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Beyond energy communities: Comparing citizen engagement, barriers, and behavioral change across collective energy initiatives

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ABSTRACT

As citizen participation gains traction in the European energy transition, diverse forms of collective energy initiatives (CEIs) emerge as key mechanisms for enabling stronger citizen involvement in the energy system and changing consumption behavior. Fully understanding all forms of collective energy initiatives is crucial to avoid the risk of misaligning engagement with people's lived realities, interests, and capacities, and to inadvertently alienating or excluding groups whose preferred forms of participation do not fit the dominant form of engagement.

Drawing on original survey data from 232 participants across Europe, collected within the Horizon 2020 ENCLUDE project, this paper compares two main CEI types: Energy Communities (ECs) and Collective Targeted Actions (CTAs), across different dimensions including participant demographics, motivations, barriers, behavioral outcomes, and internal diversity of engagement.

Findings reveal distinct motivation factors, participation patterns and behavioral changes. EC participants display broader, value-driven engagement encompassing both technical actions and lifestyle shifts. CTA participants engage more instrumentally, focusing on specific project goals with limited lifestyle transformation. While ECs face higher institutional and procedural barriers, CTAs offer easier entry but may produce limited engagement. Within ECs, a clustering analysis based on mean self-reported behavioral change scores identifies three profiles (Low-Engagement Members, Technically Driven, and Lifestyle Transformers), illustrating different participation and behavioral changes.

Policy frameworks should therefore support a diverse ecosystem of CEIs, recognizing CTAs as entry points and ECs as catalysts for deeper transformation. Reducing participation barriers, tailoring engagement strategies, and embedding energy justice considerations are essential for an inclusive and equitable energy transition.

1. Introduction

As global climate change and ecological crises intensify, the need for large-scale sustainability transformations has become both urgent and unavoidable. Recent assessments by the Intergovernmental Panel on Climate Change (IPCC) and international scientific panels emphasize the need for "rapid and far-reaching" transitions across energy, mobility, housing, food, and broader social systems [1]. These transformations are not simply a matter of technological substitution; they require the restructuring of institutions, infrastructures, values, and behaviors at multiple levels [2,3]. Accelerating these transitions is considered a core policy and research imperative, particularly in light of repeated climate emergencies, energy instability, and social inequalities that compound the challenges of decarbonization.

While technological innovation and policy regulation remain essential, there is increasing recognition that sustainability transformations must also be socially driven and inclusive. Therefore, recent scholarship on socio-technical systems transformation calls for more participatory, distributed, and democratic approaches when it comes to driving technological and social innovations [4–6]. At the heart of this shift is the question of citizen engagement: how, why, and through what means can people contribute to and shape the pathways of sustainable change?

Citizen engagement in the energy transition is now widely

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acknowledged as a key driver of system-level transformation. This engagement takes many forms. Some citizens join or co-found Energy Communities (ECs) that collectively invest in renewable energy infrastructure or manage energy supply and demand locally [7,8]. Others participate in political advocacy, protest movements, or neighborhood campaigns for climate justice [9,10]. Many others engage indirectly with the energy transition by voting for pro-climate policies, changing consumption behaviors, or joining peer initiatives to improve energy efficiency. Although such actions fall outside formal governance or ownership structures, they influence energy demand, normalize low-carbon practices, and contribute to collective learning and diffusion processes that are central to socio-technical transitions. These varied forms of participation illustrate the multiple pathways through which citizens can co-create sustainable transitions.

Among these, Energy Communities (ECs) have received the most attention in both scholarly and policy domains, especially within the European Union. ECs are increasingly recognized in national energy strategies and EU directives as mechanisms for decentralization, democratization, and local empowerment [11,12]. Academic research has explored the institutional configurations, governance structures, and social dynamics of energy communities, providing evidence that they can build trust, raise awareness, and foster behavioral change. Yet, ECs tend to attract certain types of participants, typically older, highly educated, and more affluent individuals [13,14].

As a result, a growing body of literature has begun to question the dominance of ECs as the primary form of recognized citizen participation. While ECs, defined by the European Union as legally recognized entities that may be citizen-led, non-profit oriented and focused primarily on local social, economic and environmental benefits rather than profits, play a crucial role, they are not the only mode through which citizens act. Other forms of engagement, which we broadly refer to as Collective Targeted Actions (CTAs), include collective campaigns and local initiatives of varying scale and scope that focus on specific, targeted energy-related actions or services, such as energy efficiency measures, renovation support, renewable energy adoption, or related training and advisory activities. These initiatives may be informal or formalised and often take the form of service-based collaborations or campaign-style actions that do not meet the legal or governance criteria of Energy Communities. CTAs tend to be more flexible in structure and, in some cases, more effective in engaging younger or more diverse demographics [15,16]. While they typically lack fixed legal status or policy recognition, such initiatives can nonetheless exert significant influence on energy-related practices, social norms, and learning processes.

Despite this evidence, few studies have systematically compared the motivations, barriers, and outcomes across different types of citizen engagement in the energy transition. Research tends to either focus on a single form (for example ECs) [17,18], or analyse participation through narrowly defined lenses (energy demand reduction, voting behavior, technology adoption) [19,20]. This pattern reflects several factors. Firstly, researchers tend to favor their disciplinary traditions and therefore frame citizen engagement differently (sociologists might see it as participation in social movements, behavioral scientists in changing individual behavior, and engineers in adopting new technical solutions). Secondly, funding and policy priorities will strongly influence research opportunities and thereby scope. However, this fragmentation limits our understanding of how different kinds of collective, citizen-led initiatives complement, challenge, or substitute for each other in driving large-scale transformation. Without a comprehensive view that values the diverse ways citizens engage, policymakers and practitioners risk promoting only a restricted set of participation opportunities. This not only increases the risk of not aligning engagement with people's lived realities, interests, and capacities, but can also inadvertently alienate or exclude groups whose preferred forms of engagement do not fit dominant policy or research framings. In turn, this weakens the inclusivity, resilience, and social legitimacy of the energy transition.

To address this gap, this paper draws on original empirical data collected as part of the Horizon 2020 ENCLUDE project. We explore the motivations, barriers, participant profiles, and behavioral outcomes of individuals involved in different forms of collective energy initiatives. We pay particular attention to Energy Communities (ECs) and Collective Targeted Actions (CTAs). In addition, we also look at variation within ECs (as the dominant policy framing) analysing how motivation and behavioral outcome differ within one organisational form. This dual focus also allows us to acknowledge the internal diversity of engagement within ECs, offering a deeper understanding of what is possible within the same organisational framework. We thereby define CTAs as companies or groups of people aiming to support communities and/or individuals in pursuing behavioral and/or technological changes to reduce energy use and improve energy efficiency. While ECs are often anchored in legal and policy frameworks that enable co-ownership and structured governance, CTAs tend to offer more flexible, accessible pathways for public engagement, particularly for individuals who may face barriers to participating in formal cooperatives or infrastructure-intensive initiatives.

By focusing on these two types, our goal is to understand how different organisational forms and collective arrangements shape the depth and breadth of citizen engagement. In doing so, we contribute to broader debates on individual and collective agency and efficacy, the role of citizen engagement and participatory governance in contributing to sustainability transitions.

We address the following research questions:

- What are the dominant motivations and barriers associated with participation in Energy Communities (ECs) and Collective Targeted Actions (CTAs)?
- What distinct behavioral engagement profiles exist among participants in Energy Communities (ECs)?

