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RESEARCH ARTICLE

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Actor perceptions and network characteristics around climate-wise housing and construction in Finland

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ABSTRACT

Interaction between actors in sustainability transition is fundamental for generating knowledge about what constitutes a just, equitable and sustainable society. This paper focuses on the Finnish housing and construction sector as a socio-technical system, which currently accounts for about 40% of energy consumption and 35% of greenhouse gas emissions. A qualitative interview study with 18 organizations and a larger network study involving 35 actors were conducted to address the research questions: How do actors constitute a network and define climate-wise housing and construction? What specific focus areas can be identified around climate action? What issues support or inhibit climate-wise housing and construction? Although the network appeared relatively dense and inclusive, misalignment emerged upon closer examination. The actors were uniformly engaged in energy-related topics, but differed in their emphasis level on household choices, low-carbon materials, and the circular economy. Supporting and inhibiting factors were identified within three broad categories: alignment of goals, network characteristics, and transformation propensity. The findings suggest that climate action is gaining ground in housing and construction, but there is evidence of institutional inertia, a demand for accelerating support for intermediation, and a need to harness organizational resources and individual capabilities to create sustainability transitions.

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Sustainability transition; networks; climate action; energy efficiency; circular economy

Introduction

Environmental problems related to climate change are manifold, and they impact human societies in countless ways (Griggs et al., 2013). Despite an increasing focus on mitigation and adaptation to the current climate crisis, not enough has been done to limit global warming to acceptable levels (IPCC, 2022). This 'wicked problem' of climate change is unique, complex and uncertain (Incropera, 2016). Thus, the only way to manage the problem in the absence of a simple solution is a major shift in current societal functions, a so-called sustainability transition (Elzen et al., 2005).

Transitions impact all sectors of society and are related, for example, to interconnected changes in cultures, policies, markets, science and technologies (Kanger & Schot, 2019). The catalyst for change is often associated with new innovations, disruptive technologies in a particular niche, as they enable transformation[1] in society (van Bueren & Broekhans, 2013). Sustainability transition requires both technological innovations, commonly motivated by economic goals, and social innovations, which are driven by societal needs and the uptake of new practices, which may be either hindered or supported by existing institutions (Cajaiba-Santana, 2014; Kivimaa et al., 2021). In line with this, according to a review by Köhler et al. (2019), transition research has more recently engaged in studying a wide range of actors, including organizations, industries, citizens, consumers and other representatives of civil society, or social movements, as they possess and represent different geographies, power, agency and resources.

The overall purpose of this study is to investigate actor-related issues – alignment of conceptions of climate wise-housing, perceived characteristics of network relations, and patterns of institutional learning, which support or inhibit sustainability transition in the context of housing and construction. This study utilises the term *climate-wise housing and construction*, which refers to solutions that enable reductions in carbon dioxide emissions during the life cycle of buildings (i.e. operational and embodied emissions) (for more information, see, e.g. Horup et al., 2023). Correspondingly, *housing and construction sector* that encompasses the actors dealing

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with climate-wise housing and construction issues is referred to. Regarding the global sustainability transition, housing and construction play a key role both in reducing carbon dioxide emissions and in enhancing human well-being in the built environment (Harju & Lähtinen, 2022). First, it has been estimated that about one-third of carbon dioxide emissions are caused by the manufacture of building materials and the use of residential buildings (United Nations Environment Programme, 2021). Second, the world's growing population has an ever-increasing need for safe and healthy dwellings (Moore & Doyon, 2023). Despite this, the construction sector has lagged behind in sustainability transition and in the uptake of innovations that could promote positive future development (Munaro & Tavares, 2023; Sadeh et al., 2023).

The pace of sustainability transition in housing and construction is affected by interactions between actors within both niche and dominant regimes to enhance mutual learning and adaptation of environmental and social innovations (van Bueren & Broekhans, 2013). Accordingly, actors' visions for and actions within environmental sustainability, and the networks they foster, play a key role when looking to understand the potential for accelerating sustainability transitions. Understanding the perceptions and attitudes of diverse stakeholders is therefore crucial to success in regulating the carbon life cycle of buildings (Räihä et al., 2024).

Finland represents an interesting case of a country actively working to reduce its climate footprint from the built environment, in line with its national goal of achieving carbon neutrality by 2035. In recent years, Finland has substantially increased wind and solar energy production, enhanced energy efficiency and household use of heat pumps, and reduced dependence on energy imports from Russia since the start of the war in Ukraine. According to Räihä et al. (2024), however, a further increase in the energy efficiency of new buildings and renovating old buildings will not suffice, and hence more emphasis will be placed on building materials and construction activities. In addition to improving energy efficiency, the shift towards the use of renewable energy sources in the construction industry cannot be ignored, since they can be used for both material production and operational energy consumption (Murtagh et al., 2020).

To achieve the overall purpose of the study, information is provided on the following research questions: First, how do actors conceptually define climate-wise housing and construction? Second, how are actors related to one another, namely, what type of network characteristics and actor positions can be identified? Third, and crucially, what are the issues that support and inhibit the sustainability transition of the Finnish housing and construction sector? The data for the study consist of semi-structured online interviews with a pre-defined set of stakeholders, which were conducted as a starting point for the network analysis.[2]

Conceptual background

Sustainability transitions are long-term societal changes brought about by the emergence of new innovations in socio-technical systems that are characterised by strong path dependencies and lock-ins due to a high level of institutionalization of key elements (Markard et al., 2016). According to the Multi-Level Perspective (MLP) framework (Geels, 2002), structures for a systemic socio-technical change may be depicted through interactions between a niche level, a regime level, and a landscape level. For Geels (2011, p. 27), a regime of established actors is key to 'orient and coordinate the activities of the social groups that reproduce the various elements of socio-technical systems'. However, in terms of sustainability transition, regimes are usually only able to generate incremental innovations. This paper focuses in particular on the niche level of the MLP, emphasizing potential alternative socio-technical configurations (Fuenfschilling & Truffer, 2014). Hence, transitions are perceived as involving continuous contestation between emerging niche innovations and existing socio-technical systems and regimes.

In the broader context, following the more dominant technology orientation in the early 2000s, research on sustainability transitions has also evolved in new directions, including deeper consideration of actor perspectives (Köhler et al., 2019). Strategic niche management by Kemp et al. (1998) and Schot and Geels (2008) has specifically developed to provide information about the role of actors and networks in transitions.[3] This approach focuses on studying the circumstances under which the emergence of niche innovations is possible, traditionally looking at internal processes within the early stages of innovation development (Kemp et al., 1998). The theory regards three processes as critical to the success of an innovation: the articulation of expectations and visions, the construction of social networks to involve actors and provide resources, and the facilitation of learning processes in multiple domains (e.g. technology, markets, regulatory, cultural) (Kemp et al., 1998; Schot & Geels, 2008).

