Making energy renovations equitable

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Review

Making energy renovations equitable: A literature review of decision-making criteria for a just energy transition in residential buildings

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ABSTRACT

Energy renovation of residential buildings is a key strategy for a just energy transition, involving complex socio-technical challenges and increasingly requiring attention to social implications and equity. However, what constitutes just energy renovations remains undefined and often limited to more abstract conceptualizations, lacking a field-specific definition, with integrated, implementation-oriented guiding strategies. Limiting the scope to developed countries, this study systematically reviews 104 interdisciplinary studies on energy renovation that consider social and resident dimensions. The literature is analysed through a synthesised framework of energy and spatial justice theories, adapting the principles of recognition, procedural, and distributive justice to residential environments and energy renovation requirements. Firstly, the study provides a comprehensive overview of socially oriented renovation research, demanding greater attention to vulnerable contexts, stakeholders' dynamics, design and post-renovation phases, through iterative, co-creative field research. Secondly, the study identifies critical domains, subdomains and related (in)justice trajectories within the three justice principles, offering context-sensitive application pathways and highlighting the relevance of beyond-energy-efficiency aspects and trust-building strategies. This results in a flexible framework of decision-making criteria that align environmental and social needs, supporting researchers, policymakers, and practitioners. Achieving justice requires interconnected mechanisms across decision-making levels and renovation phases, that rely on collaborative mutual-learning dynamics among actors. To complement strategic policies, design and implementation criteria emerged as crucial for ensuring effective engagement and user-centred interventions. This study contributes to validating energy justice as a decision-making guide, demonstrating the added value from spatial justice integration for a just urban transition, and laying fertile ground for further empirical research.

1. Introduction

Residential buildings consume approximately 75 % of the energy in the building sector globally [1]. Thus, their energy renovation is a critical local measure within the multi-scalar phenomena of energy transition and decarbonisation, navigating the tension between a just and rapid low-carbon transition [2]. A just energy transition mandates the recognition of diverse community needs, ensuring equitable benefits and access to energy services through inclusive and representative decision-making processes [3,4]. This socio-technical perspective is supported by the energy justice theory, which with its theoretical and philosophical foundations, provides a valuable framework for addressing practical energy service issues [5–7]. However, just transitions research often overlooks the urban context [4], despite numerous inequity issues within the built environment due to marginalisation and inadequate services across multiple areas such as housing, infrastructure, healthcare facilities, etc. [8].

The complexities of the renovation as a construction project, with repercussions on energy demand and consumption, strongly exemplify the socio-technical nature of the energy transition, which comprises both challenges and opportunities regarding technological and social innovation [9–12].

Energy renovations typically involve insulating the building envelope to reduce energy demand and implementing fossil-free heating solutions, often coupled with non-energy-related upgrades that enhance living space quality. Although households could gain from reduced energy bills and improved comfort, these benefits often come with financial burdens [13,14], intricate interactions with multiple stakeholders [15,16], disruptive events during construction [17], and challenges in adopting sustainable behaviours and interfacing with renovation

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technologies [18,19].

The growing focus on socio-technical and (in)justice implications of energy transition has gained prominence in European policies. On one side, the Renovation Wave (2020) [20] addresses the critical role of existing buildings – with a 75 % energy inefficiency rate and responsible for 40 % of the EU's annual energy use and 36 % of its greenhouse gas emissions [21]. It emphasises the need to double the renovation rate to achieve a 55 % reduction in net emissions from 1990 levels by 2030 and climate neutrality by 2050. On the other hand, recent revisions to the Energy Efficiency Directive (2023) [22] and Energy Performance of Buildings Directive (2024) [21] integrate socially just elements. They prioritise worst-performing buildings and incorporate critical socio-technical issues, including energy poverty, the need for user engagement and support services, and technical and financial guidance, particularly for vulnerable and social housing residents. Thus, there is a growing call for inclusive and user-oriented processes through initiatives that approach living spaces, such as the New European Bauhaus [23].

Residential building renovations play a central role in this scenario: energy poverty, due to unaffordable energy needs, is a significant concern within building energy efficiency [24–27], with many vulnerable low-income groups inhabiting inefficient housing [28,29]. Furthermore, involving residents in decision-making processes and providing them with adequate information has proven to be effective in fostering acceptance and encouraging investment in renovations. [30,31].

Renovation decision-making process is crucial for energy justice [32] and speeding up renovations [33]. It is structured across multiple and iterative levels and phases, from the strategic level of policy formulation to the tactical and operational phases of planning, design, construction, and post-renovation management, currently facing challenges in evolving into resident-oriented renovation models. In a delicate environment such as the domestic one, scholars have extensively explored barriers and influencing factors to renovation decision-making [34,35], namely (a) financial, (b) information and communication, (c) institutional and regulatory, (d) technical and (e) social and behavioural. Such challenges lead to a twofold injustice: enviromental (slowing down the pace and effectiveness of projects to achieve efficiency goals) and social (user misrepresentation and spreading inequalities). Therefore, research increasingly advocates for systemic approaches that empower residents and incorporate social criteria to mitigate uncertainties in energy efficiency projects [36–38]. Factors such as households' socioeconomic status and energy behaviour significantly influence renovation engagement [13,14,39,40] and energy performance gap between designed and actual consumption [41–43]. Consequently, involving residents in co-management and co-decision mechanisms resulted in more efficient and accessible use of sustainable technologies [31,44].

However, limited research has explored ways to address these drivers, barriers, and social components to orient energy renovation towards more inclusive, equitable, and efficient processes. Consequently, the prospect of a just energy transition tends to remain in abstract, top-down narratives, and statements in policy documents, limiting its connection with local realities and effective implementation of low-carbon objectives. While justice theories have recently been applied to building energy renovation research, proving their effectiveness in exploring (in)justice trajectories [14,17,45–48], these studies are few and typically focus on specific cases. The need to contextualise justice and reject 'one-size-fits-all' approaches is widely acknowledged but seldom realised. Thus, advancing *just* and resident-centred renovation practices requires a more comprehensive and shared understanding of '*just renovation*', as well as effective decision-making criteria to ensure that renovation processes contribute to a just energy transition.

We argue that *inclusive studies on energy renovation* - meaning research that, in analysing renovation processes, incorporates social and resident-related aspects - have the potential to shape just decision-making strategies. The implications, suggestions, and guidelines of these studies are closely aligned with the core justice principles of recognition, procedural, and distributive justice [32,49], however they are not yet fully interpreted through this lens. Furthermore, much of the literature focusing on residents, which analyses their domestic practices and technology choices, is more oriented towards technical development - optimising technology features and assessment methods - rather than exploring and supporting the co-evolutionary conditions of users [50]. Similarly, despite their evolution towards multi-criteria approaches, decision-support tools for renovation still lack sufficient integration of social aspects [51], with a few examples of comprehensive frameworks [52].

This study conducts an interdisciplinary and interpretative systematic literature review of such *inclusive studies on renovation*, applying energy justice principles to extrapolate just decision-making criteria. The aim is to establish a foundation for understanding and implementing just energy renovation, focusing on the research question: How can justice theories develop criteria for decision-making in energy renovation processes?

Addressing this question mitigates the existing gap in a general understanding and overview of how energy renovation research has incorporated social dimensions and end-user perspectives. Additionally, it supports a well-defined and comprehensive integration of the justice perspective into housing renovation decision-making, blending environmental and community well-being into the definition of *just*.

This study advances the operationalisation of justice theories in urban energy transitions, guiding their practical implementation. It promotes the integration of sustainability practices with social justice – not as an abstract synthesis but as a "proactive collision" or "creative tension" that creates commons for planners in the built environment, fostering multidisciplinary reasoning [53].

The review is structured as follows: Section 2 provides a theoretical framework; Section 3 details the article selection and analysis methods. Sections 4 and 5 offer a comprehensive critical literature analysis, identifying trends in social-oriented research (4) and extrapolating insights for just renovation decision-making (5). Sections 6 and 7 discuss and conclude the article.

2. Theoretical framework

This study builds on the trajectories and research agenda of a just urban transition [4,6], offering more concrete indicators for its implementation. Renovation projects, indeed, span the realms of urban policies and planning, as well as socio-technical energy transition strategies. Such bridging connotation reflects spatial and scalar implications of justice in transition [54].

This research examines energy renovation processes using a synthesised analytical framework of energy and spatial justice, with a tailored definition of *recognition*, *procedural,* and *distributive* justice principles as defined in Fig. 1, further validated through the literature analysis.

Integrating socio-technical perspective and justice theories into energy and beyond-energy aspects of renovation projects enables a critical formulation of the *just renovation* concept, challenging process complexities and contextual vulnerabilities.

2.1. Energy renovation as a socio-technical transition system

Energy renovation operates within a complex socio-technical system, co-evolving alongside technological innovations, new social norms, and practices [11,45,55]. Socio-technical realities have been recognised throughout all renovation phases [56], requiring corresponding organisational models, performance evaluation methods [11], and post-occupancy monitoring [57].

Multi-actor dynamics are critical in this two-dimensional sustainable transition within the construction and energy sectors [12]. Service providers, including energy companies, contractors, suppliers, advisors,

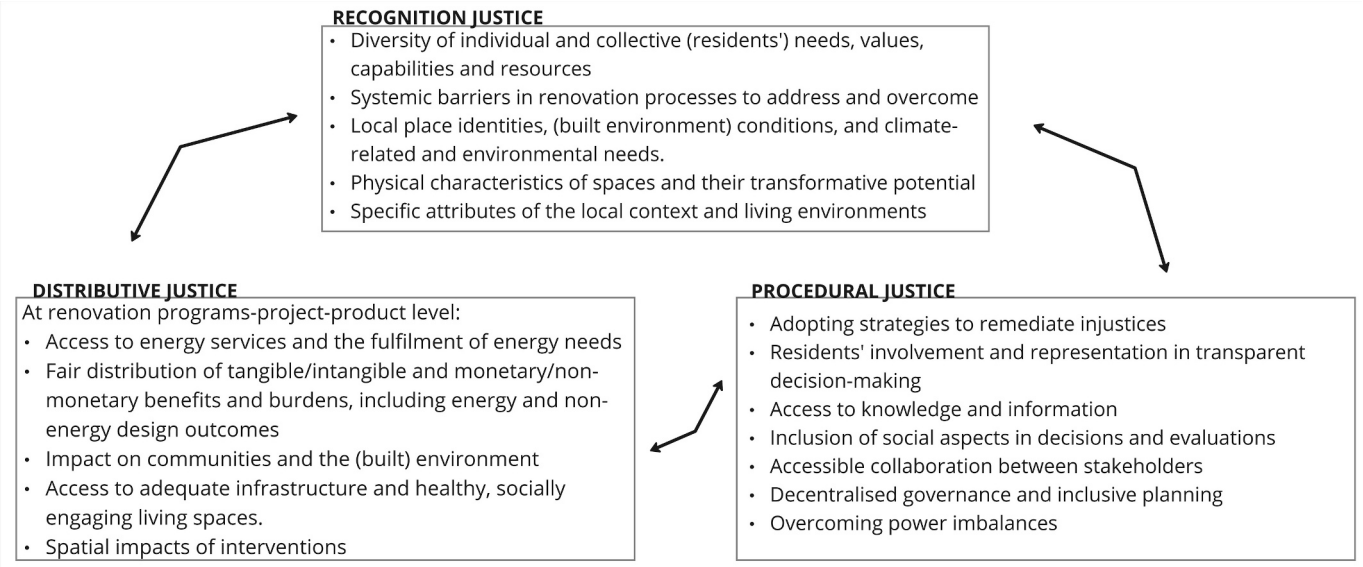

Fig. 1. Synthesised framework of energy and spatial justice principles, adapted to energy renovation processes in residential buildings, based on [5,32,46,49].

and property owners in cases of tenancy, engage with users to varying degrees, influenced by the regulatory and incentivising roles of governance and local authorities. Differences in decision-making autonomy, representativeness and renovation impact vary according to ownership. Individual homeowners independently balance personal preferences and resources, requiring adequate information throughout their customer's journey [58]. Homeowner associations in multi-apartment buildings manage complex negotiations due to diverse household needs and priorities [15]. Tenants have limited decision-making power and often face split incentive dilemmas, typically leading to underinvestment in energy-efficient renovations and increased rents [59].

Considering the Multi-Level Perspective (MLP) of socio-technical transition [60], building renovations can be framed within this structure, serving as carriers of innovation and sustainable development for low-carbon scenarios [9,55]. Users play a significant role in crossing transition layers as co-creators of change and consumption practices [50]. The growing focus on inclusivity and equity calls for prioritising their role at strategic, tactical, and operational decision levels. However, while renovation practices, from a technical stance, are rather stabilised, the social innovation component, both in practice and research, is still in that initial stage of niche-level transition: an experimental phase full of uncertainty [9,61]. To achieve a more comprehensive and equitable sociotechnical transition pathway, Jenkins et al. [6] recognise the potential of energy justice, underpinned by moral considerations, to guide technological and energy choices.

2.2. Energy and spatial justice: An analytical tool for energy renovation

Injustices in energy renovation processes manifest in various forms. High costs can exclude low-income groups from energy-efficiency interventions, while their inclusion may impose financial burdens that negate energy-saving benefits [14,62,63]. Cultural injustices arise from the loss of community identity and the marginalisation of vulnerable groups struggling to adapt to changes in their living spaces [16,46]. Inaccessible decision-making processes and inadequate information sharing can limit equitable participation [30,34], while inadequate technical solutions may overly prioritise energy efficiency, neglecting user-centred considerations [57,64]. Environmental impacts of injustices become evident as systemic barriers hinder the scaling up of renovations and sustainable behaviour, discouraging even those who can afford upgrades, thereby slowing down decarbonisation pathways [58,65].

However, when guided by social justice principles, housing renovation can act as a catalyst for fostering justice opportunities and delivering tangible benefits. Reducing building energy demand can improve comfort and alleviate energy poverty [66] while leveraging local values and fostering bottom-up collaboration can strengthen community cohesion and representation [67,68]. Thoughtful technical design choices can further align environmental sustainability with user well-being [19,69].

