Community energy in residential sector: Exploring housing company residents' awareness and motivations

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***Abstract* – Community energy is essential for the green and digital transformation, legitimizing the shift to decentralized energy systems and addressing local challenges. Energy communities enable active public participation in energy consumption and production as well as improve the energy system resilience. Over the last decade, more supportive policy conditions have created a need to study public awareness and motivations for energy communities, especially in the residential sector. This study evaluates energy community awareness and motivation among Finnish housing company residents. A survey of 618 respondents reveals low familiarity with energy communities (7% moderately familiar, 1% members). Especially financial benefits and environmental gains drive the citizens' motivation to participate, while traditional media and personal networks are key information sources. Regression analysis shows limited socio-demographic influence on motivation. The findings highlight the need for tailored incentives and communication strategies to activate housing companies as pivotal players in the community energy sector.**

***Index Terms*—Energy management; Consumer behavior; Socio-technical systems; Social factors**

Introduction

With the enactment of the Clean Energy for All Europeans Package [1] European Union (EU) made a commitment to a new approach to energy production and sharing in the member countries. The regulatory change was implemented through a mix of new directives featuring engaging energy consumers in the energy system transition through energy communities. Energy communities (ECs) are "legal entities that empower citizens, small businesses and local authorities to produce, manage and consume their own energy" [2]. However, regulation presents two definitions for energy communities, "Renewable energy communities" (RECs) [3] and "citizen energy communities" (CECs) [4]. In REC, the emphasis is on the geographic proximity of community members and non-profit activity, whereas CEC definition states there are no restrictions to participation in the EC. Community energy is not a new phenomenon, especially in more remote communities [5]. However, the motivation for recent resurgence has been to proliferate energy community development in the existing communities. In the context of energy system transition, energy communities are expected to serve several purposes: (1) promote local renewable energy (RE) production, (2) empower energy consumers [6], (3) lower energy costs and reduce energy poverty [7], (4) increase the use of RE power sources [8], (5) strengthen energy security and resilience [9], (6) ensure economic benefits [10], (7) ensure citizen engagement and community empowerment [2], [11], [12], (8) bring social benefits for its members [13], (9) ensure justice in energy systems and (10) advance just energy transition [14].

In Finland, energy communities are seen as an important factor in the energy landscape, particularly within the context of multifamily housing units. Our empirical starting point is to study housing companies in Finland through the lens of community energy. Previous research has shown how decision-making in housing companies is complex and risk aversive [15], [16], [17]. On the one hand, housing companies provide a large share of urban building stock in inner-city areas, urban outskirts and urban cores of rural areas, adding up to more than 2 million residents in a country of 5,5 million people. On the other hand, housing companies engage constantly with mundane energy decisions about purchasing electricity, heat and water from the utilities, maintenance of energy technologies and deciding over renovations and retrofits. Thus, housing companies show potential to operate as de facto energy communities.

Nonetheless, there is little empirical work on awareness and motivations of housing company residents regarding energy communities. To address this gap, this research aims to capture the housing company residents' point of view through a comprehensive survey.

Our research focused on three main research questions:

- What is the level of awareness on energy community among housing company residents, and through what information channels that awareness is gained?

- What motivates housing company residents to participate in an EC?
- What socio-demographic and motivational factors contribute to the awareness and interest in participating in ECs among the housing company residents?

This paper is structured as follows: Section 2 provides literature review and describes the theoretical framework. Section 3 introduces the methodological approach. The results are introduced in section 4, and the key points of the results are discussed in section 5. Finally, conclusions are drawn in section 6.

Background

Energy communities

Energy communities have gained significant policy and research attention in recent years as a means to promote renewable energy adoption and foster citizens' participation in the energy transitions [18], [19]. Literature reviews on energy communities highlight their multifaceted nature, encompassing varied definitions, conceptualizations and applications – with 183 different definitions [18]. However, at their core, energy communities are a group of citizens, organizations, municipalities or other stakeholders who collectively engage in generation, consumption, storage, and management of energy resources, typically produced through clean, distributed energy sources [20], [21].