The first strategic niche management process necessitates envisioning how certain technological changes will alleviate societal problems, or expectations of specific outcomes will help to attract attention and legitimise their market entry. As predicted by theory, the diffusion of climate-wise housing and construction,

in our case, should therefore be more likely to succeed if the expectations and visions of the future are more specific and robust (Schot & Geels, 2008). The alignment of goals gives clear direction to niche activities, reduces uncertainty, facilitates coordination and attracts support, but as Schot and Geels remind us, a diversity of goals can also be useful for innovation. Alignment with external factors such as societal expectations and policy frameworks can increase the likelihood of diffusion. This *alignment of goals* is linked to the first research question on defining climate-wise housing and construction.

Second, the building of new actor relationships is required to embed the necessary resources and capabilities for experimentation and market entry (e.g. funding, expertise, customer connections enabling market access), and to create suitable networks for the production of new technology to function (e.g. infrastructure and supply). Hence, the strategies, resources and capabilities of individuals and organizations may trigger innovations and initiate transitions (Farla et al., 2012), or inhibit development. Although pro-transition networks are often associated with the niche level, the regime-level incumbent actors have also been found to act as intermediaries or to play a pro-transition role (Fischer & Newig, 2016; Köhler et al., 2019). According to the review by Fischer and Newig (2016), actor roles in transitions are often erratic, since roles can change over time, and actors can also belong to multiple categories. Different actors can take on intermediary accelerator roles in transitions, and in the case of housing and construction, for example, perspectives on the circular economy (e.g. renovations, re-use and circulation of materials) (e.g. Ghafoor et al., 2023; Kocaturk & Reza Hosseini, 2023) are less well understood, having a multitude of organizational, economic, technical, social, political and environmental challenges in implementation. Crucially, Fischer and Newig (2016) see merit in paying more attention to networks, as they may provide linkages and channels that enable transitions when actor roles change. Furthermore, seeing network collaboration as developing and nurturing reciprocal[4] relations also suggests social learning as the model for understanding actions (Molm, 2010). These factors of *network characteristics* are connected to the second research question on the nature of the network that actors are embedded in.

The third prerequisite is that the technology development processes should build on market knowledge (from the regime level) and be able to enact a learning process starting from current mindsets. The term adopted here is *transformation propensity* (Hammond, 2020). This encompasses the perceived factors of and likelihood to engage in, support, and endorse transformative sustainability actions (Marcus et al., 2015). In addition, as Farla et al. (2012) point out, as the transition unfolds, the roles of these actors, as well as their relative positions and relationships, may also start to change, especially if the current regime becomes more destabilised.

Berninger et al. (2017) discuss three aspects that should apply to any pro-transformation actor: First, the ability to contest human-made institutional practices and core parameters such as the 'efficiency' or 'viability' of the proposed action; second, to connect and network with pro-regime actors to gain support and counter opposition; and third, to maintain the momentum for change for relatively long periods of time. Learning as both organizational reflection and interactive processes (see Argyris & Schön, 1996; Lundvall & Johnson, 1994) works towards the ability to change mindsets in the technology, market, culture and policy domains at the regime level (van Mierlo & Beers, 2020). We therefore consider institutional learning in the context of how actors construct explicit information, knowledge, ideas, structures and mindsets that work – create actions – for and against transitions (see Fagerberg, 2018; cf. Schot & Steinmueller, 2018). This relates to the third research question on the issues supporting and inhibiting transition (Adabre et al., 2023; Häkkinen & Belloni, 2011; Shooshtarian et al., 2023).

Methods

Our research questions called for a research design that, within the overall framework of the Multi-Level Perspective, enables the operationalization of the key Strategic Niche Management factors, namely the alignment of sustainability goals in relation to climate-wise housing and construction; characteristics of the (policy) network as determined by the actor relationships; activities and potentials for intermediation; and the propensity of the actors to initiate transformative action. Figure 1 depicts the research design and process.

Interviews were selected as the primary data-gathering method (Stages 2a and 2b), supported by the use of an interactive graphic tool (Stage 2b) and document analysis (Stage 1), designed to facilitate discussion of the complex issues underlying climate-wise housing and construction with actors representing a wide range of organizations.

Semi-structured online interviews were carried out with a pre-defined group of actors from the 'housing and construction sector' in Finland in connection with the DECARBON-HOME research project. The project focuses on understanding how best to reduce the climate impact of the construction and housing sector.