Therefore, this study aims to address potential injustices on multiple fronts by applying energy and spatial justice theories to develop a robust decision-support framework derived from existing literature, designed to operate effectively across multiple levels.

2.2.1. *Energy justice – renovation as a service for equitable energy-efficiency*

Energy justice theory frames justice as a conceptual, analytical, and decision-making tool, outlining its theoretical and practical connotations [5,32,49]. It supports the socio-technical transition considering as *just* those energy decisions that incorporate everyone's needs, leaving no one behind in a fair distribution of benefits and burdens through representative, accessible and transparent decision-making processes [6,32]. Such perspective originates from enviromental justice theories [70] and developed representing energy justice through pluralistic frameworks of core principles [71], such as recognition, procedural, distributive, cosmopolitan and restorative justice [72].

The theoretical underpinnings of energy justice, once established, prompted a shift towards practical application across various low-carbon transition scenarios and scales [72–74], including domestic energy retrofit and its impact on vulnerable groups [14,45–47,74]. Energy renovation, aimed at minimising energy demand and transitioning to sustainable heating and energy sources, exemplifies a service that enhances building efficiency, affecting the entire energy chain - from production to distribution and consumption - where energy justice applies.

Energy justice is predominantly expressed through its three tenets of *recognition*, *procedural* and *distributive* justice [5,32,49] that provide a framework to shape and asses values and strategies in energy systems, addressing injustices. This widely adopted approach has also faced criticism for its fragmentary and ambiguous nature, often deemed unable to fully capture the interconnected justice implications in energy issues, and overly biased towards unsubstantiated and top-down normative assertions [75–77]. Our study addresses such limitations by

applying the justice triad within the bounded notion of home setting: where domestic practices, intimacy, and a sense of place and community are central to energy-efficient decisions. Consequently, valuing local realities and structuring flexible *just* trajectories around the mutual interplay of recognition, procedural, and distributive justice, the proposed framework, encourages a pluralistic, context-sensitive adoption of justice principles, expanding considerations to the whole (built) environment ecosystem [75,77].

Although energy justice aligns with environmental and climate justice narratives, Jenkins [78] emphasises its distinct strategic and decision-making impact. This study leverages the decision-support function of energy justice while relating to the multidomain environmental justice framework [79], as applied by Broers et al.'s [46] to social housing retrofit, to provide a nuanced perspective on renovation complexities and inequities. Thus, we also refer to *capability* and *responsibility* in the recognition principle analysis, considering them as values-shaping contextual dimensions necessary to avoid discrimination. Indeed, the relevance of energy's role in enabling or restricting individual capabilities, to freely enjoy energy sources and services for well-being, led scholars to link Nussbaum's and Sen's *Capability Approach* [80,81] with energy justice [82]. A similar role is played by the spatial and material connotations of living environments [83], hence the need to include spatial justice implications for an integrated analysis of energy renovations.

2.2.2. *Spatial justice – renovation as a service for the quality of living spaces*

Energy renovation of residential buildings and neighbourhoods, as part of urban interventions, draws a connecting line among energy justice, spatial justice theories [83,84] and perspectives of just urban transition [4]. Spatial justice critically rethinks (in)justices through multi-scalar spatiality "from the space of the body and the household, through cities and regions and nation-states, to the global scale" [85]. This review exclusively considers the implications of spatial justice within its local spatial dimension, centring on demand-side interactions—specifically, the residents and the quality of their residential living spaces. Thus, it responds to the need for multi-scalar and cross-system approaches to decarbonisation and justice, complementing a global focus [54].

Fainstein's "Just City" (2010) [86] proposes approaches that prioritise the quality of life, address the misrecognition of marginalised groups, and foster inclusive decision-making closely aligned with energy justice principles [4]. Bouzarovski and Simcock [83] *spatialise energy justice*, showing the influence of spatial and environmental features of living spaces on energy poverty vulnerability, with significant impacts from building energy efficiency, healthiness, and infrastructure provision. Energy renovation processes alter socio-physical spaces, urban fabric, and social relations, crossing various moments of spatiality, from tangible material spaces to the perceived and lived social dynamics [87–89].

The principles of recognition, procedural, and distributive justice have also been adopted as crucial dimensions of spatial justice [54,90], highlighting their inherent spatial connotations: context-dependency and the influence of cause-effect dynamics of the surrounding physical, social, and natural environments.

Thus, recognition justice in our study extends to both people and places [70,79], and to systemic renovation barriers that foster injustices, thereby incorporating aspects of *restorative justice* to prevent the perpetuation of past unjust dynamics [3]. Distributive justice encompasses traditionally cited yet vaguely defined *benefits and burdens*, framing them as the final deliverables and implications of renovation directives, programs, and projects. This interpretation includes both financial and policy implications, as well as effects of architectural and engineering interventions, covering both energy and non-energy outcomes and integrating the concept of just design [91].

3. Research methods

Systematic Literature Reviews (SLR) offer a comprehensive, transparent, and replicable scientific method [92,93], instrumental in advancing research, identifying significant topics for future exploration [94,95], and providing valuable insights to support decision-making by planning professionals [96]. SLR adheres to predefined inclusion criteria, ensuring a thorough aggregation of pertinent publications relevant to the research question. The analytical framework defined in Section 2 guides the literature analysis, enabling the SLR to overcome its typical reliance on quantitative methodologies and its shortcomings in addressing complex, interdisciplinary issues [97].

3.1. *Articles identification and selection*

A title, abstract and keyword search was conducted on February 27, 2024, in the Scopus and Web of Science databases, without any timespan or geographic restrictions. The search was restricted to the main relevant fields, including only academic peer-reviewed journals, conferences, and review articles in the English language. The interdisciplinary scope of this review and a thorough background investigation informed the query selection to capture the broadest array of relevant literature. Iterative test searches culminated in the final search strategy detailed in Table 1. Recognising that many studies from social disciplines in this domain may not use technical terminology, the terms 'renovation' and 'retrofit' were included alongside more specific technical terms.

To comprehensively understand decision-making aspects throughout renovation phases, the review focused on both process-oriented and outcomes-oriented research, also encompassing themes such as renovation technologies acceptance and user-building interactions post-retrofit.

A rigorous selection process, depicted in Fig. 2, was implemented following the PRISMA2020 protocol [98] and SLR guidelines [95,96] to ensure quality and mitigate potential biases. Using Wohlin's [99] snowballing method, additional significant papers were included, mirroring Kamal et al.'s approach [100] in their SLR on energy efficiency costs and benefits. Based on the research scope and predefined exclusion and inclusion criteria, detailed in Table 2, the initial pool of 1872 records was meticulously narrowed to 104 articles for analysis.

The screening process consisted of two primary stages. First, titles and abstracts were reviewed using the Rayyan web tool, which facilitated duplicate detection and semi-automated preliminary screening [101]. While the platform streamlined record organisation and counting, the critical tasks of article inclusion and exclusion were manually conducted by the authors.

The second screening stage involved full-text reviews and critical appraisals of selected papers, using a thematic coding system in Excel. Section 3.2 details the analysis method, and Table A1 in Appendix A specifies the coding system and workflow.

The review's novel and forward-looking perspective on energy renovation prompted the inclusion of both empirical and theoretical studies, acknowledging that *justice* insights can also stem from reflective and critical theoretical analyses, particularly given the limited empirical research on households' daily experiences with retrofit interventions [102].

3.2. *Analysis method*

The analysis of the included articles is structured in two parts. The first is an inductive quantitative metadata analysis to identify patterns and trends in how inclusive renovation studies incorporate social implications. This includes bibliographic and methodological details, as well as principal thematic focuses. The second part, forming the core of the analysis, applies a deductive approach by using pre-defined theoretical constructs to inform a decision-making support framework for equitable energy renovation projects. Each article was analysed to

Table 1
Combination of search query terms.

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

[a] The search string "AND NOT" was included to refine the focus on residential buildings, excluding the terms:
[*] *Transport* OR *School* OR *Rural* OR "*Historical building*" OR *Heritage* OR *Office* OR *Hospitals* OR *Industrial.*

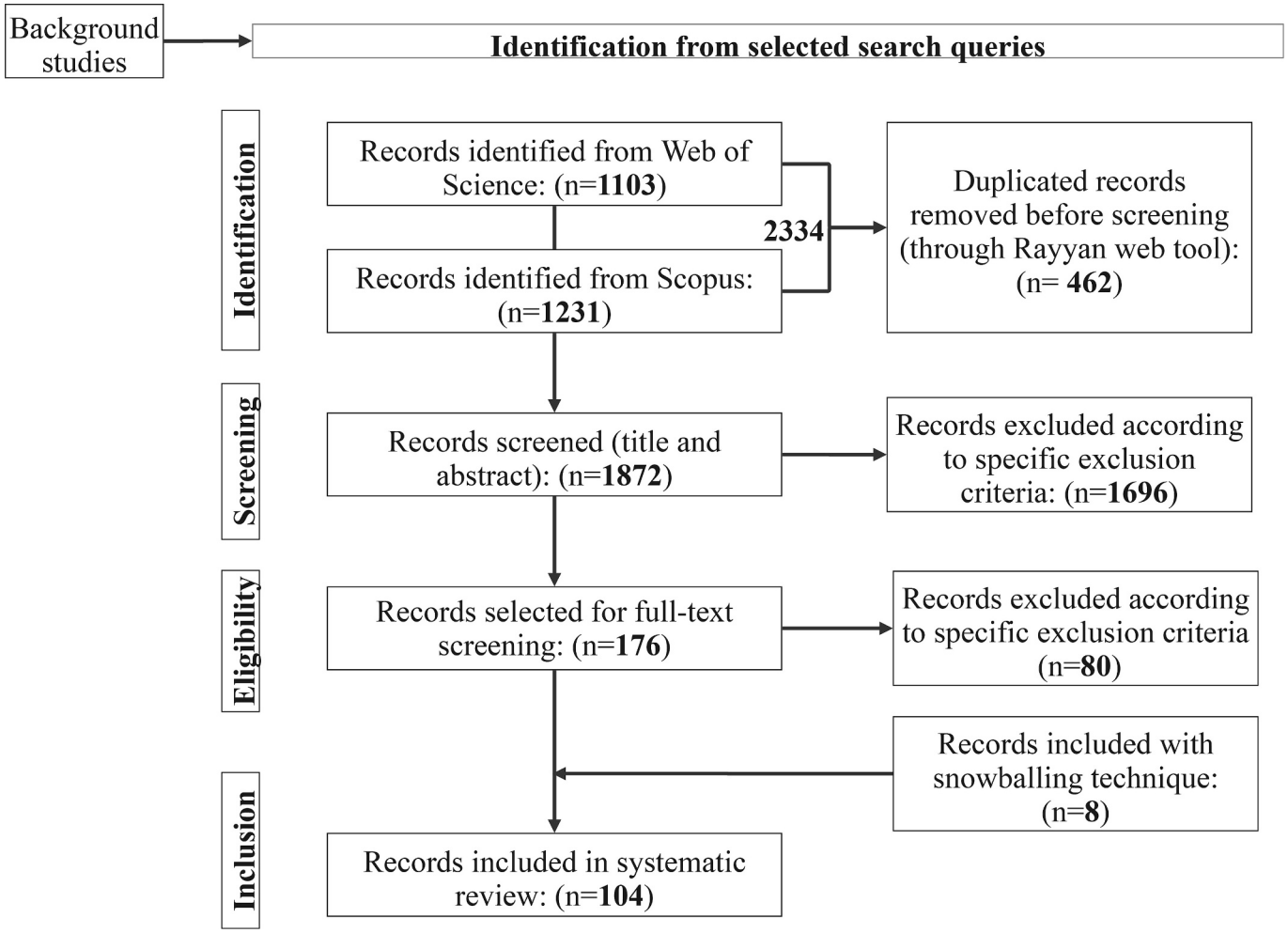

Fig. 2. Flow diagram for the screening process.

Table 2
Screening phases: exclusion criteria.

Exclusion criteria – screening stages
• Duplicates
• Document unavailability
• Sources not relevant or not related to the review scope:
- Non-residential buildings
- Lack of reference to energy-efficient renovation
- Lack of focus on residents and domestic-related social issues: (only technical, financial, and policy analysis without discussing the direct social impacts and implications on residents)
- Newly constructed buildings
- Urban renewal (district, city scale). Accepted: Blocks of building, outdoor spaces surrounding the buildings
- Informal housing and developing countries

unearth relevant trajectories of (in)justice —recognition, procedural, and distributive—specifically aimed at enhancing their practical application (see Fig. 3). This analysis identified key domains and subdomains as qualitative thematic clusters, guiding further targeted coding and validation (see Appendix Table A1).

The definition of an a priori conceptual model deductively structures the literature analysis, fitting the SLR into the 'framework synthesis' typology defined by [96], creating a higher-order and innovative construct, going beyond data summary. This analytical procedure aligns with a meta-synthesis approach, prioritising an interpretative evaluation that is especially valuable in energy efficiency, to generate novel insights for addressing the persistent challenges of the energy transition [56].

While the application of justice principles in SLR is well-established in energy transition research – for instance, in studies on public engagement [103] and smart local energy systems [104] – a systematic focus on energy renovation processes through a justice lens remains unexplored.

4. Meta-data results

4.1. Articles distribution across the years and journals

Fig. 4 highlights the chronological development of publications reviewed, highlighting the disparity between the initially collected studies and those retained after screening. The extensive volume of pre-screening literature predominantly exhibits a technical, economic, and engineering bent, with a notable surge in publications from the 2000s, accelerating after 2015, in response to rising concerns over the climate crisis, energy efficiency, and a shift towards retrofitting rather than new construction. The included studies, while reflecting academia's growing focus on inclusivity in technical fields and sustainable transitions, remain relatively limited but are steadily increasing.

The dataset primarily features European research, with the Netherlands (21 %), the UK (19 %), and Sweden (10 %) together accounting for over half of the articles. This concentration likely stems from easier access to European research and a methodological emphasis on urbanised, developed contexts, skewing data towards countries with robust academic and urban development resources. The review's interdisciplinary character is highlighted by the varied journals in Fig. 5, although authors with affiliations of social disciplines predominate.