Research has focused on exploring the conditions of ECs: what energy communities are, how they operate, what technologies and solutions they require, and different socioeconomic, technical and regulatory considerations associated to their success [22], [23], [24]. These studies can be broadly categorized into outcome focused and process focused perspectives to explore communities [25]. The outcome-focused perspective emphasizes the impacts energy communities deliver, such as energy autonomy, enhanced energy security, and reduced environmental footprints [26], [18]). The process focused perspective views energy communities as initiatives involving different actors and stakeholders united by common interests and are subject to formal or informal rules that govern these communities. These aspects include the upscaling of sustainability practices, enhanced social cohesion, increased public awareness, and facilitation of renewable energy adoption [27], [28], [24], [9], [23], [29].

Energy communities can be either place-based, or non-place-based (Moroni et al. 2019). Place-based shares a geographical location, with members typically located in close proximity. Non-place-based, on the other hand, are geographically dispersed, with members and resources divided beyond a place, but are connected through digital platforms and advanced technology that enables coordination and collaboration [30].

Housing companies currently represent the most typical form of energy communities in Finland [31]. Recent legislative changes have facilitated the creation of local network or energy communities, making it easier for housing companies to share jointly produced electricity among residents. According to Datahub, as of end of August 2024, there were 316 energy communities registered in Finland [32], consisting mainly of housing companies that utilise compensation calculations and/or operate with a singular meter. Compensation calculations involve monitoring electricity production and distributing it among community members. Priority is usually given to shared electricity consumption in communal spaces, with any surplus distributed among members. If residents cannot fully consume the generated surplus, the electricity is sold to grid tax free [31].

Awareness on energy community and sources of knowledge

Awareness of EC is a little-known phenomenon, connected to diversity in technological and organizational forms of ECs. By using public media discourse as a proxy, it has been elaborated that the awareness on EC has slowly begun emerging and still remains quite limited among general public [33], [34]. It has been discussed that information sources differ depending on adopters [35]. On the one hand, the generic information transferred through mass media has been concerned important in facilitating attitude development towards novel sustainability topics [36]. Therefore, news media plays a gatekeeper role regarding the general interest for EC in different country contexts. On the other hand, more specific information related to the benefits and services of technology may increase participation and the level of cooperation between the residents in RE projects [37]. Specifically the early adopters of technologies often utilise direct peer channels, such as internet forums, meetings and direct contacts as reliable information sources [38]. Similarly, knowledge-sharing platforms, such as internet forums are central in acceleration phase of technology diffusion, as communities share their experiences, and provide access to the technology and market information [39]. Different information sources for EC developments are thus central depending on general or more specific concerns.

Motivations to participate in the energy community

Motivations to participate in an energy community are heterogeneous and vary from anthropocentric motives (social), over egocentric (individual motives) to biocentric (environmental) motives [18]. Research on motivations to participate in the energy community has brought up somewhat contradictory results. Some studies emphasize environmental factors as a key predictor of participation in the energy community (e.g., [40]. However, others have found that motivations to invest in renewables at community level are economic and environmental, but hedonic motivations, such as other people, having fun and integrating in a strong community, are also present [41], [42], [43],. Community identity and interpersonal relations are identified as important conditions for the realization of and participation in energy communities, but social conflicts are also identified as a potential barrier [40], [44]. Motivations may change in different phases of energy community participation. According to some studies, normative motivations (e.g., environmental reasons, value of renewable energy) are more common in early stages [18], whereas incentives and economic gains gain relevance later [18], [45]. In another study [46], altruism and adventurous attitudes were a strong driver for EC participation in early

stages, while subjective norms and community identity became dominant later.

Methodology

This study utilizes data from a survey exploring housing company residents' energy efficiency retrofit decisions and preferences for energy communities. Previous literature was used in the initial planning of the survey instrument [47], [22], [48], [49]. After this, the survey was developed iteratively through researcher workshops. A pilot round was conducted in Spring 2023 to test the formulation and understanding of the survey items. The pilot included five interviews as well as a collection of five test responses in Webropol.

After refining the survey instrument based on the pilot feedback, the final survey gathered diverse information on energy communities. It included questions about familiarity, motivations to participate and potential experiences related to energy communities, along with questions about relevant background information like socio-demographic factors and energy-related attitudes.

The survey was targeted at the Finnish adult population (ages 18 – 80) living in apartments or houses that belong to housing companies. A simple random sample of 10,000 individuals living in housing companies was ordered from the official population records managed by the Digital and Population Data Services Agency of Finland. A third-party service was used to deliver an invitation by post with instructions for participating in the online survey. The invitations were delivered at the beginning of September 2023, and the survey remained open until the end of the month.

