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All together now: building resilient citizen energy communities through collaborative learning

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Abstract

As the energy transition deepens, a key component of this effort has been the advancement of citizen energy communities (EC) which are vital for fostering the innovation needed to achieve net zero. While notable effort has been made to capture the perspectives of energy cooperatives, little attention has been paid to the shared perspectives of energy cooperatives and the energy distribution system operators they must engage with when establishing an energy community. This paper seeks to address this by examining how collaborative learning, a participatory approach where stakeholders share knowledge and experiences to identify challenges and co-develop strategies, can help practitioners identify and better understand the key barriers and drivers to citizen energy community formation. Drawing from original research conducted across four distinct EC situated in four European countries, it outlines how a living lab, a real-world, user-centred research environment for testing and refining energy solutions, was utilised to understand the motivations that underscore people's attitudes towards, and participation in, a 'community'. Findings indicate that togetherness—expressed through social and functional relationships—is a foundational component of EC, supported by key factors such as context, values, and needs. The study also highlights major challenges, including a lack of social democracy, regulatory issues, and uncertainty about benefits, with social engagement emerging as the most effective strategy for building resilience, or the capacity of communities to adapt and sustain participation. The paper also engages with the wider debates found within this journal on the deployment of living labs and their applicability as a tool for socio-technical innovation that can empower EC and build greater resilience amongst stakeholders.

1. Introduction

The emerging energy communities (EC) concept offers a promising vehicle (Reinsberger and Posch 2014) for understanding and framing the transformation of the energy system into a more sustainable, decentralised space that can facilitate more participative and democratic energy processes for citizens (Caramizaru and Uihlein 2020). While previous energy transitions can be characterised by an absence of ordinary citizen participation, this transition is unusual in that it presents an opportunity for including citizens in the decision-making process. Indeed, more than ever before there is a clear need for energy projects to secure greater social acceptance, and more importantly social acceptability, of energy technologies at the local level (Bauwens and Devine-Wright 2018, Toke *et al* 2008). The 'energy community' concept involves the inclusion of local citizens in the production, consumption, and management of renewable energy sources (Roberts *et al* 2019). EC are collective initiatives where citizens, local organisations, and stakeholders collaborate to produce, manage, and consume energy, often from renewable sources. They operate a decentralised, participatory model that prioritizes local engagement, democratic governance, and shared benefits. ECs can

take various forms, including cooperatives, virtual networks, or district-level energy projects, with the overarching goal of enhancing energy resilience, sustainability, and community empowerment. Also, within the socio-technical transitions to a sustainability framework, ECs can provide considerable societal benefit by potentially resolving some of the multi-dimensional tensions emerging between radical niche innovations and incumbent socio-technical systems (Geels 2019). Community-based energy projects offer a means for realising more deliberative and inclusive citizen participation to implement stronger local governance over energy production (van der Schoor and Scholtens 2015), particularly through new technical advances in renewable energy and associated demand flexibility solutions commonly referred to as demand response (O'Connell *et al* 2014).

The European Commission's Clean Energy for All Europeans Package[5] recognises the role of prosumers and EC in future energy systems and provides a legal framework to support their development with participation often folded within the cultural signifier of the 'energy citizen' (Lennon and Dunphy 2023). Indeed, considerable work has been carried out into deconstructing the many representations and expressions of energy citizenship (e.g. see Dunphy and Lennon 2022, Debourdeau *et al* 2024, Held *et al* 2024). However, the energy community concept is not always well defined in some jurisdictions and can be interpreted in different ways by different actors. Therefore, this article aims to explore ideas around the notion of 'community' held by stakeholders involved in establishing and maintaining an 'energy community'. It will look beyond the functional and technical aspects, and account for the social context, relationships, and values of the stakeholders involved to understand the concept of 'community' within a living lab context. This investigation utilises a mixed methods approach with both quantitative and qualitative tools used to gather data which reflects the perspectives of real energy market actors (e.g. distribution system operators (DSOs), engineers, and software designers) and importantly ordinary citizens who are members of existing EC. The article identifies the different dimensions of 'community' that are most relevant for the participating EC, such as identity, belonging, participation, trust, and governance, and discusses the implications of these findings for the design and implementation of energy community projects and policies in Europe.

At its core, an energy community represents a collaborative venture where stakeholders collaborate to manage and benefit from a (local) energy resource. This extends beyond conventional energy models, based exclusively on transactional arrangements, and embraces a more decentralised and participatory perspective that empowers community members to actively engage in the energy lifecycle, from production to consumption (Seyfang *et al* 2013). The process of developing an energy community involves a myriad of interconnected steps, encompassing the establishment of shared goals, the integration of diverse energy sources, and the cultivation of a sense of ownership among community members. All of these are crucial elements to creating a sustainable and inclusive energy community (Clayton *et al* 2016, Kivimaa and Martiskainen 2018). Indeed, ensuring the vitality of an energy community requires sustained effort on the part of project leads, community leaders and others to foster collaboration, manage resources effectively, and adapt to evolving energy landscapes. This article will also explore the challenges EC face and the relative importance of various potential mitigation strategies. Providing insight into the mechanisms that contribute to the longevity and resilience of EC is essential for providing best practices which lead to their continued success (Kivimaa *et al* 2021).

2. Background

2.1. Interpreting what is an energy community

Defining an energy community can pose a significant challenge given the amorphous and often contradictory interpretation of what is a 'community' when engaging with different actors and stakeholders across different scales and contexts. Consequently, there lacks a universally accepted definition of what an 'energy community' is, with ambiguity and/or contradictory interpretations found between the literature and the different policy cycles across all scales of government. For instance, some research suggests EC are local initiatives within a specific geographical area, whereas others argue EC include virtual communities, energy cooperatives and district or regional markets (Whitton *et al* 2015).

[5] Within the Clean Energy Package, citizen energy community (CEC) and renewable energy community are considered new legal entities and defined as non-commercial energy market actors whose primary purpose is to provide 'environmental, economic or social community benefits' (REScoop.EU 2019, p 9). As such Member States must ensure that both definitions must be able to operate in the energy market without discrimination (European Parliament 2018, European Parliament and Council of the European Union 2019, p 16). CECs are defined as an energy system covering all types of electricity, while RECs are exclusively concerned with renewable energy sources. Rather than focused solely on profit-making, these EU legislative documents establish energy communities as new types of non-commercial entities that primarily focus on providing environmental, economic and/or social benefits to communities (REScoop.EU 2019). As part of these directives, energy communities are framed using specific criteria and activities which ensure they may operate within the energy market without discrimination (Roberts *et al* 2019).