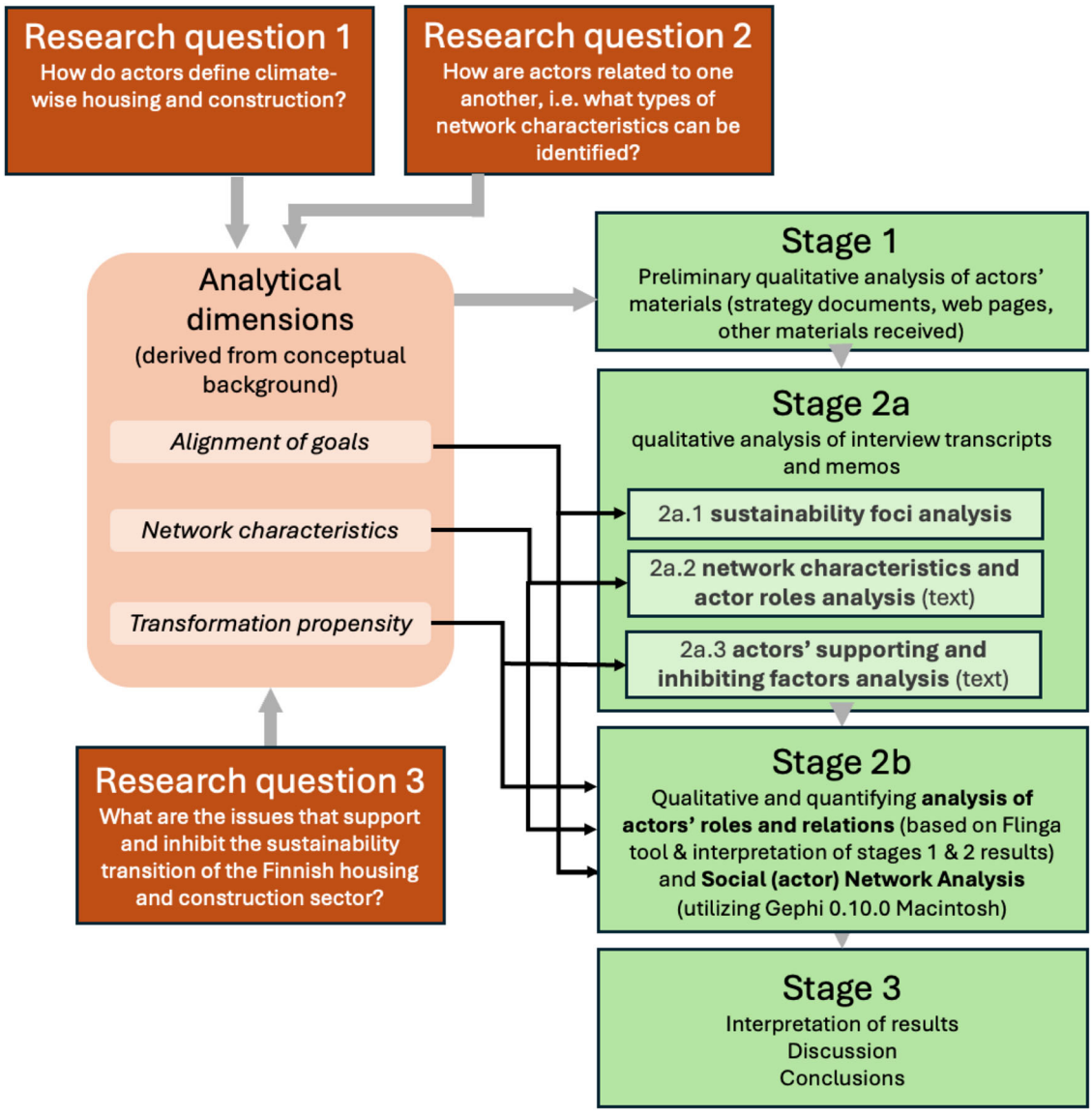

Figure 1. Research design and process.

Actors from different industries and sectors have been invited to join as stakeholders, and to participate in project activities. These actors range from government ministries and executive bodies to cities, energy, construction and housing sector industry associations, NGOs and the media. The selection of actors was guided by the results of previous related studies in Finland (e.g. Kivimaa et al., 2019; Vihemäki et al., 2020) on the main organizations in different sub-sectors of what is here called the housing and construction sector, and modified according to the scope of the project. This group is understood as a policy network, as opposed to a broader 'sector' network that also includes actors at the operational level, namely construction companies, energy suppliers and service providers.

A total of 18 actors were interviewed during February 2022, with each interview lasting 50–90 min (see Table 1). A structured interview guide was followed to ensure uniformity in the themes addressed with the interviewees. To ensure reliability, the interview results were assessed multiple times and compared to written documents. All interviews were recorded and transcribed, and the graphical presentations co-produced during the interviews were compiled for analysis. The quotes from the transcriptions used in this paper were translated from Finnish by the authors. Importantly, the graphical network analysis also considers an additional 17 actors that were mentioned by the interviewees as relevant to the overall policy network in the housing and construction sector.

The first half of the interviews explored the actors' understanding of what constitutes 'climate-wise' action for them within housing and construction, and their plans and strategies to achieve it. During the second

Table 1. List of network actors, including their sector and actor type classifications. Actors in bold were interviewed for the study, and the rest were mentioned in the interviews. Some generic mentions were grouped ('EU' and 'media', 'NGOs', 'educational institutes') to enable meaningful network analysis.

Actor	Abbr.	Actor's sector	Actor type
Ministry of Environment	**MoE**	**Government**	**Ministry**
Housing Finance and Development Centre of Finland	**ARA**	**Government**	**Executive body**
Motiva	**Motiva**	**Government**	**Executive body**
Rural Policy Council	**MANE**	**Government**	**Policy council**
City of Helsinki	**Helsinki**	**Municipality**	**City**
City of Vantaa	**Vantaa**	**Municipality**	**City**
City of Turku	**Turku**	**Municipality**	**City**
City of Joensuu	**Joensuu**	**Municipality**	**City**
Finnish Energy	**FE**	**Energy**	**Industry association**
Finnish Clean Energy Association	**FCEA**	**Energy**	**Industry association**
Finnish Heat Pump Association	**SULPU**	**Energy**	**Industry association**
Finnish Association of Architects	**SAFA**	**Planning and Construction**	**Planning industry association**
Finnish Youth Housing Association – Apartments	**YHA Ap**	**Planning and Construction**	**Developer and real estate manager**
Green Building Council Finland	**GBC**	**Planning and Construction**	**Construction industry association**
Finnish Real Estate Management Federation	**FREM**	**Real estate**	**Real estate association**
Finnish Real Estate Federation	**FREF**	**Real estate**	**Real estate association**
Finnish Home Owners' Association	**HOA**	**Civil Society**	**Housing association**
Martha Organization	**Marthas**	**Civil society**	**Housing and living NGO**
EU	EU	Other	International regulatory body
Centres for Economic Development, Transport and the Environment	ELY	Government	Executive body
Association of Finnish Municipalities	AFM	Government	Municipality network
ST1	ST1	Other	Energy provider
Confederation of Finnish Construction Industries	CFCI	Planning and Construction	Construction industry association
RAKLI Finnish Property Owners	RAKLI	Planning and Construction	Construction industry association
Central Union of Agricultural Producers and Forest Owners	MTK	Planning and Construction	Construction industry association
Confederation of Finnish Industries	CFI	Planning and Construction	Construction information provider
Finnish Association of Civil Engineers	FACE	Real estate	Consumer association
Media	Media	Other	Media outlets (combined)
Building Information Foundation	BIF	Planning and Construction	Other industry association
	CUF	Civil Society	Consumers' Union Finland
Environmental NGOs	ENGOs	Civil Society	Environmental NGOs (combined)
VTT Technical Research Centre of Finland	VTT	Research and Education	Research institute
Finnish Environment Institute	SYKE	Research and Education	Research institute
Natural Resources Institute Finland	Luke	Research and Education	Research institute
Research and Education Institutions (e.g. Universities, Polytechnics)	R&E	Research and Education	Education institutes (combined)

half, information was gathered for the network analysis by asking the interviewees to list relevant and less relevant actors in their sector, and to describe their relationship with these actors. This was carried out with the help of a Flinga tool, which provides an efficient methodological aid for visualizing the content of discussions. For the purpose of this study, the use of the Flinga tool strengthened the possibilities for reliable, comprehensive and transparent qualitative interview data collection (for the use of Flinga, see Ludvigsen et al., 2019).

To gain an understanding of the actors' focal points in climate-wise housing and construction, qualitative content analysis was applied (e.g. Stemler, 2000). This is a flexible method that can be applied in relation to research questions that require the systematic exploration, understanding and interpretation of textual or visual data (Schreier, 2012), and was therefore a suitable complement to our data gathering. Following Forman and Damschroder (2007), the analysis was conducted in three steps. After the initial content analysis and preliminary coding of the data, additional insights were gleaned by studying the actors' strategy documents and online website information. These were used to determine the level of intensity in each focus area (0–3). Further analysis was then conducted to make sense of the substance and importance of these focus areas for the actors in general and per sector.