While journals with a technical orientation are increasingly heeding the call for interdisciplinary research, integrating social sciences and humanities [105], the initial abstract screening revealed that most still underrepresent social factors, despite their substantial influence on engineering and economic outcomes.

4.2. Research design and methods

Inclusive renovation research spans various scopes and research approaches. A significant portion of the studies reviewed (68 %) present a theoretical underpinning, with predominantly socio-behavioural, process and system theories. Table 3 outlines the principal themes identified through the analysis, however, this categorisation is not meant to be rigid. Identifying core themes in the literature proved to be challenging, owing to the overlap of topics and implications that extend beyond the primary focus areas. This highlights the interdisciplinary complexity of renovation processes and confirms the necessity for systemic approaches [16].

Most of the analysed studies (60 %, 62 articles) primarily inform process management dynamics, with 9 % (9 articles) prioritising only design-oriented aspects related to the selection of renovation strategies and 32 % (33 articles) providing criteria pertinent to both aspects. This reflects a growing trend towards refocusing the pursuit of equity and project success from design outcomes to processes [14,91].

Research has largely explored factors that hinder or promote the renovation process, prioritising socio-attitudinal adoption patterns, governance and financial challenges, and residents' involvement issues. While attention to holistic decision-making and social equity, addressing energy poverty and renovation injustices, is emerging, it remains limited. Similarly, studies on user-centred renovation design and stakeholder interactions are rather unexplored.

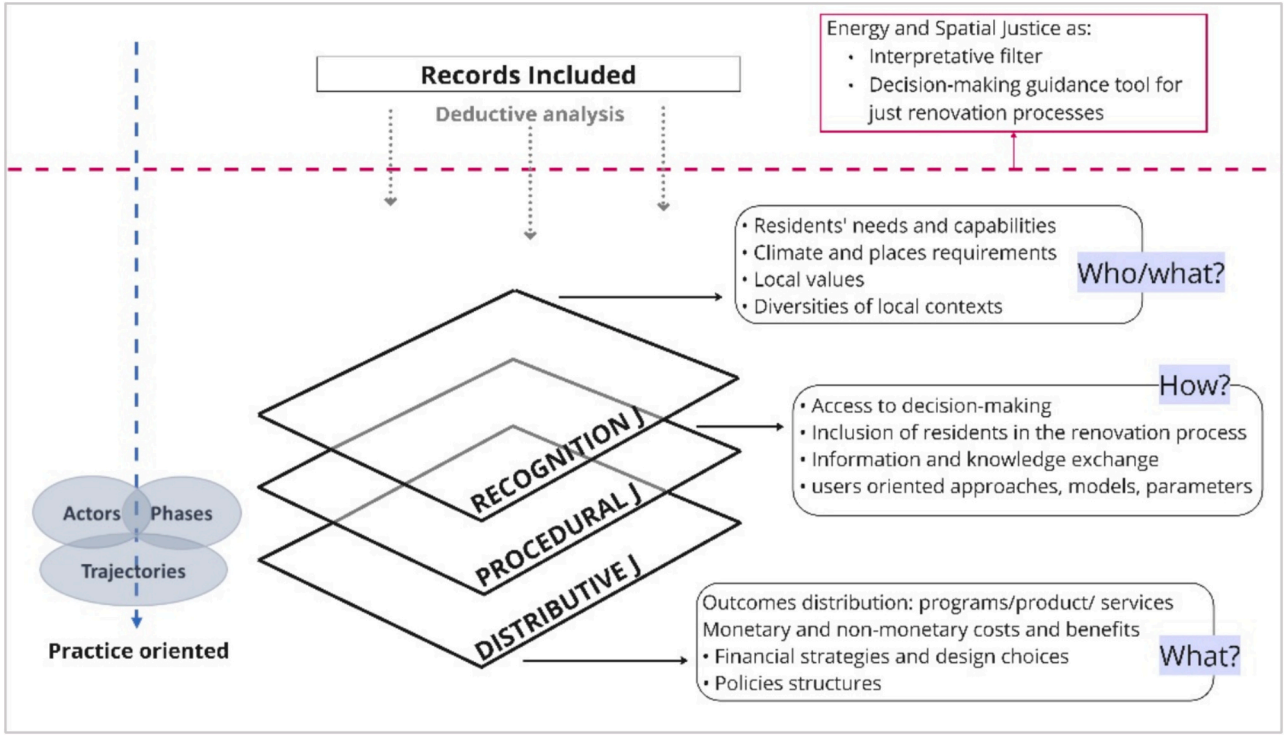

Fig. 3. Structured approach to literature analysis through the energy and spatial justice framework.

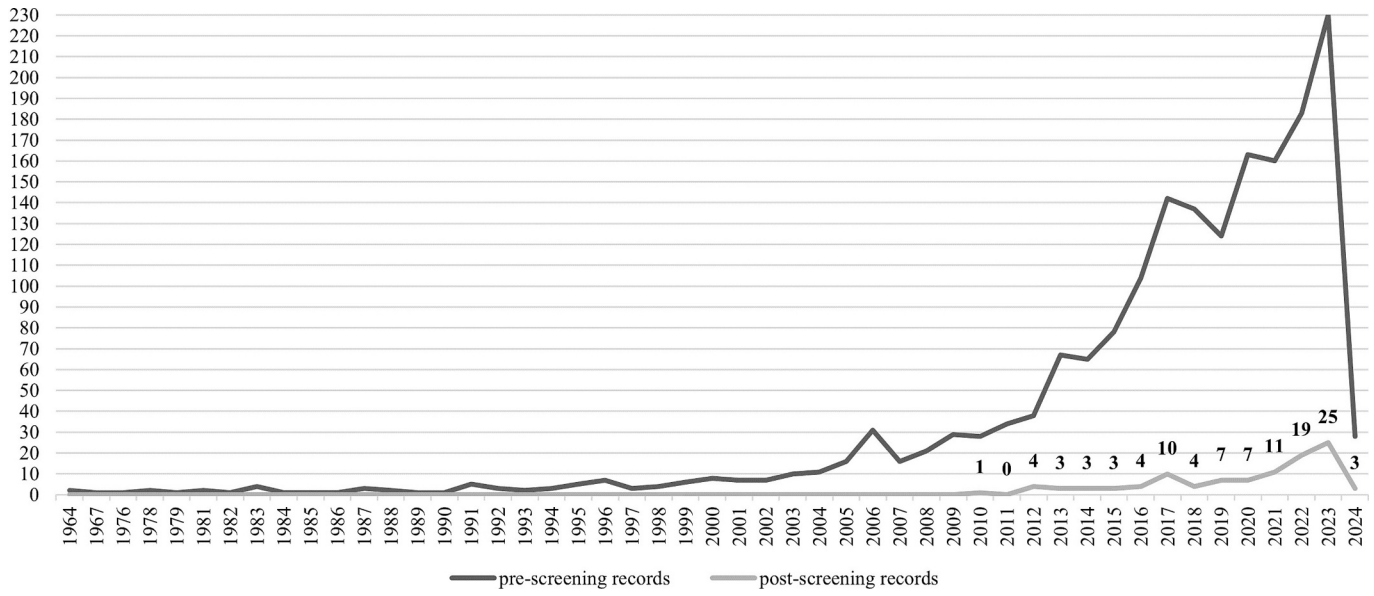

Fig. 4. Distribution of the reviewed articles by year of publication and comparison with the preselection sample.

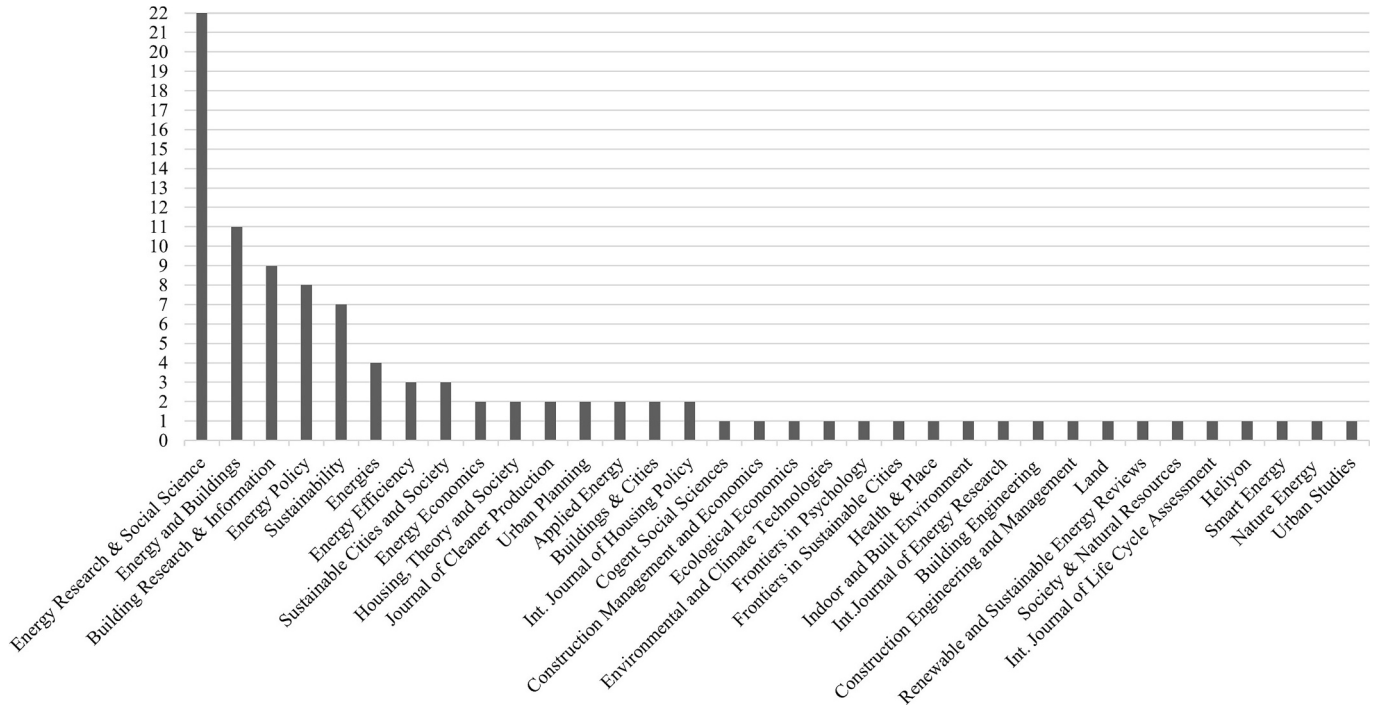

Fig. 5. Distributions of reviewed articles across journals.

The analysis of research methods shows a predominance of qualitative studies, comprising 46 articles (44 %). Quantitative studies account for 28 records (27 %); mixed methods are used in 30 studies (29 %).

As detailed in Fig. 6, research-through-design and monitoring practices are underrepresented, along with immersive methodologies, including ethnographic methods (e.g., long-term fieldwork), and participatory approaches like workshops and iterative co-design processes. Although currently underutilised, many of the reviewed studies advocate for their broader adoption in future research and practice as effective tools for fostering trust and authentically representing local transition realities. The prevalence of surveys suggests that vulnerable groups might be excluded, given their pressing priorities, lack of awareness about energy and renovation issues, the medium's impersonal nature, and the complexity of technical questions [17,126,142,159].

Most studies are exploratory and retrospective, focused on identifying barriers rather than proposing innovative frameworks and forward-looking methodologies, and seldom testing new approaches in ongoing pilot cases, a trend also recognised by Hughes and Hoffmann [4] for just urban transition literature.

Looking at the actors involved in empirical studies (Table 4), the representativeness of residents' perspectives appears consistent in academic research, while this integration still seems to remain insufficient in practical applications [45,106]. A greater inclusion of the supply side seems necessary, particularly given the considerable number of barriers to renovation processes that lie in organisational management and collaborative dynamics with those actors planning and implementing

Table 3
Main themes addressed in the analysed literature (see Table A2 for specifics on authors' interpretation of each theme).

Main research themes	Articles	N
Barriers/drivers to renovation processes	[34–36,45,56,62,102,106–119]	21
Motivation/ attitudes/ expectations towards renovations	[13,18,34,36,39,40,56,65,107,113,115–117,120–126]	20
Financial, governance and regulatory aspects	[29,35,39,47,59,63,107–110,114,127–134]	19
Residents' engagement: Information accessibility/ participatory methods	[16,30,44,48,68,118,132–143]	18
Integrated decision-making + social sustainability criteria	[19,25,37,58,67,69,109,128,144–152]	17
Social equity - energy (retrofit) affordability	[14,16,17,27,29,45–48,63,66,127,133,143,153–155]	17
Interaction users-building, users-renovation technologies	[42,44,48,57,62,64,102,156–163]	15
(Energy) behaviours - social interactions	[18,19,42,113,121,163–167]	10
Stakeholders' dynamics	[15,16,59,106,112,157,168,169]	9
Decision-making on alternative renovation strategies	[27,31,109,114,148,155,170]	7
Renovation and aging	[62,129,148,171,172]	5
Health impact	[171,172]	2

solutions.

4.3. Renovation decision-making phases

The decision-making process in building renovation projects typically unfolds in a conventional sequence of key stages, influenced by policy and regulatory frameworks [33,51,173,174]. Despite variations in subphases and terminology, there is consensus among publications and practitioners on delineating the typical renovation journey with common main stages to facilitate decision-making [33]. Far from being a prescriptive and linear path, these stages establish a conventional, iterative framework. Each phase not only involves crucial decisions, that impact subsequent phases, but also provides valuable learning opportunities for preliminary stages in other similar projects.

The initial planning phase is crucial, as it establishes renovation awareness and project goals through diagnosis and evaluations [51]. During the design phase, retrofit options are weighed, and performance is estimated, culminating in the final design for construction. Post-renovation occupants adapt to the renovated environment, with monitoring and maintenance as follow-up procedures.

Fig. 7 illustrates the conventional renovation journey with phases and subphases of the decision-making process. We mapped the reviewed literature both chronologically and according to the stages each study addresses, with arrows indicating studies spanning multiple phases. The literature density distribution shows a varied pattern, with a notable concentration in the planning and early stages. This trend reflects the identification of key barriers requiring early strategic decisions and the presence of studies targeting potential future renovation scenarios. In contrast, studies addressing renovation design, implementation, and post-renovation phases are comparatively rarer and more recent. Notably, the implementation and handover stages receive less academic focus, despite their highly disruptive nature and logistic implications, such as tenants' relocation during construction [31,46].

