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A Framework for Just Decision Support Systems

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Chapter 54
A Review of Climate and Resident-Oriented Renovation Processes: A Framework for Just Decision Support Systems

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Abstract The renovation of existing buildings is widely recognized as a powerful strategy for reducing emissions and land use. However, when it comes to residential buildings, the socio-technical challenges are particularly complex. The necessity and urgency of increasing energy efficiency often lead to retrofit processes that overlook residents' needs and fail to consider the impact of renovation techniques on their lives. This study conducts a systematic and interdisciplinary literature review to explore how and to what extent social aspects, particularly residents and their needs, are considered in building renovations. An analysis of 40 studies from the Web of Science and Scopus databases is presented. The holistic overview focuses on two interrelated aspects: the orientation of decision-making processes towards residents and social components of multi-stakeholder involvement, and the relationship and interaction between design choices and residents. By doing so, the review enables a collection of meaningful and heterogeneous criteria for process management and retrofit solutions selection. Recognizing the existing gaps in the literature and clarifying relevant criteria, this review can help identify areas that require further research and intervention.

54.1 Introduction

In the contemporary era, the built environment faces a significant challenge and opportunity due to its dynamic nature, encompassing both physical-environmental and social domains, necessitating adaptation and transformation. The urgency to address climate change and European directives has compelled the building sector,

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to undergo a sustainable and energy-efficient transition, as it is a major contributor to greenhouse gas emissions, accounting for 35% of energy-related EU emissions in 2020 [21]. The Renovation Wave initiative [22] aims to double renovation rates by 2030, with the goal of renovating 35 million buildings across Europe. However, the dynamic nature of the built environment also encompasses its inhabitants and the social systems that animate it. Renovation processes also involve socio-technical dynamic systems, including technologies, infrastructures, actors, networks, and social norms, which have co-evolved over time [11]. When it comes to residential buildings and neighbourhood renovations, this dynamism poses a delicate challenge due to the heterogeneity of residents and their diverse needs. Neglecting these factors may render energy improvements futile. Addressing the human factor is crucial for achieving energy efficiency, climate adaptation, and mitigation strategies. Homes are intimately connected to personal habits, and the introduction of innovative technologies often requires efforts to learn and modify behaviours [9]. Nevertheless, a holistic approach to housing renovation, combining physical improvements with social interventions has the potential to enhance physical health, mental well-being, and overall quality of life [31]. Without proper guidance and planning, this process struggles to be universally applicable, particularly for vulnerable groups. The Renovation Wave and recent studies have emphasized the importance of social inclusion and the mitigation of energy poverty to ensure a just transition and improve living conditions. A literature review on these issues is lacking, so with a holistic approach, it delves into this cross-sectoral field of socio-technical challenges, examining the attention given by existing literature on neighbourhood and building renovation processes to residents' inclusion. This review has a twofold objective. Firstly, it analyses residents' involvement in the decision-making process, due to the importance of procedural domain for justice in energy transition theory [37]. Secondly, it focuses on the deliverables, investigating the relationship between end-users and innovative or traditional retrofit solutions (Sects. 54.1 and 54.2).

54.2 Methods

The present study undertakes a systematic literature review with a transdisciplinary approach, incorporating existing literature from various disciplines such as architecture, engineering, sociology, political science, psychology, and economics, to comprehensively analyse the research issue. Review articles are instrumental in advancing research within a field and discipline, aiding in the identification of significant topics for future exploration [39]. A title, abstract, and keyword search was conducted on 4 May 2023, on the Scopus and Web of Science databases. The search was restricted to the main relevant fields including only journal articles, conference papers, and reviews, all published in English language. Table 54.1 shows the search queries. To further refine the results, as the search focuses on residential buildings, the following terms were excluded with the Boolean operator "AND NOT": *Transport**

Table 54.1 Search queries concepts combination

Combinations with AND
Renovation OR Retrofit OR Refurbishment OR Renewal OR "Sustainable transformation" OR "Energy Transition"
Residents OR Particip* OR Tenants OR Households OR "End-users" OR Inclusi* OR Community
"Energy consumption" OR Emission OR Efficien* OR Improv* OR Renovation OR Retrofit
"Decision making" OR "Decision support framework" OR "Decision system" OR Technical OR Technique OR Technology OR Accept* OR Justice OR Process
Building OR Neighbourhood OR Housing

