International Journal of Engineering Research and Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 22, Issue 8 (August 2026), PP 74-82

Integrated Evaluation Criteria and Decision-Making Factors in Single-Family House Renovation and Adaptive Reuse: A Structured Literature Review

Elma Trkić[1]

[1]*Department of Architecture, Faculty of Engineering, Natural and Medical Sciences, International Burch University, Sarajevo, Bosnia and Herzegovina*
Corresponding Author

ABSTRACT
Renovating and adapting existing single-family houses can reduce the environmental burden of the residential building stock, improve energy performance and strengthen resilience to a changing climate. In practice, however, decisions are often divided between energy upgrades, material choices, affordability and project delivery. This structured literature review examines the main criteria used to evaluate the renovation and adaptive reuse of single-family houses. It draws on 28 academic and institutional sources covering passive and active design measures, life-cycle assessment, low-carbon and circular materials, climate adaptation, cost evaluation, digital tools and construction management. The findings are organised into five connected areas: environmental and energy performance; material and life-cycle performance; economic feasibility; resilience, functionality and user needs; and construction management and implementation capacity. The review shows that no single indicator can provide an adequate basis for a renovation decision. More reliable outcomes depend on early coordination, life-cycle thinking, sensible sequencing and the ability to translate technical evidence into choices that homeowners and project teams can use. On this basis, the paper sets out an integrated evaluation structure linking technical assessment with planning, procurement, risk management, quality control and post-renovation feedback. The framework is intended as a practical conceptual basis for renovation strategies that are lower in carbon, resilient, financially realistic and suited to the conditions of small residential projects.

Keywords: single-family house renovation; adaptive reuse; sustainable adaptation; construction management; life-cycle assessment; low-carbon materials; decision-making

---

Date of Submission: 05-08-2026 Date of acceptance: 17-08-2026

I. INTRODUCTION

The performance of the existing building stock is now a central concern in climate policy, energy planning and sustainable construction. Most of the buildings that will still be in use over the coming decades have already been built. A transition towards a lower-carbon built environment therefore cannot depend on new construction alone. Renovation and adaptive reuse are therefore important because they extend service life, reduce the demand for new materials and create opportunities to improve energy performance without replacing the entire building. Single-family houses merit particular attention because they tend to remain in use for long periods, are usually privately owned, and vary considerably in construction quality and renovation need.

Renovating a single-family house involves both technical and organisational challenges. Many were constructed before current standards for thermal performance, airtightness and building services. Their owners may have limited access to technical expertise, and the renovation process is often organised through small teams with fragmented responsibilities. Decisions are therefore frequently influenced by immediate affordability, visible defects and short-term comfort concerns rather than by a complete life-cycle assessment. The result may be a partial intervention that resolves one issue but introduces another. A heating system may, for example, be replaced before the envelope is improved, or insulation may be installed without a proper assessment of moisture risk.

The literature consistently presents passive measures as a sensible starting point for reducing residential energy demand. Early consideration of orientation, solar exposure, envelope performance, thermal bridges, shading and natural ventilation can reduce the loads that must later be met by active systems [1], [2]. However, passive measures cannot be assessed in isolation. Their environmental value depends on the materials used, their durability, installation requirements and effect on indoor comfort. Similarly, active technologies such as heat pumps or renewable energy systems need to be selected only after the underlying energy demand and building condition have been evaluated. Belmonte et al. state that "the incorporation of passive design strategies at the early stages of the design process can significantly reduce the energy demand" [1].

Climate adaptation broadens the evaluation beyond energy use alone. Buildings need to respond not only to gradual warming but also to overheating, intense precipitation, moisture stress, wind and other extreme events [3], [4]. Consequently, an intervention that performs well under present conditions may not remain effective throughout its expected service life. Renovation decisions therefore need to consider future climate conditions, adaptability and resilience, rather than focusing solely on current energy consumption. As Saifudeen and Mani observe, "it is imperative to address all the extreme climate change events" affecting the built environment [4].

Material choice is equally important. The reuse of existing building elements, reclaimed products and bio-based materials can reduce embodied impacts and support circularity [6], [7], [19]. Yet these strategies require technical verification, reliable procurement, dimensional flexibility and careful planning. Their success depends as much on construction management as on material properties. Without early coordination, reusable components may be identified too late, low-carbon products may be unavailable when needed, and design decisions may become incompatible with circular procurement. Friedman describes "sustainability and the principles of circularity" as key drivers in the continuing development of housing design [7].