Finally, 618 responses were received, corresponding to a 6.2% response rate. The representativeness of the data was moderate. The collected sample was representative of the Finnish adult population in terms of gender and household size. Roughly the same percentage of respondents were tenants compared to the corresponding population. Older and highly educated respondents were slightly overrepresented in the sample. Comparable information on the income levels of the respondents' households was not available, as income was surveyed in income categories. However, when average income was computed for all respondents by taking a median from each income category, it was observable that the collected sample had higher average income than the Finnish average. Additionally, a greater share of respondents lived in urban communities and in terraced houses compared to national statistics.

In the empirical analysis, sociodemographic factors associated with i) higher awareness on ECs and ii) interest in participating to ECs were explored with ordered probit and binomial probit regression models [50].

Results and discussion

Awareness

The survey data analysis sheds new light on housing company residents' awareness and information channels on EC, and motivation to participate in one. Based on the survey findings, housing company residents are rarely familiar with ECs, however, there are motivational factors that may increase interest in participation in the EC. As Figure 1 shows, the level of awareness on ECs among the residents in housing companies is very low at this point. 71 percent of respondents are not at all familiar with the EC concept, which is well aligned with the earlier empirical findings (Piselli et al., 2022).

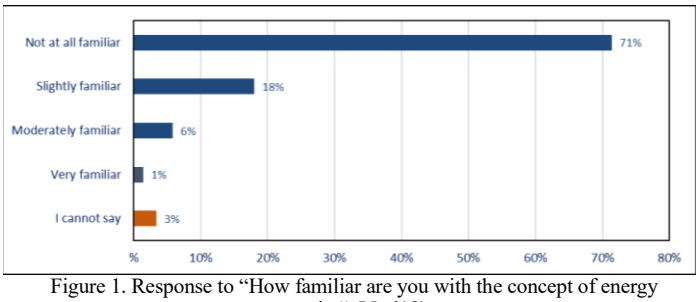

Figure 1. Response to "How familiar are you with the concept of energy community" (N=618)

The results of the ordered probit regression (see Appendix and Table A1) imply that the likelihood of indicating level of familiarity with ECs increases if the respondent is a male. However, home ownership, urban versus rural living area, age education, household size or building type do not make difference in the level of awareness on ECs. Previous research on factors linked with familiarity with ECs is limited. However, men have found to be more confident in themselves regarding their knowledge over energy topics [51].

Figure 2 illustrates how those who had knowledge on energy communities received information from traditional media and by searching on the internet. Also, personal contacts such as peers in the family and neighborhood, and local specialists are an important and trusted source of information on energy communities.

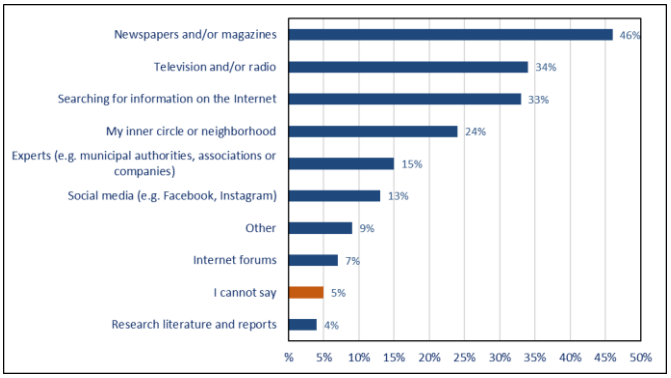

Figure 2. Response to 'How did you get information about energy communities?' (n = 156).

Central role of newspapers and television show that the interest has been on a general level rather than connected to specific details [33]. Also peer networks and expert information have been considered relevant, indicating towards potential of more energy community adopters emerging in near future [38]. Compared to activity on private household user forums, the peer sharing on internet and social media platforms on energy communities remains quite rare [39]. However, development and dissemination of general information through mass media channels appears to be a more relevant currently to increase the

overall awareness on the novel phenomenon and potentially encourage new energy community adopters.