OR *School* OR *Rural* OR "*Historic* building*" OR *Office* OR *Hospitals* OR *Industrial OR Heritage*. The background research and interdisciplinary nature of this study influenced the selection of search queries to achieve the most comprehensive results. Specifically, to address the limited inclusion of technical terms in social studies, the terms "renovation" and "retrofit" were used as alternatives to the more precise and quantitative concepts of energy efficiency and emissions reduction. The screening process was conducted in two main steps. Firstly, the database from Web of Science (972) and Scopus (1043), for a total of 2015 documents, was imported on the Rayyan web tool, which helps detect duplicates (401) and expedite the initial screening of abstracts and titles using a process of semi-automation [38]. This step resulted in 137 papers included (109 journals, 22 conferences, 6 reviews). The second step consists of a complete reading and analysis of the selected papers and a categorization of the included ones on an Excel sheet. It should be noted that this second screening is ongoing. From the full reading conducted so far, 4 articles have been excluded while 40 (1 conference, 39 journals) fully read papers are included and analysed and briefly presented in the following section.

54.3 Results

The results are divided into two sections. Section 54.1 analyses the papers that look at the residents and/or social aspects in the decision-making of the renovation process, while Sect. 54.2 deals with the interaction between residents and renovation technologies.

54.3.1 Inclusive Decision-Making Processes

The process of renovating buildings and urban areas represents a spatial–temporal phenomenon. In fact, most of the analysed studies focus on the factors that influence the process in its various stages and aspects. In recent years, there has been a growing interest among scholars in energy efficiency and how factors beyond technical aspects affect this process. Dolšak [18] gives a general overview in his bibliometric review and thermal comfort, economic factors, sustainable retrofitting, and behaviour change are identified as determinants in households' decision-making for energy efficiency renovations. Participatory strategies and user-oriented tools have been shown to be successful approaches for renovations and improving decision-making [32]. This includes detailed local strategies as well as general organizational models. Zuhaib et al. [47] illustrate how even technical information documents, such as energy performance certificates, can be user-friendly and support the renovation process. By incorporating new features like retrofit measure suggestions and costs information, awareness of energy consumption and the importance of high-quality renovation can be increased. Xue et al. [46] explore the potential of co-creation in building retrofit by proposing a Public–Private-People partnership business model, allowing and more equitable distribution of responsibilities, costs, investments, and resources. One of the key areas of focus is the launch moment relative to the decision to renovate [13, 16, 20, 34]. The influencing factors operate at various scales and hierarchies. A pivotal variable, from the decision to renovate to the post-renovation phase, is the buildings' ownership and management, from which other specific related components branch off. Broers et al. [13] outline the steps of the decision-making process for homeowners and suggest how the influence of a social network and energy audits tailored to the individual household's needs are relevant influencing elements. Cirman et al. [16] argue the central role of social capital in motivating the renovation of multi-dwelling. This social capital primarily encompasses positive neighbourhood relationships aimed at reaching an agreement and the organizational ability; while households income, in this case, seems to have a less significant influence on the decision, contrary to what state in [23, 30] that positively associate income with energy-relevant investment decisions. Therefore, Cirman et al. [16] suggest that policies should also provide organizational conditions, as the privatization of property often faces challenges in creating effective organizational schemes and collective actions. In a similar context, Miezis et al. [34] report that even the location of apartments within multi-apartment buildings influences the collective decision to renovate. Residents may show less interest in renovation if the building's condition does not directly impact them. Ástmarsson et al. [2] highlight the landlord/tenant dilemma as a hindrance to the renovation of residential buildings. Therefore, they propose a comprehensive solution using energy labels, legislative changes, financial incentives, and improved information dissemination to engage low-income landlords and raise tenants' energy awareness. Beyond economic aspects, other factors such as moral values, attitudes, and socio-demographics aspects play a significant role in the decision. Integrating economic and decision-making theories, Fernandez-Luzuriaga