This study contributes to energy citizenship scholarship by moving beyond an exclusive focus on ECs and empirically examining multiple forms of collective energy engagement using a single, cross-national dataset. Drawing on original survey data from participants in ECs and CTAs, the article offers a comparative perspective on how different organisational forms shape motivations, barriers, and self-reported behavioral change across both technical and lifestyle domains. In addition, by applying behavioral clustering within ECs, the analysis reveals substantial heterogeneity in how citizens engage even within the same institutional framework, challenging assumptions that participation in collective initiatives uniformly translates into transformative engagement. Together, these contributions provide a more differentiated, capability-sensitive understanding of energy citizenship that accounts for both plural engagement pathways and uneven participation outcomes.

The paper is structured as follows. Section 2 reviews the relevant literature on sustainability transitions, collective energy initiatives, and motivators and barriers to citizen engagement. Section 3 outlines the methodology, including theoretical frameworks, data collection, and analytical approach. Section 4 presents the results comparing ECs and CTAs across demographics, motivations, barriers, behavioral outcomes, and clustering profiles. Section 5 discusses these findings in light of existing scholarships, while Section 6 concludes with policy recommendations and directions for future research.

2. Background

2.1. Sustainability transitions and the role of social actors

Research on sustainability transitions has traditionally emphasized the importance of multi-level and systemic change processes [2,21]. While much early work focused on technological innovation and institutional dynamics, more recent studies argue that transformative change requires rethinking the roles as well as the values, norms, behaviors, and

power relations within a society [22,23]. Citizens are increasingly seen as not just passive recipients of policy or consumers of new technologies but are as agents of change, whose actions shape the direction and speed of sustainability transitions [24].

The concept of transformative power [25] has thus emerged as a central concern. It refers to the capacity of actors, including civil society, grassroots groups, and individual citizens, to question dominant regimes and contribute to alternative futures. In energy transitions specifically, this has led to growing interest in bottom-up innovations, social movements, and participatory governance mechanisms that include people directly in shaping energy systems [26].

On a collective scale, grassroots movements and activist networks play a significant role in shaping transitions. They exert pressure on incumbents, resist harmful infrastructure, and broaden the political imagination [27]. These dynamics can be seen as contests between incumbents and challengers, where social actors mobilise to disrupt dominant energy regimes. Activism, including the youth-led climate strikes to local opposition to fossil fuel projects, brings urgency and justice concerns into the sustainability agenda [28].

On an individual scale, transition analyses must extend beyond technologies to encompass everyday life of people, setting forward social practice theory to conceptualize how shifts in everyday routines and behaviors contribute to sustainability transitions [29]. Rather than viewing consumers as passive, this practical-theoretical view examines how various sustainable practices (e.g. new mobility or energy habits) emerge, persist, or disappear through iterative interactions between people, technologies, and cultural norms. Such an approach highlights that individual citizens, through their daily choices and habits, exercise agency that can cumulatively drive demand for sustainable innovations [30]. In this sense, everyday practice becomes a site of transition, as mundane actions (commuting, heating, eating, etc.) are reconfigured in more sustainable ways through citizen involvement and social learning.

The literature suggests that accelerating transitions will depend on mobilising multiple types of actors, including those outside of formal political or economic institutions. However, it also acknowledges the challenges that social movements and local initiatives often lack access to power, resources, or technical expertise, and may struggle to scale up or influence entrenched systems [28,31]. This tension between empowerment and marginalization is a core theme in the scholarship of collective action.

2.2. *Collective energy initiatives: energy communities and beyond*

Among the most prominent manifestations of direct citizen involvement in the energy transition in Europe are Energy Communities (ECs). These are typically legal entities that allow citizens to collectively invest in, generate, manage, or consume energy [32]. Examples include renewable energy cooperatives, community solar farms, and shared mobility cooperatives that may be powered by local renewables.

ECs are widely recognized as key instruments for promoting democratization, local empowerment, and sustainability within energy systems. By enabling citizens to co-own and co-govern energy infrastructure, ECs redistribute power away from centralized utilities and toward local actors, often fostering more transparent and inclusive decision-making processes. In doing so, they may contribute to reducing energy poverty by offering lower energy prices or targeted support to vulnerable households, increasing public acceptance of renewable energy technologies through participatory ownership, and enhancing local resilience by anchoring energy production and control within the community [33–35]. These benefits have led to growing political support at the European level. Notably, the EU's Clean Energy for All Europeans Package formally recognizes Citizen Energy Communities (CECs) and Renewable Energy Communities (RECs) as legal entities, with defined rights and responsibilities in energy production, distribution, and supply [32]. This institutionalization has bolstered the legitimacy and potential of ECs, encouraging national governments to establish regulatory frameworks that facilitate citizen participation in energy transitions.

The academic literature on ECs is both rich and rapidly evolving. Early studies focused on foundational aspects such as organisational structures and governance models, highlighting the importance of democratic control, transparency, and accountability [36]. More recent work has investigated the socio-political dimensions of ECs, including their role in reshaping energy imaginaries, fostering community identity, and contributing to a broader culture of environmental stewardship [37,38]. A growing body of research also emphasizes the co-benefits generated by ECs, as they can strengthen social capital through collaboration and trust-building, enhance environmental awareness via peer learning and local visibility, and drive behavioral change by embedding pro-environmental norms and practices in everyday life [17,39,40]. Despite these strengths, scholars also caution against over-romanticizing ECs, noting challenges around inclusivity, scalability, and dependency on favorable policy conditions, highlighting the need for continued critical and contextualized analysis [13,41].

The EC literature also reveals important limitations. First, ECs often attract a narrow participant profile - highly educated, middle-class, and often middle-aged men [17,42]. Second, ECs face certain barriers to entry, including regulatory complexity, financial risk, and high informational demands. These conditions make them less accessible to marginalized groups or those with fewer resources. As a result, scholars warn that ECs can become exclusionary spaces, reinforcing existing inequalities even while promoting sustainability [43–45].

Moreover, the dominant focus on ECs risks overshadowing other forms of citizen engagement. While European regulatory frameworks allow for a range of legal forms beyond cooperatives such as associations and non-profit organisations, research agendas, policy instruments, and funding schemes have largely centred on ownership-based, formally organised community energy models. As a result, more informal, semi-formal, or service-oriented collective initiatives that do not rely on shared ownership or long-term collective governance often receive less analytical attention. This includes campaign-based or time-limited actions as well as broader forms of collective mobilisation around energy and climate issues (e.g., Fridays for Future, Extinction Rebellion) [46,47]. Although such initiatives may not manage energy infrastructure directly, they can shift narratives, influence policy, and shape public attitudes. Their impact, while harder to quantify, is increasingly recognized in transition studies as essential to long-term change [28,48]. Moreover, some researchers have begun to explore other forms of direct citizen engagement that go beyond the formalised ECs. For example, actions such as neighborhood-led energy-saving challenges or citizen-led renovation efforts may be regarded as scalable alternatives to ECs [49]. They tend to be more flexible, require fewer resources, and can be more inclusive of underrepresented groups. However, they are less institutionalized and often overlooked across policy, funding and research.

Participation in energy transitions is not solely a matter of individual motivation or civic engagement, but is shaped by systemic conditions that enable, constrain, and channel who can participate, how, and to what extent. These dynamics are conceptualized as ecologies of participation [50], emphasizing that participatory forms are embedded within broader socio-technical, institutional, and cultural arrangements that distribute opportunities for engagement unevenly across society. From this perspective, participation is co-produced by policy frameworks, organisational models, material infrastructures, and dominant imaginaries of “appropriate” participation, rather than emerging from citizen agency alone.