While this overview details the phases addressed in the methodologies and analyses of the reviewed studies, their recommendations and suggested actions often extend to other stages, primarily at the strategic and policy levels. The articles' analysis through the justice principles follows these phases, clarifying how, at each stage, trajectories and inputs exist to promote equity and residents' inclusion within the decision process (see Sections 5 and 6). Throughout the process, the strategic, tactical, and operational dimensions of decisions coexist and complement one another, making each phase of renovation essential to managing a just energy transition [175].

5. Justice principles as a decision-making guide in renovation processes

The analysis operationalises recognition, procedural, and distributive justice principles - as configured in Section 2 – to interrogate decision-making dynamics and derive criteria for socially sensitive processes and equitable interventions in housing energy renovations. The results are structured in domains and subdomains with corresponding (in)justice trajectories elaborated in Table 5.

Recognition justice clusters critical considerations requiring thorough understanding and integration into renovation processes to ensure sensitivity to context and all users. Scholars primarily identify these as barriers or key factors influencing renovation investments and outcomes. Procedural domains encompass strategic, tactical, and operational strategies, spanning from overarching approaches to specific

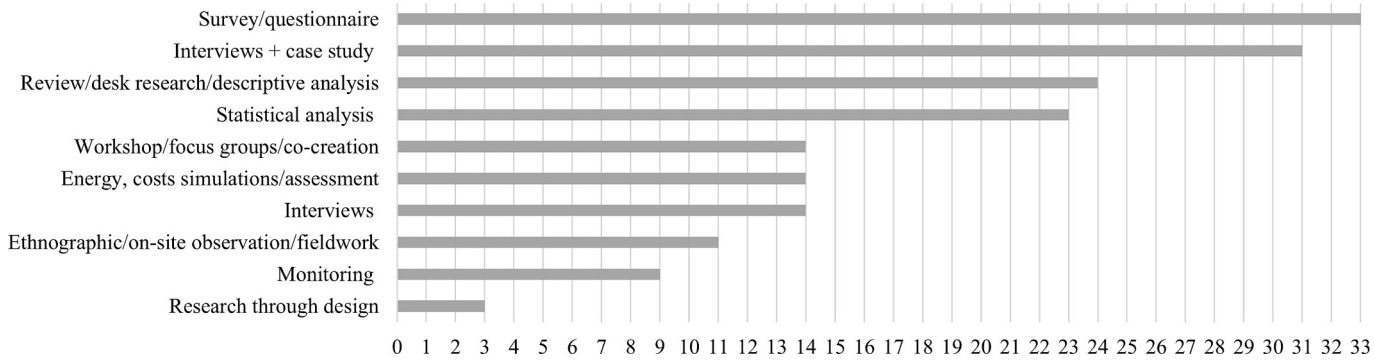

Fig. 6. Research methods of the analysed studies. Table A3 in Appendix A specifies the references of the articles per each method.

Table 4
Stakeholders directly involved in the empirical studies analysed.

Stakeholder directly involved in the study	Articles	N
Residents	[14,15,17,18,30,34,58,65,111,115–117,119,120,122,123,126,129,135,136,139,142,156,157,159–161,163,165,167,170,172]	32
Residents + other stakeholders: (Professionals: e.g. project coordinators, housing associations, advisors, energy companies, contractors)	[16,19,44–46,57,64,68,69,102,106,118,124,141,145,155,158,168]	18
Other stakeholders	[46,48,57,59,63,67,109,110,132,146,149,151,152,169]	14

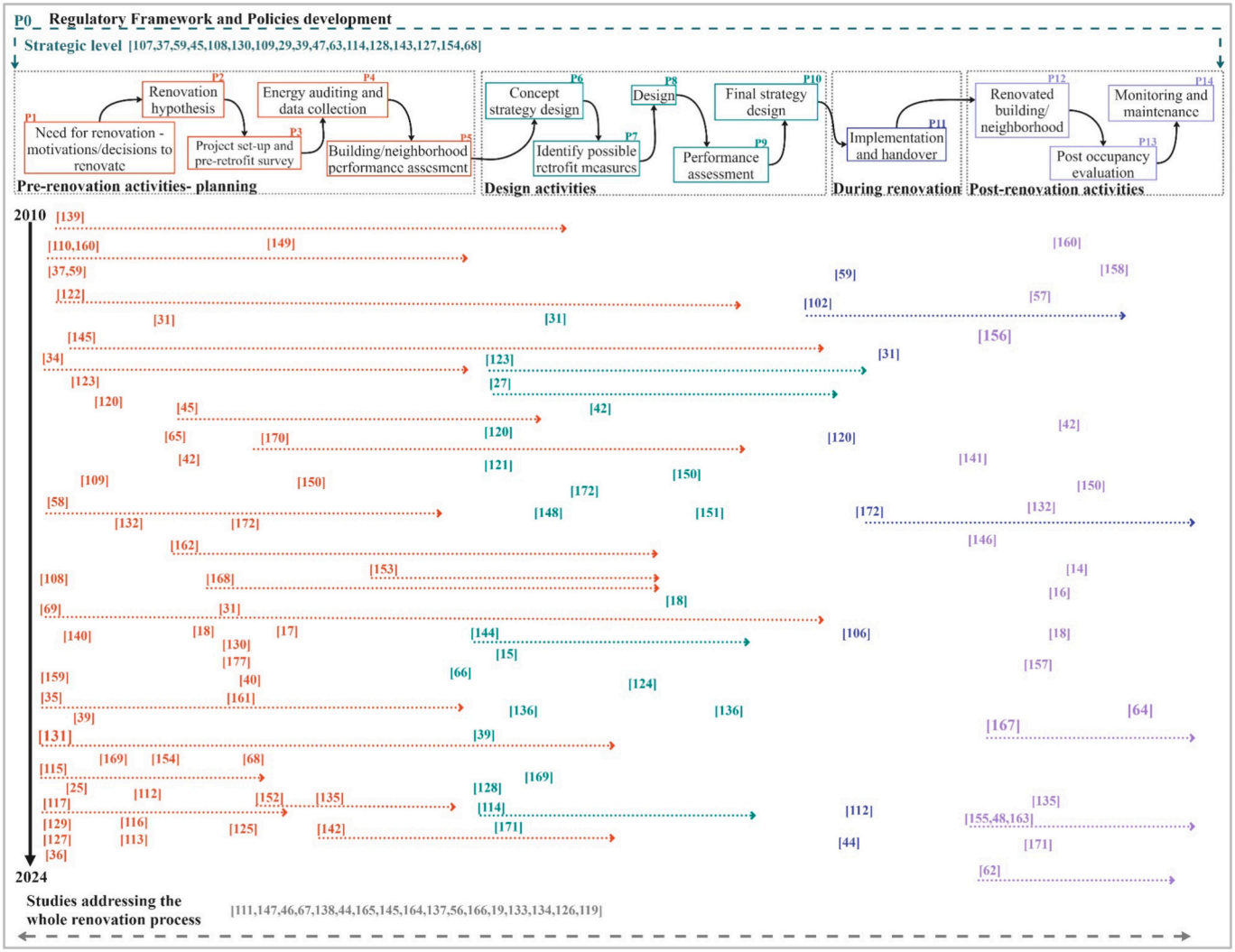

Fig. 7. Distribution of reviewed inclusive studies across decision-making phases in the renovation process, based on conventional renovation stages adapted from [33,51,173,174].

dynamics or metrics essential for fostering inclusive processes. In this study, distributive justice is construed as energy renovation deliverables that can act as either providers or detractors of normative, financial, energy, architectural, and needs-fulfilling resources for the built environment and its users.

The identified trajectories largely stem from narratives of existing injustices [45,62,143]. Indeed, researchers have mainly focused on exploring the bottlenecks of renovation processes and their impact on residents and an effective transition [34,47,62,68,110], highlighting crucial factors and strategies that both policy frameworks and renovation practices should adopt to overcome existing barriers [39,63,116] . However, the literature also provides real-world examples of projects that effectively apply justice principles. In Belgium, for instance, initiatives such as neighbourhood energy ambassadors [68], free housing scanning and innovative financial solutions [145] have fostered accessible, community-led renovation programs. Similarly, in other contexts, technical design choices have been made more equitable by focusing on users' unique needs and practices [19,162,172], prioritising health and comfort [48,171] while being guided by iterative feedback mechanisms [64,118]. Integrating renovation interventions with social and healthcare assistance programs has proven to support vulnerable residents further and encourage energy efficiency [171,172], as does investing in educational activities on sustainable behaviours and community-building initiatives, such as garden design and planting [141]. The analysis reveals how justice trajectories and related decision-making criteria can be integrated across renovation stages and

Table 5
Key domains and subdomains with corresponding trajectories of (in)justice identified across *recognition*, *procedural*, and *distributive* justice principles, along with potential actors and actuation phases to consider for a just implementation.

Subdomains	Recognition (in)justice trajectories from literature	Citations	Actors	Phases[b]
Domain: Superstructure factors in renovation processes				
Process barriers	• Nature and timing of structural and psychological barriers, varying across renovation phases. • System and stakeholder barriers to heating technologies • Predominant barriers: financial and information/communication issues	[34,58,110,113,115–117,140] (>15) [c]	Policymakers, energy companies, financial institutions, contractors, design team, local authorities and institutions, community groups, residents	P0–14
Design barriers	• Impact of renovation on energy performance, residents' behaviours and effort demanded by new technologies. • Space constraints and energy infrastructure compatibility	[20,42,86,97,104,161]		
Trust mechanisms	• Mistrust towards people and principles/procedures: local institutions, market agents (e.g. contractors and energy agents). • Precarious tenant-landlord relations, and with other residents due to limited interactions and acquaintances.	[16,17,44,46,110,137,162]		P1–3, P10, P11, P14
	• Lack of trust in implementation quality and renovation technologies: proficiency of construction companies and quality of work, mismatch between intended and actual design, complex smart technologies, and systems performance.	[93,95,131,150,152,155]		
Institutional responsibilities	• Misrecognition of local needs and values, complex bureaucratic processes and limiting regulatory frameworks. • Ensuring that local residents' associations are truly representative of households' interests	[35,45–47,56,63,65,109,110,118,127,132]		P1–5
Variety of households' individual characteristics				
Socio-economic and demographic factors	• Recognition of the relevance of income, age, household size, ownership/rental period, and gender factors in renovation investments (homeowners) and acceptance (tenants) and design requirements	[13,39,40,58,62,107,116,117,121,125,134,161]	Policymakers, regulatory bodies, researchers and analysts, design team technology developers, project facilitators and coordinators, energy, and financial advisors	P0, P1–4, P6
Psycho-attitudinal factors	• Household behaviour, priorities (self-living, rental, sale, investment), and motivations to guide renovation strategies and optimal design measure combinations. • Pre-retrofit knowledge, beliefs and specific biases as factors influencing renovation promotion and engagement and shaping technology choices and use.	[40,56,65,113,115,116,119,120,122,124,161]		P0, P1, P3, P6,P7
Households' vulnerabilities and resources	• Lack of energy/technical knowledge and interests (>15)[c] • Local heterogeneity in personal capabilities, cultural background, and language barriers. A spectrum of users' engagement based on capabilities, interests, and technology interaction to aid renovation management and design choices. • Risk of displacement due to renovation-driven rent increases.	[14,16,45–47,62,102,127,137,154,171,172]		P0–14

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Table 5 (*continued*)

Subdomains	Recognition (in)justice trajectories from literature	Citations	Actors	Phases[b]
Energy poverty	• Recognition of energy as a basic need rather than a commodity. • Recognition and integration of energy poverty in planning and design assessments. • Cost metrics sensitive *to special needs consumption* and *under-consumption* due to affordability constraints.	[17,27,48,66,130,150,154,155]		P0,P2–4, P6,P9, P13,P14
Domestic practices	Energy renovation as part of an ongoing housing practice, shaping domestic habits, experiences, and non-material values.	[57,113,118–120,157,160]		P2–4, P6, P12–14
Residents-building interactions: Occupants' behaviour and comfort subjectivity	• Subjective nature of thermal comfort, influenced by domestic practices and divergent meanings between occupants and experts. Risk of unintended adaptive energy behaviours • Recognition of the dynamic and iterative adaptation process users-technology, users-project teams. • Heterogeneity of user consciousness needed for proper building/technology interactions, and of consumption patterns by household types.	[19,42,48,57,102,116,125,126,135,157,158,161,163,164,167]	Design team, energy advisors, contractors, housing associations	P3–5, P7, P9, P12–14
Community dynamics and values				
Social Networks	• Residents' peer social networks and relations with local institutions and communities as a valuable source of renovation knowledge and support.	[56,68,102,113,115,119,161,165]	Policymakers, local authorities, designers, contractors, property owners	P0-P4, P7,P11, P13
Beyond energy implications	• Health-correct energy consumption for vulnerable groups • Mental and physical well-being beyond • only thermal comfort: air quality, level of control over systems, noise reduction, natural light, and aesthetics, determine residents' well-being, retrofit decisions and energy use	[13,46,113,120,121,126,132,139,147,150,154,156,162,171,172]		0,P1–3, P5–7, P11,P13
Cultural values	• Sense of belonging to the neighbourhood; architectural and cultural features	[16,19,106,112,126,162]		P0-P6, 7, P12–14
Spatial and physical dimensions of the built environment				
Buildings and surroundings requirements	• Spatial and physical conditions at neighbourhood-building-dwelling scales; Unique needs of urban vs. rural context • Type and functioning of existing heating systems	[39,69,111,128,134,148,152,162]	Local authorities, residents, researchers, design team, Energy consultants	P1-P6,P8, P13
Accuracy of models	• Local energy models incorporating social features, and spatial and building peculiarities through detailed disaggregated data. • Variability of building type, age, thermal zones across the dwelling, and updated local climate conditions	[25,29,36,42,48,57,66,108,130,144,152,153,167]		P3,P4, P5,P7, P9,P14
Subdomains	**Procedural** (in)justice trajectories from literature	Articles	Actors	Phases
Domain: Inclusive processes: Supportive, interdisciplinary, and collaborative strategies				
Favourable setting for participation	• Strengthening social capital and norms for sustainable and cooperative behaviour. Streamlining bureaucratic hurdles.	[15,16,18,36,64,107,116,118,155]	Local authorities and institutions, community groups, coordinators, Project managers, design teams, residents, researchers	P0,P1–3, P6–8,P13