To construct, dissect and understand the relationships between the actors studied and to identify potential intermediaries, social network analysis was carried out (see Lienert et al., 2013), albeit in a simplified form. Gephi software was used for both network structure analysis and the calculation of key node characteristics. Graphical representations of the network were generated with the Yifan Hu algorithm, which functions well in depicting the parts of the network that are closely

connected (e.g. Palmer, 2016), while staying true to the forces prevalent in the network structures (see Hu, 2005). The Yifan Hu graph was interpreted by visualizing clustering and community structures within the network, as the method groups together nodes with similar attributes. Identifying these clusters provides insights into the organization and functionalities within the network.

As Lienert et al. (2013, p. 138) note, two attributes readily explain the central characteristics of the network structure: *Degree centrality* of nodes shows the potential for access to information and for framing power in network actions (see also Hansen et al., 2020). *Betweenness centrality* depicts the integration of actors into the network, thus showing the potential to act as a hub, an intermediary, or a gatekeeper. These measures were found to be well suited to the case, since the network information has been acquired through visual interrogation within the interviews, which provided rich data on the actual interactions and notions of collaboration (and, indeed, the lack thereof), thus enabling quality assurance of the computer model outcomes. The initial network analysis was strengthened by paying attention to, for example, the absence of links and the relative strength and reciprocity of individual relationships (see Reed et al., 2009). In this case, the diverse portfolio of actors creates a complex system with different motives, institutional logic and behaviour, and further categorization can help to better analyse relationships (Czischke, 2018). Hence, the initial sectoral categories (see Table 1, third column) were included in the network analysis.

Results

Alignment of goals

Actors' self-stated focus areas in climate-wise housing and construction were used as a basis for focus area categorization. This resulted in five distinct themes. The first four had been identified in previous studies and were therefore recognised as initial focal points for analysis, but the last, material circularity, was strongly emphasised by several respondents and was duly appended to the category listing. Figure 2 shows the actors and their respective focus areas.

Energy issues

All interviewees had an identified focus on an energy issue within the built environment. Renewable energy was the most common focus area, reported by all but one actor, followed by Energy efficiency. Energy-related initiatives within the industry were deemed highly important for the overall likelihood of the sustainability transition, but there was a difference of opinion on whether the focus should be broader or limited to these initiatives. Some considered that the operational focus should now shift to other issues, such as the building materials used. Others felt that ageing housing stock in particular would benefit from energy-related refurbishments.

Government-related organizations dealing with policy development or implementation provide funding for the refurbishment of renewable energy systems or offer guidance to organizations and individuals.

	Renewable energy	Energy efficiency	Household choices	Low-carbon materials	Circularity
Finnish Energy (FE)	+++		+++		
Finnish Clean Energy Association (FCEA)	+++	++	+++		
Finnish Heat Pump Association (SULPU)	+		+++		
Finnish Home Owners' Association (HOA)	++	+	+++		
City of Vantaa (Vantaa)	+++	+++	+++	+	++
Finnish Real Estate Management Federation (F	+	+++	++		
Finnish Real Estate Federation (FREF)	+++	+++	++		
Martha Organization (Marthas)		+	++		+
City of Helsinki (Helsinki)	+++	+++	++	+	+
Youth Housing Association (YHA Apartments)	+++		++	+	+
Rural Policy Council (MANE)	+		+		
Housing Finance and Development Centre (ARA	++	+++		+	
City of Joensuu (Joensuu)	+	++		+	++
Motiva	+	+++	+	++	+++
City of Turku (Turku)	+++	++	+	+	+++
Ministry of Environment (MoE)	+	++		+	+++
Finnish Association of Architects (SAFA)	++	++		+	+++
Green Building Council Finland (GBC)	++	+		+++	+++

Figure 2. Focus areas of the interviewed actors (darker green depicts greater emphasis; + signs denote the assigned strength on a scale between zero and three. Interpretation based on (a) interview mentions, (b) organizational strategy, and (c) organization webpage content. 0 = focus was not mentioned in the interview; 1 = more than one mention in the interview, some mentions in either strategy or webpages; 2 = multiple mentions in the interview with some emphasis explicated, some emphasis of focus in strategy or/and webpages; 3 = multiple mentions in the interview and central emphasis explicated, focus centrally present in strategy and/or webpages.

Energy efficiency initiatives were therefore often mentioned as more important than renewable energy actions. However, municipalities had a contrasting view. This is understandable since three out of four cities have their own energy production facilities, leading them to consider the transition to renewable energy. Nonetheless, some municipal interviewees saw little direct influence on this aspect of the transition, as energy companies are independent of city administration.

Household and material choices

Second, the importance of household choices was emphasised to some degree by most interviewees. These choices were mainly expressed in terms of the ability and right of citizens to make informed choices about energy-related options for heating their homes. The topics included, for example, the provision of energy-saving tips for households, or obtaining impartial advice on which heating solutions would be most energy – and cost-efficient. Interviewed actors saw their role either as a disseminator of information to citizens, or as an advocate of household rights within the wider community.

> *We help energy consumers understand how they can produce and use renewable energy, and empower them to move from being a bill-payer to a more diverse role.* – Energy sector actor.

> *Our basic mandate is to promote a good and sustainable everyday life for ordinary citizens. We see energy saving as an important theme.* – Civil society actor.

Many of the actors have an official mandate that involves dealing with citizens or homeowners on a regular basis, which helps explain their keen interest in household decision-making. Energy-focused actors in particular regarded house occupants' choices as important, as they considered that the role of the energy consumer is changing to a more active one, including involvement in energy production.

Third, choices favouring low-carbon materials were considered by about half of the interviewees, and also featured strongly in their mandates. Although generally defined as any construction material with a lower carbon footprint, throughout the interviews these materials were almost always synonymous with wood. Overall, it was the public and construction sectors that put emphasis on low-carbon materials whereas the energy, real estate and civil society sectors were silent. Pilot actions were also frequently mentioned, and all construction sector actors agreed that material considerations are becoming more important.

Circular economy

Lastly, a majority of the actors had some degree of focus on circular economy. Circularity was often seen as a wider theme, extending beyond the built environment. Within planning and construction, circularity aspects were related to the life-cycle performance of buildings, including the reuse of materials or whole structures in new buildings, and the recycling of materials for a different use post-demolition. Additionally, aspects of planning, such as knowledge of how to design buildings suitable for the circular economy in terms of both materials and use, were also underlined. The circular economy at the household level was connected to recycling or practices associated with the sharing economy (e.g. communal bikes).

> *Our take on [material] circularity is closely connected to refurbishing […] A big aspect for us is the use of existing buildings, at least the frames, as it represents the best circularity.* – Planning and construction sector actor.

> *We see [material] circularity as a wider issue that enables the low-carbon transition.* – Municipal actor.

The actors with the greatest emphasis on circularity, for example through recycling materials and considering the life-cycle impacts of buildings, were found within the public sector and the construction industry. Many of them strongly felt that circular economy thinking will play an enabling role in sustainable housing and construction, and that considering the whole life cycle of a building is the next step forward.