Energy citizenship research similarly highlights that responsibilities for socially driven and inclusive energy transitions cannot be placed solely on citizens, but must be shared across institutions, markets, and governance arrangements that shape access, recognition, and decision-making opportunities [51]. This implies that observed participation patterns such as the overrepresentation of older, highly educated, and

more affluent citizens in Energy Communities reflect not only individual preferences or capacities, but also the structuring effects of participation models themselves. Understanding participation in this way shifts attention from deficits in civic engagement to questions of justice, responsibility, and institutional design.

2.3. Understanding motivations, barriers, and differences in citizen engagement

A growing body of literature emphasizes the importance of understanding how and why citizens engage in collective efforts toward sustainability. Participation in citizen-led initiatives, whether through formal mechanisms such as ECs, or broader, informal actions such as protests, advocacy, or community-level behavioral campaigns, has been shown to increase environmental awareness, knowledge, and citizens' agency, build peer networks, and catalyze technology adoption [7,52,53]. Yet, the depth and character of behavioral change vary significantly across individuals and forms of engagement, shaped by diverse motivations, social dynamics, and institutional contexts [16].

While ECs have been at the centre of energy transition policy in the EU, offering a structured framework for collective ownership and democratic control over energy resources, they are not the only avenue for citizen engagement. Other forms, such as campaign-based actions, community learning and engagement initiatives, or political activism, differ in their organisational models and may appeal to individuals who are unable or unwilling to engage within the formal structures and long-term commitments that might be required by ECs. These alternative approaches may lower barriers to entry by demanding less financial investment as well as lower administrative or bureaucratic efforts. Yet despite their potential to engage broader and more diverse groups of citizens, they are frequently overlooked in both academic research and policy frameworks.

Understanding what motivates individuals to engage and what prevents them from doing so is essential to broadening participation and avoiding the entrenchment of inequality. Motivations are multifaceted and can include environmental concern, desire for community belonging, financial benefit, or political identity [54,55]. At the same time, barriers to engagement are equally complex. They may include lack of time or resources, limited access to information or technical support, distrust in institutions, or a perceived lack of efficacy. These factors are not evenly distributed. For example, higher education is often associated with stronger environmental values and greater access to technical or social capital needed for engagement [7]. Higher income often enables individuals to cover upfront costs or absorb financial risks associated with energy initiatives. Gender differences may reflect structural inequalities, especially in contexts where caregiving responsibilities are unevenly distributed. Age, similarly, can influence engagement through differing levels of time availability, digital literacy, and long-term planning horizons [56].

Several studies now use segmentation methods such as behavioral clustering or regression modeling to categorize participants by motivation, behavior, and demographic profile [57,58]. These approaches consistently reveal a heterogeneous landscape of engagement. Some individuals adjust everyday practices such as energy use or mobility patterns; others invest in renewable technologies without changing their behaviors, while others may participate in community initiatives or public actions. These diverse forms of engagement reflect different capabilities, preferences, and contexts, and all contribute to the broader transformation of energy systems. Understanding the underlying patterns is essential for designing inclusive policies that reflect the range of motivations, including environmental concern, financial benefits, desire for autonomy, social belonging, or improved comfort, all of which may drive people to act.

Yet current energy policy often centres on officially recognized models of participation, particularly ECs, without fully accounting for the diversity of engagement pathways available to citizens. This approach risks excluding those who engage through less visible, more flexible, or differently organised initiatives. If the goal of accelerating sustainability transitions is to be realized equitably, it is imperative that researchers and policymakers alike develop a broader understanding of citizen engagement, one that moves beyond dominant models and accounts for the pluralism of actors, motivations, and structural constraints.

Considering these arguments, a nuanced approach is needed to understand the interplay of motivations, barriers, social identities, and behavior in shaping participation across different engagement forms. Such understanding is essential for designing inclusive strategies that target the transformative potential of citizen action, both within and beyond energy communities. This study responds to that need by analysing who participates in collective energy initiatives, what drives or hinders their involvement, and how participation relates to broader behavioral shifts. In doing so, it contributes to ongoing efforts to make the energy transition not only faster, but fairer and more participatory.

3. Methodology

This study draws on original empirical data collected during the Horizon 2020 ENCLUDE (Energy Citizens for Inclusive Decarbonization) project, which ran from 2021 to 2023 across multiple European countries. The project aimed to better understand the role of citizens and collective action in accelerating energy and sustainability transitions. Our analysis is based on a structured survey of individual participants of different types of CEIs, and we offer a comprehensive view of citizen engagement across formal and informal initiatives, with a particular focus on Energy Communities (ECs) and broader grassroots actions that we define as Collective Targeted Actions (CTAs).

3.1. Theoretical frameworks

The methodological design of this study is grounded in three interrelated conceptual frameworks: the Energy Cultures Framework [59], the Socio-Ecological Systems Framework for Integrated Community Energy Systems (SES-ICES) [60], and the Social Identity Model of Pro-environmental Action (SIMPEA) [61]. Together, these frameworks support a broader understanding of how cognitive, material, institutional, and social-psychological dynamics shape energy behavior and

Fig. 1. The theoretical framework.

citizen participation. As illustrated in Fig. 1, the Energy Cultures Framework is represented through its three core components - cognitive norms (yellow), material culture (red), and energy practices (blue), while the linkages between these components and their embedding in broader social, economic, and political settings are captured through the green arrows derived from the SES-ICES framework. SIMPEA complements this representation by explaining how shared social identities and perceived collective efficacy mediate these interactions, shaping when cognitive norms and institutional conditions translate into coordinated collective action rather than isolated individual behavior. This visual integration highlights how energy practices emerge within specific action situations, mediated by collective identities and institutional conditions, allowing the analysis to coherently connect individual behavior, collective engagement, and systemic contexts.

The Energy Cultures Framework conceptualizes energy behavior as emerging from the interplay between cognitive norms, material culture, and energy practices. Cognitive norms encompass the beliefs, values, and expectations that individuals hold about energy and sustainability. Material culture refers to the technologies, infrastructures, and physical assets through which energy is produced, distributed, and consumed. Energy practices describe the routine activities through which people interact with energy in daily life. Together, these elements form dynamic clusters that shape and are shaped by behavior [59].

Recognizing the limitations of the Energy Cultures Framework in addressing collective dynamics, we also employed the SES-ICES framework, which adds a socio-institutional lens. This framework considers how broader social, economic, and political settings such as governance arrangements, institutional trust, market structures, and access to resources influence the development and functioning of collective energy initiatives [60]. A key feature of this framework is the concept of "action situations," which refers to decision-making environments where actors interact, negotiate, and coordinate actions. By combining both frameworks, the study captures how energy behavior is shaped not only by individual preferences and technologies but also by institutional contexts and group dynamics.

To further integrate the psychological and group-level dimension of participation, we draw on the Social Identity Model of Pro-environmental Action (SIMPEA). This model explains how individuals' identification with social groups such as communities, initiatives, or movements motivates collective environmental behavior. According to SIMPEA, when people perceive themselves as part of a group with shared pro-environmental values, they are more likely to engage in coordinated actions, adopt group norms, and sustain long-term commitment to collective goals. This framework is particularly relevant for understanding engagement within Collective Energy Initiatives (CEIs), as participation often depends on feelings of belonging, shared purpose, and social recognition [61]. Incorporating SIMPEA allows the study to connect structural and institutional conditions (captured by SES-ICES) with internalized social identities and motivations, thereby linking the "external enablers" of collective action with the "internal drivers" of sustained behavioral change.