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Table 5 (*continued*)

Subdomains	Recognition (in)justice trajectories from literature	Citations	Actors	Phases[b]
	• Negotiation dynamics towards consensus in decision-making.			
Early engagement	• Benefits of focused pre-retrofit feedback and ethnographic survey and monitoring, with flexible investigation depth and engagement strategies, tailored to the project's scale and resources. • Early learning of mutual expectations to prevent design issues affecting space usability and cost structures.	[44,63,64,114,125,126,139,166]		P0–6, P11–14
Strategic stakeholders	• Strengthening the role of intermediaries and project managers in enhancing inclusivity and coordination. • Mediating and supportive role of local social community organisations.	[44,56,64,110,112,113,118,119,132,151]		P8–14
Information and support services	• Clear and transparent financial information - available funding/ incentives and life cycle costs- more effective when combined with non-financial data and benefits. • Strategic management of the amount, timing, format, and type of information: comfort-related benefits tend to increase acceptance.	[16,30,34,35,45,46,48,62,111,126,132,134,161,162,168]	Policymaker, local institutions, service providers, design team, energy companies, financial advisors, contractors,	P0,P1–14
	• Information hubs - virtual or physical collaborative platforms – that are accessible and tailored also to vulnerable households. • Facilitated access to financial assistance and energy consciousness. • Single point of contact for all renovation needs: Effectiveness of One Stop Shops' business model to address process complexities and involve hard-to-reach residents.	[13,14,17,30,31,45,62,116,118,133,137,161]		
Continuous learning processes	• Promotion and implementation of education and training across both the demand and supply side at all renovation stages. • Complement technological with social innovation: staffing projects with skilled professionals for user-centric approaches.	[48,64,115,139,141,154,162,168,171]	Mediators, community groups, local institutions and authorities, design team, contractors, researchers, energy and financial advisory	P0, P2, P3, P6, P7, P11–14
	• Use prototypes or demonstration homes to set expectations, guide technology use, and gather feedback.	[17,44–46,62,64,110,112,141,162,168]		
	• Post-retrofit follow-up: long-term monitoring, training, and ethnographic engagement to promote community-building and sustainable behaviour, informing future renovation projects.	[19,31,46,62,64,102,119,141,145,150,162]		
Effective co-creation	• Avoid apparent users' involvement without a real impact on decisions, limited to late-stage evaluations, while confining public/private partners to early 'definition and conception' phases. • Interactive vulnerability-sensitive planning and design workshops, co-creating tactical approaches and operational choices with residents. • Interdisciplinary collaboration in local Living Labs to facilitate stakeholder mediation and trust-building.	[35,44,68,118,136,138,140,142,143,149,162]		P0,P2, P3, P6, P7, P9-P12

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Table 5 (*continued*)

Subdomains	Recognition (in)justice trajectories from literature	Citations	Actors	Phases[b]
Residents' sensitive implementation logistic				
Construction impact	• Work-site disruption mitigation and management. • Relocation-preference-aware design and implementation. • Occupants-sensitive schedule, support for moving and storage. • Impact of design choices: prefabrication index.	[17,31,44,46,62,69,102,125,154]	Community groups, project managers, design team, contractors, residents	P0–7,, P11–14
Frontline involvement	• Do-it-yourself activities or job opportunities for unemployed tenants • Co-managed interactions: Active households as service providers, motivators, and quality controllers.	[36,44,46,68,118–120,132,135,136]		
Indirect participation: User-oriented models				
Systematic decision making	• Decision-making frameworks integrative of bottom-up values • Holistic approaches and assessments comprehensive of social criteria for individual and collective wellbeing • Multicriteria analysis weighing diverse stakeholders' preferences with quantified performance on renovation alternatives	[69,125,146,147,149–152,159,169]	Local institutions, design team, researchers	P0–14
Inclusive approaches and indicators	• Monitoring data instead of statistical ones for energy simulations: the inaccuracy of standard profile-based forecasts. • Adoption of specific decision matrices balancing architectural requirements and residents' values. • Life Cycle Sustainability Assessments integrative of social impacts. • More comprehensive well-being-oriented performance parameters. • Energy poverty-sensitive and comfort-prioritising indicators for retrofitting technologies options.	[27,42,66,67,148,150,152,155,163,167]	Energy consultants, researchers, design team, and technical experts	P0, P4–10, P12–14
Subdomains	**Distributive** (in)justice trajectories from literature	Articles	Actors	Phases
Domain: Inclusive policies				
Tailored and flexible policies	• Equitable strategies and support services. • Hybrid governance models with baseline social regulatory protection and standards. Tenant-friendly renovation policies. • Different retrofit paths rather than one prescribed approach. • Account for well-being co-benefits and strengthening of social networks and capabilities: policies as relationship mediators. • Context-adaptive frameworks for local spatial needs: balanced spatial use across socio-economic divisions.	[25,29,47,63,108,109,114,123,128–130,132,165],	Policymakers, researchers, policy advisory boards, non-governmental organisations	P0, P13, P14
Policy responsiveness	• Adjustments over time through post-occupancy feedback and assessments. • Life cycle perspective in policymaking crossing modelling and monitoring data.	[16,47,56,67,116,149,150,166]		

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Table 5 (*continued*)

Subdomains	Recognition (in)justice trajectories from literature	Citations	Actors	Phases[b]
	• Climate change well-being-oriented and risk-aware models.			
Financial implications				
Rent increase	• Preserving low-income tenants with zero, gradual or capped rent. Increase options, regulated with energy bill savings. • Targeted grants for rent increase affordability.	[16,29,30,46,59,69,106,110,125,127,132,152]	Property owners, local authorities, energy and financial advisors, researchers, design team, policymakers, financial institutions, low-income	P0,P1–3
Cost-effectiveness	• Focus on high-saving-impact, cost-effective measures. • Inclusion of future CO^2 and energy prices predictability and impacts.	[40,114,115,117,124,130,131,143,146,155,170]	tenants, utility companies	P0,P4,P5, P8,P9, P14
Cost distribution	• Public-Private-Social Sector Partnership for equitable investment, operational, and risk-related cost-sharing. • Long-term affordability.	[17,35,47,48,112,113,133,145,154,162]		P0–14
	Equitable energy bill distribution in multi-dwelling buildings: • Combination polluter-pays with ability-to-pay principle. • Special-needs-consumption-aware accounts mechanisms			P0,P3, P4
Repayment of renovation costs	• Prioritization of cost-neutrality strategies over additional rates on the actual post-retrofit bills. • Staged approaches and total cost of ownership models.			P0,P3, P4,P6–10
Tailored financial incentives	• Substantial public subsidies for an equitable transition. • Income-based packages with low-cost or free energy audits. • Combination of subsidies with low-interest loans or tax rebates • Conditional incentives to address free-riding risks	[39,56,108,113,116,131,135,154]	Policymakers, financial institutions, financial advisors, local authorities	P0,P1,P2, P4, P6–9, P12–14
Innovation in funding strategies	• Revolving funds and scalable grants: avoiding immediate debt for low-income. • *Neighbourhood funds* for local initiatives, energy issues and support services.	[68,115,145]		
Design outcomes: Design beyond energy for energy				
Tailored and quality design	• Combination of energy efficiency and transition measures with social regeneration programs. • Durable interventions with low maintenance and long-term benefits. • Compatibility with traditional building components. • Spatial implications and households' priority comfort parameters • Effectiveness of passive over active measures in vulnerable contexts • Aging- and health-driven design. • Effortless and stress-reducing technical design solutions.	[19,27,36,47,62,64,112,121,125,129,146,148,157,161,171,172]	Local institutions, architects and design teams, contractors, engineers and technical experts, residents, technology providers, contractors,	P0–10, P11, P12
Adaptable equipment and retrofit strategies	• Adaptability to building types and occupant profiles and behaviours. • Adjustable heating systems control and user-friendly smart interfaces • Modular design and incremental retrofit. • Flexible spaces to ensure future adaptability.	[19,57,109,123,126,155,157,158,160,161,163]		P3-P12

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Table 5 (*continued*)

Subdomains	Recognition (in)justice trajectories from literature	Citations	Actors	Phases[b]
Combinations with non-energy-related measures	• Inclusion of non-energy upgrades to improve functionality, aesthetic and quality, practicality, and structural safety. • Enhancing space usability and material quality to foster focus and simplify housekeeping. • Design for social cohesion: common, green, outdoor spaces.	[36,46,67,69,112,126,143,148,151,156,162,171]		P0, P6–10, P12
Alternative renovation packages	• Provide multiple renovation packages for alternative scenarios. • Evaluating the implications of staged versus complete renovations on user needs and neighbourhood requirements.	[69,111,128,133,155,170]		P0, P2, P3, P6–11
Design outcomes: Environmental impact				
Energy and environmental focus	• Processing trade-offs with embodied and operational carbon, energy efficiency, and residents' well-being. • Energy-efficiency improvements [common to all articles analysed], sustainable heating systems, circular design, overheating.	[14,31,44,110,131,140,155,157,163,164,167,170]	Local authorises, property owners, design team	P0,P1,P2, P3, P6–10, P13, P14

[b] Phases suggested by the authors for the potential application of just trajectories, based on critical points in the renovation process identified in the literature, where greater inclusiveness and equity are required (reference phases in Fig. 7).
[c] (>15): particularly relevant aspect recognised in >15 studies analysed.

implemented by diverse actors—including policymakers, property owners, contractors, designers, residents, energy and financial advisors— while also identifying potential new stakeholders. This underscores critical decision-making moments, particularly at the operational level, essential for advancing justice in renovations yet often overlooked in research and practice [17,18,46].

Additionally, due to distinct decision-making processes, the *inclusive* literature uncovers varying applications and relevance of justice mechanisms depending on ownership. For homeowners, the objective is to align renovation promotion with their driving motivations, to shape attractive and accessible investment incentives and support services throughout their decision-making journey [13,25,40,56,58,116,119]. For tenants, the emphasis is on ensuring effective participation to secure project acceptance while addressing their vulnerabilities and capabilities in management and technical design strategies [19,30,45,48,63,125,127,136,143,162]. Despite these differences, both groups encounter common barriers to inclusive and equitable processes. Among the studies reviewed, 41 (39 %) address both tenants and homeowners or do not specify ownership, 35 (34 %) target tenants, and 27 (26 %) homeowners. However, only 30 recent studies (29 %) consider vulnerable, low-income residents, exposing a significant research and support gap for these populations, despite their pronounced need for equitable processes [14,27,46], and the growing criticality of unequal social implications in local energy transition and building renovation.

5.1. Recognition justice

Recognition injustices primarily arise from overlooking or misinterpreting households' socioeconomic characteristics, unique needs and the social impacts of projects. To ensure equity, renovation strategies should address vulnerabilities such as energy poverty and limited resources, while also reflecting shared values and community priorities in renovation planning and design. As evidenced by the domains identified, recognition justice permeates various scales. Besides the social individual and local community scales —where financial capacities [13,14,30,58,117], comfort practices and needs [164,167], varying levels of technical understanding [19,119,121], and social networks play a key role — a system-level scale composed of rooted process and design barriers [34,64,130], and dynamics of trust and responsibility [44,63,109,113,114] strongly requires recognition. To fully understand and implement recognition justice nuances, it is crucial to acknowledge and address existing barriers and drivers. These are central elements of the recognition framework and act as superstructure factors to safeguard other justice dimensions and the success of future renovations. Thus, we categorise them separately to emphasise their key role.

Key barriers to equitable and scalable renovation processes include financial limitations and information sharing [e.g. 19,39,45,46,108], with institutions and social interactions significantly influencing decision-making [63,110,112,143,165,168]. Design barriers predominantly stem from neglecting domestic practices [64,118], health-related energy needs [126,171], and comfort subjectivity [121,163], valuable input data for reducing the energy performance gap and guiding technological choices such as ventilation systems and window types [48,161]. Similarly, household composition, gender-based differences [13,113,121] and contextual values, beyond energy implications, demand recognition for appropriate design options of space layout and control systems [36,48,64,112]. as well as for monitoring planning [57] and information campaign management [30,68,128], ensuring appropriate dissemination channels based on awareness and literacy levels [1,2]. These factors strongly influence the sustainable use of spaces and devices, directly impacting energy performance and user satisfaction.

Policy frameworks emerge as key arenas for integrating recognition elements to promote equitable renovation, shaping financial mechanisms, procedural strategies, and design practices. Complementing this, phases such as pre-retrofit surveys and initial design stages prove decisive for early local data integration, fostering residents' trust in both stakeholders and renovation technologies through genuine and direct engagement [64,139]. This positions designers and contractors as pivotal actors from the earliest planning stages, with community groups serving as key intermediaries in transferring local values into the process.

Moreover, technical tools and documents can embody recognition justice, as Zuhaib et al. [134] illustrate by tailoring Energy Performance

Certificates to residents' needs, incorporating features like retrofitting suggestions and cost details to improve usability.

The spatial implications of justice require an accurate and detailed representation of the physical and functional status of residential environments. This necessitates integrating diagnostic criteria for quality and sustainable space design, as scholars have identified building and dwelling characteristics [30,69,130,133,144,153] and local climate conditions [27,108,157] as key factors influencing renovation decision-making and occupant comfort [126,163].

Recognising the diverse needs of residents and their living contexts affects action measures in renovation processes and ways of assessing energy efficiency according to socio-economic context [107,153]. For affluent homeowners, efforts would target optimising energy and space, preserving heritage values [65,126], and facilitating access to technological innovations and support services by easing bureaucratic hurdles [116,133]. In contrast, low-income tenants benefit from no rent increase post-renovation [16,63,153], and targeted engagement strategies that enhance their control over the process [68,136,141], such as energy-focused neighbourhood events with familiar faces [68,118]. Their poor housing conditions— marked by inadequate heating, air leakage, and poor insulation— require comfort- and air quality-oriented design solutions [27,125,153], that go beyond low-quality, minimal interventions and may favour passive over active measures for their efficiency and better alignment with user capacities [27,163].

