2026 European Conference on Computing in Construction
Corfu, Greece
July 12-15, 2026

CATEGORIZING RECURRING TASKS FOR FASTER AND CONSISTENT EMBODIED CARBON ASSESSMENTS

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Abstract

Embodied carbon (EC) assessments are slowed by fragmented information handover, requiring extensive information-retrieval effort. This study decomposes EC workflows for windows across four building projects by categorizing recurring life cycle assessment (LCA) tasks. Results show that 71-81% of tasks involve data extraction and data wrangling rather than requiring EC expertise. Standardized EC property sets and consolidating data into one information source could reduce EC workflow tasks by 41-67%, improving assessment speed and consistency.

Introduction

The absence of standardized information handover slows embodied carbon (EC) assessments, despite rising demand driven by EC regulations (One Click LCA, 2022).

To complete an EC assessment, Life Cycle Assessment (LCA) specialists refine the Bill of Quantities (BoQ) and compile additional LCA-relevant information (Tam et al., 2022). This involves substantial effort in information-retrieval tasks such as data extraction (Matillion, 2024) and data wrangling (Wickham, 2014), often requiring consultation of multiple sources, including Building Information Models (BIM), 2D drawings, and project stakeholders (Scagliotti & Fischer, 2025).

Existing standards provide high-level guidance on BIM-based information management (ISO, 2018) and building LCA (Papakosta & Sturgis, 2017). Nevertheless, no standards developed from the LCA specialist's perspective define the LCA-relevant information that architecture, engineering and construction (AEC) stakeholders should provide for each building component (Abdelaal & Guo, 2022). Furthermore, the success of BIM to LCA data exchange through standardized file formats, such as Industry Foundation Classes, depends on whether the models have been properly enriched with LCA-relevant information (Theißen et al., 2020).

Given these insufficient requirements, it is necessary to determine what information should be included in the BIM (Guntermann et al., 2025). This study decomposes the EC workflow LCA specialists follow by categorizing the tasks completed, measuring their recurrence, and deriving LCA-relevant information in the case of windows. Establishing this building component information as a BIM requirement for AEC stakeholders would improve information handover and enable faster, more consistent EC assessments.

Methodology

To better understand where LCA specialists expend the most effort and why, we conducted cradle-to-gate EC assessments for windows in four residential projects, ranging from single-family houses to low- and high-rise multifamily buildings. We selected windows as a representative component because they are a carbon intensive element of the building envelope and are present in all residential buildings.

We systematically decomposed EC assessment workflows by analyzing recurrent LCA tasks and grouping them into three categories: (1) data extraction; (2) data wrangling; and (3) impact factor search and assignment. Each category includes several tasks typically performed by LCA specialists, leading to a total of 17 (A-Q), as shown in Figure 1.

Figure 1 shows the LCA tasks required to complete an EC assessment for windows in four projects. For example, in Case Study 1, out of 30 tasks, the LCA specialist requested five clarifications from the project team (data extraction) and performed six simple calculations (data wrangling). We hypothesize that many such tasks could be avoided through standardized information handover, enabling LCA specialists to focus on core activities, such as assigning environmental product declarations (EPDs).

Case Study Results and Discussion

Decomposing the EC assessment workflow for windows revealed that most LCA tasks revolve around creating or enriching a BoQ and do not require EC expertise. As shown in Figure 1, data extraction accounts for 24-30% of total tasks, while data wrangling represents 43-56%.

In contrast, tasks requiring genuine EC expertise, such as searching and assigning impact factors, account for only 9%-29% of total tasks. Therefore, AEC stakeholders should improve BoQ information handover, so LCA specialists can focus on tasks requiring their expertise.

Decomposing the EC workflow also revealed the LCA information requirements for windows. Multiple sources (e.g., BIM, 2D drawings) were used to compile the geometric (e.g., dimensions, area, volume) and non-geometric (e.g., number of panes, glass type) properties required for the EC assessment. The reliance on multiple

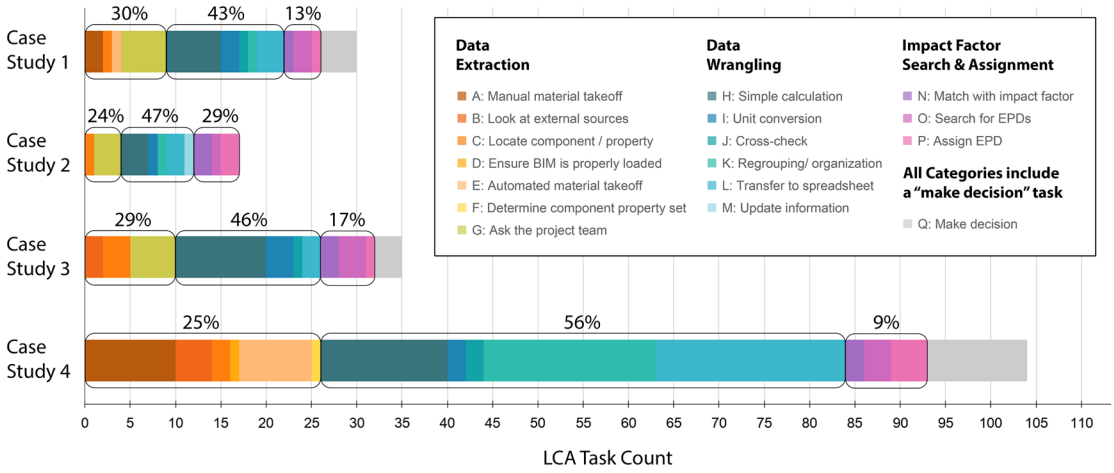

Figure 1: Recurring LCA tasks required to complete EC assessments for windows. Tableau color palette based on Arnold.

sources to retrieve LCA-relevant properties contribute to slower and inconsistent EC assessments.

Improving information handover can make EC workflows faster and more consistent. This can be achieved if project teams (1) have a standardized LCA-specific property set for each building component and (2) consolidate all LCA-relevant information into a single BIM. Building on existing BIM property set definitions (Guntermann et al., 2025), we defined an EC property set for windows. Revisiting the EC workflows for windows, we demonstrated that data extraction and wrangling tasks could be largely eliminated. This approach could reduce total task counts by 41%-67% across the four case studies, significantly streamlining EC assessments.

Conclusions

To make EC assessment faster and consistent, we identified and categorized recurring LCA tasks using windows as a representative building component from four case studies. Future work should extend this method to other components and building types to confirm the effort in data extraction and wrangling for completing EC assessments.

Our results demonstrate that providing completed and standardized EC property sets and consolidating data into a single BIM can reduce LCA task counts by roughly half. By shifting effort from data extraction and data wrangling to impact factor search and assignment, LCA specialists can focus on tasks requiring genuine EC expertise.

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