasets from across the EU due to limitations in region-specific alternatives, highlighting interoperability challenges in intra-European workflows.

2 Methodology

The assessment covers modules A1-D per EN 15978 over a 50-year RSP. Operational scenarios are modelled as follows: 2022 non-residual mix of Lithuania in OneClickLCA, a static present yearly average and progressive (as planned for grid carbon neutrality) Danish grid mix in LCAbyg. These assumptions reflects tool constraints, as LCAbyg is limited to Danish factors. Results are expressed as kg CO_2eq/m^2y. The goal is to compare how much whole-life-carbon (WLC) fidelity each workflow can provide for a scientific building. General project details are as follows:

- **Building type** - three-storey + basement concrete-frame research facility; gross (functional) floor area 3794 sq.m.
- **Operational demand** - net heating 25.5 kWh/m^2yr net electricity balance 40.9 kWh/m^2yr (identical for both routes).

This work is a comparative workflow experiment, not a definitive as-built LCA, through the lens of requirements of EN-15978+A2. All quantities, factors and data-quality grades are design stage (LOD300) fidelity, and no attempt is made to capture final procurement choices. The BIM model included architectural, structural, HVAC/plumbing and electrical levels. Generic or sector-average EPDs are retained where product data are missing, and operational energy is taken directly from 2024 energy consumption (project completed by 2023). Simulated timeframe is 50 years, to allow comparison with other similar studies. The goal is therefore to reveal workflow-induced object loss, mapping and database gaps, not to produce the most accurate absolute CO_2eq value for the building. The following workflows are assessed:

1. IFC export → OneClickLCA
    - Data transfer: Bentley OpenBuildings → IFC 4 with default property sets, no manual patching → import into Revit 2025; run OneClickLCA plugin (500-row API cap; identical layers grouped).
    - Data mapping (priority): direct project material EPD - manufacturer EPD from geographically closest supplier - European generic dataset.
    - Loss assessment - missing curtain-wall and HVAC objects flagged as Other (or separated as components instead of assessed as products), dropped by OneClick or aggressive manual intervention.

2. Drawing take-off → LCAbyg 5.3
    - Data transfer: vector PDF details; layer tables list material, λ, and thickness.
    - Data mapping: data typed directly into LCAbyg, Danish sector-average or generic material class best matching plans/drawings.

2.1 How the two engines calculate carbon

Table 1 summarizes key modelling assumptions differentiating the two tools, including data engines, mapping and end-of-life handling. Although both programmes quote ISO 14040/44 and follow EN 15978 at the whole-building level, they differ in database structure, mapping and default factors (Table 1) [18]. It is important to note, in LCAbyg one can manually specify each product and its A1-A3, C3,C4 and D environmental CO_2-eq impacts [20], meaning that inputs of OneClickLCA can be re-mapped to LCAbyg (almost) directly. To better isolate workflows, only available dataset products in LCAbyg will be referenced. Understanding these differences is essential for interpreting workflow gap reported later - to help compare the outcomes, one result is presented where OneClick scenario excludes items that are not available at any form in LCAbyg dataset. Outputs are expressed in $kgCO_2eq/m^2$.

Dataset pedigree was logged per ISO 21931. Both workflows fell back to sector generic-average records due to inconclusivity of documentation (OneClick imported IFC with material names frequently in "colors", requiring manual remapping; documentation overall specified performance requirements, with some specific products mentioned, their EPD not available in most cases, but otherwise specifying generic product names) and were marked DQ-2/3. Further, because LCAbyg cannot switch its grid factor away from Denmark, the operational GWP reported in Section 3 reflects a tool limitation rather than a workflow error. Overall, in LCAbyg, the dataset is limited to subset of Okobau, thus limiting accuracy as compared to actual project specifications. While dataset is much larger in OneClickLCA, most of the specified product EPDs were not available, thus also limiting accuracy.