Motives to participate in energy communities

The survey respondents showed interest towards ECs. Housing company residents are interested in participating in an EC primarily for economic gains, and secondly for environmental benefits (Figure 3). Figure 3 also shows that about a quarter of the respondents value energy security or independence from incumbents as benefits of an energy community.

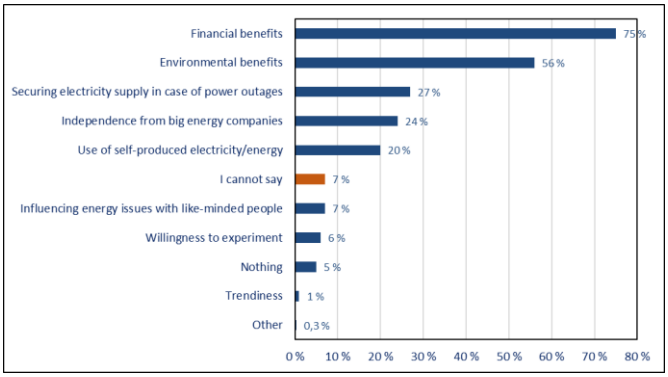

Figure 3. Response to 'What things would increase your interest in participating in energy communities?' (n = 617).

Financial and environmental factors have been also highlighted as important EC motivators by [52] and [53]. Especially the recent energy crises in Europe have made the cost of energy a recurring topic in public deliberation and policy development.

Considering the earlier results regarding dominance of normative goals in early stages of EC development, this is a slightly conflicting result [45]. However, wider EC adoption in housing companies is likely to emerge only in later stages, when economic benefits have dominated also earlier cases [18]. Moreover, the decision-making processes of housing companies are driven by economic rationality that create a ready framework to deliberate also EC issues. In addition, motivating factors are different regarding founding or joining an EC than regarding transforming an existing community into an EC.

Nearly all respondents (150) in the question "do you belong to an energy community" answered not belonging to any energy community. Only three respondents indicated being part of an EC, in turn highlighting that ECs are still very uncommon among housing company residents in Finland.

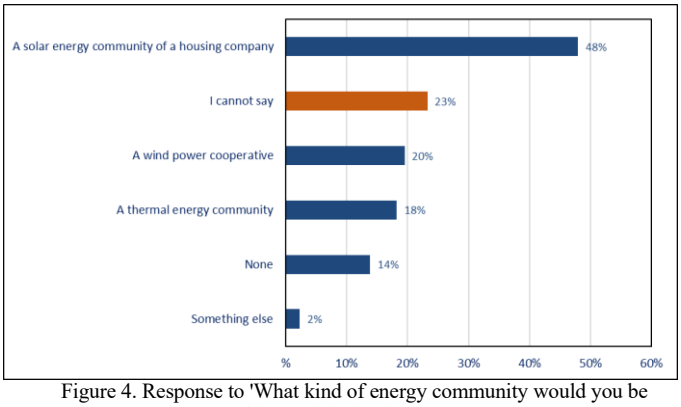

Figure 4. Response to 'What kind of energy community would you be interested in participating in?' (n = 615)

On the other hand, when interests and different types of ECs were considered, 63% of respondents indicated interest in joining at least one type of an EC. Preferences were asked for three types of ECs: a solar EC, a wind power cooperative and a thermal EC (Figure 4). Solar EC was the most preferred choice for about half of the respondents. Almost a fifth would be interested in participating in a wind power cooperative and another fifth in a thermal EC. However, almost a quarter of respondents could not say their opinion. In addition, other types of ECs were suggested, such as nuclear and biogas communities and knowledge-sharing communities.

As the housing company solar ECs are the most rapidly expanding EC type, the results align well with the recent developments [54]. However, the diversity of interests indicates that a more informed and diversified discussion around ECs might open new forms of energy engagement. For example, thermal energy communities based on heat-pump technologies and sharing of heat on a local (e.g., block scale) heating network have been identified as a type of urban EC in decarbonization of the central heating systems [15].

To study the factors associated with interest in participating in ECs, a binary dependent variable was created which took 1, if respondent chose one of EC types presented in Figure 4, and 0 otherwise. Then, the participation interest was linked with socio-demographic factors within binary probit regression model. The results of the regression analysis reveal that socio-demographic variables do not explain the participation interest (see Appendix and Table A2). This indicates participation is likely driven by other factors such as environmental attitudes and subjective [52] or communal identity [55].