While these frameworks provide a robust lens for analysing how individual and collective energy behavior is shaped, they do not imply that responsibility for energy transitions rests equally or primarily with citizens. Rather, they allow us to examine how citizen agency is conditioned by material infrastructures, governance arrangements, social identities, and broader intersectional factors such as income, education, tenure status, time availability, and institutional access. This perspective is deliberately critical of narratives that over-allocate responsibility to citizens without accounting for systemic constraints, uneven capacities, and power asymmetries. Accordingly, citizen engagement is analysed here not as an individual moral obligation, but as a socio-technical and institutional outcome that is enabled or constrained by structural conditions.

Considered together, these three frameworks offer complementary insights into the cognitive, institutional, and social-psychological dimensions of citizen engagement in the energy transition. They provide a multi-level foundation for analysing how material infrastructures, governance arrangements, and collective identities interact to shape both individual and collective energy behavior.

3.2. Survey design and participant recruitment

A structured online survey was developed to capture individual-level experiences within collective energy initiatives. The survey was designed to reflect the conceptual dimensions of the Energy Cultures, the SIMPEA and the SES-ICES frameworks and was co-developed by project partners. It included questions on socio-demographic characteristics, individual motivations for participation, perceived barriers to engagement, and self-reported changes in energy-related behavior.

Socio-demographic variables included age, gender, education level, income, and employment status. Motivational items covered environmental values, financial concerns, desire for community belonging, and interest in autonomy or empowerment. Barriers were assessed in terms of time availability, informational needs, institutional trust, and financial constraints. Participants also reported on behavioral changes across several domains, including building retrofits, adoption of heating and cooling technologies, installation of solar systems, changes in transportation habits, and sustainable consumption. Survey questions were, whenever possible, taken from established questionnaires tested in various cultural contexts (e.g. climate change perception and beliefs and environmental identity taken from [62], sustainable behavior from [63]). Questions on socioeconomic characteristics were partly asked in a culture-neutral way (e.g. instead of asking for absolute income the questionnaire asks for income in comparison with the respective country's average) to account for differences and to allow cross-country comparison. The question on education was adapted to the respective country's education system.

The survey was translated into eleven languages and pilot-tested before being administered between November 2022 and February 2023. Potential initiatives were identified through a combination of desktop research and the personal contacts of the research team, ensuring coverage of diverse organisational types, ages and geographical contexts in Europe, including 11 EU countries such as Austria, Netherlands and Greece, and 2 non-EU countries (North Macedonia and the United Kingdom). Representatives of these initiatives were contacted via email and/or phone, during which the purpose and the scope of the study were explained. When representatives agreed to participate with their initiative, they were sent a link to the online survey with a request to forward it to their members, who could fill it out online by clicking the provided link. Doing so, we achieved direct outreach to participants from more than 60 initiatives. In total, 232 full survey responses were collected and subsequently anonymized.

3.3. Analytical strategy

The analytical strategy was designed to systematically compare citizen engagement across two primary types of Collective Energy Initiatives (CEIs): Energy Communities (ECs) and Collective Targeted Actions (CTAs). Energy Communities are defined as associations engaging in renewable energy-related activities without financial gain as their primary purpose, characterized by shared ownership of energy assets, democratic decision-making structures, and a strong emphasis on collective community benefits (e.g. communities that generate and share electricity from commonly owned photovoltaic installations).

Collective Targeted Actions (CTAs), by contrast, are defined as collective initiatives that engage citizens in targeted energy-related actions or services, such as energy efficiency measures, renovation support, renewable energy use, or related training and advisory activities, without shared ownership of energy assets and with limited participant involvement in democratic decision-making. Participation in CTAs is typically organised around specific actions or service provision rather

than long-term collective governance, and financial or individual benefit considerations may play a more prominent role (e.g. training programmes on improving household energy efficiency, energy advice organisations, or service-oriented energy optimisation initiatives).

Participants classified under CTAs were affiliated with multiple types of such initiatives rather than a single organisational model. These included energy advice and support organisations, collective energy efficiency or renovation campaigns, training and awareness-raising initiatives, and service-oriented energy optimisation programmes. While these initiatives differ in scope and operational focus, they share the defining characteristics outlined above - namely the absence of shared ownership and limited democratic governance which justified their aggregation into a single analytical category.

These two CEI types and their broad definitions were chosen because they collectively represent, apart from social and political movements, the vast majority of collective energy initiatives active in practice. Social and political movements were excluded from this analysis because their goals, structures, and modes of citizen engagement differ fundamentally, focusing primarily on advocacy and systemic change rather than the direct provision or facilitation of energy-related actions or services.

The analysis employed a mixed-methods approach grounded in quantitative comparison and exploratory clustering to identify engagement profiles and behavioral patterns within and across initiative types. This section details the variables selected, the comparative procedures, and the clustering techniques used.

3.3.1. Comparative analysis of EC and CTA participants

To assess differences in participant characteristics, motivations, barriers, and behavioral outcomes between ECs and CTAs, we first classified all survey respondents according to their initiative type. The analysis included:

- Demographic Profiling: Descriptive statistics (mean, median, proportions) were used to compare EC and CTA participants based on gender, age, education, employment status, income, household size, and city size. This provided contextual insights into the socio-economic backgrounds of participants.
- Motivations and Barriers: Binary variables capturing self-reported motivations (e.g., climate concern, financial savings, community orientation) and barriers (e.g., lack of time, knowledge, trust) were compared using mean scores to reflect the proportion of respondents selecting each reason.
- Behavioral Outcomes: Ten self-reported behavioral changes, ranging from retrofits and solar installation to lifestyle shifts such as reduced meat consumption and flight avoidance were assessed on a three-point Likert scale (1 = no change, 2 = some change, 3 = significant change). Mean scores were calculated for each behavior and compared across CEI types to identify differences in depth and breadth of engagement.

3.3.2. Behavioral clustering within ECs

Given the substantially larger number of EC respondents, behavioral clustering was conducted exclusively for EC participants, as the CTA sample size was insufficient for robust segmentation. To explore the heterogeneity of engagement among EC participants, we applied K-Means clustering to the standardized scores of the ten behavioral change variables. Only respondents affiliated with ECs and with complete data across all behavioral indicators were included in this analysis. The elbow method was used to determine the optimal number of clusters.

Each cluster's behavioral mean scores were described to reflect differentiated engagement pathways within ECs. This disaggregation allowed for a more nuanced understanding of participation dynamics and the identification of internal diversity beyond initiative type.

3.4. Ethics and limitations

Ethical approval was secured from all participating institutions involved in the ENCLUDE project. Informed consent was obtained from all participants before data collection, and all survey data were anonymized and stored in compliance with GDPR and the different institutional data management requirements.

However, this study is subject to several limitations that should be acknowledged. First, the survey sample size ($n = 232$), while sufficient for exploratory analysis and pattern identification, is relatively small and not statistically representative of the broader European population or the full diversity of collective energy initiatives (CEIs) across different countries and contexts. As such, the findings should be interpreted with caution and understood as indicative rather than definitive, offering insights into emerging trends rather than generalizable claims. Second, the reliance on self-reported behavior introduces the risk of social desirability bias, wherein participants may overstate pro-environmental actions or motivations in an effort to align with perceived social norms or expectations. While efforts were made to ensure survey clarity and anonymity, such bias is a common challenge in behavioral research and may modestly inflate the reported depth of engagement.