Table 1: Key software modeling assumptions

	OneClickLCA	**LCAbyg 5.3**
Data engine	Cloud SaaS, global EPDs (external data sources, and internally verified sources)	Offline; Okobaudat + Danish EPD-Denmark subset
Material mapping	Matches TypeName/Material to EPD title, user can override	User picks dataset manually per layer; no string-matching logic
Operational factors	Static grid mix per IEA, country-specific; user cannot edit	Hard-coded Danish factor from 2020; forecast factor possible but also Danish
Background LCI	EcoInvent 3.6, Gabi, internally verified	Okobaudat, can manually enter impacts per product
On-site wastage	Takes values from each EPD, not user-editable	User can override per material, defaults from Okobau
Transport/ Construction (A4/A5)	Defaults	By default not required → specified from OneClickLCA
End-of-life	EPD module C + D or generic downcycling options	EPD module C + D

3 Results

The results are in order of study objective: first, qualitative data fidelity, then influence on whole-life carbon variance. Data fidelity is judged qualitatively at LOD 300 because no external as-built bill of quantities is available. Three signals are used:

1. whether an element class is present, lumped or absent after import;
2. how material is mapped (product EPD, sector-average, or generic placeholder);
3. whether class is needed for the four DBL passport blocks (geometry, materials & products, energy, carbon).

3.1 Observed geometry discrepancies

Table 2 lists major element classes and their status post-workflow, revealing differences in geometry retention. IFC export/import preserves heavy structure-floor slabs and cast-in-place columns, but drops curtain-wall system and most HVAC equipment into a set of material geometries rather than products. By contrast, the documentation (drawing) take-off keeps every element as a distinct object because it is input by hand. Lighting fixtures appear in both routes, yet come from different EPDs (auto-filled UK 2021 vs. manually selected Finland 2023), a point that drives a noticeable share of carbon gap discussed later. The immediate implication for a Digital Building Logbook upload is that IFC path would flag an incomplete envelope and an undefined HVAC system, forcing either a re-export or manual patching before any further auditing.

Table 2: Qualitative geometry status after each workflow.

Element class	OneClick BIM import	LCAbyg documentation route
Floor slabs	Lumped	Distinct
Cast-in-place columns	Lumped	Distinct
Curtain-wall aluminium	-	Distinct
Glazing panes	-	Distinct
HVAC air-handling units	-	Distinct
Lighting fixtures	Distinct (auto-filled)	Distinct (manual EPD)

Initial IFC import artefacts included geometry simplifications, such as unknown 1000+ m^3 of copper and steel that were removed immediately, outliers such as 2cm white paint, which were clarified with project documentation and switched to correct materials (in this specific example, gypsum boards). Furthermore, a loss of 78 m^3 concrete and more than 2000 m^2 window area became apparent when comparing early inputs, estimating 275+ tCO_2-eq discrepancy before manual fixes.

3.2 Cradle-to-grave GWP consequence, incl. Module D

Table 3 presents whole-life GWP results (in $kgCO_2$-eq) across the five scenarios, broken down by LCA modules, allowing direct comparison of workflow and assumption impacts. Interpreting table 3, three contrasts are important: same engine, two workflows (OneClick BIM vs. OneClick PDF); same quantities, two grid scenarios (LCAbyg static vs. progressive); cross-tool scope (OneClick PDF vs. LCAbyg). Figure 1 illustrates the distribution of emissions across modules, highlighting the B6/7 dominance in static scenarios and the variability in Module D credits.

Table 3 also presents 5th scenario to compare the dataset influence between OneClick and LCAbyg, as per methodological limitations. The difference between dataset selection has a delta of 18 % when limiting to A1-A5, as shown in Table 3. The main difference came, overall, from available dataset selection, leading to 24% higher B4/5 in OneClick, 44% higher C1-4 in LCAbyg. Impact delta, when limiting to A1-A5, came from differences in internal flow management A5, as A1-A3 delta was 4%. In both cases, there are generic m^2 specifications of construction site impacts. However, unlike LCAbyg, OneClick attaches A5 impacts to product EPDs by default, while this is not included in LCAbyg. Generic site impacts in OneClick contributed 69.82% of total A5 CO_2eq impacts, but between generic impacts of software, a three-factor gap still remained between the generic specification in LCAbyg, and OneClick. This could be because LCAbyg limited site impacts to building area (total floor area divided by stories), while OneClick included full project site area impacts, thus leading to net delta impact difference. Further:

- OneClick BIM → OneClick PDF - an 8 % "fidelity penalty". A1-A5 differ by only 0.6 % after clean-up; remaining +11 % in B4/B5 stems from an older UK-2021 LED EPD in BIM route, while PDF route adopts a FI-2023 record. C1-C4 is still +157% caused by mismatch of materials in BIM-LCA route vs those confirmed purely from documentation. A DBL upload based on BIM path would therefore need an envelope patch to ensure traceability [5].
- LCAbyg: static → progressive grid - scenario choice dominates. Swapping nothing but electricity factor cuts B6/B7 from 2 123 t to 553 t (-46 %), pushing whole-life total below all OneClick results (10.54 kg m^{-2} yr^{-1}).

Table 3: Whole-life GWP over 50-year RSP, including D

	OneClick BIM	OneClick PDF	LCAbyg static	LCAbyg prog.	OneClick PDF, dataset limited to LCAbyg
A1-A5 (kg)	1 599 809	1 589 830	1 298 636	1 298 636	1 535 633
B4/B5 (kg)	474 277	421 256	299 936	299 936	371 168
B6/B7 (kg)	990 646	990 646	2 123 230	553 718	990 646
C1-C4 (kg)	337 468	131 351	187 661	187 661	130 826
Total A1-C4 (kg)	3 402 200	3 145 475	3 716 473	2 146 961	3 028 274
Module D (kg)	-604 215	-626 305	-422 334	-145 681	-601 065
Net total A1-D (kg)	2 797 985	2 519 170	3 294 139	2 001 280	2 427 208
Normalised (kg m^{-2} yr^{-1})	14.75	13.29	17.37	10.54	12.79

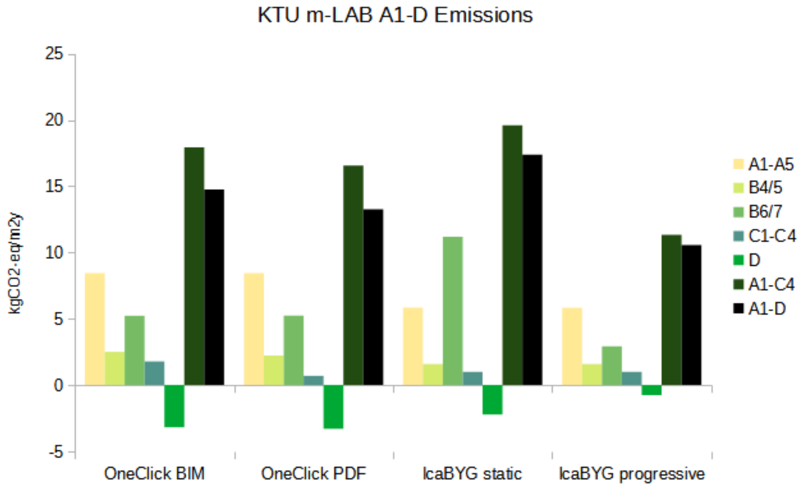

Figure 1: Whole-life emissions by module, normalised to kg CO_2-eq m^{-2} yr^{-1}.

Module D should capture avoided impacts when materials are reused or recycled. Based on observations, both tools inherit what is written in the EPD, but OneClick defaults to generic practical downcycling options, hence the wide spread in Table 3:

- **OneClick** Defaults to down-cycling template (e.g. crushed concrete as road sub-base, scrap steel recycled via electric-arc furnace), or EPD if no such is available. Experimentation is limited.
- **LCAbyg** Simply passes through Module D line in each EPD. The datapoint selection and from OneClick differs, potentially leading to lower module D (- 422 t). However, it could be also due to dynamic module D calculation in the tool, as in the case of progressive grid, it uses the same EPD values but recalculates avoided electricity impacts with a future (cleaner) grid-mix trajectory. This leads to - 146 t credit, explaining delta between LCAbyg runs.