Whether a renovation measure is implemented often depends first on its perceived affordability. Initial cost is highly visible to homeowners, while long-term benefits such as energy savings, reduced maintenance and improved resilience are more uncertain. Systematic reviews of adaptation and life-cycle cost methods show that economic evaluation remains inconsistent and that practical projects often rely on simplified short-term calculations [11], [12]. This creates a gap between analytical knowledge and the decisions made in ordinary residential projects.

Taken together, the literature supports a more integrated form of evaluation. Renovation is not a single technical action but a coordinated process that links diagnosis, option development, cost assessment, procurement, implementation and feedback. The role of construction management is therefore central because it provides the organisational structure through which environmental, technical and economic criteria can be compared and translated into feasible project decisions [8], [21]. Tijo characterises renovation as a process in which "environmental, technical and economic considerations are addressed independently rather than through an integrated framework" [8].

This paper identifies, organises and critically discusses the key criteria that influence the evaluation of renovation and adaptive reuse of single-family houses. It addresses three objectives: first, to synthesise the main environmental, technical, material, economic and managerial factors reported in the literature; second, to explain the relationships and trade-offs between these factors; and third, to propose an integrated evaluation structure suitable for small-scale residential renovation. The contribution is conceptual rather than empirical. It does not propose a universal scoring system, but establishes a coherent basis for future decision-support tools and project-specific assessment frameworks.

II. RESEARCH DESIGN AND REVIEW METHOD

The study adopts a qualitative, desk-based design and a structured literature review. The review draws on the 28 references assembled for the original conference paper, including peer-reviewed journal articles, conference papers, books, dissertations, a master's thesis and an institutional report. Together, these sources form the review corpus. The available material does not record the databases, full search strings, search dates or a PRISMA screening process. For that reason, the present version is described as a structured review rather than a fully reproducible systematic review. It applies a transparent thematic synthesis while retaining the scope of the original research.

2.1 Scope and unit of analysis

The unit of analysis is the renovation or adaptive reuse decision concerning an existing single-family house. The review focuses on criteria that influence whether a measure should be selected, how alternatives should be compared and how a renovation strategy can be implemented. Sources concerned only with new construction were considered relevant only when their concepts directly informed residential evaluation, material impact, adaptability, digital assessment or construction management. The review therefore includes both house-specific studies and broader methodological sources where they support the evaluation framework.

Lähteenmäki argues that sustainable renovation must address "functionality, adequacy of use and user related aspects" alongside energy efficiency [14].

2.2 Inclusion logic

The literature was included where it contributed to at least one of the following themes: passive and active energy strategies; climate adaptation and resilience; life-cycle assessment; embodied energy or carbon; low-carbon, reclaimed or circular materials; economic and life-cycle cost assessment; digital tools and decision-support; construction management; or user-related and functional criteria. The purpose was not to count isolated keywords. It was to understand how the sources connect different criteria and what conditions they identify as necessary for implementation.

2.3 Analytical procedure

The material was analysed in three stages. First, each source was reviewed for its main evaluation focus and the type of decision it supports. Second, recurring criteria were coded and grouped into broader categories. Third, the relationships between the categories were interpreted from a construction management perspective. Particular attention was paid to trade-offs, early-stage decisions, sequencing, responsibilities and the practical limitations of advanced assessment methods in small residential projects. The resulting categories were refined until they captured the main themes across the corpus without excessive overlap.

2.4 Limitations of the review method

The corpus supports a structured conceptual synthesis, although it cannot be regarded as statistically representative of the full body of research. Several sources address adjacent topics, such as modular construction, build-to-rent development or new elevated foundations [23], [26], [27]. They are used only for the specific methodological or managerial insights that are transferable to renovation evaluation. The review also does not independently verify every numerical claim in the original studies. Its purpose is to organise the factors supported by the supplied literature and identify implications for integrated decision-making.