The sample sizes of Energy Community (EC) participants ($n = 171$) and Collective Targeted Action (CTA) participants ($n = 37$) are uneven. This imbalance reflects both the empirical and policy landscape of collective energy initiatives in Europe. The comparative analysis between ECs and CTAs is therefore intended to be exploratory and descriptive, focusing on identifying patterns and contrasts in motivations, barriers, and self-reported behavioral outcomes rather than establishing statistically representative or causal differences. To avoid overinterpretation, no inferential statistical testing was applied, and results are reported as mean scores and proportions. Importantly, the larger EC sample enabled additional intra-group analysis through behavioral clustering, which was not feasible for CTAs due to their smaller sample size. This asymmetry is therefore treated as an analytical feature rather than a methodological limitation, allowing the study to both compare engagement forms and explore internal heterogeneity within the most policy-relevant CEI type. Moreover, as CTAs encompass a heterogeneous set of initiative types, the reported results should be interpreted as reflecting broad patterns of engagement across this category, rather than outcomes attributable to any single CTA subtype.

Despite these limitations, the study makes a significant contribution by providing comparative and intra-group insights across two of the most prevalent CEI types - Energy Communities (ECs) and Collective Targeted Actions (CTAs), and by identifying distinct behavioral engagement profiles within ECs. This multi-dimensional perspective enables a more nuanced understanding of citizen participation, moving beyond binary distinctions between active and passive roles to explore the forms, drivers, and depth of engagement. Moreover, the cross-national scope of the data, though not representative, captures a diverse range of socio-demographic contexts, adding richness to the analysis and supporting the relevance of the findings for both research and policy development. Future studies would benefit from larger, longitudinal datasets and mixed-method approaches to deepen and validate the patterns identified here, especially considering the evolving European energy landscape and the growing institutionalization of citizen-led initiatives.

4. Results

This section presents the results from the comparative analysis of Energy Communities (ECs) and Collective Targeted Actions (CTAs), the two most prevalent types of Collective Energy Initiatives (CEIs) in the dataset. As a reminder, we excluded the Political/Social Movements (PMs) and the Testing Conditions (TCs) from the comparisons due to their limited geographic representation. The analysis of ECs and CTAs is structured around five domains: participant demographics, motivations,

barriers, behavioral impacts, and behavioral clustering within ECs.

4.1. Participant demographics

While both ECs and CTAs attract participants who are highly educated (over 70% in each group reported having completed tertiary education) and are largely employed full-time, notable demographic differences emerge between the two types of initiatives, as shown in Table 1. EC participants reported a higher proportion of individuals with high or very high income levels (55%) compared to CTA participants (43%), suggesting that ECs may attract individuals with greater financial capacity to invest in longer-term energy solutions. Conversely, CTAs appear to engage a more gender-balanced or even women-led demographic, with 58% of participants identifying as women, in stark contrast to the male-dominated ECs, where only 29% of participants were women.

In terms of life stage and employment status, ECs had a significantly higher proportion of retired participants (27%), indicating that older or post-career individuals may be more actively involved in longer-term or ownership-based models of energy participation. CTAs, on the other hand, involved a younger demographic, with only 14% retired, which may reflect their more campaign- or action-oriented nature.

Settlement patterns also varied between the two groups. EC participants were predominantly based in rural or village settings, whereas CTAs were more commonly located in medium-sized cities. This geographic distinction may reflect differences in access to infrastructure, forms of organisation, or local energy needs, and further illustrates how context shapes the modes and demographics of collective energy participation.

4.2. Motivations to join collective energy initiatives

Motivational patterns varied notably across CEI types, reflecting different logics for engagement. While climate concern emerged as the most commonly selected driver in both groups, with 45% of CTA participants and 48% of EC participants selecting it, this was one of the few shared priorities across the two types of initiatives, as shown in Table 2. Beyond climate concern, EC participants were significantly more likely to report a range of additional motivations, suggesting a more multidimensional or embedded form of engagement.

Community belonging was selected by 35% of EC participants, more than double the rate among CTA participants (15%), indicating that social connectedness and local identity may play a stronger role in motivating participation in energy communities. Similarly, motivations related to economic benefits were more prominent among EC participants: 32% cited financial savings, compared to only 21% in CTAs. Energy self-sufficiency also emerged as a stronger motivator among ECs (29%) than CTAs (24%), reflecting a desire for long-term autonomy and resilience in energy provision.

Interestingly, lifestyle-related motivations such as the pursuit of a healthier lifestyle were also more present in ECs (16%) than CTAs (9%), suggesting that some participants viewed their engagement as part of a broader transformation in everyday practices. Comfort improvement, although present in both, showed an inverse pattern: it was more relevant to CTAs (12%) than ECs (5%), possibly pointing to more immediate or practical concerns in grassroot-style initiatives. Legal obligation was largely absent as a motivating factor across both types, further emphasizing the voluntary and values-driven nature of participation.

These results suggest that ECs foster deeper collective and material motivations, while CTAs may appeal more to individuals seeking lighter, issue-specific involvement.

Table 1
Demographic characteristics by CEI type.

Demographic characteristic	CTA (n = 37)	EC (n = 171)
Gender (% female)	58%	29%
Education (% higher)	~71%	~73%
Full-time employment	Majority	Majority
Employment (% retired)	14%	27%
Income (% high or very high)	43%	55%
Settlement type (predominant)	Medium cities	Villages

Table 2
Average motivation scores by CEI type (0 = Not selected, 1 = Selected).

Motivation	CTA	EC
Climate concern	0.45	0.48
Community/People	0.15	0.35
Financial savings	0.21	0.32
Energy self-sufficiency	0.24	0.29
Healthy lifestyle	0.09	0.16
Comfort improvement	0.12	0.05
Legal obligation	0.00	0.01

4.3. Barriers to participation

Barriers to participation were more frequently reported by EC participants than by those involved in CTAs, suggesting that deeper or more sustained forms of engagement come with more pronounced institutional and structural challenges, as shown in Table 3. Among EC participants, nearly half reported encountering a lack of support from authorities (48%) and bureaucratic hurdles (45%), highlighting systemic obstacles that may impede the implementation of citizen-led energy initiatives. Similarly, 43% cited lack of access to funding as a barrier, pointing to the difficulties of securing financial resources for community-scale energy projects. These findings reflect the institutional complexity and longer time horizons typically associated with establishing and operating energy communities.

While technical knowledge was a relatively minor barrier overall, reported by 14% of EC participants and 16% of CTA participants, this is likely related to the generally high education levels of participants across both initiative types, which may reduce perceived informational and technical constraints. Instead, the challenges faced by ECs were more often institutional and procedural rather than informational. Interestingly, low engagement of key personnel was mentioned more often in ECs (10%) than in CTAs (4%), suggesting that sustained momentum and leadership may be harder to maintain in more complex or resource-intensive initiatives.

In contrast, CTA participants reported lower average barrier scores across all categories, which may reflect the shorter-term, action-oriented nature of these initiatives. However, some challenges remained: 24% of CTA participants cited lack of support from authorities and lack of access to funding, indicating that even grassroot- or event-driven forms of participation are not immune to systemic barriers. Bureaucracy was also a notable concern (20%), albeit to a lesser extent than in ECs. These findings suggest that while CTAs may be easier to initiate, they still operate within the same regulatory and financial constraints that affect more institutionalized forms of collective action.

Overall, the data reveal that ECs, despite their potential for long-term structural impact, face steeper institutional and logistical hurdles. Addressing these barriers through policy support, streamlined procedures, and accessible funding could help unlock the full transformative

Table 3
Average barrier scores by CEI type (0 = Not selected, 1 = Selected).

Barrier	CTA	EC
Lack of access to funding	0.24	0.43
Lack of technical knowledge	0.16	0.14
Bureaucracy	0.20	0.45
Lack of support from authorities	0.24	0.48
Low engagement of key personnel	0.04	0.10

potential of community energy initiatives.