The implications: module D credits are highly sensitive to assumed downstream scenarios - grid carbon intensity, recycling yield, substitution ratio-none of which are recorded in IFC or DBL schemas. Building passports or DBLs should therefore store, alongside numeric credit, three explicit tags - scenario type (EPD / Tool-Default or similar) and electricity factor (kg CO_2e kWh^{-1}). Without these, a negative Module D line could be challenging to audit or compare across tools.

4 Discussion

This study set out to test whether BIM-to-LCA plugins can already deliver data quality and traceability levels that 2024 EPBD will demand of Digital Building Logbooks (DBLs). Two workflows were assessed on the same project: IFC transfer route using OneClickLCA and a drawing take-off route using LCAbyg. After correcting import artefacts, 8 % delta was left inside OneClick, but larger spread across tools, as shown in Table 3.

4.1 Interoperability gaps

Geometry loss still dominates inside a single tool. Exporting OpenBuildings model to IFC then re-importing it in Revit drops entire curtain-wall system and most HVAC equipment into material components, or simplifies geometries leading to necessity of manual intervention. As quantified in Result section, unknown volumes during plugin route lead to manual recheck and removal, potentially caused by geometry simplification (solidifying) of pipes and cables, switching of materials, and exclusion of verifiable unknowns, such as 78 m^3 of concrete and over 2000 m^2 window area, which estimates 275+ tCO_2eq. After aggressive fixes, to a point where documentation-based route took about the same time, delta between pdf and IFC-based OneClick assesment matched 10-25 % loss band [21, 1]. However, blindly trusting BIM-IFC export could have lead to over 4x larger emissions (mainly due to the 1000+ m^3 each unknown steel/ copper). Until import filters block such omissions or overestimates, any future DBL upload will require manual intervention.

Overall, DBL visibility could make omissions harder to hide. The EPBD minimum viable dataset requires an envelope block, thus missing curtain-wall objects would show up as a blank field. That could force design teams either to re-export fixed geometry or to insert manual quantities - costly late in design timeline, and reducing traceability/ transparency. Automating BIM-IFC pre-export element-count check would catch loss upstream; the same can be implemented during IFC import in LCA software, catching downstream effect - this can even be just checking whether expected IFC components are present, such as IFC window elements.

4.2 Material choice versus geometry loss

Once the missing geometry is patched, swapping one reasonable EPD for another (UK-2021 vs FI-2023 LED luminaires) moves cradle-to-grave total by +90 t CO_2e - twice smaller than structural gap. The rule of thumb that emerged: geometry precision first, EPD fine-tuning second. In practice, teams should allocate review time to element counts before assessing EPD accuracy.

4.2.1 Operational factors Using LCAbyg static Danish grid raises B6/ B7 by $\sim$1.1 M t CO_2e; switching to a progressive grid cuts to 0.553 Mt. Because both grid factors sit outside BIM-PDF workflow boundary, operational spread is treated as tool-scope effect. DBL record should therefore store grid scenario next to the numeric value, so cross-tool comparisons are not mistaken for design improvements.

4.3 Whole-Life GWP variance and implications

Following Table 3 and figure 1, workflow fidelity (missing geometry, data generity) moves results by $< 10\%$ within a tool, while scenario and scope choices (grid trajectory, external works) shift them by 25-46 %. A passport record therefore needs two metadata blocks: a geometry-completeness flag for each EN 15978 element class (could be LoD level indication); a scope / grid-scenario header, so auditors can tell whether a gap reflects a real design improvement or just a modeling boundary effect.