III. CONCEPTUAL BASIS FOR INTEGRATED RENOVATION EVALUATION

An integrated evaluation starts from a simple point: renovation measures interact throughout the building life cycle. A decision to replace a façade system, for example, influences operational energy, embodied impacts, construction cost, moisture behaviour, disruption, procurement and future maintenance. Evaluating only one outcome can therefore produce a misleading result. A technically efficient measure may be too expensive, a low-cost measure may have poor durability, and a low-carbon material may be impractical if it is unavailable or incompatible with the existing construction.

Life-cycle thinking gives this integration a time-based structure. It expands assessment beyond the completion of construction and includes production, transport, installation, use, maintenance, replacement and end-of-life processes [12], [15], [20]. In renovation, this perspective is particularly valuable because the retained building already contains embodied resources. The decision is not simply which new product to select, but which existing components can remain, which should be repaired and which must be replaced.

Construction management supplies the organisational structure needed to put this thinking into practice. It links the analytical questions of what performs best with the practical questions of who decides, when information is required, how cost and risk are controlled, and whether the selected strategy can be delivered [8], [21]. Integrated evaluation is therefore both an assessment process and a management process. It requires criteria, but also responsibilities, communication channels and review points.

Table 1. Main dimensions of integrated renovation evaluation

Dimension	Representative criteria	Typical decision question	Selected sources
Environmental and energy performance	Heating and cooling demand; envelope; airtightness; ventilation; renewables; thermal comfort	Which combination reduces demand and maintains comfort under present and future climate conditions?	[1]-[5], [15], [22]
Material and life-cycle performance	Embodied carbon; retention; reclaimed and bio-based materials; durability; maintenance; end of life	Which components should be retained, repaired, reused or replaced?	[6], [7], [17]-[20], [28]
Economic feasibility	Initial cost; operating cost; maintenance; life-cycle cost; affordability; financing	Is the strategy financially feasible now and over the expected service life?	[11], [12], [26]

Resilience, functionality and users	Overheating; moisture; adaptability; adequacy of use; household change; health and comfort	Will the renovated house remain safe, useful and adaptable?	[4], [9], [10], [14]
Construction management and implementation	Stakeholders; sequencing; procurement; risk; quality; digital tools; feedback	Can the preferred strategy be coordinated and delivered in practice?	[8], [16], [21]-[23], [27]

IV. RESULTS: KEY EVALUATION DIMENSIONS

4.1 Environmental and energy performance

Environmental and energy performance receive the greatest attention in residential renovation research. Existing houses frequently have inadequate insulation, uncontrolled air leakage, thermal bridges and outdated systems. The literature therefore gives strong attention to reducing operational demand through envelope improvement, passive design and efficient building services [1], [2], [15]. The central evaluation question is not whether one measure saves energy in isolation, but how measures interact as a package. Sinha et al. conclude that "integrated evaluation approaches consistently outperform fragmented assessment practices" in supporting sustainable renovation outcomes [16].

Passive measures should normally be assessed before active systems are selected or sized. Improved insulation, controlled ventilation, solar protection and reduced thermal bridging lower the heating and cooling loads that mechanical systems must satisfy. If an active system is selected first, it may be oversized after the envelope is improved. Sequencing therefore has technical and economic consequences. It also affects procurement and design coordination because the capacity and layout of building services depend on the final demand profile.

Energy assessment should also account for indoor environmental quality. Airtightness without appropriate ventilation can create moisture and air-quality problems, while excessive solar gains can produce overheating even when winter energy performance improves. Climate-responsive evaluation therefore needs to examine seasonal performance, user behaviour and future climate scenarios [4], [22]. The objective is not only lower annual energy use, but stable comfort and reduced vulnerability under changing conditions.

Operational energy indicators should be considered alongside embodied impacts. Deep renovation may require significant quantities of insulation, finishes and replacement products. The environmental benefit therefore depends on the time required for operational savings to offset the impacts associated with materials and construction. This does not imply that deep renovation is undesirable, but it reinforces the need for life-cycle comparison rather than reliance on one operational indicator.

4.2 Material retention, low-carbon materials and circularity

In renovation, material assessment should begin with what is already present. Retaining a functional structure, roof or internal component can avoid the impacts of new production and preserve resources already invested in the house. Adaptive reuse is therefore inherently connected with circularity because it extends service life and reduces demolition. Research on wooden single-family buildings and reclaimed products demonstrates the potential benefits of reused components when their technical suitability is confirmed [6], [19]. Van de Moortel and Allacker find that renovation generally produces lower cumulative impacts, especially where "biobased and reclaimed materials are applied" [19].