4.4. Behavioral impacts of participation

Participants reported behavioral changes across both technical domains (such as solar installation and home retrofits) and lifestyle areas, including transport choices, dietary habits, and leisure activities. Overall, the level of self-reported change was modest across both CEI types, with mean scores ranging from 1.4 to 1.8 on a scale where 1 indicates no change and 3 indicates significant change. However, Energy Community (EC) participants consistently reported slightly higher levels of behavioral change across nearly all categories compared to those involved in Collective Targeted Actions (CTAs), as seen in Table 4.

The most pronounced difference appeared in heating behavior, where EC participants reported a substantially higher mean score (1.80) than CTA participants (1.42), suggesting deeper shifts in energy-related routines. Similarly, EC participants indicated greater changes in adjusting temperature (1.67 vs. 1.48), home retrofits (1.64 vs. 1.47), and adopting solar energy (1.81 vs. 1.73). Lifestyle-related shifts such as eating less meat, changing transport habits, and reducing leisure-related impacts were also more common among EC members, albeit to a lesser extent. The only category where both groups reported identical scores was flight reduction (1.64).

These findings suggest that while both ECs and CTAs can catalyze change, ECs may foster more sustained or deeper forms of behavioral transformation across technical and everyday life domains.

4.5. Behavioral clustering and profiles of engagement in ECs

To explore intra-group diversity in patterns of behavioral engagement, a clustering analysis was conducted exclusively on participants affiliated with Energy Communities (ECs). This decision was guided by the larger sample size within the EC group, which provided sufficient statistical robustness to perform meaningful segmentation. In contrast, the number of respondents affiliated with Collective Targeted Actions (CTAs) was too small to support an adequate cluster analysis.

Using K-means clustering, with k = 3 determined through the Elbow method, the analysis identified three distinct behavioral profiles among EC participants, based on ten standardized behavioral change indicators encompassing both technical measures (e.g., retrofitting, solar installation) and lifestyle-related practices (e.g., reducing meat consumption, changing transport and leisure behaviors). As shown in Fig. 2, these profiles capture the variation in how individuals engage within the same organisational context, offering deeper insight into the heterogeneity of citizen participation even within a single CEI type.

4.5.1. Cluster 0: Low-Engagement EC Members (n = 71)

This group displayed minimal behavioral change across all measured dimensions, with average scores ranging between 1.1 and 1.5. Participants in this cluster reported limited action on both technical aspects (such as retrofitting or installing solar panels) and lifestyle changes like reducing meat consumption, modifying leisure habits, or avoiding flights. Their engagement appears to be largely symbolic or peripheral, possibly stemming from social affiliation, passive membership, the feeling that the membership stands to be a sufficient contribution to the transition, or a limited capacity to act. Factors such as time constraints, lack of confidence, or unclear benefits may inhibit deeper involvement. These individuals may support the goals of the energy transition in principle, but lack the material, social, or motivational resources to translate support into concrete behavioral change.

Table 4
Mean behavioral change scores by CEI type (1 = No change, 2 = Some change, 3 = Significant change).

Behavior	CTA	EC
Install solar	1.73	1.81
Heating behavior	1.42	1.80
Adjust temperature	1.48	1.67
Home retrofit	1.47	1.64
Eat less meat	1.55	1.67
Reduce consumption	1.48	1.55
Reduce flights	1.64	1.64
Change transport	1.61	1.70
Change leisure	1.59	1.66

4.5.2. Cluster 1: Technically-Driven ECs Members (n = 41)

Participants in this group demonstrated strong engagement in technical measures, with high scores in retrofitting, solar installation, and heating-related behaviors (approaching or exceeding 2.0). However, they reported lower levels of lifestyle change, particularly in areas such as diet, travel, and leisure consumption. This suggests a form of engagement driven primarily by technological opportunity or economic rationality, rather than broader ecological or sufficiency-oriented values. Members of this cluster may be motivated by energy cost savings, efficiency gains, or environmental concerns that are addressed through infrastructure, but are either less interested in (or less able to adopt) behavioral shifts that require changes in daily habits or social norms. This profile illustrates a technocratic or investment-oriented pathway to participation in the energy transition.

4.5.3. Cluster 2: Lifestyle Transformers (n = 40)

This is the most comprehensively engaged cluster. Participants reported significant behavioral changes across both technical and lifestyle domains, with nearly all scores exceeding 1.8. These individuals not only invested in home energy improvements (e.g., solar panels, heating upgrades, retrofits) but also made substantive lifestyle adjustments, including reduced consumption, dietary shifts, and changes in transport and leisure behaviors. This group exemplifies the transformative potential of ECs, where deep engagement occurs through the alignment of structural supports (e.g., community ownership, access to knowledge, peer reinforcement) and personal motivation. These participants may be more embedded in community practices, more informed about climate and energy issues, or more empowered to act across multiple dimensions of their lives.

Together, these three profiles highlight the heterogeneity of engagement within ECs, emphasizing that even formal participation does not guarantee behavioral impact. Understanding this variation is critical for designing inclusive engagement strategies within collective energy initiatives.

5. Discussion

This article aims to provide a detailed, multi-dimensional examination of how citizens engage with the energy transition through different forms of Collective Energy Initiatives (CEIs). While much of the academic discourse on CEIs has centred on Energy Communities and focused on governance structures, technological deployment, or environmental impacts, our analysis foregrounds the human dimension of participation. We examine why individuals engage, how they experience participation, and the extent to which engagement is associated with transformative behavioral change. Importantly, we approach participation not simply as a matter of individual motivation or civic responsibility, but as being shaped by the socio-technical, institutional, and organisational conditions under which engagement becomes possible.

Through a comparative analysis of two CEI types - Energy Communities (ECs) and Collective Targeted Actions (CTAs), we demonstrate that citizen engagement is shaped by different motivations, barriers, structural designs, and personal capacities. Our findings show that not all engagement is equal. While some participatory arrangements enable deeper shifts in behavior and identity, others facilitate participation through more narrowly defined, outcome-oriented channels. The