Therefore, this recognition justice framework provides key ingredients and decision criteria for renovation strategies that directly involve procedural and distributive justice, highlighting their interrelated nature.

5.2. Procedural justice

Strategies aligned with procedural justice can serve as a remedy for misrecognition practices, mainly highlighting the need for changes in organisational models and supply-side dynamics.

Key issues include inadequate communication, limited access to information, and reliance on top-down technocratic approaches [34,35,45,46]. Such factors undermine process transparency and fairness, often resulting in discrepancies between the information provided to residents and their firsthand experiences [45,64,156].

From policy design to on-the-ground interactions between residents and construction companies, trajectories of procedural (in)justices manifest across decision-making levels. Notable applicability lies in early design and implementation phases, involving residents in renovation measures selection and construction planning.

If tenants' voices impact the renovation process, it is often through informal power rather than structured collaborative methods and legal rights [106]. Combined with standardised retrofit packages and fixed financial incentives, this results in procedural injustices, lock-ins, and supplier-oriented outcomes, leading to uneven benefit distribution. Therefore, studies promote hybrid governance structures and technological advancement models that invest in community-based initiatives with active early participation, both building on and positively reinforcing local social relationships [47,63,113,132]. This enables co-decision-making and adaptation to domestic practices, addressing widespread organisational and technical shortcomings in the producer-consume chain for housing retrofit [64,112,132]. While these measures formalise safeguards for vulnerable tenants [63], they also benefit homeowners by shaping retrofit expectations, resulting in a more effective energy use post-retrofit [37,56].

Enhanced cooperation at the organisational mezzo-level [16,107,127] and innovative business models like “Public-Private-People Partnerships” [35] can effectively manage renovation uncertainties, risks and profit dilemmas.

Participatory initiatives that empower residents and raise energy awareness are equitable and effective when accessible to all and calibrated to households' engagement capacities and literacy levels [14,142,143]. However, few studies document real-world co-creation in selecting technical design options and managing construction implementation, both deemed significant phases for procedural justice. Flexible and customisable design options, rather than fixed ones [64] encourage sustainable building-user interaction [162] and positively influence residents' sense of ownership and satisfaction with the project [31]. Similarly, well-structured logistics —such as clear timeline communication, detailed scheduling, alternative accommodations, and compensation—can minimise disruptions and renovation aversion [17,46,125].

Co-creation activities, such as design workshops and living labs, help gather feedback on draft plans, test ideas, and build trust between residents and project teams [64,136,138,142], effectively incorporating local knowledge and enhancing the social acceptability of new heating systems [68,125,140]. Visual aids, small-group discussions, and introductory events can further support the workshop development, particularly with vulnerable communities [136,138,142]. However, such approaches often face structural barriers, including stakeholder power disparities, limited resources, and prolonged timelines [138,142]. Intermediaries, such as social organisations and dedicated project managers, play a key role in facilitating collaborative participation and sustainable behaviours adoption post-retrofit [64,68,112,113]. Similarly, training programs for households and professionals (e.g., installers and social housing managers) can ensure empathetic interactions [44,118,133,168]. These strategies can exploit virtual platforms like web spaces and mobile applications [31,44,135,152], along with design prototypes and demonstration flats [62,64,110,162], to create customised and user-oriented spaces and technologies equipped with accessible control systems [19,64,157]. Online tools, such as EnergieID and city-level energy platforms, can make residents more aware of their energy consumption and inform them about planned local interventions [68,152].

Traditional methods have failed to capture the complexities of renovation, underscoring the need for holistic and systematic approaches to decision-making. Consequently, research increasingly supports interdisciplinary approaches that integrate social sustainability criteria and performance indicators to assess individual and collective well-being [146,147,150,151,159]. These methodologies enable the early integration and balancing of stakeholders' tangible and intangible values [149], often using multicriteria analysis to prioritise diverse preferences while quantifying performance across renovation alternatives [69,151,169].

The literature interpretation suggests that such inclusive methods represent an indirect achievement of procedural justice at tactical and operational levels. Institutions and technicians can promote residents' influence on decision-making by adopting user-oriented models. These models integrate social parameters, local needs, and characteristics through specific indices, tools, or assessment methods [27,42,66,67,148,155], while also accounting for environmental well-being, building life cycles, and factors sensitive to energy price fluctuations and climate change projections [69,150,163,164]. In this way, equitable and representative processes are ensured even when active involvement is not feasible or preferred, particularly for vulnerable households favouring less invasive and effort-demanding methods [14,46,138].

5.3. Distributive justice

The literature primarily associates distributive (in)justice with financial implications, including operational cost distributions [17,48] and funding allocation [108,127,131], stressing the need for equitable actions at macro-level policy-making [16,17,39,131]. As with other principles, the structure of distributive justice is also multilevel, with implications in financial strategies, policy design, energy systems and design choices.

Scholars advocate for flexible policies responsive to community-

specific contexts, supporting local, community-led initiatives and support services such as preliminary energy assessments and post-renovation performance checks [68,113,118,119,137]. Similarly, tenant-landlord dilemmas should be regulated with measures sensitive to vulnerable households, such as rent caps ensuring cost neutrality or energy-differentiated rent and CO2 cost allocation to balance financial responsibilities and benefits [47,63,114,127].

Financial assistance is critical to achieving equity, ensuring all community segments have access to renovation funding and trusted contractors [113,154]. Proposed strategies include tiered support based on income and contextual needs, such as comfort and family dynamics [39,58,113,129]. Studies recommend specific incentives for high-benefit impact interventions that maximise emissions reductions and cost savings with minimal disruption, like renewable upgrades, and alongside support for more extensive interventions involving structural and envelope improvements to ensure more comprehensive and long-term outcomes [19,128,155]. Recognising the value of co-benefits demands funding allocation towards holistic area-based approaches that are not limited to energy-efficient upgrades and cost savings but integrate social programs and broader quality-of-life improvements, such as comfort and health [47,113,172].

Injustices may also manifest as non-material burdens, such as renovation fatigue, which predominantly affects vulnerable groups [171], and the spatial distribution of renovation efforts [153].

Vulnerable residents in suburban areas with inefficient buildings often bear the burden of intensive renovations: Von Platten et al. [153] suggest that using energy use per capita metrics rather than normalised energy use per area indicates that high-income central urban areas consume the most energy. Accordingly, urban energy policies should prioritise balanced approaches, including less intensive renovation types in multifamily buildings [109,153], and strategies targeting high-income households to reduce energy use, such as decreasing living space per capita or discouraging excessive use [29].

Therefore, distributive justice is a key consideration in the strategic phases of regulatory framework creation, with significant applicability potential in the development of retrofit options for implementation, particularly during hypothesis formulation and design phases.

Incorporating a design perspective into just renovation strategies involves considering design outcomes that reflect key recognition patterns, such as local needs and the effort required by residents to interact with renovation technologies and adopt sustainable energy behaviours [19,167]. Research shows that energy renovation acceptance and residents' satisfaction with project outcomes can be improved by including non-energy-related design measures that enhance living conditions and are often more visible and needed than purely energy-focused ones [46,102,148,156]. Spatial implications, comfort, ventilation practices, and practical usability emerged as critical design criteria, recommending the prioritization of passive over active measures for low-income, vulnerable residents [19,27,157,163], while promoting climate design strategies such as tailored insulation and ventilation based on dwelling position and orientation, with careful consideration of building typologies and thermal zoning [159,163,167].

An effective strategy involves offering flexible and customisable packages of alternative measures with varying levels of environmental performance and user impact, enabling greater influence in decision-making and alignment with individual needs [111,112,169,170].

However, few studies delve into design-oriented choices and approaches that address user needs and promote equitable renovation scenarios. The literature primarily refers to traditional measures like envelope insulation and heating upgrades, with limited attention to added-value measures or passive bioclimatic solutions (see Appendix A, Table A4). Renovation measures are often listed to describe context or investment options, with minimal analysis of design impacts or resident preferences, apart from studies [57,64,69,148,155,157,159,162,163,170] that detail the implications of renovation measures and design criteria.

6. Discussion: Towards decision-making criteria for just energy renovations

This study synchronises various urban transition needs [4], aligning energy and environmental objectives with social justice, and identifying potential paths of inclusivity and equity within interactions between residents and renovation challenges, based on literature insights. Considering these paths as potential and not absolute is relevant since, at the core of the principles of justice, lies the imperative of tailoring to local contexts and not pursuing one-size-fits-all solutions.

The analytical framework of justice principles strategically oriented the literature analysis to depict decision-making criteria, confirming its validity as a decision-support tool for low-carbon scenarios [74,176]. The synthesised theories of energy and spatial justice provide a valuable contribution, as considering spatial dimensions helps to spot further inequities in urban energy transitions [177] and outline equitable strategies accordingly. For instance, in suburban vulnerable neighbourhoods, inefficient buildings and the lack of adequate infrastructure can indicate the need for targeted intervention programs and specific technical solutions such as incentivising more innovative sustainable technologies [112] or improving complementary aspects of energy interventions, like building accessibility [64,148,162]. This perspective on the spatial and material dimensions of living spaces encourages a stronger emphasis on the architectural and engineering design processes and related actors in energy intervention. It advocates for incorporating people-related recognition and procedural criteria into design criteria, proving to be influential in shaping environmental impacts in accepting construction interventions and new energy systems [31,36,136,164]. As a systemic complement to this, just energy renovation requires inclusive policies and regulation systems shaping equitable financial mechanisms and fair cost distribution structures, as well as guaranteeing accessible and targeted information and building community capacity for decision-making through context-sensitive participation.

While such process and governance dynamics, along with planning phases, receive greater research attention, the analysis reveals a gap in addressing design aspects —such as the selection of renovation alternatives—and implementation logistics, including construction systems or site-building strategies that minimise impacts on residents. Recognising their importance in structuring (in)justices, the developed framework brings them to the forefront alongside other focal domains of socio-technical decision-making. As summarised in Fig. 8, these domains form an interconnected system of critical areas where potential injustices can be identified and opportunities for justice fostered across the three justice principles.

Recognition, procedural and distributive components have often been found to coexist among inclusive renovation literature, albeit mainly in the form of reporting mismatches and injustices or proposing more social-oriented approaches. However, the literature reviewed predominantly focuses on identifying drivers and barrier factors that influence households' adoption of energy-efficient technologies. In line with the study by Yeatts et al. [178], these barriers cluster across different levels (e.g., individual, organisational, and systemic), emphasising knowledge, access, and intent obstacles. This adoption-oriented focus, however, often overlooks how a resident-focused approach can effectively shape sustainability transition choices within socio-technical mechanisms [179] and mitigate social inequalities.

Barriers to energy renovation are multifaceted and interlinked across the three levels of the MLP framework, hindering systemic transitions and requiring interdisciplinary multiscalar, and interscalar approaches to address energy issues in buildings and support system change [180,181]. Identified as superstructure factors in this study, these barriers reveal areas where system change is needed, with the MLP offering an architecture of interconnected systems strategically designed to manage complex socio-technical systems, such as housing renovation, and shape new reconfigurations [182]. This occurs through niche developments and regime shifts, where social innovation is intertwined

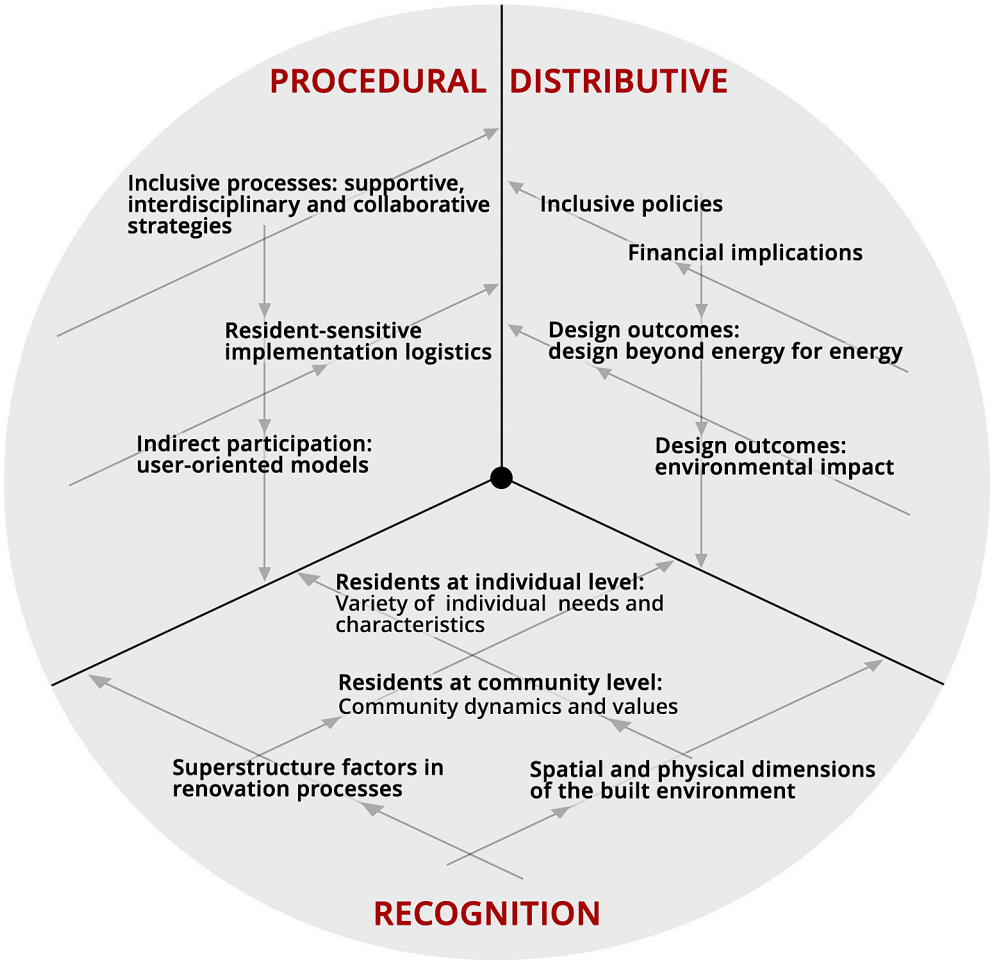

Fig. 8. Key domains for just energy renovation, extrapolated from the literature, highlighting the interdependence of justice tenets and the domains themselves.

with technological and material elements [183]. Same-level and vertical multi-level interconnections can be developed and strengthened to reconfigure relationships among diverse stakeholders, institutions and technologies [180].