4.4 Tool-scope limitations

4.4.1 Module D credits vary more by rule-set than by design Both OneClick and LCAbyg passes module D line in each EPD, OneClick having additional preset options to select generic downcycling options, in which it defaults to. Therefore, module D mainly comes to differences in datasets, under static grid scenarios. However, when LCAbyg recalculates the same EPDs with a progressive grid, credit falls to -146 t, instead of 420t. The ranking changes, but design not, as the swing is a consequence of tool logic. For DBL uploads, a numeric Module D line is therefore meaningless unless the passport also stores tags of scenario type and electricity factor.

More on database width and noise, OneClick has continously updated 300 000+ lca dataset of international EPD [18], LCAbyg static < 1000 of expected building elements, also, generalizing HVAC/plumbing to typical per building function per m^2. OneClick aims to auto match materials based on material name, but this can lead to errors such as gypsum boards on BIM model described as paint, leading to 2cm thickness paint in OneClick, the same for white polycarbonate finishings. Such details require standardized data quality assurance; logging ISO 21931 pedigree scores + entry time logging in the passport could allow greater audit traceability.

4.4.2 Manual curation The IFC-OneClick import produced 26k+ line items; grouping duplicates to < 200 usable elements required robust grouping scripts. Unless APIs expose flexible bulk-grouping presets, every BIM-LCA project will repeat this task. For this project, OneClick had the possibility to re-export their imported materials before grouping, as their API did not support high flexibility, rather, opaque grouping functionality, leading to manual python script development to group based on material and family names, selection of both due to the names being improperly spread over multiple columns/ material name was not necessarily in the material name field, rather often including just generic IFCElement names. At the same time, a several thousand elements were dropped due to null volumetric data, which were likely improperly exported floor heating pipes (they were manually input later).

4.5 Data-model implications for BIM-to-LCA

4.5.1 IFC and minimum viable requirement for passports Neither IFC 4 nor IFC 4.3 export exposed attributes for `EPD_ID`, `GWP_A1_C4`, although officially supported by documentation of Environmental Impact Indicators Property set - likely not included by original building modeller, or attribute unsupported by OpenBuildings. plugins therefore would have to guess dataset links from fuzzy names such as Partition Glass, leading to either generalization or forced manual intervention. The result is pedigree noise quantified earlier. IFC 5 roadmap indicated alignment with ISO 23386 property dictionaries and buildingSMART Data Dictionary, which could help mitigate this gap at a DBL-compliant level [22]. Two design choices can close the gap: enrich existing classes by adding mandatory Pset_EnvironmentalImpact to IFCMaterial and IFCMaterialLayer with EPD_RegistrationID, GWP_A1_A3, module coverage and optional Uncertainty; or introduce a dedicated IFCLCASet, linked to products via RelAssignsToProduct, pointing either to a product EPD (DQ-1) or a generic dataset (DQ-2/3) - geometry-only objects could inherit the set directly.

The latter choice could significantly enhance the potential of BIM-integrated LCA, and traceable end of life handling (assurance of product origin for demolition, potentially connecting to performance). Even a single numeric slot per layer (`GWP_A1_C4`) plus an `EPD_ID` URI would let LCA engines bypass heuristics and preserve fidelity through the export chain. We therefore recommend that future DBL IDS templates mark these attributes as "must-support" and that software vendors expose them in export dialogs by default.

4.6 Relevance to DBL audits

- Geometry first - an 8 % BIM-PDF delta is driven almost entirely by missing curtain-wall objects and lost concrete. Element-count (product first, then material) checks before export or import would catch this, giving auditor assurance for complete (envelope/HVAC) representation.

- Scenario traceability - Grid-mix choice moves whole-life GWP by 46 %; passports must tag the electricity factor scenario. By doing so, auditor can normalise values to be tool-neutral, thus assuring interoperability.

- Inclusion of Pedigree/DQ tags - EPBD 2024 does not require greater than LoD of 300 (only if possible), however, for as-built inclusion, data quality assurance is a must; ISO 21931 scores let auditors see the uncertainty. However, for as-built transparency, each product should also carry

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supplier batch ID scanned at delivery. That link could turn the DBL from a design file into a living asset log, for end-of-life performance assessment and warranty claims.

