BEYOND OPERATIONAL ENERGY: SCENARIO-BASED ASSESSMENT OF CIRCULAR ADAPTABILITY IN BUILDING ENERGY RETROFIT

Abstract

Energy retrofit of existing buildings is typically driven by operational performance targets, yet its implications extend beyond energy savings alone. This paper situates energy retrofit within a circular building perspective and presents the Scenario-Based Circular Adaptability Assessment workflow for case study analysis of existing buildings. The method evaluates retrofit strategies through ageing-driven scenarios, with the aim of extending service life and slowing material turnover. Rather than focusing solely on immediate operational efficiency, it examines how design strategies can support long-term adaptability while reducing resource-intensive interventions. A demonstrative scenario addresses thermal upgrading of the building envelope alongside spatial reconfiguration and plan flexibility. By linking energy retrofit pressures with circular adaptability, the proposed approach highlights a broader basis for retrofit decision-making, encompassing embodied energy, material demand, waste reduction, and resource-efficient building lifecycles.

Keywords: energy retrofit, circular adaptability, embodied energy, service life extension, design for adaptability, building transformation, resource efficiency, retrofit assessment

Field of application for the findings: Assessment and decision-support for circular retrofit strategies in existing buildings, particularly in the context of sustainable renovation, long-term building transformation, and resource-conscious design.

Addressed audience: Architects, engineers, consultants, and policy actors involved in the renewal and long-term adaptation of existing buildings.

1. Problem Statement

In the current practice of adapting existing buildings, there is still no sufficiently systematic method for identifying, selecting, and prioritizing design considerations for interventions at the early strategic stage of a project (Hamida, 2025). This methodological gap is especially critical in the context of thermal energy upgrading, where immediate measures intended to improve operational energy performance may directly conflict with longer-term sustainability goals, such as adaptability, future flexibility, circularity, and service life extension (CIRCuIT, 2023; Hamida, 2025). Consequently, there is a pressing need for a decision-support approach capable of addressing and balancing these trade-offs at the outset of retrofit planning. Insights derived from the CIRCuIT project demonstrate that these trade-offs typically arise in at least three distinct ways: first, in the tension between building preservation and default demolition for new construction; second, in the conflict between immediate technical upgrading and the preservation of future spatial flexibility; and third, through rigid energy-efficiency regulations that may unintentionally overreach and constrain the implementation of circular solutions (CIRCuIT, 2023).

2. Objectives

This research aims to develop a tool that supports systematic, early-stage decision-making in retrofit planning for existing buildings. Particular attention is given to navigating the complex relationship between thermal energy-saving interventions and adaptability-related performance. The proposed tool is intended to help practitioners explicitly identify and prioritize design parameters that can effectively improve operational energy performance while simultaneously supporting long-term transformation capacity and promoting more resource-conscious intervention strategies (Hamida, 2025; International Organization for Standardization, 2020).

3. Methodology

The tool is developed through a targeted literature review and a structured extraction and synthesis of

parameters from existing frameworks, standards, and assessment methods relevant to building performance during the use phase. The review focuses on sources addressing adaptability, circularity, durability, deconstruction, and retrofit evaluation in relation to existing buildings.

Its conceptual foundation combines several complementary references. Circular Building Adaptability provides the overarching logic for integrating adaptability and circularity in the assessment of building transformation (Hamida, 2025). ISO 20887 contributes principles related to design for disassembly and adaptability, particularly layer separation, standardization, and context-sensitive evaluation (International Organization for Standardization, 2020). FLEX 4.0 informs the distinction between support and infill and the use of graded assessment (Geraedts, 2016). The Level(s) framework contributes measurable indicators related to future adaptation and deconstruction potential (European Commission, 2021). Reversible Building Design strengthens the technical assessment of dismantlability through the evaluation of connection and assembly logic (Durmisevic, 2018). Arup's circular design strategies, integrated with Stewart Brand's shearing layers concept, support the differentiation of building layers according to their different rates of change and provide strategies for building for long-term reuse (Arup / Zimmann et al., 2016). CIRCuIT contributes specific insight into the trade-offs between thermal upgrading, circularity, and future flexibility (CIRCuIT, 2023).

4. Tool Description

The proposed tool is designed to systematically assess retrofit options by examining interventions through three main building layers: the structure, the envelope, and the layout (Hamida, 2025). It utilizes a dynamic scoring and weighting system in which the relative importance of specific design parameters is scenario-based rather than fixed. Under this system, the weighting assigned to each parameter changes according to the specific project context, taking into account critical variables such as the building typology, construction technology, material system, expected service life, and ownership profile (Geraedts, 2016; International Organization for Standardization, 2020).

5. Anticipated Outcomes and Contribution

The anticipated outcome of this research is a structured assessment framework that supports more informed retrofit decision-making in existing buildings. The research contributes to sustainable renovation discourse by framing retrofit quality in terms of future use potential, transformation capacity, slowing of the resource loop, and extended service life (Durmisevic, 2018; Hamida, 2025). Methodologically, it offers a scenario-based synthesis of existing frameworks into an operational tool tailored to early-stage project evaluation. Practically, it provides architects, engineers, consultants, and policy actors with a clearer basis for comparing retrofit strategies and identifying interventions that support both energy improvement and long-term resilience.

References

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