Understandably, definitions of an energy community vary given the dynamic interplay at work between what are ever-evolving energy markets and the respective stakeholders who engage in them. As the energy transition progresses and new technologies emerge, the boundaries and characteristics of EC will also continue to evolve (Koehrsen 2017, Creamer *et al* 2018). The diverse objectives and structures of EC further complicate efforts towards establishing a uniform definition. Some EC focus on promoting renewable energy generation and energy efficiency, while others prioritise energy access, affordability, or community empowerment (Koirala *et al* 2016, Braunholtz-Speight *et al* 2021). In addition, the lack of a clear definition is problematic for the evaluation of innovative energy solutions implemented within a community in terms of desired transitions, sustainability targets and building community resilience (Marique and Reiter 2014, Faria *et al* 2021).

The approach taken in this research has been to understand how a community definition is shaped and informed by market actors and the various gatekeepers to the communities who are the target of innovative energy solutions. In addition to the community participants, key stakeholders identified comprise energy co-operatives, DSOs, and living lab managers. Developing an understanding of how these key stakeholders define and interpret 'a community' offers useful insights into how best to approach communities (in all their forms) and successfully implement innovative energy solutions.

2.2. Key social, psychological, economic, and technological factors in an energy community

To fully understand the overt and hidden interactions taking place within EC, it is crucial to examine the complex interplay of social dynamics, psychological aspects, economic considerations, and the technological innovations experienced by stakeholders, offering a comprehensive view of their operation and impact. The social dynamics within an energy community refer to interpersonal relationships, attitudes and motivations within a society or community (Sloot *et al* 2018). For example, Allcott (2011) discusses the impact of social norms on energy conservation, emphasising the role of psychological interventions in shaping individual behaviour. For social acceptance to occur when attempting to introduce renewable energy innovation, it is imperative to consider the socio-political landscape and the community values and culture within the target region (Wüstenhagen *et al* 2007). The social dynamics within an energy community are also paramount in terms of the practical application and achievement of innovative energy solutions. Parkhill *et al* (2015) suggest there is a fundamental social nature when dealing with individual preferences associated with the decision-making process in energy behaviours. To steer citizens within a community towards a desired energy-related behaviour, project leads must explore shared visions and social actions to create a common goal that matches citizens' values. In addition, the social pressure of participating in community energy projects can be a key motivator for community members which can be leveraged (Dóci and Vasileiadou 2015) to achieve a desired behavioural change.

Innovative energy projects can also serve as a vehicle to enhance a sense of community. Callaghan and Williams (2014) suggest renewable energy projects can revitalise local communities, emphasising the social impact of community renewables in fostering new social networks and enhancing community confidence to take on more proactive actions around energy. This translates to the potential solutions being developed within a community-based innovative sustainability project. Adopting a co-creation approach in the design of technological solutions in renewable energy projects evolves social relations between the public and renewable energy technology developers (Walker and Cass 2007).

2.3. Dealing with barriers to an energy community

Despite the promise of contributing to transformative systemic change, EC often encounter barriers that impede their formation and operation. Consequently, EC must contend with diverse challenges ranging from regulatory hurdles and financial constraints to societal resistance (e.g. see Lennon *et al* 2021, Lennon and Dunphy 2024). The legal complications are well documented in the literature due to the barrier of aligning legislation related to EC with legal frameworks and market conditions (Biresselioglu *et al* 2021). Research has demonstrated that regulatory barriers and inequalities arise when attempting to involve communities more actively in new energy initiatives (Batidzirai *et al* 2021). For instance, energy community-based innovative solutions related to wind farms have been problematic because of the regulatory challenges hindering community acceptance (Maleki-Dizaji *et al* 2020). Barriers also exist in terms of inclusivity and community participation due to the financial considerations associated with energy initiatives. Consequently, identifying appropriate strategies for overcoming economic barriers is essential for fostering an environment conducive to community-driven energy initiatives (Palm and Reindl 2018, Lazdins *et al* 2021).

The barriers experienced by an energy community are not restricted to energy market-related issues such as regulation and economy, the social dynamics within a community are also a key factor contributing to the success or failure of a community energy project and the collapse of its associated energy community. Hutter *et al* (2011) suggested that communal attitudes towards competition and collaboration within an energy

community pose a barrier to continued participation in new energy solutions. Without finding a correct balance between competition and collaboration, individuals within a community will not feel committed and disengage. Disengagement has proven to be a significant stumbling block in many previous innovative energy solution projects. Therefore, there is a need to provide circumstances for an energy community which encourages active participation from motivated community members. Ryghaug *et al* (2018) argue that a lack of meaningful involvement of citizens within a community negatively impacts the success of an innovative sustainable energy solution. Failure to provide a clear and tangible concept of the energy solution to affected stakeholders will lead to a loss of interest and ultimately a diminution in participation by the community.

In the context of collaborative learning between DSOs and energy cooperatives in forming and maintaining EC, previous research highlight the operational and regulatory challenges linked to such endeavours. For instance, Jasiński *et al* (2021) discuss the effectiveness of energy cooperatives operating within the capacity market, emphasizing the need for regulatory frameworks that support local energy independence and the establishment of EC. Similarly, Mucha-Kuś *et al* (2021) explore the simultaneous competitive and cooperative ('coopetitive') nature of EC, analysing regulatory and practical aspects without detailing how DSOs and cooperatives navigate these challenges together. Furthermore, Hentschel *et al* (2018) provide insights into renewable energy cooperatives and their role in facilitating energy transitions. However, they do not address the interplay between DSOs and cooperatives in overcoming regulatory hurdles or explore the collaborative potential between these two entities regarding the mitigation of operational challenges. Additionally, case studies within the current literature on cooperation between DSOs and energy cooperatives often lack empirical evidence of joint initiatives. For instance, while Liu *et al* (2018) discuss cooperative optimisation strategies in multi-microgrid systems, they do not provide concrete examples of how DSOs and energy cooperatives work together in practice. Similarly, case studies on energy management in urban buildings showcase cooperative energy management schemes but fail to demonstrate joint initiatives involving DSOs (e.g. see Vardakas *et al* 2018). This indicates a gap in the literature where the dynamics of cooperation are acknowledged, yet empirical evidence of collaborative efforts is absent.

While there is a wealth of literature exploring DSOs and energy cooperatives independently, as well as their regulatory and operational challenges, there is a notable lack of studies that examine how these entities navigate these challenges together. This presents a significant opportunity for research that can contribute to the understanding of collaborative learning in the context of EC. This paper offers valuable insights into the transformative potential of community-oriented energy initiatives and provides a roadmap for overcoming challenges, fostering sustainability, and creating a resilient energy future through engaged participation and collaborative learning. The approach of this research is to understand how a community is defined, what are the key barriers faced by EC and what are the potential strategies for building the resilience of an energy community from the perspective of market actors within the energy system.