5 Conclusions

This benchmark study demonstrates to what extent today BIM-LCA workflows deliver the data quality that EPBD will demand of Digital Building Logbooks (DBLs). Two routes were compared:

- Plugin route: BIM → IFC4 → OneClickLCA (largely automated but prone to geometry loss and hard-wired site-impact templates).
- Drawing route: 2D PDFs → manual take-off in LCAbyg (entirely manual but semantically complete and with explicit scenario control).

Key study findings were:

1. Geometry can be the main discrepancy driver. Restoring the missing curtain-wall and HVAC objects in OneClick cut the route-to-route gap from 30 % to 8 % (+257 t CO_2e). Manual take-off never lost those elements, but took 80 min longer. An IFC-compliant element-count at export would eliminate most plugin penalties.
2. Scenario logic diverges more than geometry does. LCAbyg lets the analyst swap from a static Danish grid to progressive, cutting whole-life GWP by 46 % - for currently less-poluting grid mixes, such divergence would be smaller. One Click fixes the grid factor by national selection (static only) and pushes generic site impacts into A5 by default. Thus, DBLs must store electricity factors so auditors can normalise results across tools.
3. Module D credits are tool-rule artefacts. One Click applies a built-in down-cycling template (-600 t CO_2e), whereas LCAbyg passes raw EPD values (-422 t static grid → -146 t progressive grid). Extra DBL fields of scenario type (EPD, grid-adjusted EPD or custom/tool default) and grid factor used in downstream modeling could be valuable to make negative numbers auditable.
4. Both workflows hit the same pedigree ceiling. Because design package still lacks product-specific EPDs, both routes rely on DQ-2/3 sector averages. Further accuracy gains now depend on documentation details and supplier data, not on choosing plugin versus manual LCA.

5.1 Practical and policy implications

Most of the 8 - 46 % measured variance is caused not by improper LCA mathematics but by missing metadata. Until IFC 5 and the EU-DBL schema expose native mandatory slots for EPD id, GWP_A1_C4 and (module D) scenario parameters, project teams and regulators can close the gap with three safeguards:

1. Automated geometry gate. Embed two model checks:
   (a) Fail the IFC export when external wall or window area deviates by, for example, >5 %, and slab volume by >3 % from the expected design baseline.
   (b) For each object category that should appear as products (not materials) - Windows, HVAC, luminaires, elevators - compare the sum of material volumes against an expected band per m^2 of usable net floor area for the building function. Trigger/ log a "lump" warning if the ratio exceeds an upper band and the IFC objects lack product EPD id. In this study, the rule would have auto flagged 1 000+ m^3 copper/steel solids during IFC export.
2. Scenario tags in every DBL record. Append two fields to the existing hand-off: grid factor (kg CO_2 kWh^{-1}, potentially in a separate sheet should dynamic yearly projection be used) and Module D rule/scenario. Practically, adding the columns would make the 46 % spread shown between static and progressive grid runs transparent. In terms of policies, making the tags compulsory in national EPBD transpositions could be valuable to assure traceable, tool/software-neutral comparison at audit.
3. Dataset-quality logging. Store three fields next to every EPD link: the ISO 21931 pedigree score (DQ 1-4), EPD id, and at hand-over supplier/ batch tag. OneClick exports the first two automatically; LCAbyg can add them via an Excel lookup and, during construction, the final products can be recorded on site. An auditor can then sort the DBL by (impact x low-DQ) and spot records where

the batch tag does not match the declared EPD. Public EPD registers need to expose pedigree and make EPD ID machine-readable; mandate a batch tag at practical completion so mismatches between specified and installed products surface immediately. This could not only allow further transparency but also enable product performance guarantee at the buildings EoL.

Together, these measures could fit into current BIM-LCA workflows and deliver DBL-ready traceability before the IFC 5 schema or a fully harmonised EU-DBL comes into force.

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