et al. [23] find that the investment cost for existing building renovations is lower than homeowners' willingness-to-pay for facade insulation. Other factors like income, age, presence of children, and heating system type also affect energy renovations. Their study shows how older individuals are more likely to participate compared to findings from Druta et al. [19]. Ebrahimigharehbaghi et al. [20] look at the role of homeowners' cognitive biases during the retrofit decision process. Decision-making behaviours have a bearing on whether to invest in a renovation intervention specifically those related to the importance of status quo, risk-seeking in losses, and risk aversion in gains are significant. Thus, it is more effective to leverage cost/loss reductions compared to energy efficiency retrofit on benefits and gains. In social housing and rented buildings, some of these social variables may remain more concealed due to other influential factors in decision-making that often come from top-down initiatives. Zwickl-Bernhard et al. [48] state that in rented buildings where the decision to renovate is in the hands of the property owners a fair and equitable transition to a sustainable heat system is possible, but with massive public subsidy payments. Otherwise, to seek the investment benefit, the landlord must resort to burdens on the tenants as rent increases that lead to distrust and their rejection of renovations. Although tenants are not the initiators of the decision to renew, their role is essential in accepting the renovations and embracing the energy-saving behaviours required by new retrofit technologies. In contrast to more pessimistic views, Bal et al. [4] present a picture of social housing residents who are motivated and guided by good intentions towards renovation and adopting sustainable behaviours. Some negative aspects instead lie in the process due to social norms that do not support residents' good intentions. Therefore, they suggest putting more effort into creating and participating in favourable conditions and environments, than on motivating tenants. The significance of considering the context, values, attitudes, lifestyles, and preferences of residents as decision-making criteria is also summarized in the review by [33] on occupant energy behaviours towards renovations. Considering these criteria can both catalyse decisions to renovate and support the renovation process management and the selection of retrofit technologies and strategies, guiding various stakeholders in making informed choices within their respective domains. One of the problems noted is the mismatch between energy predicted by the project and energy calculated in simulations. Guerra-Santin et al. [27] aim to reduce uncertainty regarding building performance resulting from occupant behaviours by recommending the utilization of various methods to define occupancy, such as monitoring or statistical data, depending on the evaluation objective. Their research highlights the variation in energy consumption and behaviours based on specific situations, buildings, and occupants, which deviate from the national average data used in energy simulations. This leads to inaccurate energy demand forecasts, impacting design choices, and post-occupancy evaluations of decision effectiveness. To facilitate decision-making among different stakeholders, several studies in the field employ multi-criteria evaluations. More recently, this approach has also expanded to include end-users, with a growing incorporation of social criteria. Torabi Moghadam and Lombardi [44] develop a dynamic tool at an urban scale for energy building retrofits. This tool incorporates technical, environmental, economic, and social criteria within an ArcGIS-based extension, enabling

interactive analysis and assessment of the impact across various scenarios. At a building scale, Pinzon Amorocho and Hartmann [40] present a flexible multi-criteria decision support framework for selecting retrofit solutions, allowing the participation of various stakeholders across different fields and stages of the process. While Torabi Moghadam and Lombardi focus more on socio-demographic factors, Amorocho and Hartmann [40] social criteria refer to enhancing internal comfort and architectural quality. To effectively manage and steer the renovation process scholars have identified communication with residents and among other stakeholders and the sharing of knowledge and information as primary obstacles [41, 46]. In this regard, Bertoldi et al. [6] and Biere-Arenas et al. [7] underscore the advantages of employing one-stop shop advisory services as an inclusive point of reference throughout all renovation steps. Prati et al. [41] propose a personalized and closer approach, akin to an ethnographic methodology. Residents' perceptions and satisfaction analysis conduces to pivotal factors that contribute to the establishment of a user-friendly decision-making process. Enhanced resident support and acceptance are linked to the pursuit of long-term economic savings and improved well-being. For social housing residents is important to consider in the project criteria like thermal and acoustic comfort, interior lighting, building durability, effective communication, and personalized knowledge regarding energy use, indoor environment, health, and lifestyle. Furthermore, the study includes the importance aesthetic improvements that are often overlooked in energy retrofits. The implementation of inclusive approaches and strategies has the potential to foster the development and restoration of trust, both in renovation process itself and in the institutions. Trust component is frequently cited by scholars and identified as a leading cause of resident dissatisfaction and reluctance to embrace renovation initiatives [17, 25, 29, 34, 46]. However with a positive outlook De Feijter [17] posits that circular design and the renovation process offer many access points to build trust through a proactive and transparent role of all stakeholders involved. Other recent studies address the issue of renovation-residents through the lens of environmental and energy justice. Broers et al. [12] decline the environmental justice theory and domains to social housing renovation and outline main barriers and recommendations for people-centred energy renovation process. Challenging technocratic and top-down approaches in deprived neighbourhoods, Breukers et al. [11] emphasize the significance of the recognition, and participation as environmental justice's concepts: institutional choices that disregard the actual residents' desires and capabilities, leads to dissatisfaction, mistrust and disinterest, exacerbating social inequalities. Seebauer [42] conducts one of first attempts to pose survey questions on energy justice, suggesting that tailored distributional and procedural arrangements are needed for low-income renters.