3. Methodology: characterising community participation through living labs

The data presented in this paper comes from work undertaken as part of the community engagement effort for the ACCEPT Horizon 2020 project. This work involved the active participation of members of four EC in four European countries (Greece, Spain, Switzerland, and the Netherlands) engaged in the co-design and implementation of appropriate demand-response tools required for scaling up renewable energy projects. The selection of these four EC was determined based on their participation as demonstration sites within the ACCEPT Horizon 2020 project. These sites were chosen as they represent diverse socio-technical and regulatory environments, allowing for an in-depth exploration of EC' engagement with demand response solutions. The communities involved were those that were both willing and able to participate in the ACCEPT project's co-design and implementation of innovative energy management tools. As such, the selection was not arbitrary but rather based on the pre-existing infrastructure, organisational capacity, and willingness of these communities to engage in a living lab methodology to test and refine demand response technologies. While the sample is not fully representative of all European EC, it provides valuable insights into real-world challenges and opportunities in the transition towards decentralised, citizen-driven energy models.

Working with these communities over 4 years, we deployed a range of qualitative and quantitative methods in each of the four living labs (Feurstein *et al* 2008). While some (e.g. Paskaleva and Cooper 2021) suggest that despite a 20 year history operationalising living labs the approach is often still poorly understood, we found it a useful vehicle for moving beyond traditional user-centric methodologies and incorporate the multi-contextual, intersecting, sometimes contradictory experiences of the many different actors we engaged with throughout the lifetime of the project (Feurstein *et al* 2008). What is key to the success of engaging an energy community built through a living lab process is designing an engagement plan which incorporates knowledge building of the community and its needs and fosters stakeholder interaction to achieve the goals of an energy initiative (Tobin *et al* 2023a).

In addition, socially-centred living labs consider the local context by developing spaces for participants to encounter each other through methods that align with the research design and local requirements (Franz 2015). Due to the constraints brought on by the COVID-19 pandemic during the first half of the project, we had to pivot much of our engagement activities online, only carrying out in-person semi-structured interviews, workshops, and onsite visits after government restrictions were lifted. While this presented significant challenges, it did provide us with an opportunity to implement novel approaches to the engagement programme to account for the diversity of experiences and geographic dispersity of the participating communities.

This paper reports on an online workshop conducted during the first half of the project with participants consisting primarily of consortium members from various organisations and institutions including non-profit organisations, research institutions, SMEs and large enterprises with national footprints in the participating countries. The workshops engaged a diverse range of stakeholders representing different segments of the energy sector. Participants included representatives from energy cooperatives, DSOs, technology developers, energy service companies, research institutions, and community leaders from the four demonstration sites (Greece, Spain, Switzerland, and the Netherlands). These individuals were selected based on their direct involvement in the energy transition, demand response initiatives, and community energy projects.

The participants brought expertise in various domains, including electricity distribution, consumer engagement, software development for energy management, regulatory compliance, and cooperative governance. Representatives from DSOs provided insights into grid integration challenges and regulatory barriers, while energy cooperatives contributed perspectives on citizen participation and community-led renewable initiatives. Additionally, technology developers and research institutions involved in the project offered technical insights into demand response solutions and digital tools designed to enhance community energy systems.

By engaging individuals from organisations with practical experience in EC, the workshops facilitated a multi-stakeholder dialogue that captured real-world challenges and opportunities in implementing community-led energy solutions. Although the findings are based on a selected group of experts and practitioners, the range of roles and expertise ensures that the insights reflect a broad spectrum of perspectives from across the European energy landscape.

Gathering insights from these energy market and community stakeholders on how to address the range and types of obstacles communities face regarding innovative energy solutions is vital for determining effective strategies that lead to the success of those sustainable initiatives. Another significant factor underlining the importance given to these stakeholders in the project is the role they have as gatekeepers to EC. Energy community gatekeepers are responsible for controlling the flow of information (Domingo *et al* 2008), influencing the decision-making processes and ensuring that the interests of community members are considered (Cooper 2008). Gatekeepers are also responsible for ensuring that the values of a community are upheld. Respecting community values promotes acceptance of solutions offered in innovative energy projects (Schuh 2006). Furthermore, individuals or organisations taking on the role of gatekeeper possess knowledge and expertise critical for the success of energy projects by ensuring progressive innovation and enhancing creativity in the design and implementation of new solutions (Petruzzelli 2008).

The workshop was designed to first assess how a community is defined, by investigating what the keywords or phrases come to mind for participants when conceptualising what a community means to them. While it is widely recognised that community as a concept is still widely contested for good reason (Crow and Mah 2012) it was important for us to capture a bottom–up, individual perspective of what it means to participants engaged in setting up an energy community. The workshop also investigated the barriers faced by communities and the potential strategies to make EC more resilient. To assess the potential barriers and strategies, hypothetical scenarios that tapped into areas that pose the risk of obstacles arising for community participation in innovative energy solutions, such as forming an energy community (Berka and Creamer 2018) and the deployment of new technology and community disengagement (Reinsberger and Posch 2014).

3.1. The workshop as a method

A workshop, when applied using three different perspectives—workshops as a means, workshops as practice, and workshops as a research methodology—can be a useful tool for engaging in meaningful negotiation between researchers and participants (Ørngreen and Levinsen 2017). Ahmed and Asraf (2018) point to Lain's (2017) contention that workshops help foster engagement through collaborative discussion and obtaining constructive feedback between participants and researchers. Our research approach reflects this perspective, with the workshop discussed in the paper conducted online through Microsoft Teams with 2 moderators. The workshop consisted of two main phases: (1) defining participants' perceptions of the understanding of 'community' and (2) identifying barriers and strategies related to the formation and resilience of EC.