For instance, limited tenant participation underscores the need for more transparent and inclusive processes, allowing new consultation models to emerge [184]. Similarly, neglecting behavioural, social, and energy practices can lead to performance gaps and discomfort, calling for a reconsideration of design strategies in renovation technology selection [18,121].

A critical analysis of these barriers through a justice lens can reveal how systemic change can foster not only sustainability but also equity, addressing structural injustices and promoting inclusive socio-technical transitions. At the niche level, innovative retrofitting technologies, practices, or social innovation initiatives, often overlook residents' vulnerabilities, behaviour, effort demanded by new systems, and issues like space constraints and infrastructure compatibility, leading to low adoption rates and exclusion of certain groups [110,112,140]. Fixed and complex regulatory frameworks, coupled with the inability of institutions and market agents to establish solid, trusted relationships and take responsibility for safeguarding the vulnerable, prioritise established practices over inclusive decision-making. This creates recognition and procedural injustices at the regime level, reinforcing existing power imbalances [45,132,180]. At the landscape level, distributive injustices are exacerbated by broader socio-economic pressures like energy poverty, climate change, and socio-spatial inequalities, disproportionately affecting low-income households and amplifying inequality [153,177]. Justice trajectories effectively destabilise regime inertia by ensuring access not only to innovative renovation practices but also to social innovation engagement strategies that help to align stakeholders' interests and address landscape challenges. This awareness of both hindering and driving factors in system change for a just energy transition and renovation also exemplifies the application of the restorative justice dimension of energy justice, which proactively prevents future harm to residents and the environment [185].

Our analysis demonstrates that achieving the European directives' vision of a just energy transition requires a collaborative, multi-level approach in residential building renovation at strategic, tactical, and operational decision-making levels that systematically incorporates recognition, procedural, and distributive justice principles. This finding supports the results from [17,46], highlighting the mutually reinforcing nature of justice principles in the context of housing energy renovations.

The justice principles reinforce each other: for example, procedural strategies such as co-creation activities [42,136,140] and support services [59,133,137] both aid and are shaped by the effective recognition of users' needs and capabilities, leading to climate- and user-sensitive designs [27,157,164] and targeted financial models [16,39,145] (distribution).

Furthermore, building on holistic, multi-criteria, socio-technical assessment models that incorporate social parameters [e.g. [67,149,151,159,169]], we propose user- and context-oriented approaches as just procedural strategies. These strategies can complement or substitute direct resident participation, particularly in contexts with limited resources or low engagement willingness, while ensuring the collection of locally context-driven data on people and buildings.

The identification of domains, subdomains, and (in)justice

trajectories from the literature can be synthesised in a decision-support framework (Fig. 9), highlighting criteria for just renovation. By aligning the justice perspective with more concrete indicators related to renovation management and design, this framework not only informs renovation practices but also aids in collecting multidimensional metrics for energy justice decision-making [186].

The proposed decision-making criteria simultaneously activate justice principles by translating them into actionable practices that ensure key recognition patterns into procedural strategies and distribution measures. For example, co-design workshops can be tailored to household compositions and support gathering comfort priorities and building requirements to be translated into design criteria for renovation technologies. Likewise, energy cost distribution in multi-apartment buildings can follow health-related needs, leveraging on community-led initiatives to share information and manage negotiation dynamics, thereby reinforcing local social cohesion. This interplay at different decision levels builds trust and ensures sensitivity to local contexts.

As a multilevel mechanism, the just energy renovation framework reveals its system-like nature, governed by the interrelations rules of justice principles in housing renovation [46]. Ensuring justice, therefore, requires creating positive feedback causal loops that leverage the mutual relations of principles and operate across different decision-making phases and levels. This suggests the potential for applying systems thinking to energy renovation in buildings, as in other energy fields, by illuminating complex interdependencies between actors and sectors that are critical to accelerating energy transitions [180].

The order of justice principles presented in this review reflects the conventional iterative stages of the renovation process. Recognition primarily involves a thorough initial investigation and sustained awareness throughout the decision-making phases. Procedural justice entails inclusive management strategies at tactical and operational levels, determining how the project unfolds. Distributive justice assesses the outcomes of energy renovation initiatives, whether strategic or operational, focusing on their distribution and impact on residents, given the local demand-side scale of this study.

The justice-driven analysis of actors and phases shows that just renovation processes require the concurrent involvement of multiple stakeholders across stages, often extending their roles beyond designated phases. This approach enables continuous monitoring, feedback exchange, mutual socio-technical learning, and the opening of sectoral niche boundaries [37,138,168].

The analysis highlights that justice principles are relevant and influential at every stage of renovation decision-making (Fig. 10), with high recognition demands in initial planning phases– such as the strategic integration of local values and needs through diagnosis and data collection– inclusivity in drafting renovation options, and distributive implications during design phases, when cost-effectiveness is assessed within design choices.

This establishes the just decision criteria framework as a practical, transversal guidance for decision-making and evaluation across various renovation stages and sectors.

Effectively transferring justice into renovation policies and implementation demands bridging the gap highlighted in this review: the underrepresentation of professional stakeholders' perspectives and dynamics in managing the socio-technical challenges of renovation. Integrating this perspective, alongside residents' viewpoints, is crucial to operating effectively with combinations of top-down and bottom-up strategies. Thus, the review findings suggest that to be able to cross

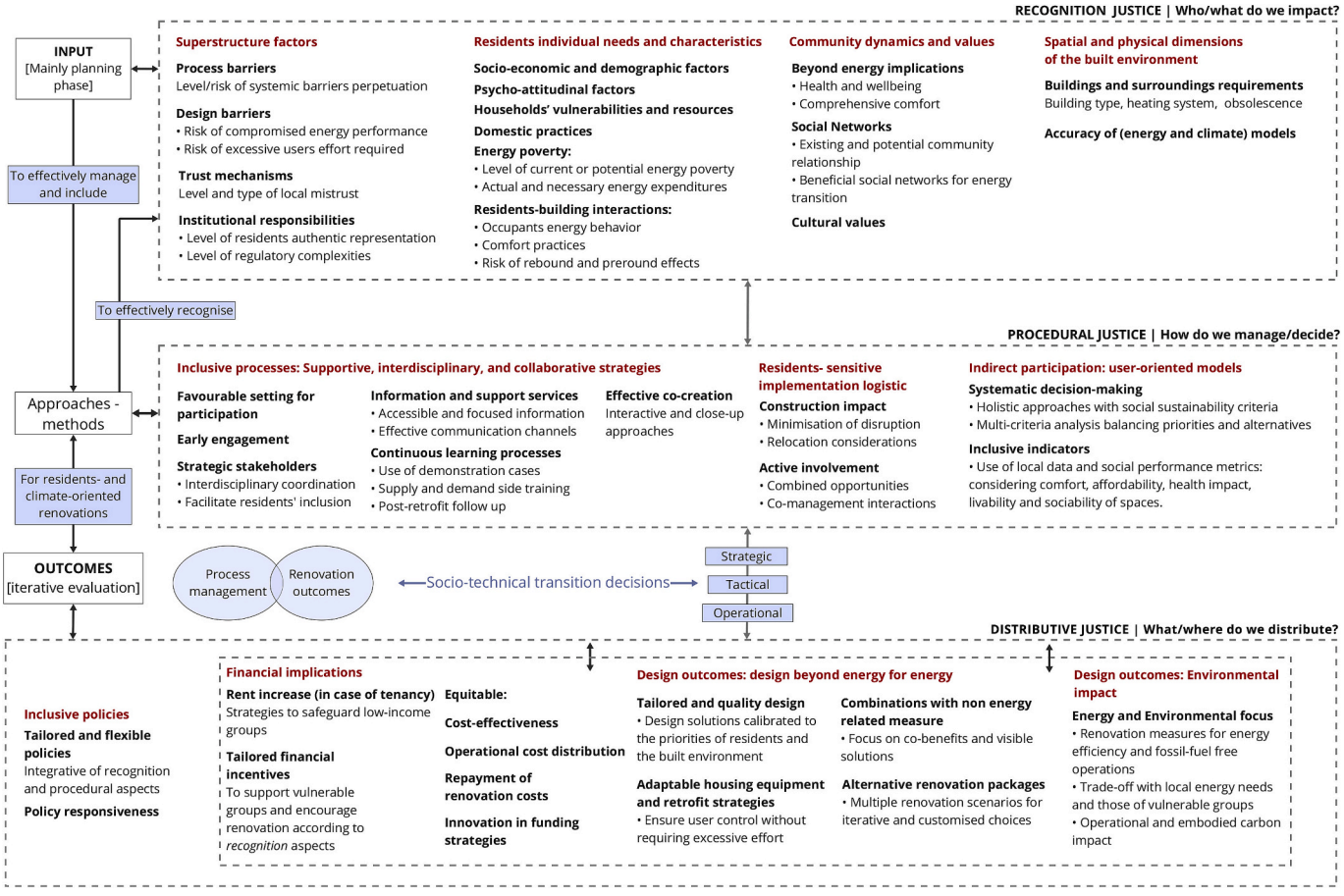

Fig. 9. Summary framework of decision-making criteria as a guiding tool for just restructuring according to scale and context. It is structured around the principles of recognition, procedural, and distributive justice, based on the analysis of Table 5.

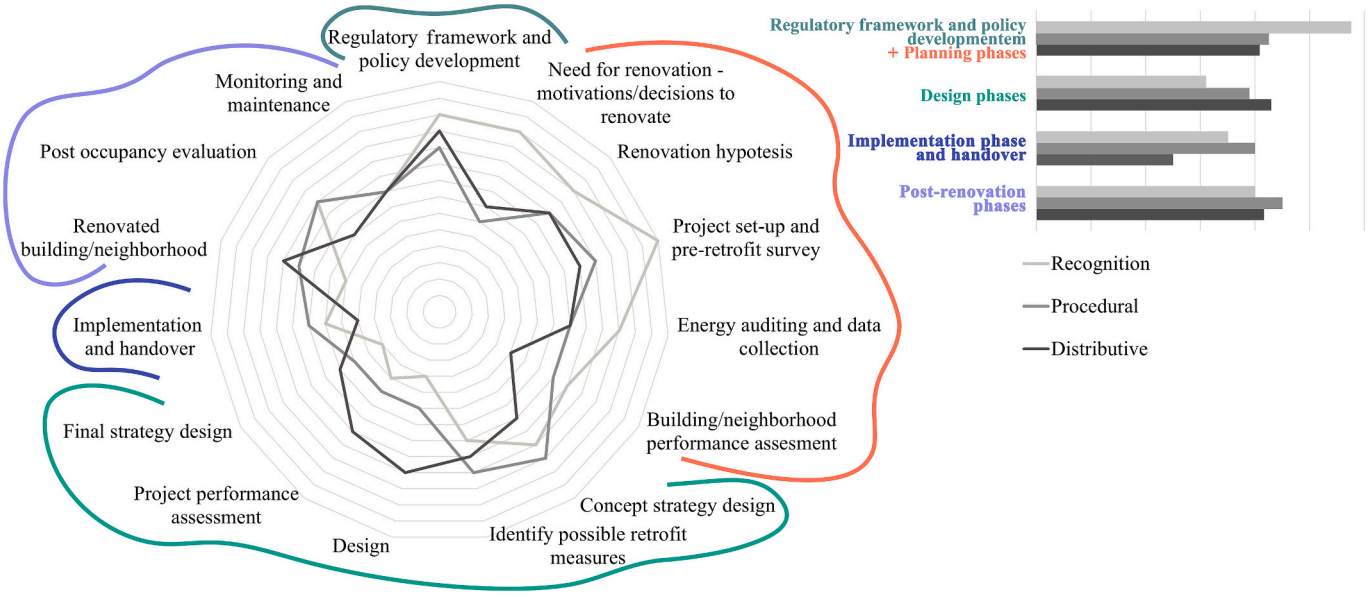

Fig. 10. Qualitative radar chart indicating how justice principles are distributed across renovation phases, according to the analysis in Table 5 and the renovation phases outlined in Fig. 7.

transition levels [60] a just energy renovation requires socio-technical innovation initiatives starting from supply-side actors, service providers, and institutions.

Similarly, renovation planning and design must balance strategies and solutions to address both user and technical needs. This prospect is already shaping recent research, as seen in the Guerra-Santin et al. [187] behavioural model, which integrates social sciences and engineering to evaluate energy performance in residential buildings while considering occupant diversity and behaviour.

Scholars concur on the valuable role of qualitatively assessing technical choices and proposing flexible renovation packages that incorporate measures beyond energy efficiency in incentivising and fostering acceptance of energy transition projects. This may require rethinking organisational models, management, and financial strategies to support initiatives such as showcases, training sessions, and iterative design processes [44,136,164,168]. The proposed decision-making framework presents practical implications for policymakers, supporting the findings of [63,188], by promoting the development of tailored financial mechanisms, rent control adjustments and renovation obligations to prevent tenant displacement and ensure deep renovations. Likewise, in agreement with [187,189], it provides key insights for practitioners working on the ground – energy engineers, architects, housing associations, and project managers - on balancing passive and technological solutions while prioritising usability and comfort ensuring user-centric building systems.

Significant progress can be achieved by advancing fieldwork-focused projects and research that integrate iterative, co-creative processes with residents —currently scarce in the field— and by applying methods capable of detailing dynamics of local energy transitions in vulnerable contexts and their interactions with the built environment, also addressing spatial implications, such as visual ethnography [190].

The review demonstrates that achieving just energy renovation and transition requires greater attention to vulnerable groups and contexts, supported by dedicated decision-making mechanisms [45,47,171]. While this focus remains limited in the literature on energy renovation interventions, it is steadily gaining attention.