54.3.2 Retrofit Strategies and Technologies

One of the primary socio-technical hurdles in the renovation process involves the incorporation of novel technologies and energy systems. These innovations are often

complex to comprehend and operate, lacking designs that align with the practices and preferences of residents. Consequently, this leads to two significant issues: suboptimal achievement of desired efficiency outcomes due to underutilization of retrofit technologies and the provision of an unsatisfactory and challenging end product. Some tenants reflection on adopting and living with retrofit technologies are reported in [14]. The findings reveal a general positive impression during the installation phase; however, tenants express significant discomfort when it comes to familiarizing with the operation of their heating and control systems, which are often perceived as enigmatic. Furthermore, mechanical ventilation and heat recovery systems are negatively portrayed, primarily due to their unfavourable placement and residents' concerns regarding the generation of dust and cold air. Gianfrate et al. [24] examined major retrofitting measures from a user-technology relation perspective, distinguishing between high-tech retrofit solutions with low or high user consciousness. The study emphasizes the importance of considering social and cultural implications when designing emerging technologies for social housing, as residents may not understand the technical system and its potential benefits. Therefore, several studies propose multidisciplinary, user and context-oriented approaches. Considering an appropriate evaluation of energy behaviour and lifestyle can guide both the definition of processes, as seen in the previous section in [27], and the design and technological system choices for delivering products that they can better interact with. Guerra-Santin et al. [28] promote an approach that can reduce energy consumption by more than half by considering both the efficiency of appliances and pre- and post-renovation behaviours as input data for simulations. When local behaviour monitoring is not possible, their study provides profiles of occupants with different usage and consumption patterns. Another perspective on energy behaviour is studying it during the post-occupancy evaluation phase. The residents co-living experience with renovation technologies undergoes a phase of adaptation and changes in energy behaviour, which can often lead to rebound effects [3, 15, 26] or undesirable adaptive behaviours [35] resulting in higher energy consumption after efficiency interventions. Chiu et al. [15], however, point as insignificant most theoretically ungrounded and purely quantitative post-occupancy assessment methods consumptions due to residents' energy behaviour and their interactions with technologies. They propose an interdisciplinary up-close approach for social data collection that can guide understanding the user-technology relationship and help design: different retrofit strategies were successfully negotiated between designers and residents. As further elaborate in [35] heating and cooling practices are not solely determined by the installed technologies but also depend on the practices adopted by residents as they adapt to the new thermal conditions post-retrofit. For instance, in highly insulated buildings, overheating may lead residents to seek comfort by opening windows or through psychological and habitual adaptations. Boess [10], Glad [25], Mooses et al. [36] support the vision of considering renovation processes as social learning opportunities through the interaction between residents, technologies, and experts. Mooses et al. [36] emphasize the influence of pro-environmental and/or pro-technological predispositions on the meanings attributed to the process and smart technological products, which impact acceptance and use adaptation. Often, green predispositions