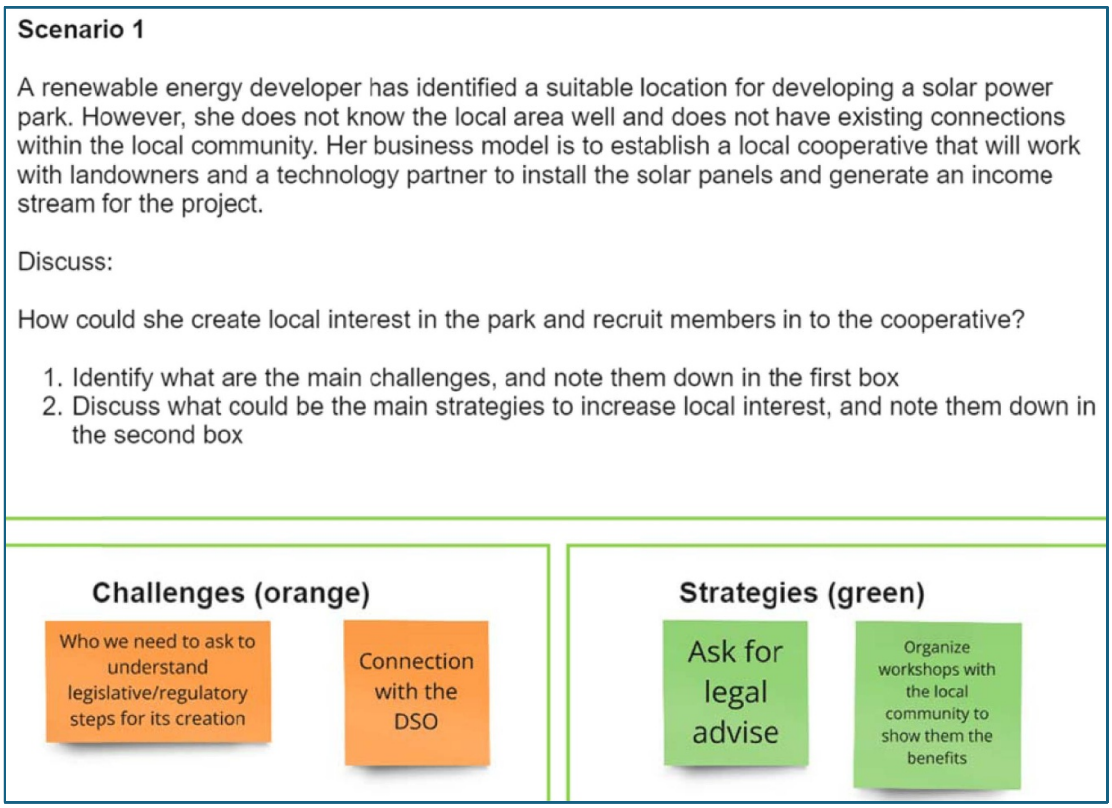

Figure 1. Example template and responses from respondents engaging in the workshop scenarios. For the full list of scenarios see appendix.

In phase 1, we applied the online tool Mentimeter to ask participants to provide a word or phrase that immediately comes to mind when they hear the word 'community'. Participants were encouraged to not only consider English words but also applicable words in their local language.

In phase 2, participants were presented with a series of energy community-related scenarios (see Tobin *et al* 2023b) to which they were required to identify potential challenges that could arise and strategies for overcoming potential challenges via a template created through the online tool Miro (see figure 1). Although barriers and strategies can be synonymous, it was not specified to the participants that they should report challenges and linked strategies.

For the second phase of the workshop, participants were randomly assigned into four groups of 5 participants via the breakout rooms function in Microsoft Teams. Each group had a workspace board for providing challenges and strategies for the scenarios. Participants were allocated 15 min to discuss and propose challenges and strategies for the given scenario. Participants were instructed to provide at least two challenges and two strategies, each challenge and strategy proposed could be linked but this was not a requirement. Participants were encouraged to offer opinions from their perspectives that are informed by their specific lived experiences. They were also advised to give a short statement of potential challenges and strategies as opposed to providing overly elaborate plans and finite details. Participants were advised to spend the first 5–10 min considering and noting down challenges and relevant factors and then in the final 5 min organise the notes into specific challenges and strategies to share with other participant groups in the workshop.

A slight deviation in our approach was taken with the third and final scenario investigating the challenges and strategies. Participants were presented with a scenario in which a sustainable energy project was failing. Instead of providing potential challenges and strategies, participants were presented with nine potential strategies for dealing with a failing energy project and instructed to select one primary and one secondary strategy. Each of the provided strategies fell into one of three categories, business modelling, social, or technology. Table 1 shows the nine strategies and related categories. The category types were not presented to the participant, only the potential strategies. Selections were voted for through the voting function in Miro.

Table 1. Potential strategies and related categories presented to participants.

Potential strategy	Category
Perform market analysis to assess current BM	Business modelling
Consult market expert for feedback on BM	Business modelling
Focus the BM towards a more community-orientated approach	Business modelling
Obtain a better understanding of the local culture	Social
Research ways to encourage L/T commitment	Social
Engage the community more to help them understand the technology	Social
Analyse other similar technologies in the market/used by the customer	Technology
Improve the technical foundations of the APP	Technology
Modify the user interface of the APP	Technology

4. Results

4.1. Defining an energy community

From the collaborative engagements in Phase One of the workshop, the participants provided 30 words or phrases which they related to the concept of 'community' (for a word cloud demonstrating the selection provided, see Lennon *et al* 2023). To gather additional insight and clarify the responses that were not provided in English, the information gathered was subjected to a refinement process whereby participants were interviewed after the workshop to clarify and potentially offer a more detailed description of the words/phrases they gave. After the refinement process, a thematic analysis was performed to identify key factors for answering the question 'What is a community?'. To ensure reliability, the thematic analysis was conducted by a second researcher and then results from both researchers were discussed and agreed upon.

4.1.1. Thematic analysis and coding process

Thematic analysis was employed to examine the data collected from the workshop discussions and participant contributions. The coding process was conducted manually, drawing from both the content produced on the Miro board and the transcripts of the discussions. To enhance the reliability of the analysis, two researchers independently coded the data, identifying key concepts, patterns, and emerging themes. After the initial coding, the thematic analysis produced by each researcher was shared and discussed to compare interpretations and ensure consistency in the identification of themes. Where discrepancies arose, these were deliberated upon, and themes were either refined, combined, or reconsidered based on mutual agreement, ensuring a balanced and rigorous analytical process. This collaborative approach allowed for a more robust synthesis of findings and mitigated individual coder bias. While no software (e.g. NVivo) was used, the manual coding method provided flexibility in capturing nuanced insights from the qualitative data. By employing this structured approach to thematic analysis, we ensured that the findings were systematically derived and reflective of the diverse perspectives expressed by workshop participants.

Following the thematic analysis, a framework containing one prominent theme ('togetherness'), informed by three notable factors (i.e. context, values, and needs) emerged (see figure 2), capturing the perspective of the market actors for defining a community.

From the definitions provided, it was clear that 'togetherness' in the form of social and functional relationships was a key theme for the participants when conceptualising an understanding of community. The social element can be observed through definitions such as interpersonal relationships, mutual support and conviviality. Regarding functional relationships, the value of this is expressed through terms such as collaboration and cooperation. Because the majority of responses provided fell into this togetherness theme, we postulate that this can be considered as a foundation for building and maintaining an energy community.