Low-carbon and bio-based materials may reduce embodied impacts, although their suitability remains context-dependent. Moisture behaviour, durability, fire requirements, maintenance and availability need to be assessed together. A material with a favourable environmental profile may create technical risk if it is incompatible with the existing wall build-up or local climate. Material selection therefore requires coordination between environmental assessment and building physics.

Reclaimed products create additional management demands. Their dimensions and condition may vary, supply can be uncertain and documentation may be incomplete. The design must allow flexibility, and procurement needs to begin earlier than in conventional projects. Quality assurance is also essential because the environmental benefit of reuse is weakened if components fail prematurely or require substantial reworking.

Circularity should not be reduced to recycling at the end of the project. A more complete approach follows a hierarchy: retain the building, repair components, reuse products, select low-impact replacements and design future interventions for disassembly and adaptability. This hierarchy helps prevent unnecessary replacement and connects immediate renovation choices with future material cycles [7], [17], [25].

4.3 Life-cycle assessment and embodied impacts

Life-cycle assessment supports comparison between alternatives by accounting for impacts beyond the operational phase [20]. In renovation, LCA can clarify whether demolition and replacement are justified, whether a low-energy option creates high embodied impacts and how material choices influence long-term performance. It is particularly useful when several packages achieve similar operational results but differ substantially in material intensity.

However, the practical use of detailed LCA remains limited in small projects. Data collection can be demanding, product-specific information may not be available and homeowners may find the results difficult to interpret. An integrated framework therefore needs a tiered approach. Early screening may rely on simplified indicators such as retained material quantity, expected service life and major carbon-intensive components. More detailed analysis can then be reserved for decisions with significant environmental consequences.

Embodied energy and carbon should be considered alongside durability. A component with a low initial impact may not be preferable if it has a short service life or frequent maintenance requirements. Conversely, a somewhat higher initial impact may be justified when the component has a long life, reduces operational demand and can be repaired. The evaluation should therefore state the assumed service period and replacement cycles rather than presenting material impact as a fixed one-time value [28].

4.4 Economic feasibility and life-cycle cost

Financial constraints strongly shape residential renovation. Homeowners commonly make decisions within fixed budgets and may prioritise urgent repairs over comprehensive improvement. Initial cost is therefore unavoidable, but it should not be the only economic criterion. Life-cycle cost assessment can include energy, maintenance, replacement and residual value, providing a more balanced understanding of affordability [11], [12].

The economic comparison of alternatives should distinguish essential works from optional improvements. Structural safety, moisture defects and regulatory compliance may require immediate intervention, while energy and comfort measures can be packaged or phased. This distinction supports transparent prioritisation and prevents sustainability objectives from being abandoned when the complete package exceeds the available budget.

Cost uncertainty is particularly important in renovation because concealed conditions may not be known before work begins. Contingency allowances, surveys and risk registers are therefore part of economic evaluation. Accurate quantities and cost estimates improve feasibility, but they need to be combined with uncertainty ranges rather than treated as exact predictions [26].

Phased renovation can improve affordability, but only when the sequence is planned. Measures completed in one phase should not obstruct future work or create avoidable duplication. For example, façade finishes should not be renewed immediately before additional insulation is planned. A long-term renovation roadmap can therefore connect financial capacity with technically coherent sequencing.

4.5 Resilience, adaptability, functionality and user needs

Sustainability in housing includes the ability of a building to remain useful under changing environmental and household conditions. Resilience criteria can include overheating, moisture, extreme weather, energy disruption and recovery after disturbance [9], [10]. Adaptability concerns the ability of the house to respond to changes in family size, ageing, accessibility needs or work patterns without major material-intensive reconstruction.

User-related criteria are particularly important in single-family housing because operation and maintenance depend directly on occupants. A technically advanced system may underperform if controls are confusing or maintenance is demanding. Evaluation should therefore consider usability, training and the match between technology and household routines. Adequacy of use and sufficiency can sometimes achieve sustainability improvements without extensive construction, for example through functional reorganisation or better use of existing space [14].