All but one of the actors emphasizing the circular economy also shared a focus on low-carbon materials. Conceptually, the two issues are adjacent in relation to the development of a circular bioeconomy. Circularity was also sometimes connected to the sharing economy and household recycling practices, rather than materials. However, only one actor mentioned a specific circularity pilot project. Some actors have developed their own circularity strategies (in addition to low-carbon climate plans).

Overall, the variance and different weights are given to the perceived focal points of sustainable transition point to complex intersections of policy adherence and actor-specific interests. Energy is a strong focus in the network. However, goal alignment is a dividing factor: while public sector actors have a strong affiliation to circularity, energy sector actors in particular have little interest in it. Issues of household decisions concern many, but the focus is isolated from other perspectives. Thus, the potential contribution of households to the transition is not fully exploited in the policy network. For example,

sustainable materials – seen as an increasingly important area in the future (e.g. Räihä et al., 2024) and well aligned with circularity – are not seen as central to the sustainability transition.

Network characteristics

Network structure

During the interviews, all but one of the interviewees received mentions from the others. These aspects would indicate that actor relations are indeed networked, a sentiment corroborated by the social network analysis. The network analysis revealed the important role of the public sector in the decarbonization of the housing and construction sector in Finland. All but one actor mentioned ministries, especially the Ministry of the Environment (MoE), as an important or very important connection. Similarly (the transition to net-zero buildings in Finland), Kivimaa et al. (2020) noted that the MoE had taken an active role in driving development, particularly in agenda-setting and policy formulation, while in policy implementation other actors also assumed prominent roles in the emerging network.

Also municipalities received a high number of mentions, and city-government linkages in particular were deemed important. Finnish municipalities, by virtue of their self-governing powers and obligations, are multifaceted actors in the housing and construction sector. Their central position is therefore to be expected.

The visualization of centralities and the network structure (Figure 3) shows that most key actors have strong and relatively even degree centrality scores, and that there are key actors in many sectors. This denotes a well-rounded network. The visualization highlights the close connections between government actors and municipalities, as well as the relative abundance of planning and construction actors in peripheral locations.

The MoE was found to be an essential actor, as reflected in the network analysis with the highest centrality scores in both degree centrality and betweenness centrality (Figure 4). It is both a central information and power node. Indeed, many non-public sector interviewees highlighted the

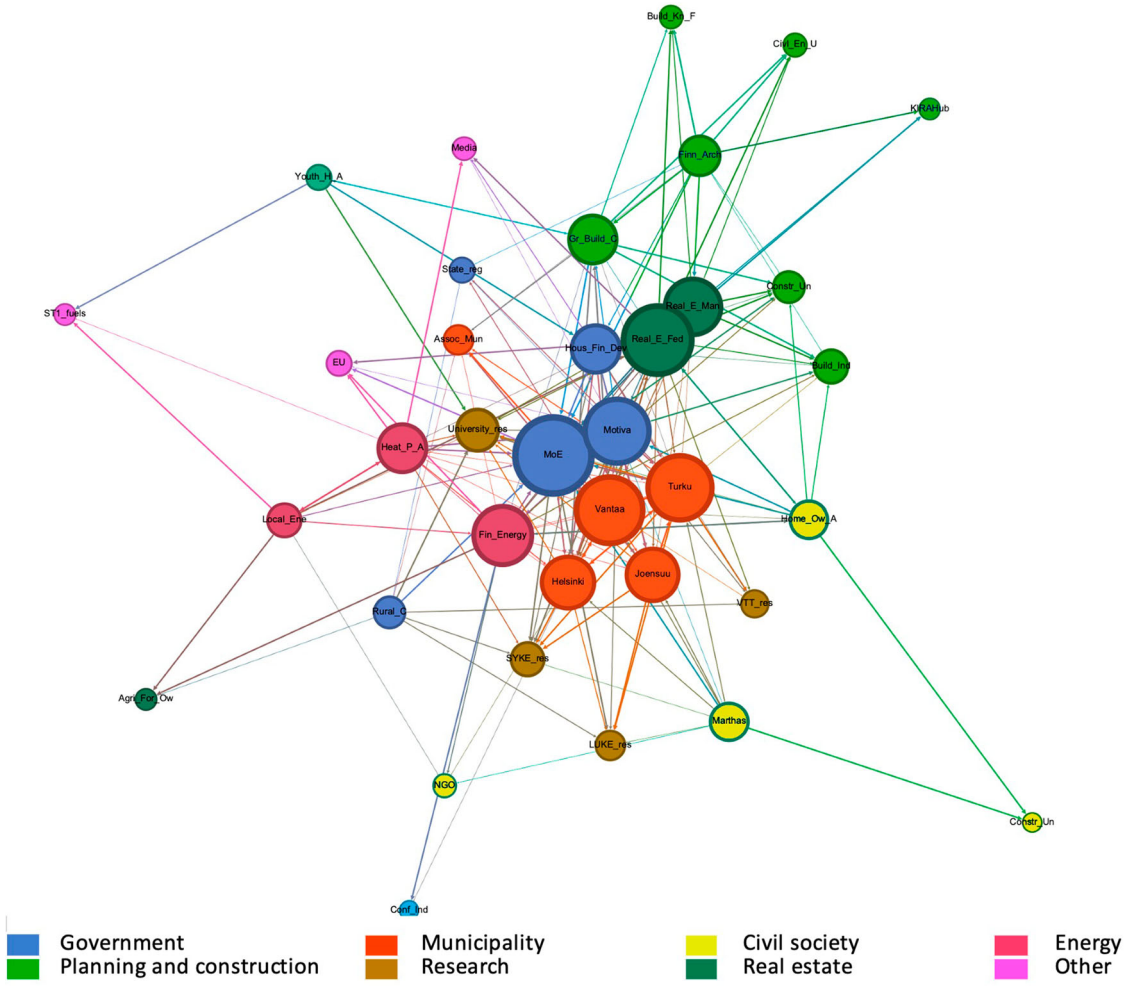

Figure 3. Network structure according to the Yifan Hu algorithm. Circle size denotes the degree centrality of each actor. The link weights are included in the calculation.