In addition to the togetherness theme, the key factors of needs, values and context can be observed from participant definitions. Needs refer to the conditions to be fulfilled for a community to function harmoniously, such as feeling protected or having a sense of democracy. Values are the ideals that are part of a community, such as having a sense of identity or preserving family values. Finally, context refers to the importance of the geographical location and environment of a community.

4.2. Challenges faced and strategies to empower EC

From the second phase of the workshop, the responses from all groups were subjected to a thematic analysis to identify key factors regarding the challenges faced by an energy community and the potential strategies to build resilience. As with the analysis of the definitions in the first phase of the workshop, an independent

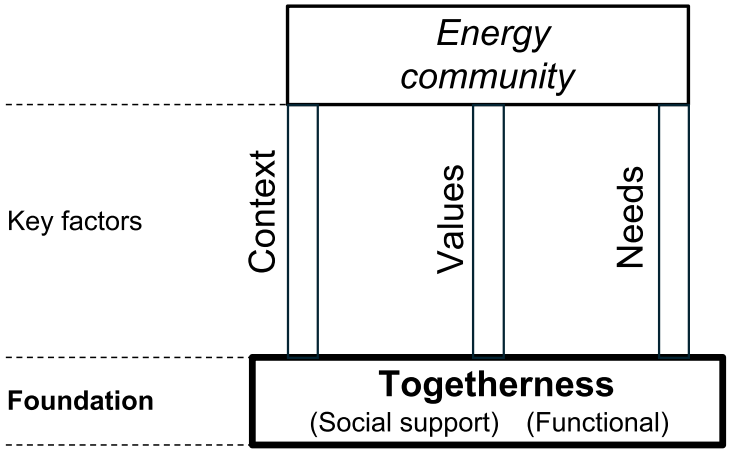

Figure 2. Framework for understanding an energy community underscored by the theme of 'togetherness' and supported by the key factors of context, values and needs.

Table 2. Challenges faced by energy communities and strategies to build resilience.

Challenges	Strategies
A lack of social democracy and trust	Community outreach and inclusion
Regulatory issues	Transparency
Developing a new stakeholder network	Building a support network
Addressing local needs	Developing community-orientated business models
Uncertainty of change	Implementing analysis and strategy
Dynamic nature of communities	
Lack of clarity regarding benefits	

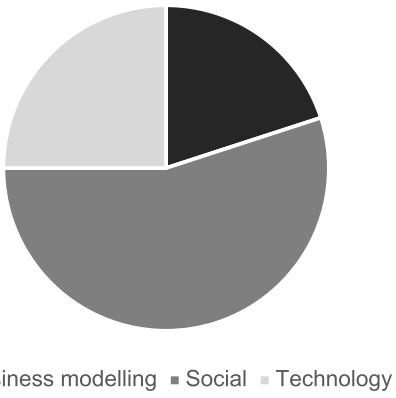

Figure 3. Primary vote.

thematic analysis was conducted by two researchers and the results from both researchers were discussed and agreed upon. The key factors identified in the second phase of the workshop are displayed in table 2.

The voting task undertaken by participants in the second phase of the workshop provided descriptive data on the relative importance of strategies related to preserving EC. Before looking at the relevant importance of the individual strategies, a broader perspective from the voting task based on which category the individual strategies fall under can be reported. Results show that for the primary votes, the highest-voted category of strategies (55%) was accounted for by the social category, and the technology and business modelling strategies accounted for 25% and 20%, respectively (see figure 3). When analysing the secondary choice votes, a similar pattern emerged, such that the highest voted category (45%) was the social category, with the technology and business modelling strategies accounting for 30% and 25%, respectively (see figure 4).

Regarding the data on the individual strategies within the categories, figure 5 shows the results of the participants' primary and secondary strategy selections for preserving an energy community.

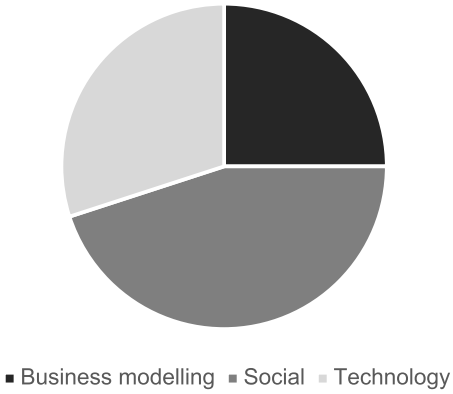

Figure 4. Secondary vote.

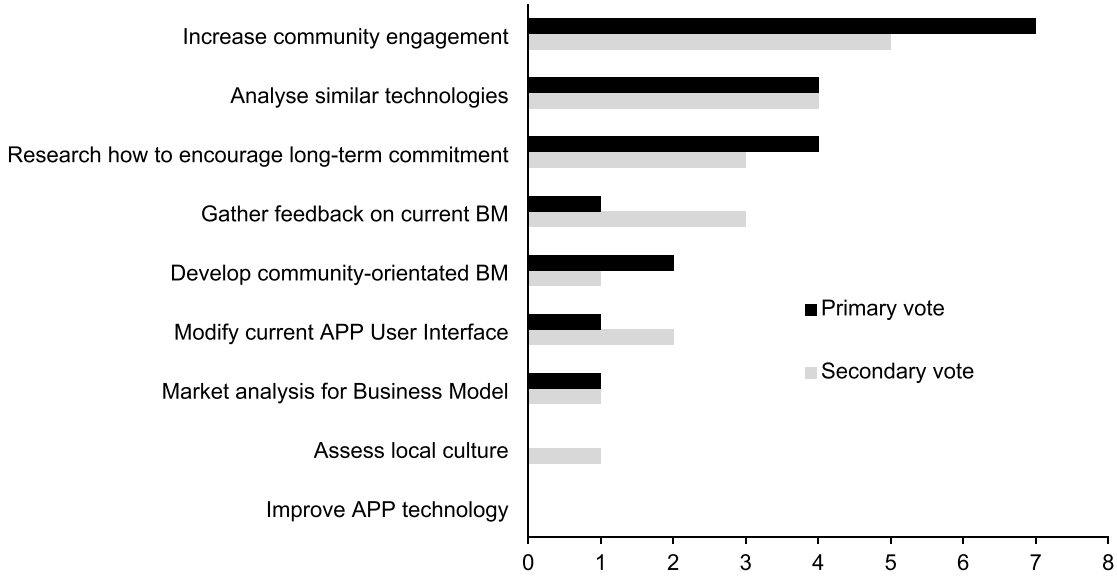

Figure 5. Primary and secondary strategies selected by the participants for preserving an energy community.