negatively affect the acceptance of renovation technologies, associating them with life-cycle uncertainties such as cost and environmental impact. Glad [25] examines the resident-expert and resident-technology relationships years after a 1960s/70 s apartment block renovation project, revealing that there is a gap between the knowledge and meanings attributed to them by experts and the inclusion of residents in the social learning process. Thus, it is crucial to focus on understanding how residents can interact with new technologies and energy systems from the early stages of the project, facilitating knowledge transfer and meaningful communication between professionals and residents. Boess [10] arrives at similar conclusions by interpreting zero-energy renovations as socio-technical product systems, emphasizing the role of design thinking as a valuable approach for co-learning through strategies like demo dwellings, user manuals, and technological communication. Also Berry et al. [5] argue for the potential of real-life narrative strategies, such as show-home strategies, which can stimulate and support renovation efforts while gathering technical information. By integrating residents' preferences with the technical and architectural prerequisites, the design of retrofit solutions holds a greater potential for facilitating positive interactions. Serrano-Jiménez et al. [43] introduce a diagnosis matrix that converges residents' needs with architectural priorities. Residence acceptance and satisfaction with energy renovation also increase if the measures and technology are directly experienced and visible [8]. Likewise Breukers et al. [11] show residents interest in neighbourhoods renovation more than in energy measures, while Broers et al. [12] provide some examples non-energy-related benefits of energy renovations, derived from respondent's experiences. In certain context some retrofit measure are more effective than other due to specific resident's needs, capability and behaviours. Vilches et al. [45] discovered that passive retrofit measures are preferred overactive ones in low-income households. In the context of fuel poverty, energy retrofitting often fails to reduce consumptions but enhances thermal comfort. Thus, claiming the invalidity of cost-effective methodologies for these contexts, they propose an alternative assessment based on the expected improvement of thermal comfort. The accessibility of these solutions is another factor that influences the relationship between residents and retrofit measures. Aniello and Bertsch [1], instead, advocate for cost-efficiency methods demonstrating that top-down factors, such as incentives and regulatory frameworks, can facilitate and encourage households to adopt sustainable energy practices. Therefore, it is crucial to evaluate energy solutions based on both their effectiveness in decarbonization and their affordability for households.

54.4 Conclusion and Future Directions

This study demonstrates that the role of residents and social interactions has become crucial in addressing climate change, as the success of efficiency upgrades of existing residential buildings depends on it. Simultaneously, renovation processes play a

significant role in promoting resident well-being and minimizing social inequalities. Conducted as a systematic interdisciplinary literature review, this study analysed 40 papers from a pool of 137 eligible resources. The recent publication dates demonstrate the topicality and urgency of the topic, driven by the rapid pace of climate change. Scholars are rather aligned in stating the importance of involving residents in the development and decision-making processes of renovation projects. Clusters of studies focus on identifying barriers beyond technical and economic factors, including psychological and attitudinal obstacles. Communication issues between experts and residents, as well as a lack of trust in stakeholders and unfamiliar technologies, emerge as primary barriers. Hence, it is essential to recognize the preferences and habits of end-users early in the process, adopt context-specific procedural strategies and design choices, and foster close collaboration to prevent disinterest and dissatisfaction among residents during renovations. Top-down political and financial institutions and programmes are also nominated as valuable tools for improving renewal processes. The sections about the decision-making process and the interaction between residents and technology are closely interconnected. Evaluating user-design solutions interaction becomes a fundamental parameter in designing effective renovations. Recognizing the energy behaviour of users and effectively disseminating information and knowledge about retrofit technologies and their benefits can facilitate a smoother post-renovation phase, minimizing discrepancies between expected and actual energy consumption. However, there is a lack of studies that explore collaborative and co-creative methods and strategies during the selection phase of retrofit solutions, which could lead to fairer and more effective processes for both social and environmental well-being. Existing research tends to focus on identifying lock-ins rather than promoting innovative models for process improvement. As the review is ongoing, it may have limitations due to the studies analysed in relation to the sample selected, resulting in a polarization towards some topics to the detriment of others. However, the present study already identifies crucial lines of action necessary for achieving a just energy transition in buildings and neighbourhoods.

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