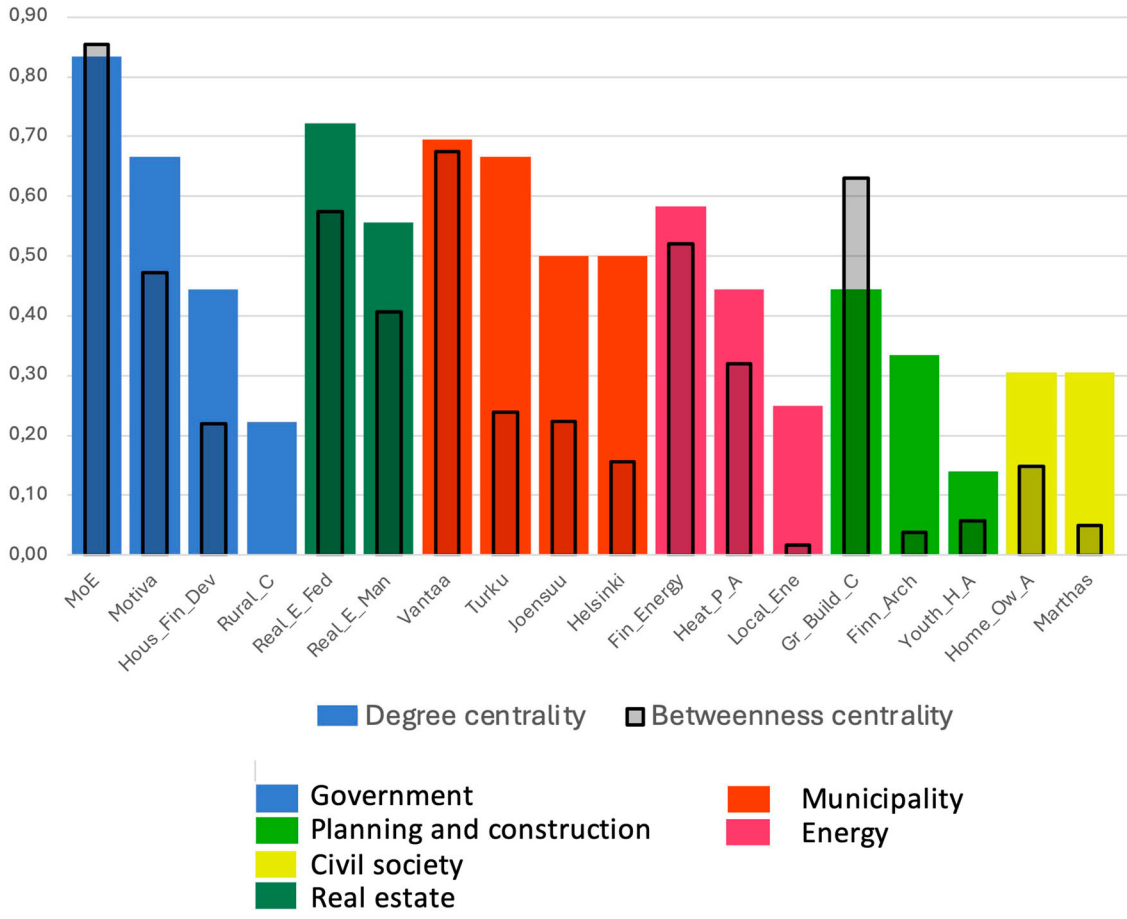

Figure 4. Centrality scores with actors grouped according to sectors. The comparatively high values of betweenness centrality denote potential intermediaries. Scores have been normalised to values between 0 and 1 for meaningful presentation, but direct comparisons between degree and betweenness should not be made.

importance of influencing government decision-making. Again, this mirrors the findings of Kivimaa et al. (2020), who highlight the central and overarching role of the MoE.

As shown in Figure 4, the distribution of betweenness centrality is somewhat more uneven than that of degree centrality. The core network (actors with the highest degree centralities) is dense and includes actors from four sectors. This coincides with calls for a diverse ecology of intermediaries, including systemic ones, in order to enable comprehensive transitions. The high betweenness scores indicate potential bridging abilities, potentially as systemic intermediaries (highest combined centrality scores) or niche intermediaries (actors below the top of the sector, yet with relatively high betweenness score). Indeed, these actors were also most often mentioned as actual or potential intermediaries by the interviewees.

Actor roles and interrelations

While the overall network structure appears to be well connected, with actors perceiving a balanced network, there are also some missing links between actor groups. This hints at the potential existence of network silos, even though there was no clear consensus among interviewees on whether silos existed. In terms of the relations between different centrality measures (e.g. Farhan et al., 2019), three actors (one planning and construction, two energy sector) stand out as having the potential to serve as bridges between different parts of the network, even if they were not highly referenced by all actors. Also, few others said that they would like to broaden their network of actors, in turn suggesting that there is willingness to integrate external information. This is often linked to improving an actor's power position (e.g. Salsberg et al., 2017) and to influencing network power dynamics for network resilience, innovation and growth (e.g. Du & Zhang, 2022; Freeman, 1978)

Further analysis focused on the bidirectionality in reported links between the interviewed actors (Figure 5, Appendix 1). Overall, just 50% of the links had some level of bidirectionality. The government and municipalities are connected by a network of reciprocal

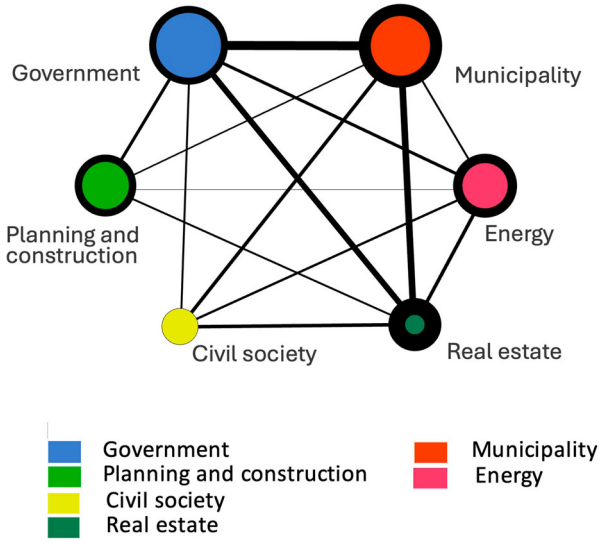

Figure 5. Reciprocity of relations within and between actor groups in the network of interviewed actors. The thickness of the lines corresponds to the perceived/reported strength of reciprocal relations between actors in sectors, while the thickness of the circle perimeters corresponds to the internal reciprocal relations within a sector (composite scores). Circle sizes denote the number of actors in the sector according to this dataset.

relationships in which each considers the other to be an important or very important partner and there is evidence of sustained mutual actions. Connections to real estate actors were also perceived by government and municipal actors as relatively reciprocal, linking real estate to the core actor grouping. On the other hand, missing interaction potentials were revealed: the energy sector has surprisingly few connections to the rest of the actors, and the planning and construction sector even fewer (Figure 5). However, many real estate, energy and government actors mentioned planning and construction sector actors who were not interviewed for this study. The results therefore highlight the specific nature of the connections between central policy actors rather than those of the broader network. The interviews also suggest that established personal relations – which are always reciprocal – are an essential part of the formation of this network (cf. Issac & Thomas, 2019; Molm, 2010). As such, the data gathering probably underestimated actual reciprocities as it captures mostly institutional links. Hence, actual reciprocity and the potential for new beneficial connections are likely to be higher than revealed in the study.