Table 3. Outline of the relative importance attributed to each of the nine strategies.

High-level importance	Mid-level importance	Low-level importance
• Increase community engagement • Research how to encourage long-term commitment • Analyse similar technologies	• Modify current APP user interface • Gather feedback on current BM • Develop community-orientated BM • Market analysis for BM	• Assess local culture • Improve APP technology

The results indicate that the nine proposed strategies can be categorised into three priority levels among the initiatives (see table 3).

The high-level importance strategies 'Increase community engagement' (7 primary, 5 secondary votes), 'Research how to encourage long-term commitment' (4 primary, 3 secondary votes), and 'Analyse similar technologies' (4 primary, 4 secondary votes). These received the most votes, suggesting a strong focus on fostering community involvement, ensuring long-term sustainability, and understanding competing technologies.

The mid-level importance strategies include 'Develop community-oriented BM' (2 primary, 1 secondary vote), 'Market analysis for Business Model' (1 primary, 1 secondary vote), 'Modify current APP User Interface' (1 primary, 2 secondary votes), and 'Gather feedback on current BM' (1 primary, 3 secondary votes). These indicate a balanced emphasis on refining the business model and improving user experience.

The low-level importance strategies are 'Assess local culture' (1 primary vote) and 'Improve APP technology' (0 votes), showing that they are currently less critical in decision-making. The focus is primarily

on engagement and strategic improvements rather than cultural context and immediate technological advancements.

How these findings fit with the current literature and the implications of these results will be discussed in detail in the next section.

5. Discussion

5.1. An assessment of energy community definitions

Due to the prevalence of responses that referred to togetherness, we argue that this is foundational for successful community formation which other factors, such as needs, context and values, support. The importance of togetherness in communities has been highlighted by Yiasoumas *et al* (2022) who suggest togetherness within an energy community promotes participation and is paramount for collaboration between community members, setting common goals, and using energy management technologies.

From the definitions provided, togetherness can be separated into two elements, social support and functional. Social support emphasises interpersonal relationships and dependency between community members and is evident from responses such as social harmony, conviviality and mutual support. A study by Dóci and Vasileiadou (2015) investigated how socio-emotional relationships can drive participation and engagement in communities partaking in renewable energy projects. They concluded that a key driving force for successful outcomes in community projects is the existence of strong socio-emotional connections between community members.

Regarding the functional interpersonal relationships in togetherness, many definitions provided by the participants suggest practical goals are important, such as being together for a common purpose, shared responsibility, having a sense of purpose, and community goals. For an energy community, togetherness manifests through shared responsibility and moving towards a specific goal as a collective. Interpersonal relationships thrive through functional means, sharing goals and creating mutual benefits is therefore integral for developing a successful energy community (Garrison 2019).

Findings from the workshop also showed that consideration for the specific needs of the community was an important factor. These needs are predominantly related to concrete factors such as the economy, assistance in market participation, or protecting community members in terms of data use and security. These needs are also likely to vary from community to community. However, for the successful development and maintenance of an energy community, it is important to understand what these needs are and address any potential risk factors that threaten or neglect the needs of the community and its members (Koirala *et al* 2016).

The results also revealed that consideration for the specific values of a community would be important for building resilient EC. Similar to community needs, values, which can be a sense of family or culture-specific principles, will vary from community to community. However, regardless of the type of value, neglecting or missing values prioritised by a given community will harm any innovative process. Research has shown a variety of values such as health, economic, educational and affective values need to be considered when attempting to build a successful energy community (Goodman and Sanders Thompson 2017, Potting *et al* 2022). For innovative energy solution integration into a community, project leaders must therefore investigate and accommodate community values into their strategy to achieve social acceptance.

A final factor for consideration is the contextual details associated with a specific community which can refer to the site (physical or online), the surrounding environment (online ecosystem), and the culture in which the community operates. Context evaluation of an energy community should therefore also go beyond geographical and physical location or current infrastructure and technologies. A community context carries meaning related to aspects such as cultural norms and social relations within a geographical area (Devine-Wright 2009).

It is not surprising, given the literature on community, that participants offered a variety of perspectives on the term community. Essentially, community has always meant different things to different people. During the early part of the twentieth century, for example, it was seen as a *creative* process that involved the integration of the individual (Follett 1919). While Aitken (2017, p 2392) notes, it is common for people to see the 'function of community as a 'natural' unit of human togetherness'. This inclination to the idea of 'togetherness' was also reflected in the assumptions of our participants who tended to see togetherness as a foundational component to building an energy community. Applying lessons learned from post-political theory, Aitken (2017, p 2383) goes on to argue against applying what he terms blanket post-political diagnoses that coalesce around 'a settled, static and reified condition of (human) togetherness' when describing an (energy) community. Such an approach can potentially minimise the complex, often contradictory experiences of those currently engaged in energy community formation. Having said that, focusing on establishing a sense of togetherness within an energy community does bring with it many

positives, not least as a counterweight to recent societal trends towards greater isolation through individualisation and the subsequent loss of social cohesion experienced in many Global North countries.

5.2. Challenges involving EC

While we recognise the numerous challenges faced by energy community members, as evidenced in the literature, the key topics to emerge from our discussions with the participants include the following:

A lack of social democracy and trust: participant responses ranged from concerns relating to cost and benefits sharing (distributional justice) to the approaches one should take when engaging with people. Trust issues arise through the potential loss of trust experienced by an energy cooperative after pivoting to a new role as a developer and general difficulties in building trust. Consequently, barriers related to social democracy and trust become a major factor influencing overall local community acceptance. These responses highlight the challenges that exist at the social level in terms of engaging the community and achieving social cohesion.

These barriers can be mitigated by implementing an energy democracy framework that includes community members in the decision-making process and advocates multi-stakeholder involvement to promote community ownership (Becker and Naumann 2017). Additionally, deliberative democratic approaches can serve to empower citizens and encourage active participation within EC (Lennon *et al* 2019). Trust is a key element in the social dynamics of a community involved in renewable energy projects as it has a direct functional value for the development of an energy community in terms of progressing and realising renewable initiatives (Walker *et al* 2010). Research indicates that trust is key in the perception of energy sources and those responsible for managing energy within a household are highly influenced by how much they trust the source of a renewable energy source (Żywiołek *et al* 2022)

Regulatory issues: participants expressed concerns around local/national legislative landscapes, more specifically regulations and legal instruments relating to energy community formation. Several participants noted that regulatory conditions often acted as a barrier that hindered innovation. The complex structure of legislation in various geographical locations can be a challenge for EC which can be affected by regional, national and EU legislation (Tews 2018). Additionally, the evolving nature of the energy market requires continual updating and adaption of associated legislation. This can be particularly problematic for EC which invariably comprise highly complex, intersecting social relationships. Therefore, there is a need for improved and specific legal frameworks for renewable EC that account for these challenges (Inês *et al* 2020).