Comfort should be assessed across thermal, visual and acoustic dimensions rather than reduced to indoor temperature. Renovation measures can create trade-offs, such as improved airtightness with reduced natural ventilation or increased glazing with higher overheating risk. User preferences should be documented early so that design optimisation does not overlook practical living requirements.

4.6 Digital tools and decision-support

Digital tools can connect building information with energy, material and cost analysis. BIM-based models can support quantity take-off, scenario comparison and coordination, while integration with LCA can improve the visibility of operational and embodied trade-offs [22]. One-stop-shop and digital service models can also reduce fragmentation by providing homeowners with coordinated technical and financial guidance [16]. Falegari and Shirzadi Javid note that BIM–LCA integration enables “a more comprehensive evaluation of energy performance and climate-responsive design parameters” [22].

The value of digital tools depends on data quality and usability. A detailed model does not automatically improve a decision if input assumptions are uncertain or outputs are not understandable. Tools should therefore support, rather than replace, professional judgement. For small-scale projects, simplified dashboards and clear option comparisons may be more useful than complex simulations with limited transparency.

Digitalisation can also support documentation and post-renovation learning. Recording installed products, maintenance requirements and performance data creates a basis for future intervention. This is especially relevant to adaptive reuse because the building will continue to change. A digital record can help preserve knowledge that would otherwise be lost between owners, designers and contractors.

4.7 Construction management as the integrative dimension

The reviewed literature supports the interpretation of construction management as the integrative layer of renovation evaluation [8], [21]. Environmental, technical and economic criteria only influence outcomes when they are incorporated into decisions, responsibilities and project controls. Construction management links evaluation to action through planning, stakeholder coordination, procurement, cost control, risk management, quality assurance and feedback. Olanrewaju emphasises that integrated construction management helps align "analytical evaluation methods with practical project implementation across the building lifecycle" [21].

Stakeholder coordination is particularly important because the homeowner is often both client and end user, while specialist input may be distributed among architects, engineers, energy assessors, contractors and suppliers. Without a clear decision structure, recommendations can conflict or arrive too late. An integrated process should therefore define who provides information, who approves options and when decisions become fixed.

Procurement affects the feasibility of low-carbon and circular strategies. Reclaimed or specialist materials may require longer lead times, alternative suppliers and flexible specifications. If procurement is treated as a late administrative task, these options are likely to be removed. Early market engagement and supplier consultation are therefore part of sustainability evaluation.

Quality assurance and commissioning are also necessary. Predicted energy savings depend on correct installation, airtightness, system balancing and user understanding. Post-renovation checks can identify performance gaps and provide feedback for future projects. This closes the loop between evaluation, implementation and operation.

V. PROPOSED INTEGRATED EVALUATION FRAMEWORK

The synthesis supports a staged framework in which decisions become progressively more detailed. The framework is intended as a conceptual guide rather than a fixed scoring tool. It can be adapted to the scale, condition and budget of an individual house.

Table 2. Staged integrated evaluation process

Stage	Main activities	Key outputs	Management focus	Relevant criteria
1. Diagnosis	Survey condition, energy use, moisture, structure, services and user needs	Baseline building profile and constraints	Define responsibilities; identify missing information	Safety, energy, comfort, functionality
2. Objectives and priorities	Set performance, resilience, budget and functional objectives	Agreed project brief and priority hierarchy	Align homeowner and project team expectations	Environmental, economic, user-related
3. Option development	Create coordinated renovation packages rather than isolated measures	Alternative scenarios with assumptions	Coordinate design disciplines and suppliers	Passive/active measures, materials, adaptability
4. Comparative evaluation	Compare energy, embodied impacts, cost, risk and deliverability	Documented option comparison	Manage uncertainty and decision records	LCA, life-cycle cost, resilience, feasibility
5. Sequencing and procurement	Plan phases, lead times, reusable components and contractor inputs	Implementation roadmap and procurement plan	Avoid rework; secure critical resources	Timing, circularity, cost, disruption
6. Construction	Inspect installation,	Verified implementation	Quality, cost and risk	Performance, durability,

and quality control	manage changes, commission systems	and handover data	control	compliance
7. Operation and feedback	Monitor comfort, energy and maintenance; document lessons	Post-occupancy feedback and future update plan	Close performance gap; support future adaptation	Actual performance, user satisfaction, maintenance

The framework also requires explicit treatment of trade-offs. Each option should identify benefits, negative consequences, uncertainties and dependencies. For example, an insulation package may improve winter performance but increase embodied impacts and moisture sensitivity. A reclaimed component may reduce carbon but introduce supply uncertainty. A heat pump may lower operational emissions but require envelope improvement, electrical capacity and user training. Recording these relationships prevents a single indicator from dominating the decision.