To study the relation between reciprocity and sustainability foci, indicative correlation coefficients between the overall proportion of reciprocal relations per actor and the pairwise similarity of goals were calculated. Results suggest that, overall, reciprocity and goal similarity are weakly but positively correlated. Similarity of goals is even for all lower levels of reciprocal action (below five on a scale of 1–6), meaning that increased similarity of goals does not predict increased reciprocal action nor vice versa. However, the most intensively reciprocated links were between actors with highly similar goals. Brass (2022) explains this simply as '[p]eople who are embedded in densely tied networks receive the same information' but clearly, shared normative goals are key for institutional actors. For three of the actors, the correlation was negative, suggesting a preference for selecting complementary partnerships. This indicates the potential to act as a bridge not only between network silos but also to other networks.

Overall, the network shows signs of strong leadership and a dense exchange of information between the central actors. The actions of these leading actors are in line with government policy initiatives, but other actors also recognise gaps, weaknesses and resource scarcity outside the core. The findings suggest that it is the core, dominated by the public sector, that communicates effectively, while the rest are less involved and have fewer resources to drive transformation through network activity. Reciprocity, indicating the potential for mutual learning, is limited and most pronounced between actors with similar sustainability orientations.

Transformation propensity

Throughout the interviews, respondents were explicitly asked how different actors can influence the sustainability transition in the housing and building sector. Many complained about the slow movement or resistance exhibited by certain actors, namely pro-regime actors. Several hinted that there are 'always' actors who resist change, generally traditional actors with financial interests at stake. Some commented that the sector, or 'certain' sector actors, are conservative and slow to change. Both topics drew comments on different types of actors, touching upon the energy and construction sectors:

> *Traditional operators are of course slow to change.* – Energy sector actor.

Some interviewees stated that the political will to bring about a tangible transformation was lacking, and that policymakers and decision-makers should progress from 'rhetoric to reality'. This was expressed not only in relation to decision-makers, but also in relation to the policy actors that were central to the network in our study. Regulation was seen as lagging behind, confusing and ill-suited to the needs of transformation. For example, the national energy policy was considered volatile, and concerns were expressed about altering

environmental requirements to fit the existing technologies. Similar trends were also visible within the circularity topic: some actors felt that their viewpoint on the circular use of materials was sufficient to support the sustainability initiative in construction, whereas others indicated that the industry should look at the life-cycle opportunities for reusing building structures beyond individual materials. These latter respondents voiced their concern that the other viewpoints on material-focused circularity were not innovative enough for an actual circular economy construction system. However, there were also positive, unconcerned voices:

> *Circular economy and climate change topics are commonplace, so everyone is on the same page.* – Municipal actor.

Networking relations both within and between sectors were a key development point for many respondents. They also hoped that improvements in collaboration would emerge between housing and planning and construction, between housing and energy, as well as within the energy and planning and construction sectors. Reasons for the lack of current efforts were mainly related to financial or time resources.

Actors were concerned about the difficulties in finding information on low-carbon housing and construction, both within professional circles and among consumers. Suggested solutions included increased cooperation and further work with intermediaries to help disseminate research findings. Many believed that closer cooperation with research and educational institutions would help produce new low-carbon solutions.

Work with industry associations ranged from information sharing and learning to developing joint lobbying initiatives and cross-sectoral initiatives bringing multiple actors together. Overall, the atmosphere for deepening cooperation and the willingness to share information was seen to have improved in recent years.

Some interviewees acknowledged that they mainly work with people with whom they have a good personal relationship or a prior connection, regardless of the organization or their focus within sustainability. These interviewees were, however, hoping to build new relationships or improve existing ones within or beyond their own sector.

While no open conflicts or hostile relationships were acknowledged, differences of opinion were nonetheless brought up. Although many actors were pleased that large industry associations in the energy and construction sectors had become more climate-conscious in recent years, some still considered the associations' goals, viewpoints and strategies to be at odds with their own. Interestingly, this was not seen as a reason for reducing communication, but rather important and worth improving in order to exchange views. Some also felt that it was important to keep in touch with these actors due to their influential role in the market.

> *Of course, there's this [energy sector actor] with whom we may cooperate, but we also disagree on many things. It doesn't mean that we don't work together, however.* – Energy sector actor.

Overall, actors can be considered satisfied with active networking. Although some central actors are identified as resisting change, political will for transformation is seen as lacking, and inhibiting regulation is recognized, there are signs that pro-transition actors, actions and mindsets are developing. While there are differences of opinion on how to implement transformations, collaboration is not hindered by conflicting views. In terms of providing a platform for mutual learning, incoherence was nevertheless seen by interviewees as an opportunity to make new connections across established sectoral boundaries, to develop niche actions and positions that enable innovative action, and to forge individual or sectoral visions that can nevertheless be integrated into the main transition network.

Discussion

The overall purpose of this study was to provide information on the alignment of actors' conceptions of climate-wise housing, perceived characteristics of network relationships, and issues that support or inhibit the sustainability transition in the context of housing and construction in Finland. As a theoretical background, we used strategic niche management (Kemp et al., 1998; Schot & Geels, 2008), which is characterised by processes concerning three main activities: articulating expectations and visions to provide direction; building social networks to engage actors and provide resources; and learning in multiple dimensions.

The first research question concerned the conceptualization and definition of what is meant by 'climate-wise housing and construction' among the network actors. Not surprisingly, the results show strong parallels with national policy initiatives. While energy issues, which were already articulated in the national climate strategy in the early 2000s, remain high on the agenda, circularity issues, which have become prominent at the national level since the mid-2010s, are gaining a foothold in the sector. Low-carbon materials are also a more recent addition to the agenda.

The second research question concerned the nature of network characteristics and actor roles. Overall, the

articulations point to robust networking for achieving government-defined sustainability goals in housing and construction. However, the differences in articulation of climate-wise housing and construction foci suggest low homophily (McPherson et al., 2001) that creates opportunities for niche formation and new mutual learning. The incoherence of sustainability foci also suggests, in terms of strategic niche management, that actors' operations place them at more than one level in the multilevel model (Scherrer et al., 2020). Thus, while some parts of their operations – such as overarching strategies – are aligned with regime-oriented and consensual approaches, other efforts distinctly emphasise niche development in relation to the current socio-technical system.

Large, well-known actors serve as central nodes in the housing and construction policy network in Finland. This is in line with what earlier research (e.g. Farla et al., 2012; Fuenfschilling & Truffer, 2014; Geels, 2011) sees as a principal regime constellation. The relatively dense network core with well-connected likeminded actors provides potential for efficient information flow and stability. These are the types of actual and potential intermediary actors that previous research has found to be lacking, for example in energy systems. This suggests that embracing their position in the sector could help the transition (Kivimaa et al., 2019), although possibly at the expense of the evolution of new ideas and approaches coming from niche innovations.