Developing a new stakeholder network: the definition of the roles of various stakeholders that form an energy community was also an important factor. The potential challenges included identifying who key community members would be, such as community leaders or developers. The interactions between stakeholders are also a factor, such as the relationship between the community and DSO. Previous research has highlighted the need to consider the variety of needs of the diverse stakeholders within EC through analysis techniques such as the multi-actor-criteria analysis (Lode *et al* 2021). This emphasises the need to accommodate the satisfaction needs of stakeholders within a community to promote harmony and democracy to ensure the success of renewable energy initiatives (Maqbool *et al* 2022).

Addressing local Needs: accounting for the specific needs of the community refers to factors such as developing capital, providing technological support, and identifying investment opportunities in the area. For instance, developing EC for indigenous populations requires energy solutions tailored to local contexts to ensure socio-economic opportunities and avoid energy injustice (McMaster *et al* 2023). It is particularly important to ensure a long-term plan of support is implemented as part of innovative energy solution projects to avoid neglecting the community and risking the dissolution of a sustainable energy service.

Uncertainty of change: challenges exist relating to the uncertainty of change. If a community has a strong identity or exists within a certain comfort zone, it may be reluctant to innovate. Consequently, gathering willingness and enthusiasm may be problematic. For example, research has found that the social and political views of community members can be an obstacle to achieving social acceptance. To counteract the inertia of a community, it is important to create a narrative around democracy and the transformative potential of sustainable initiatives (Burke 2018).

Dynamic nature of communities: the makeup and function of a community would likely change to some extent as part of an energy transition which could upset the harmony or dynamics of a community. New actors may need to be involved and scaling up may be required to produce desirable benefits. Transitioning to a sustainable energy system requires redefining consumers, prosumers and other energy market actors to drive new operations and system change (Schot *et al* 2016). Acosta *et al* (2018) emphasised the concept of integrated community energy (ICE) systems which prioritises the collective use of distributed energy resources and requires the involvement of new and diverse stakeholders to enhance community engagement. Furthermore, introducing a user-led approach to energy community innovation redefines the end user as leaders and visionaries (de Vries *et al* 2016).

Lack of clarity regarding benefits: explaining the details around the benefits such as weighing up capex against the long-term benefits of sustainable technologies can be challenging. Community members may also lack knowledge of market-related issues such as tariff systems. Therefore, it is important to effectively communicate the potential benefits of innovative sustainable solutions and systems to raise awareness locally and gather support for energy projects within the community (Coenen and Hoppe 2022). Communication should not solely focus on providing information however, consideration should be given to the type of communication and the audience to encourage citizens as well as enlighten them.

5.3. Strategies for empowering engaged EC

The discussions with the participants revealed a number of insights into identifying strategies that address the challenges related to EC:

Community outreach and inclusion: an important strategy highlighted by participants centred around community outreach. This includes undertaking activities and events that promote the inclusion of the members of the local community and is characterised by an open bi-directional dialogue which serves to raise awareness and show the benefits of the sustainable technology involved in a sustainable transition. It also should be seen as an opportunity for project leaders to learn from local knowledge and experiences which can be leveraged to incorporate new technologies and initiatives successfully. Actively engaging with the community and ensuring there is a focus on inclusivity with innovative energy initiatives leads to increased acceptance, participation and sustainable energy behaviour change (Goedkoop *et al* 2022). Participants also noted the importance of involving community members as early as possible. Community members need to be granted opportunities to share their perspectives.

Transparency: transparency regarding associated benefits and the breakdown of the financial process is key to generating interest and acceptance. Alongside the social and environmental domains, saliency regarding economic benefits has become an important factor in community energy projects (Nolden *et al* 2020). Evidence has shown that transparency in the information flow can increase stakeholder understanding and ensure that economic benefits are effectively communicated and understood by community members (Al Balushi 2021). Participants indicated the importance of discussions about how the potential benefits are realised and shared among the community. Additionally, options for individual financial participation should also be prioritised. The risks, benefits, and strategies of a new initiative need to be openly expressed amongst the community. Koirala *et al* (2016) in their concept of ICE systems, argue that transparency in areas such as economic benefits, risk and information flow, and the disclosure of information leads to a better service for the community and improved socio-economic impact of energy initiatives.

Building a support network: another highlighted strategy is activating the local network and the related actors (e.g. landowners, technical partners, local authorities) to support an energy community initiative. This includes organising workshops amongst the local community and gathering support and advice from local authorities and legal representatives. For energy projects to thrive within a local community, leadership and support from a network which includes professional stakeholders and members with appropriate skill sets are essential for securing the required resources, finances and legislative understanding (McMaster *et al* 2023).

Developing community-orientated business models: the development of community-orientated business models is also a key factor for a successful energy community. Any business model implemented for sustainable energy initiatives needs to be inclusive of community member perspectives. When developing business model strategies, it is important to emphasise building community capacity and collaborative relationships with relevant stakeholders (Prilandita *et al* 2022). EC should be built on principles that empower citizens and bring them into the decision-making process. Research has shown that engaging and motivating the community is vital for driving the adoption of various sustainable initiatives such as wind-power cooperatives (Bauwens *et al* 2016) and sustainable urban transformation projects (Kim 2017).

Implementing analysis and strategy: to address the challenges of an evolving community, it is important to have a clear strategy and conduct the right analysis regarding aspects such as new stakeholders, investment, and technology progression to predict and deal with potential challenges. For instance, demand response programs, which rely on participation from citizens, require a clear engagement strategy to accommodate the diverse needs of a community and motivate community members (Ospina *et al* 2024). The application of a well-defined strategy serves to guide technology choice and implementation mechanisms to foster social adoption (Trutnevyte *et al* 2012).

5.4. The importance of strategizing when building energy community resilience

Data from the workshop investigating the prioritisation of strategies to preserve EC highlight the significant importance of social strategies for maintaining sustainable EC. These strategies also need to be more fully integrated into policy making at different scales where the tendency has been to prioritize financial incentives that favour wealthier cohorts in society. Instead, utilising our framework for understanding

EC—underscored by the theme of 'togetherness' and supported by the key factors of context, values, and needs—offers an alternative pathway for scaling up the living lab model to meet the needs of the energy transition. To successfully implement new initiatives, such as energy innovation within a community, it is imperative that project leaders devise a strategy that incorporates community engagement. Prosumer community success is dependent on leveraging local generation potential to decentralise the energy system. This local potential comes in the form of geographical resources, community households and the attitudes of community members. Without consideration for these social factors within a community engagement model, energy initiatives will fail to be sustained or even begin (Koirala *et al* 2016). Furthermore, community engagement frameworks for successful sustainability projects need consideration for social harmony in terms of inclusivity, integrating diverse perspectives, potential power differentials of stakeholders and providing programs which encourage community collaboration (Taliep 2022).