A practical evaluation sheet could therefore combine a small number of quantitative indicators with qualitative ratings. Quantitative indicators may include predicted energy demand, estimated embodied carbon, initial cost and life-cycle cost. Qualitative ratings may address adaptability, implementation risk, user acceptance, material availability and disruption. Weighting should be project-specific and agreed transparently, because the relative importance of criteria differs between households and building conditions.

VI. CRITICAL DISCUSSION

The reviewed evidence confirms that fragmentation is not merely a theoretical weakness but a practical source of poor renovation outcomes. When disciplines work sequentially without shared evaluation, decisions made in one area constrain later options. Energy consultants may propose systems before the architect resolves the envelope, or cost reductions may remove measures without considering their effect on long-term performance. Integration therefore needs to occur at the process level, not only in the final report. Carvalho et al. describe integrated frameworks as essential for “translating analytical findings into actionable strategies” for sustainable and resilient development [27].

The literature also reveals a tension between methodological sophistication and practical accessibility. LCA, BIM and climate simulation can improve analytical quality, but they require data, expertise and time. Single-family house projects often cannot support the same level of analysis as major developments. The appropriate response is not to abandon these methods, but to scale them. Screening tools, default datasets and staged analysis can direct detailed effort towards the most influential decisions.

Another important issue is the treatment of uncertainty. Renovation assessments depend on assumptions about occupant behaviour, future energy prices, climate, product life and hidden construction conditions. Presenting one precise result can create false confidence. Integrated frameworks should therefore use ranges, sensitivity analysis and risk categories where possible. Decision quality depends not only on the predicted outcome but also on awareness of uncertainty.

The relationship between circularity and construction management deserves particular emphasis. Reuse is often discussed as an environmental strategy, but its implementation depends on surveys, storage, logistics, quality control and flexible design. These are management tasks. The same is true for phased renovation, which can improve affordability only when future interventions are anticipated. Circular and staged strategies therefore require a longer planning horizon than conventional replacement-based work.

The review further suggests that user participation is a condition of performance. Homeowners influence objectives, budgets, operation and maintenance. Their preferences can support or undermine technical recommendations. Integrated evaluation should therefore communicate alternatives in understandable terms and make trade-offs visible. A technically optimal solution that the household cannot finance, operate or maintain is not a successful renovation strategy.

Finally, the evidence supports a shift from measure-based thinking to package-based thinking. Individual products are easy to market and compare, but building performance emerges from interactions. Renovation packages should therefore be designed around coherent objectives such as demand reduction, moisture safety, low embodied impact, adaptability and manageable cost. Construction management then provides the structure for selecting, sequencing and verifying the package.

VII. PRACTICAL IMPLICATIONS FOR RESIDENTIAL RENOVATION

For homeowners, the framework supports clearer prioritisation. Urgent safety and moisture issues should be identified first, followed by measures that reduce demand and prevent future rework. Decisions should be recorded in a long-term roadmap, even when implementation occurs in phases.

For architects and engineers, the framework highlights the need to coordinate building physics, materials, cost and user requirements from the beginning. Technical recommendations should describe dependencies and sequencing rather than being presented as independent measures.

For contractors and suppliers, early involvement can improve buildability, cost certainty and access to low-carbon or reclaimed products. Their input is especially valuable where existing conditions are uncertain or specialist installation is required.

For public authorities and financial institutions, a simplified integrated assessment could strengthen renovation support programmes. Incentives that reward isolated technologies may encourage suboptimal sequencing. Support mechanisms should instead recognise coordinated renovation packages and the costs of diagnosis, design and quality assurance.

For researchers, the framework points to the need for practical tools tested on real projects. Future studies should test simplified multi-criteria models, compare predicted and measured performance, and examine how homeowners use decision-support information. Regional testing is also necessary because climate, construction traditions, regulations and market availability influence the relevance of criteria.