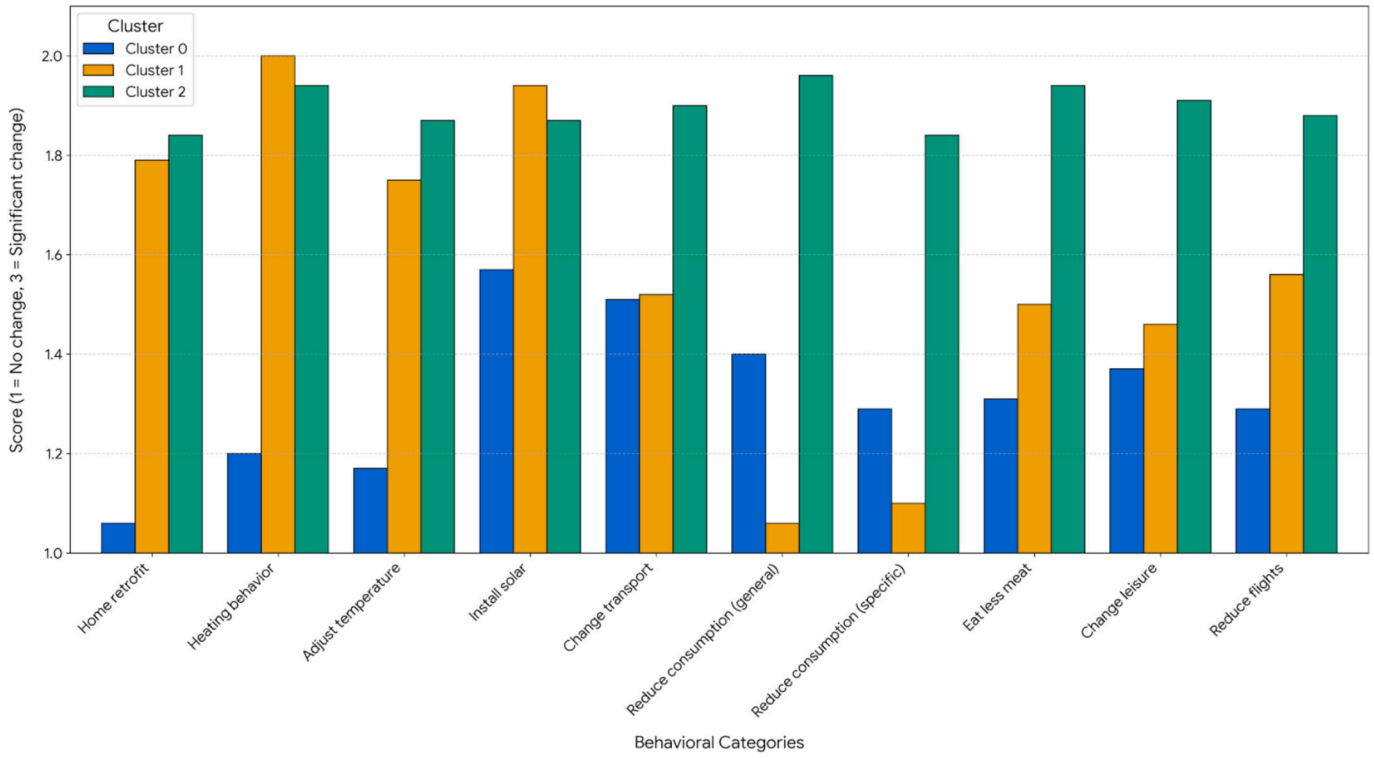

Fig. 2. Behavioral cluster profiles among EC participants.

following discussion sections unpacks these dynamics by situating our results within existing debates on energy justice, energy citizenship, and socio-technical transitions, and by highlighting the shared responsibility of institutions, intermediaries, and system designers in shaping inclusive and socially driven energy transitions.

5.1. Beyond technological adoption: engagement as a socio-technical process

The results of this study reaffirm the view that energy transitions are not purely technological substitutions, but processes of systemic transformation that require changes in norms, practices, and identities [2,48]. The difference in behavioral outcomes between EC and CTA participants exemplifies this. While both initiative types enable participation, ECs foster deeper, broader engagement, likely due to their collective governance, community embedding, and long-term orientation.

EC participants consistently reported high motivation tied to climate concern, social belonging, and energy self-sufficiency, factors that resonate with framings of energy and environmental citizenship as a transformative, value-driven form of participation [64,65]. These motivations align with what the literature identifies as normative engagement, where participation is not only about outcomes (e.g., saving energy or money) but also about expressing identity, practicing solidarity, and enacting change [51].

CTAs, by contrast, were more likely to support instrumental engagement, or engagement driven by specific project goals, incentives, or institutional nudges. Participants in CTAs reported lower rates of lifestyle-related behavioral change and were motivated more by climate concern and financial benefits than by community or autonomy. These findings suggest that while CTAs serve as effective tools for targeted impact, they may not cultivate the same long-term cultural or behavioral transformation as ECs. This divergence may also reflect underlying socio-cultural dynamics - ECs often resonate more strongly in rural or village contexts, where collaboration and shared management may be embedded in everyday practices, while CTAs may be more aligned with urban environments, where individualistic cultures and project-based engagements are more prevalent.

At first glance, the relatively modest differences between EC and CTA participants in technical behaviors such as installing solar PV or undertaking home retrofits may appear counterintuitive, given that EC often provide organisational, technical, and financial support for precisely these actions. However, this pattern can be partly explained by differences in baseline conditions and self-selection effects. EC participants already exhibit high levels of climate concern, only marginally higher than CTA participants, suggesting that many were predisposed toward climate-friendly behavior even prior to joining an initiative.

Moreover, especially in the early phases of EC development, participation might be often driven by households that have already installed solar PV and subsequently seek more meaningful or collective ways to manage, share, or valorize their existing generation. In this sense, the causal relationship may run from prior technology adoption to community participation, rather than the reverse. This highlights that ECs do not always initiate technical change but can also act as organisational structures that consolidate, coordinate, or extend pre-existing individual investments.

This reinforces the need to treat CEIs as socio-technical institutions, not just technological platforms. Their design, including governance models, inclusion practices, and communication strategies, shapes not only who participates but also how deeply they are able and willing to change.

5.2. The role of structure and complexity in shaping participation

Our findings on barriers to participation deepen this argument by illustrating how institutional design and complexity impact the inclusivity and effectiveness of CEIs. EC participants faced significantly higher barriers in terms of bureaucracy, unclear responsibilities, and internal complexity. While ECs offer rich spaces for agency and community building, they also require high levels of procedural knowledge and sustained involvement. This reflects what has been called the "paradox of participation" in the literature, where initiatives designed to

empower citizens often simultaneously impose burdens that discourage or exclude those without the means or resources for participation [31,66].

CTAs, in contrast, appeared more structurally accessible. They required fewer internal processes, and participants reported fewer barriers overall. This lower threshold makes CTAs a promising model for broadening participation, especially among individuals or groups who are new to individual and collective energy actions. However, this ease of access may also limit the depth of engagement and long-term benefits, as reflected in lower behavioral impact scores and a narrower motivational base.

These findings underline the importance of structural sensitivity in CEI design. Simplifying procedures, clarifying roles, and providing navigational support may be as important as technical tools in enabling inclusive and effective participation, which is also argued by [67,68].

It is important to note that the CTAs examined in this study represent a specific subset of collective engagement, primarily focused on targeted, service- or action-oriented interventions related to energy use, efficiency, or technology adoption. Other forms of citizen participation in energy transitions such as social movements, demonstrations, and advocacy networks play a different but equally important role by shaping political agendas, contesting dominant energy pathways, and influencing public discourse [9,27,28]. While such forms of engagement often prioritise collective mobilisation and systemic change over direct behavioral or technological intervention, they interact with initiatives such as CTAs and ECs by creating enabling social and political conditions for transformation. The present analysis therefore does not seek to compare these forms directly, but rather to position CTAs and ECs within a broader ecosystem of citizen participation in energy transitions.

5.3. *Engagement profiles: agency, resources, and the depth of change*

Perhaps the most novel insight of this study emerges from the clustering analysis of behavioral patterns among EC participants, which revealed three distinct profiles of engagement: Low-Engagement Participants, Technically Driven, and Lifestyle Transformers. These profiles provide a more nuanced understanding of citizen participation by moving beyond the question of whether individuals engage, toward how they engage, which dimensions of change they prioritise, and what these insights reveal about their capabilities, resources, and structural conditions for action.

The clustering analysis thus complements the broader comparative analysis by offering granular insight into intra-initiative dynamics within Energy Communities, currently the most researched and policy-supported form of collective energy initiative. It underscores that participation within ECs is not uniform and that formal inclusion alone does not guarantee deep or transformative engagement. Rather, engagement outcomes vary substantially depending on how participation opportunities interact with individual capacities, motivations, and contextual constraints.

Across the three clusters, clear differences emerge in the depth and scope of behavioral change. Low-Engagement participants (Cluster 0) reported minimal change across all ten domains, with average scores ranging between 1.1 and 1.4. Technically Driven participants (Cluster 1) exhibited strong engagement in infrastructure-related actions such as solar installation, retrofitting, and heating behavior (mean scores between 1.75 and 2.0), but limited lifestyle change in areas such as consumption or diet (1.06–1.5). In contrast, Lifestyle Transformers (Cluster 2) consistently reported high levels of change across both technical and lifestyle domains, with most scores exceeding 1.8, indicating a holistic engagement pattern. These distributions support the conclusion that participation unfolds through different channels - technological, habitual, or combined, and that engagement depth cannot be explained by CEI type alone.