Conclusion

ECs are recent and evolving entities that take many diverse forms and have not yet been fully conceptualized. In order to get a more coherent picture of ECs and EC participants different facets of EC need attention. This research puts one piece in this puzzle by expanding understanding of awareness and motivations of housing company residents towards EC.

Low awareness and high interest in ECs among housing company residents indicate that there would be a case for wider diffusion of energy community forms. However, the lack of existing cases and the current lack of consistency in organizational forms, definitions, and business models create

barriers for wider EC adoption [18]. Following the regulatory definitions, housing company ECs are closer to REC than CEC, as renewable energy is sourced locally by members of local housing units [3], [1]. Thus, housing companies have been approached as place-based energy communities by developing incentives to implement local retrofitting, e.g. by installing solar energy production or heat-pumps in an individual building [56]. However, housing companies could, in practice, operate also in collaboration to form non-place-based communities that could aggregate consumption management or distributed production to energy network, which should be considered in revision of the regulatory definitions for the ECs. Currently, there are no business models available for such services, and, therefore, the energy market regulations need to be amended to facilitate wider application of ECs. Conceptually, this would require shifting from outcome focused model mainly looking into checks and balances of individual housing companies to process focused model explicating the role of housing company ECs in the broader energy system operations [25].

Based on this, three policy recommendations are made to better proliferate emergence of EC beyond the current social niche:

- Public awareness can be increased and leveraged by creating publicly available information, case narratives and tangible instructions that can be taken up in decision making processes e.g., in housing companies.
- Regulatory amendments on energy community definitions are a prerequisite to facilitate more diverse forms of energy communities in practice, taking into consideration diverging demands on electricity and heat production.
- In longer-term development, the coherence of energy market regulation and readiness regarding digital technologies should be taken into consideration, as medium-sized energy communities, such as housing companies, rely on digital technologies in the implementation and management of the energy communities.

As for research implications, our findings bear relevance for end-user and stakeholder research to gain understanding on the current level of awareness and means to raise it, motivational factors, as well as barriers and drivers to initiate and participate in the EC, ultimately to increase the generation and use of RE, energy security and collaboration. As for practical implications, this research informs policy makers and local governments on how to reach housing company residents for communicating about ECs, and which motivating factors gain most attention.

To conclude, housing companies have a general interest and opportunity to operate as ECs, but they lack awareness and concrete incentives in the form of general and dedicated information support that would concretely outline economic and environmental benefits. Furthermore, housing companies could operate as several types of ECs, thus putting an emphasis on developing more clearcut definitions and business models in the sector.

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Appendix

Table A1. Results of the ordered probit regression. Dependent variable is response to "How familiar are you with the concept of energy community" (Fig 1.) Note that I cannot say responses have been removed.

Variable	Coefficient		Std. Error	P-value
Constant	-1.0805	***	0.2437	0.0000
Male	0.2258	**	0.1127	0.0452
Income	0.0322		0.0528	0.5429
High education	-0.0713		0.1143	0.5326
Age	0.0039		0.0030	0.1974
Household size	-0.0144		0.0647	0.8245
Citylike area	-0.0054		0.1415	0.9694
Rowhouse	-0.0626		0.1156	0.5883
Owner	0.1976		0.1435	0.1684
μ_1	0.8049	***	0.0891	0.0000
μ_2	1.5536	***	0.1679	0.0000
Model characteristics				
AIC	906.3			
McFadden's pseudo R^2	0.0151			
Number of respondents N	577			

*, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table A2. Results of the binomial probit regression. Dependent variable is response to "What kind of energy community would you be interested in participating in" (Fig 4.) Note that I cannot say responses have been removed.

Variable	Coefficient		Std. Error	P value
Constant	1.2015	***	0.3222	0.0002
Male	-0.1669		0.1429	0.2427
Income	-0.0084		0.0666	0.8999
High education	0.2093		0.1462	0.1524
Age	-0.0045		0.0044	0.3074
Household size	0.0179		0.0899	0.8421
Citylike area	-0.1561		0.1958	0.4255
Rowhouse	-0.1349		0.1499	0.3681
Owner	0.1861		0.1736	0.2837
Model characteristics				
AIC	444.7			
McFadden's pseudo R^2	0.0157			
Number of respondents N	458			

*, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.