Reciprocity in social relationships (Molm, 2010; Oparaocha, 2016) is seen as an enabler for building shared visions, trust and mutual responsibility, as well as facilitating interactive learning (van Mierlo & Beers, 2020). Reciprocity was found to be strongest between core actors with similar foci, while reciprocities for other actors – in roles that deal with, e.g. niche actions, bridging in peripheral positions and breaking sectoral boundaries – were less pronounced. This implies that core organizations tend to maintain existing network ties and strengthen the mainstream actions favoured by regime actors. This forms a central cluster of influential actors (Brass, 2022), in which the regime-upholding actors maintain the key relationships among themselves. This often happens at the expense of exploring new, potentially transformative connections (Clausen et al., 2017). This further suggests that the network is in an early stage of mutual organizational learning, what Argyris and Schön (1978, 1996) call 'single-loop learning', which emphasises defensive reasoning and a lack of reflection on one's own position. Indeed, some of the actors identified as having further potential in intermediation did not seem eager to take on the new role (cf. Wittmayer et al., 2017; cf. Kivimaa et al., 2019) and were concerned about their lack of resources. This attests a lack of coordination among intermediary functions, and this may also constitute an inhibiting issue, as found in earlier studies in Finland (Patala et al., 2020; Vihemäki et al., 2020).

Taken together, these aspects provide a complex framework for mutual learning to support and promote sustainability transformation in the housing and construction sector. This concerns answering the third research question about the key issues in sustainability transformation in the sector. First, the issue of incoherence of sustainability priorities points to the need to embrace diversity and use strong leadership to develop the emerging spearheads – circularity and low carbon materials – as widely as possible, and to consider the inclusion of household choices, particularly in relation to a broader perspective on circularity. Second, the network characteristics point to several issues: harnessing and supporting the strong regime leadership, realizing the potential to develop reciprocal relationships between actors with different views, and working to remain agile in promoting the niche aspects for a fuller appreciation of innovative transition opportunities.

It is important to note the inherent merits and limitations of the research design. First, the choice of visual methods for data gathering on the network proved to be successful. Collecting data about actor relations with a collective whiteboard that the interviewee controlled, with accompanying recording of the spoken reflections while placing contacts along two dimensions, provided a rich data with intricate information about actor links, enabling analysis with high certainty about interpretations. As the method provides visual cues to aid reflection, and to enable many-to-many comparisons and positioning information along multiple and flexible scales, it could easily be expanded into a highly potent tool for, e.g. bridging qualitative and quantitative approaches.

Second, due to the qualitative approach and the purposive selection of respondents during data collection in a narrow, single-country context of Finland, the results are not generalizable across actors and the networks. The network analysis is, for the same underlying factors, more indicative and methodologically interesting, but less generalizable. However, the specific results and interpretations of the study should be directly applicable in a wide variety of settings, such as in the form of reflective tools and transformative insights that enable more focused approaches.

Third, in using data collected during a short period of time in 2022, it is likely that the views of the actors could have changed, particularly considering the increased energy price volatility in European markets following

Russia's full-scale invasion of Ukraine. Hence, the results reflect a specific point in time and a specific situation within housing and construction policy development in Finland. However, any study without a longitudinal element has a similar limitation.

Conclusions

The key areas of sustainability transition in the Finnish housing and construction sector are evolving, but the overall visions and goals of the participants align with national policy. This alignment should be viewed as a success in national policy development and implementation. However, there is need to bring circularity thinking to the fore in an overarching manner, strengthen the household choice perspective, and adopt policies on low carbon materials.

The crucial role of top public sector leaders as system-level hubs and intermediaries is underscored. Their leadership is essential in advancing the sustainability transition by creating clear and shared focal points, building viable networks, and promoting effective learning through strong interconnections within and across these networks. However, the results also suggest that key industry actors have (re)framed transition initiatives according to their own interests without changing the dominant industry structures. Thus, the difficulty in transitioning to foci and actor roles oriented towards sustainability is linked to the inertia of incumbents.

Many actors, both in the core and the periphery of the network, engage in niche activities. These niche aspects should be supported through, e.g. improving formal exchanges of information throughout the network, and recognizing and fostering new policy ideas and activity. The relatively low level of networking among actors in potentially intermediary positions and the limited willingness to engage as intermediaries indicate that their role needs to be understood, incentivised and enhanced in novel ways that enhance transformation propensity, providing tangible support for a variety of intermediary actions in everyday networking. For example, as educational and research actors are highly sought after partners, their potential to support sustainability transformations through further expanding their remit towards more concrete engagement in fostering organizational, institutional and societal learning should be supported by national policies and resourcing.

The network relations also enable collaboration even when disagreements over preferred actions and priorities exist. This indicates a high level of institutional and interpersonal trust, which previous studies have found paramount. Due to strong regulatory frameworks and high levels of transparency and integrity in practices, trust in institutions is high in Finland. Building further on mutual trust highlights the potential for improving network functionality.

Finally, the different conceptions of climate-friendly housing, the diversity in actor roles, the intricate network dynamics and the ambiguous relations between supporting and inhibiting factors create a rich but complex setting for sustainability transitions. This complexity highlights two main points: first, future research should use multiple methods and develop simple yet accurate approaches, such as the visual method used here. Second, public, private and voluntary sector actors need to manage uncertainty by creating strong visions and strategies, developing effective regulations and policies, and using both organizational and individual resources to foster innovation and new developments in sustainability transitions.

Notes

1. In relation to changes in activities towards sustainable policies and practices the term 'transition' is used, often as 'sustainability transition'. However, when more profound changes that also affect the structures through which 'transition' is aimed at are discussed, the term 'transformation' is utilised.
2. Ambivalence in defining such a sector in the first place, and in identifying which actors and stakeholders are part of the network thus defined is recognized. Differentiation between 'actor' and 'stakeholder' is made, acknowledging that all stakeholders are actors, but not necessarily vice versa (Nora et al., 2021).
3. The term 'actor' refers to entities that have the potential to act within a system, and to interact with or influence other actors, and the level of agency, power and interests associated with it. Here, actors are organizations rather than individuals, and may come from public, private, or voluntary sectors.
4. The terms 'reciprocal' and 'reciprocity' refer to all bidirectional linkages in the studied network, building on Molm's (2010) notions of reciprocity, but recognizing any bidirectional exchange between two or more intentionally engaged actors as reciprocal.

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Appendix 1. Reciprocity analysis table

Reciprocal relations in the depicted network of housing and construction actors in Finland. To read an individual actor's reciprocal relations, go across and down from the right-hand actor name (see guide illustration). White denotes no reciprocity, and the darker an intersection, the larger the combined score the actors gave to one another (scale 1–3, thus combined score 2–6). Sector groupings are depicted in the table as darker lines.