VIII. LIMITATIONS AND FUTURE RESEARCH

This paper is based on the 28 sources listed in the original conference paper. It does not reproduce a database search or PRISMA screening process because those records were not included in the material. Its conclusions should therefore be read as a structured synthesis of a defined corpus, rather than as an exhaustive account of all available research. The sources also vary in building type, geography and methodological focus. Some provide direct evidence on single-family house renovation, while others contribute transferable concepts related to construction management, life-cycle assessment, modularity or development frameworks.

Future research should develop a reproducible search protocol and test the proposed framework through case studies. Empirical application could examine how criteria are weighted, which data are realistically available and whether the framework improves communication and project outcomes. Particular attention should be given to simplified LCA and life-cycle cost methods, renovation sequencing, circular procurement and post-occupancy feedback. Testing in Bosnia and Herzegovina and the wider Balkan region would be valuable because the local housing stock, economic conditions, climate and construction practices are not systematically represented in the reviewed corpus.

IX. CONCLUSION

The renovation and adaptive reuse of single-family houses cannot be reduced to the selection of individual energy or material measures. The reviewed literature shows that environmental performance, embodied impacts, economic feasibility, resilience, user needs and implementation capacity are closely connected. Decisions made in one dimension affect the others, and fragmented assessment can therefore reduce the long-term value of renovation.

Life-cycle thinking provides the time-based perspective, while construction management provides the organisational means of acting on it. Together, they support early coordination, transparent comparison, coherent sequencing and quality assurance. Digital tools can strengthen this process, but they need to be adapted to the resources and decision structures of small residential projects.

The proposed framework structures renovation evaluation around diagnosis, objective setting, option development, comparative assessment, sequencing, implementation and feedback. It does not prescribe one universal solution. Instead, it provides a structure through which project-specific priorities and trade-offs can be documented and managed.

An integrated approach can therefore support renovation strategies that are energy efficient, low-carbon, resilient, affordable and realistically deliverable. The next step is empirical testing and development of accessible decision-support tools that connect academic methods with the realities of homeowners and residential project teams.

REFERENCES

[1]. M. V. Belmonte, C. Díaz-López, J. Gavilanes, and E. Millán, “Introducing passive strategies in the initial stage of the design to reduce the energy demand in single-family dwellings,” Building and Environment, 2021, doi: 10.1016/j.buildenv.2021.107832.

[2]. S. E. Okiye and T. Ohakawa, “Framework for integrating passive design strategies in sustainable green residential construction,” Morgan State University and University of Maryland, 2023.

