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STREAMLINING BIM-BASED PROCUREMENT FOR A CIRCULAR ECONOMY: ALIGING DESIGN SPECIFICATIONS WITH RECLAIMED BUILDING COMPONENTS

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Introduction

Due to the limited digitalization of marketplaces, integrating secondary building products into new designs or renovations remains a manual, slow, and time-consuming process. However, secondary products offer a promising solution for reducing carbon emissions in the construction industry.

Transforming the construction industry requires adopting practices that make it more efficient, and data-driven over the long term (Watts et al., 2023). One key enabler for this transformation is Building Information Modeling (BIM), which serves as a valuable instrument for conducting environmental or economic assessments considering the entire lifecycle of a building (Askar et al., 2024). However, implementing CE principles in construction introduces new challenges for designers, who require specific knowledge, strategies, and methods (Dokter et al., 2021). A key challenge is using circular economy principles and digital technologies to better match supply and demand for reclaimed components, promoting material reuse in construction.

Existing digital matchmaking platforms, though still in their early stages of development that can be leveraged by developing sector-specific algorithms within the construction industry, offer promising solutions for integrating secondary building products into new projects. These tools can serve as ‘matchmakers’ across the value chain, connecting stakeholders such as owners, designers, suppliers, and workers (De Wolf et al., 2023). In this context, the parametric design environment holds great potential. By enabling integrated collaboration among stakeholders and automating life-cycle processes, they reduce material and energy consumption while promoting the reuse, remanufacturing, and recycling of building components.

Parametric design tool development and implementation methodology

The parametric design tool (PDT) matches digital design components with available second-hand items in the marketplace based on product parameters. By adjusting the tolerance input (Figure 1), users can control the allowable deviation between their design and the available components, enabling more flexible matching options. PDT ensures precise and dynamic matching by prioritizing components that closely align with the target dimensions, while excluding those already matched in the database. If no suitable match is found within the specified tolerance or original dimensions, the PDT generates a ‘no match’ result.

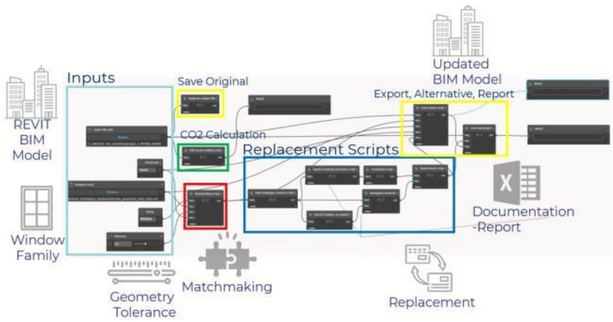

Figure 1: Pipeline of PDT in the Dynamo, Revit environment.

Upon successful matchmaking between design components and available marketplace items, the algorithm generates a report detailing the matched components, and their corresponding windows. (Figure 2). Additionally, an alternative BIM model is created, replacing the original components with second-hand alternatives based on the matches. The matching data, including geometric dimensions and GWP results for the windows, are then written to Excel spreadsheets. This process enables the Revit model to estimate carbon emissions and provides a list of reusable building components through newly generated family data.

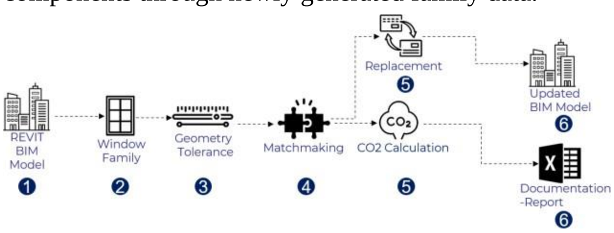

Figure 2: Simplified PDT pipeline in the Dynamo, Revit environment.

Furthermore, the Global Warming Potential (GWP) associated with carbon emission is included for comparative assessment purposes. The GWP calculation is based on geometric dimensions of windows, with the formula (Height*Width)/1000000mm2) * 7.9 used for the computation. Additionally, certain key assumptions are made as we rely on a standard wooden, double-glazed window with an area of one square meter is assumed. The GWP values for producing wooden frames and glass were sourced from previous studies (Sinha and Kutnar, 2012; Grané Anglarill, 2018) and adjusted according to the window dimensions. Windows are assumed to have no additional carbon emissions, which facilitates the direct estimation of CO_2 savings when replacing secondary components with new ones. Transportation impacts and installation are excluded from the GWP estimation due to their high variability. While this assumption simplifies comparisons, it may overlook material and supply chain variations, which should be explored in future studies.

Application of the parametric design tool in case study demonstrations

Initially, the PDT prototype was developed using a small-scale architectural project, where windows served as the primary building product. By streamlining geometric matching and data processing through Dynamo and custom Python nodes (see GitHub link), the PDT reduces manual effort, enhances accuracy, and facilitates real-time decision-making in the use of secondary components. PDT was further tested in the Katharina Haus case study to ensure robustness across different contexts. This case study successfully demonstrated the tool's effectiveness and its potential applications across various building projects, establishing a benchmark for broader implementation.

Conclusion

The demonstrations highlight how automation can simplify and amplify the design process with secondary building products by supporting traditional design workflows and enabling circular design and construction strategies. The Dynamo-based PDT demonstrates that substantial CO_2 savings are achievable by reusing building items, optimizing the design process, and reducing environmental impact. This PDT enhances efficiency and promotes environmentally friendly circular design and construction practices by automating the integration of reclaimed building components from a marketplace into Revit models.

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