From an energy justice perspective, the Low-Engagement cluster is particularly salient. Although these participants are formally members of Energy Communities, their limited behavioral change suggests constrained ability to translate participation into action. Prior research has highlighted that ECs often attract participants with relatively high levels of education and resources, while simultaneously imposing procedural, informational, and time-related burdens that can limit meaningful engagement for others [13,41]. Rather than reflecting disengagement or lack of commitment, the Low-Engagement profile likely points to unequal capabilities shaped by factors such as time availability, financial security, confidence, or access to supportive networks. This finding reinforces concerns that participatory governance structures can reproduce internal inequalities, even while promoting democratic ideals [43,44].

The Technically Driven cluster reflects a different, but well-established, pathway of participation. These participants engage primarily through infrastructural and investment-oriented actions, enabled by access to capital, technical knowledge, or homeownership. This pattern aligns with existing research on material or prosumer-oriented forms of energy citizenship, where participation is channelled through technology adoption rather than broader lifestyle transformation [19,20]. While such engagement can deliver substantial technical and environmental benefits, previous studies caution that it does not necessarily foster wider sufficiency-oriented practices or identity shifts [17,39]. This profile thus illustrates that energy citizenship can be effective yet partial, producing meaningful outcomes in specific domains without extending across everyday practices.

The Lifestyle Transformer cluster, representing the most comprehensively engaged participants, reflects patterns widely documented in the Energy Community literature. These participants were more likely to be younger, higher-income, or students, groups with greater flexibility, informational access, and alignment with pro-environmental values. Previous studies consistently show that EC participation is skewed toward socially and economically advantaged groups [13,14,17]. From an energy justice perspective, this suggests that the capacity to engage deeply across both technical and lifestyle domains is unevenly distributed. Rather than signalling greater civic virtue, the Lifestyle Transformer profile highlights how structural advantages and accumulated capabilities enable some participants to realise the full transformative potential of participation, echoing critiques that Energy Communities may inadvertently reinforce existing inequalities [43,45].

Taken together, these engagement profiles demonstrate that participation in ECs produces stratified forms of energy citizenship, shaped by intersecting socio-economic conditions, institutional design, and personal capabilities. The findings extend existing critiques of ECs by showing not only who participates, but how participation translates into uneven behavioral and transformative outcomes [13,17,43]. By empirically linking engagement depth to differentiated resources and capacities, the clustering analysis reinforces insights from the capability approach [69,70] and energy justice scholarship, which argue that genuine participation requires more than formal opportunity - it requires the means to convert opportunity into action [71].

6. Conclusion and policy implications

This article set out to broaden the understanding of citizen engagement in the energy transition by comparing Energy Communities (ECs) and Collective Targeted Actions (CTAs), and by examining how different organisational forms shape motivations, barriers, and behavioral outcomes. Drawing on survey data from across Europe, the analysis demonstrates that citizen participation is neither uniform nor reducible to a single institutional model. Instead, engagement emerges through a variety of pathways that differ in depth, accessibility, and transformative potential. Importantly, the CTAs examined in this study represent a specific subset of collective engagement, primarily focused on targeted, service- and action-oriented interventions related to energy use, efficiency, and technology adoption. Other forms of participation such as social movements, demonstrations, and advocacy initiatives play

complementary roles in shaping political agendas and collective transformation but were not the focus of the present analysis.

Our findings show that ECs tend to support deeper and more holistic forms of engagement, encompassing both technical investments and lifestyle changes, often driven by strong value-based motivations such as climate concern, community belonging, and energy autonomy. At the same time, participation in ECs is associated with higher institutional and procedural barriers, including bureaucratic complexity, regulatory uncertainty, and reliance on sustained leadership and expertise. Addressing these barriers requires targeted intermediary support, such as one-stop-shops (OSSs), which can assist citizens in navigating legal, technical, and organisational requirements without transferring the full coordination burden onto volunteers. CTAs, by contrast, offer more accessible and flexible forms of engagement, typically centred on specific actions or goals and characterized by lower entry barriers. However, this accessibility is often accompanied by more limited behavioral spillovers and weaker long-term transformation at the individual level.

Importantly, these differences should not be interpreted as a simple hierarchy in which one form of engagement is inherently superior to the other. Rather, they reveal a fundamental tension in participatory energy governance - institutionalization enables scale, stability, and measurability, but it also introduces complexity and exclusion risks; flexibility and informality foster experimentation and inclusivity but may struggle to sustain long-term impact or secure recognition and resources. This tension is particularly visible in the policy implications. While the analysis highlights the need to reduce institutional barriers for ECs, it also cautions against assuming that extending formal regulatory recognition to CTAs is an unqualified good. Over-formalization risks undermining the diversity, adaptability, and social innovation that make CTAs attractive entry points for participation in the first place.

From this perspective, CTAs should not be understood as replacements for ECs, nor as an alternative endpoint of citizen participation. Instead, they function as complementary instruments within a broader ecosystem of engagement. CTAs can lower thresholds for involvement, engage groups that may be excluded from ownership-based models, and serve as gateways toward deeper forms of participation, including eventual involvement in ECs. Policy frameworks that recognize this complementarity, rather than privileging a single model, are more likely to support inclusive and resilient energy transitions.

The clustering analysis further reinforces this conclusion by showing that even within ECs, participation takes multiple forms, ranging from low engagement to technically focused action and comprehensive lifestyle transformation. This internal heterogeneity underscores that participation opportunities alone are insufficient; citizens also require the capabilities, resources, and supportive environments to translate opportunities into meaningful action. Policies aimed at expanding citizen participation must therefore attend not only to institutional design but also to social, informational, and economic conditions that shape agency.

Finally, the context in which citizen energy initiatives operate is evolving rapidly. Since the data for this study were collected in 2023, several developments are likely to further reshape participation dynamics. Regulatory changes in many European countries are expanding possibilities for energy sharing beyond formally constituted communities, potentially lowering entry barriers and enabling new hybrid forms of collective action. At the same time, increasing emphasis on flexibility, aggregation, and demand-side participation may open new roles for both ECs and CTAs as intermediaries between households and energy systems. Ongoing and emerging geopolitical crises, combined with heightened concerns over energy security and dependence on fossil fuel imports, are also intensifying public interest in energy autonomy and collective solutions. These dynamics suggest that citizen engagement may increasingly be driven not only by environmental values but also by concerns over resilience, affordability, and security. Future research could also examine how funding criteria, investment accessibility, and the measurability of outcomes influence which types of collective energy initiatives receive institutional support, and how these factors shape the visibility and development of different participation models.

Taken together, these findings call for policy approaches that move beyond a narrow focus on single organisational models and instead support a plural, adaptive ecosystem of collective energy initiatives. Recognizing the distinct yet complementary roles of ECs and CTAs, while remaining attentive to evolving socio-technical and geopolitical conditions, is essential for fostering broad, just, and durable citizen participation in the energy transition.

CRediT authorship contribution statement

Vanja Djinlev: Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Investigation, Formal analysis, Conceptualization. **Michael Brenner-Fliesser:** Writing – review & editing, Data curation, Conceptualization. **BinBin J. Pearce:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization.

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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. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.erss.2026.104682.

Data availability

The dataset supporting the findings of this study is openly available on Zenodo at https://zenodo.org/records/17485166.

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