[3]. M. Türkeş, "The role of sustainability and sustainable development in climate change mitigation and adaptation," Sustainable Social Development, 2024, doi: 10.54517/ssd.v2i1.2407.
[4]. A. Saifudeen and M. Mani, "Adaptation of buildings to climate change: An overview," Frontiers in Built Environment, 2024, doi: 10.3389/fbuil.2024.1327747.
[5]. UN-Habitat, World Cities Report 2024: Cities and Climate Action. Nairobi, Kenya: United Nations Human Settlements Programme, 2024.
[6]. B. Petrović, O. Eriksson, X. Zhang, and M. Wallhagen, "Carbon assessment of a wooden single-family building - Focusing on re-used building products," Buildings, vol. 14, no. 3, p. 800, 2024, doi: 10.3390/buildings14030800.
[7]. A. Friedman, "Life cycle homes for adaptability, circularity, and sustainability," Architecture, vol. 5, no. 2, 2025, doi: 10.3390/architecture5020022.
[8]. S. J. Tijo, "Decision support system for the integration of sustainable parameters in single-family housing project delivery," Ph.D. dissertation, Georgia Institute of Technology, Atlanta, USA, 2019.
[9]. M. A. Ruíz and Y. L. Mack-Vergara, "Resilient and sustainable housing models against climate change: A review," Sustainability, vol. 15, no. 18, p. 13544, 2023, doi: 10.3390/su151813544.
[10]. S. B. Villa, K. C. R. de Bortoli, and L. V. Oliveira, "Resilient house evaluation matrix: Attributes and quality indicators for social housing," Buildings, vol. 15, no. 5, p. 793, 2025, doi: 10.3390/buildings15050793.
[11]. L. Felicioni, K. Klepačová, and B. Hejtmánková, "Economic assessment of building adaptation to climate change: A systematic review of cost evaluation methods," Economies, vol. 13, no. 5, p. 156, 2025, doi: 10.3390/economies13050156.
[12]. A. T. Balasbaneh, W. Sher, and J. Li, "A systematic review of the life cycle cost estimation of upgrading buildings for sustainability," Environmental Science and Pollution Research, 2025, doi: 10.1007/s11356-025-36757-x.
[13]. I. Josa and A. de la Fuente, "Traditional and modern methods of construction: Comparative study of the sustainability of single-family homes," Structural Concrete, 2024, doi: 10.1002/suco.202400802.
[14]. J. Lähteenmäki, "Sustainability measures for single-family housing: Efficiency in design and sufficiency in use," Master's thesis, LUT University, Finland, 2023.
[15]. V. Motuzienė, A. Rogoža, V. Lapinskienė, and T. Vilutienė, "Construction solutions for energy-efficient single-family house based on its life cycle multi-criteria analysis: A case study," Journal of Cleaner Production, vol. 112, pp. 3873–3883, 2015, doi: 10.1016/j.jclepro.2015.05.106.
[16]. S. Sinha, B. Mainali, K. Mahapatra, and A. Mazaheri, "Integrating digital tools in one-stop-shop business models for climate-smart single-family home renovation in the European Union," Linnaeus University, 2023.
[17]. Á. Szennay, Z. Major, R. Horváth, H. Czédli, and C. Szigeti, "Providing decent, affordable, and sustainable housing: Analysing environmental impacts of family houses built with conventional and unconventional building materials," in Energy Footprint and Sustainability. Cham, Switzerland: Springer, 2024, pp. 105–126.
[18]. A. Vestin, "Smart manufacturing for the wooden single-family house industry," Ph.D. dissertation, Jönköping University, School of Engineering, Sweden, 2020.
[19]. E. Van de Moortel and K. Allacker, "Reducing the environmental impact of a single-family house through renovation using biobased and reclaimed materials," in Sustainable Renovation and Construction, 2023.
[20]. H. Hernández, F. Ossio, and M. Silva, "Assessment of sustainability and efficiency metrics in modern methods of construction: A case study using a life cycle assessment approach," Sustainability, vol. 15, no. 7, p. 6267, 2023, doi: 10.3390/su15076267.
[21]. A. Olanrewaju, Sustainable Construction Management: Research and Practice Companion – Integrating Sustainability Targets in Construction. Cham, Switzerland: Springer, 2023.
[22]. S. Falegari and A. A. Shirzadi Javid, "Integrating building information modelling and life cycle assessment to analyse the role of climate and passive design parameters in energy consumption," Energy & Environment, 2022, doi: 10.1177/0958305X221145923.
[23]. K.-E. Hwang and I. Kim, "Post-COVID-19 modular building review on problem-seeking framework: Function, form, economy, and time," Journal of Computational Design and Engineering, vol. 9, no. 4, pp. 1369–1387, 2022, doi: 10.1093/jcde/qwac057.
[24]. A. Sarju, A. Setyawan, M. A. Wibowo, and F. S. Handayani, "Realization of low carbon housing construction: Analysis of materials, energy, technology, and policies," E3S Web of Conferences, 2025, Art. no. 02058.
[25]. A. Friedman, Fundamentals of Innovative Sustainable Homes Design and Construction. Cham, Switzerland: Springer, 2023.
[26]. Y. Kodavatiganti, M. A. Rahim, C. J. Friedland, R. B. Mostafiz, A. Taghinezhad, and S. Heil, "Material quantities and estimated construction costs for new elevated IRC 2015-compliant single-family home foundations," Frontiers in Built Environment, vol. 9, 2023, doi: 10.3389/fbuil.2023.1111563.
[27]. R. Carvalho, T. Liu, F. Zhang, R. Yu, and E. Oh, "Key themes of build-to-rent: Developing a conceptual framework for achieving successful developments through a systematic literature review," Buildings, vol. 13, no. 8, p. 1926, 2023, doi: 10.3390/buildings13081926.
[28]. N. Anderson, G. Wedawatta, I. Rathnayake, N. Domingo, and Z. Azizi, "Embodied energy consumption in the residential sector: A case study of affordable housing," Sustainability, vol. 14, no. 9, p. 5051, 2022, doi: 10.3390/su14095051.