7. Conclusion

The study systematically reviewed 104 *inclusive* studies on energy renovation of residential buildings that focused on social implications and residents, interpreting them through a justice lens. The research contributes to aligning the rapid implementation of energy transition and decarbonisation with the pursuit of social justice. The underlying driving need for this study lies in addressing systemic injustices that harm both people and the environment while missing valuable opportunities to effectively ensure energy efficiency and positive, equitable social impacts, especially for the most vulnerable.

The analysis demonstrates the valuable contribution of the analytical framework that combines energy and spatial justice in shaping just energy renovation and providing decision-making criteria to guide practical implementation. Thus, the review answered the research question and defined just energy renovation within the considered scale, revealing how *inclusive* literature incorporates elements aligned with justice principles that can shape equitable trajectories in different socio-technical domains of energy renovation.

The proposed framework of decision-making criteria provides concrete examples of (un)needed factors and approaches for equitable, resident-oriented renovations, offering insights that can also inform other energy transition sectors. It contributes to highlighting thematic categories related to people, processes, and the environment, around which future research can further deepen understanding of their implications for justice and renovation practices.

The intention of the framework is to establish guiding criteria that can be selected and broken down into situated, quantifiable, and qualitative indicators for both the social and technical engineering fields, promoting integrated assessments. This approach recognises the need to balance the prompt implementation of effective energy efficiency projects with the assurance that these initiatives are responsive to the unique characteristics and needs of the residents and the local built environment.

The identified criteria span financial, management, and design implications through multiple decision-making levels and phases, promoting holistic renovation approaches that address systemic barriers. This demonstrates that achieving justice in energy renovation requires system-based functioning supported by equitable and inclusive measures across multiple key domains.

Just energy renovation can support a variety of residents by smoothing the renovation process and addressing social needs while specifically safeguarding vulnerable groups against renovation

injustices. Indeed, the review highlighted how vulnerable contexts need more focus in renovation research and practices.

7.1. Limitations

Systematic literature reviews, while rigorous and evidence-based, have inherent limitations, particularly regarding search strategies, exclusion criteria, and the complexities of quality assessment in the interdisciplinary field of energy social science [97,191]. Exclusive reliance on academic sources excludes valuable grey literature, such as project reports, which are especially relevant in practice-oriented fields. Additionally, focusing on developed countries may overlook crucial perspectives from underrepresented regions, where energy and spatial injustices are more pronounced. As a theoretical study, it does not directly assess the spatial and temporal social equity impacts typically examined in empirical research, critical dimensions to transitions and energy justice research [177,192]. Consequently, it lacks the added value of iterative, experience-based action research, which is essential for analysing local energy projects [193].

Despite structured protocols, potential authors' bias in study selection and analysis remains, though justice theories as an interpretative filter reduced its impact. The analytical framework may have skewed the analysis towards social dynamics, limiting the representation of critical technical criteria for energy efficiency and decarbonisation, both essential for a comprehensive understanding of energy issues and environmental well-being. Such challenges are common in integrated assessments, where bridging disciplines often leads to oversimplifying one domain to reduce complexities and enhance public comprehension [191]. Additionally, the justice principles were applied in a somewhat instrumental manner, prioritising their decision-making role while potentially limiting deeper reflection on the value of a situated definition of justice.

Overall, the approach offers a novel perspective on shaping justice in energy transition scenarios and interpreting the literature on energy renovation. Although the literature review covered diverse contexts and ownership models, this broad focus limited the development of detailed, context-specific action roadmaps. However, it produced a general framework that fills a fundamental gap in existing research and provides a solid foundation for further development and refinement. Our review and framework also intend to provoke alternative viewpoints and categorisations, rather than prescribe rigid scenarios. Indeed, while the review is comprehensive, it does not cover all circumstances in renovation decision-making, leaving room for further research to enrich the framework from insights from different domains or building life cycle stages.

7.2. Research landscape and future directions

The research landscape proved to be diverse in its themes, addressing governance limits, energy simulation gaps, and behavioural implications, which underscore the multiple challenges of renovation and transition processes. A consensus across domains highlights the importance of prioritising user implications. However, the approaches tend to be uniform, relying on retrospective exploratory analysis of users' intentions, barriers, and drivers for effectively scaling up energy efficiency, with most recommendations centred on strategic changes.

To advance the field, the next step must involve critically processing evidence to proactively and collaboratively shape and test innovative socio-technical models and approaches—such as energy poverty-based design assessments or phased co-creation frameworks—that also support tactical and operational levels.

Future studies could build on our findings to empirically test the framework through case studies, thereby deepening the understanding of just renovation processes and validating the proposed criteria. An increase in action research through pilot projects closer to residents' realities would address the detached nature of many existing exploratory and retrospective studies.

The tailored justice framework for energy renovation formulated in this study can influence future research in developing field-specific, implementation-oriented energy justice principles for other sectors and areas of practice. Meanwhile, integrating spatial justice theories can guide research towards incorporating the spatial and material dimensions of living environments and energy-related interventions. This analytical lens enables researchers to address localised inequities, refine justice metrics in urban (energy) socio-technical transitions, and develop context-sensitive strategies. Similarly, the identification of key socio-technical decision-making criteria can support future research and practice in developing holistic, participatory approaches to energy renovation and transition projects, embracing a comprehensive socio-technical concept of building and neighbourhood performance.

Exploring how justice principles operate differently in developing countries, shaping distinct priorities and trajectories for just energy renovation, would be a valuable future research direction.

Finally, this study contributes to the scalability of renovations by defining as injustices towards the (built) environment those management and design aspects that hinder achieving energy efficiency and liveability goals by neglecting contextual requirements. This can capture the interests of more engineers and technical experts, as the review reveals a tendency for social studies to focus more on technical processes than the reverse. Notably, the design and post-renovation implications of integrating renovation technologies, as well as the implementation phases, are critical to just processes but remain underexplored, requiring more scholarly attention.

CRediT authorship contribution statement

Diletta Ricci: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Thaleia Konstantinou:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. **Henk Visscher:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT and Grammarly to improve the clarity and cohesion of the English writing, as they are non-native English speakers. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table A1
Coding system and analysis workflow

1) Inductive quantitative metadata analysis (Section 4)	
Inductive process: Specific observation➔ Pattern recognition➔ General conclusion	
Codes	**Description/indicators**
Authors	-
Year of publication	-
Journal/conference	Name of the Publication
Country	Main author's affiliation country
Theoretical underpinning	Presence or absence of theories; typology of the theories adopted.
Article approach	Retrospective exploratory analysis/ test case/ innovative methodology/ new perspective proposal / theoretical analysis
Article orientation	Process-oriented dynamics (e.g. planning management, decision-making influences and procedures) or design-oriented aspects.
Research Methods	Typology of research methods adopted
Target residents (ownership)	Tenants/homeowners/mix/n.a.
Renovation phases	Decision-making stage(s) (according to Fig. 7) on which the article primarily focuses.
Main research theme	Thematic categorisation to cluster the articles in core themes addressed.
2.1) Analysis by Justice Principles (Section 5)	
Deductive qualitative thematic analysis: Theory ➔ Hypothesis (synthesis framework of justice theories) ➔ Data collection ➔ New constructs and validation (domains and subdomains identified, see Table 5)	
Recognition justice elements	Aspects of the articles (empirical findings, theoretical frameworks, suggestions, approaches and methods proposed) that align with the principle of justice in question as defined by the analytical framework (Fig.1). Actors and renovation phases concerned by the (un)justice trajectory identified.
Procedural justice elements	
Distributive justice elements	
2.2) Focused thematic analysis and validation step: additional coding round and more focused analysis based on the domains and subdomains identified per Justice principles (Section 5).	

Table A2
Definitions and interpretations of main research themes derived from the reviewed literature.

Main research themes identified	Authors interpretation of the theme
Integrated decision-making + social sustainability criteria	Critical analysis of decision-making aspects or models that address social sustainability issues; proposals for decision-support methodologies that integrate social criteria.
Residents' engagement: Information accessibility/ participatory methods	Focus on residents' involvement: effectiveness of information strategies, application and/or analysis of participatory methods, critical analysis of residents' involvement barriers in renovation projects.
Interaction users-building, users-renovation technologies	Analysis of how residents perceive and interact with renovation technologies, considerations on how such relation can influence renovation investments or acceptance.
Barriers/drivers to energy retrofit processes	Extensive analysis of various process bottlenecks and drivers at different decision scales and phases.
Social equity - energy (retrofit) affordability	Critical reflection on the equity of renovation processes, how renovations are supported or hindered by financial mechanisms and their accessibility to low-income and vulnerable people.
Motivation/attitudes/expectations towards renovations	Psychological aspects affecting individuals' willingness to undertake or support renovations, including their expectations and motivations.
Financial, governance and regulatory aspects	Financial frameworks, governance structures, and regulatory policies that influence renovation practices and their implementation
(Energy) behaviours - social interactions	Focus on behavioural aspects and daily habits, energy practices. Considerations on rebound and prebound effects, and local social interactions affecting decisions and (energy) practices.
Stakeholders' dynamics	Focus on collaborative dynamics between the stakeholders involved in the renovation process, risk and responsiveness sharing considerations in the process, critical analysis of dysfunctional and functional relationships
Decision-making on alternative renovation strategies	Focus on design decisions, proposal and assessment of alternative renovation strategies, and packages of measures according to multiple criteria.
Renovation and ageing	Focus on renovation for older residents and for an ageing population, including consideration of design implications and difficulties of engagement.
Health impact	Considerations on how energy renovations in residential buildings affect residents' health.

Table A3
Research methods of the analysed literature with the specification of the authors for each method.

Research methods	Articles reference	N
Survey/questionnaire	[14,15,17,18,30,34,36,39,58,62,65,67,107,108,115,116,117,121,124,125,132,133,139,141,142,145,155,159,165,167,169,170,172]	33
Interviews + case study	[59,136,14,18,106,156,64,45,46,57,44,132,157,129,120,19,139,110,141,161,168,69,123,16,172,62,112,68,118,48,109]	31
Review/desk research	[13,16,25,29,37,45,47,56,59,106,110,132,133,135,137,138,140,144,147,149,150,154,166,171]	24
Statistical analysis	[30,36,39,40,42,65,108,115,117,121,126,127,128,130,135,150,152,153,163,164,165,167,172]	23
Workshop/focus groups/ co-creation	[14,39,42,62,64,67,68,118,121,133,136,141,142,149]	14
Interviews	[46,58,63,67,111,113,119,122,133,143,151,158,159,160]	14

(*continued on next page*)

Table A3 (*continued*)

Research methods	Articles reference	N
Energy, costs simulations/ assessment	[66,67,69,114,123,124,128,131,150,152,155,164,167,170]	14
Ethnographic/on-site observation/ fieldwork	[19,45,64,68,118,121,132,141,158,160,167]	11
Monitoring	[42,57,68,139,141,145,163,167,172]	9
Research through design	[19,155,163]	3

Table A4
Distribution of renovation measures in the reviewed literature

Renovation Measures	Specifics	Articles reference	N
Energy-related			**274**
Passive Measures			**156**
Insulation		[13,30,39,40,44,45,48,57,58,59,64,65,68,69,102,108,115,120, 122,124,126,135,139,150,159,160,161,162,163,164,167,169,170,171]	34
	Roof insulation	[30,34,36,48,65,68,69,107,114,115,119,121,125,126,132,135, 145,150,156,163,170,172]	22
	Wall insulation	[13,30,34,36,39,48,65,69,107,114,119,121,122,123,128,132,145,156, 157,158,163]	21
	Ground insulation	[13,30,34,65,119,123,132,145]	8
Windows replacement		[13,27,31,34,36,48,59,65,102,108,110,114,117,120,121,123,128, 132,135,155,156,157,168,169,170]	25
	Double glazing	[40,123,150,167,170]	5
	Triple glazing	[42,57,69,122,139,150,162,169]	8
Draught-proofing/ sealing		[13,27,48,69,115,123,124,135,139,155,167]	11
Doors replacement/airtight		[27,31,65,135,162]	5
Passive heating/ cooling or ventilation systems	e.g. Solar greenhouses, Trombe-Michel wall	[19,117,157,163]	4
Sun shading		[18,19,45,157,170]	5
Lighting improvement			
	Natural lighting	[57]	1
	LED	[117,124,132,135,155,164,172]	7
Active Measures			**118**
Mechanical ventilation		[18,19,31,36,42,45,48,57,62,64,65,69,102,124,126,132,139,150,156,157, 158,159,161,171]	24
Heating system improvements		[13,18,31,36,42,44,45,57,59,65,69,102,110,118,121,125,126,128,132,135, 140,150,158,162,170,171]	26
	Boiler upgrades	[40,57,69,110,115,123,139,145,162]	9
	Heat pump	[18,27,45,62,64,66,68,110,115,124,125,140,141,170]	14
	District heating	[68,110,125,131,140,157]	6
Air conditioning		[44,117,132,157,163,172]	6
Renewable energy			
	Solar panels	[13,18,19,30,45,64,65,68,110,115,126,140,150,161,170]	15
	Photovoltaic	[13,40,42,58,62,112,119,120,124,126,135,139,141,145,164,170]	16
	Biomass	[14,170]	2
Non-energy related			**51**
Damaged parts, moisture		[69,132]	2
Dwelling upgrades		[31,48,57,69,125,148,156,160]	8
	Space distribution	[48,57,69,148,158,160]	6
	Kitchen and bathroom	[16,48,69,132,148,158,160]	7
Security improvements		[132,148,156]	3
Accessibility upgrades		[48,69,139,148,169]	5
Floor replacement		[31,132,148]	3
Finishing, cladding/ painting		[19,69,132,156,170]	5
Seismic improvements		[148,162]	2
Water harvesting		[135,160]	2
Smart control interfaces		[57,118,132,158,161]	5
Outdoor improvements		[125,151,156]	3
Non-specified/mentioned as part of a general discussion on energy renovation		[15,17,25,29,35,37,46,47,56,58,63,67,106,109,116,127,129,130,133,134,136, 137,138,142,143,144,146,147,149,151,152,153,154,165,166,170]	**36**

Data availability

No data was used for the research described in the article.

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