Our results show that technology development was less important for the success of EC when compared with social factors. However, participants still viewed technology-related factors as an important part of the innovative energy transition process. For the interactions between citizens and from citizens to the energy market, digital platforms and applications play a pivotal role particularly when successfully delivering a good customer experience in terms of comfort, cost, connectivity, and control (Darby 2020). Digital usage and literacy among community members can enhance engagement, communication and collaboration. Information flow and communication facilitated by digital tools foster active participation and empowerment which is essential for sustainability initiatives (Ananto 2022). For Bergek *et al* (2015) who situate technological innovation systems within wider 'context structures', this interaction can be both supportive and competitive While Coccia (2014) points to the sociocultural origins supporting patterns of technological innovation, Dattée and Biurdseye Weil (2007) warn against oversimplifying attitudes and decision processes that ignore more fully interconnected social structures especially when considering technical innovation. Therefore, this paper primarily focuses on social strategies.

Similar to technological factors, although prioritised less than social strategies, approaches related to business and marketing are also important (Burchell *et al* 2016). Integrating an effective business model that accounts for stakeholder engagement and technological development is essential for the success of an energy community as it will enhance new operations and processes required for an energy transition. Also, by aligning a business strategy with the needs, opportunities and capabilities of local communities, energy access and clean energy living can be realised more efficiently (Vassiliades *et al* 2022).

When investigating the specific types of strategies to build energy community resilience, findings showed that various strategies fall within one of three levels of importance.

5.4.1. High-level importance

Three strategies that were determined as being of high-level importance include increasing community engagement, analysing similar technologies currently in the market and conducting research on how to encourage long-term commitment. It is essential to actively engage the community to understand the community and cocreate shared visions that project leaders and community members work towards. This in turn encourages social action and builds resilience with community-led energy projects (Parkhill *et al* 2015). Engaging the community in a collaborative process instils a sense of ownership within the community and collective benefit (Rodrigues *et al* 2020). Building a resilient community relies on long-term commitment from its members, without building new relationships and practices, a lack of motivation will manifest and lead to new sustainable initiatives diminishing and eventually failing. Therefore, there is a need to understand community members and stakeholders to build relationships, foster long-term commitment and drive the social change required with innovative sustainability initiatives (Evans 2015, Mwesigwa *et al* 2019). Regarding the strategy of analysing similar technologies, research has demonstrated that there are numerous difficulties when integrating new technologies related to innovative energy solutions, such as cost, maintenance and a need for a comprehensive understanding of the technology (GhaffarianHoseini *et al* 2013). Research has also shown that it is important to utilise technology that is on par or better than current solutions in the field of sustainability which makes knowledge of other market technologies imperative (Zhang *et al* 2013). Understanding technology and current advancements is particularly important in communities as there is a need for alignment between the preferences and perspectives of community members and the capabilities and usability of technological solutions to enhance social acceptance (Huijts *et al* 2012).

5.4.2. Mid-level importance

Four strategies were identified as mid-level importance including modifying the current application's user interface, developing community-orientated business models, market analysis for business model and gathering feedback on current business models. Placing moderate importance on the strategy of modifying a current application's user interface is unsurprising given that it refers to altering technology that is used by

members of the community. Because sustainability initiatives are often synonymous with new technology, residents and community members will need to interact with applications or platforms. Research has shown how significant it is for technological interfaces to be flexible and fit user preferences and needs (Xu *et al* 2018). The other mid-level strategies refer to business modelling. When developing or maintaining an energy community, having a business model that provides explicit value to the stakeholders within a community relies on consideration of all the factors associated with an energy community. Therefore, it is important to assess and integrate economic, social and environmental factors into the business model to ensure resilience for the community (Plewnia and Guenther 2021). Consideration for social factors such as values, cohesion, community development and social justice are particularly vital for developing a successful energy community-based business model (Hiteva and Sovacool 2017).

5.4.3. Low-level importance

Two strategies that were identified as being of low-level importance include improving application technology, assessing the local culture and conducting market analysis to improve the current business model. With regards to improving the technology for an application being seen as unimportant, this could be due to the expectancy that the functionality of the technology is unlikely to be problematic given the advancements in energy-related technologies such as digital technology (Omrani *et al* 2024). Therefore, it is better to focus on the user side of technology to encourage social acceptance. Similarly, the lack of importance given to conducting market analysis with regard to the business model could be that focusing on developing a socially inclusive business model is prioritised over a more general market analysis approach. The low importance of assessing local culture could be attributed to culture being devalued when considered under the broader strategy of community engagement. It may be the case that culture does fall under the umbrella of social engagement; however, research has shown that cultural awareness is a significant driver for the success of EC and a lack of knowledge of cultural values can hinder project development (Berka and Creamer 2018).

6. Conclusion

The challenges defining 'community', along with the wider barriers and strategies associated with energy community formation are presented in this paper, illustrating the perspectives of a diverse cohort of stakeholders on the challenges and potential strategies needed to build resilient EC. The methodology in this research comprised a mixed method of quantitative and qualitative techniques under the umbrella of a living lab, which was utilised as part of an energy project focused on deploying a demand response scheme within four distinct EC. The approach provided a forum for real market actors who were part of an energy community to provide their perspective on how they understood what a community is, or should be, and offer insights on how to build resilience within an energy community through experiential learning.

From our research, we were able to provide a framework for conceptualizing what is an energy community and show how understandings of community appear to coalesce around notions of 'togetherness', the importance of which can be characterised by social and functional relationships. We have shown how these in turn are informed by context, values, and the particular needs of a given community. All of these are key factors that can be leveraged to build and maintain resilience and social cohesion and as such should be of particular importance for those serious about scaling up the diffusion and integration of energy community innovations to wider energy transition strategies at the national and European Union levels. This paper also provides key lessons for those outside Europe, particularly for those interested in understanding motivating factors informing new research relating to energy poverty in the Global North and South (e.g. see Velasco-Herrejón *et al* 2023).

The challenges faced by EC and potential strategies that can help empower members to meet them are shown to comprise social and technological factors that can be shaped through receptive business modelling. At a high level, social engagement has been shown to be the primary domain for identifying and dealing with potential obstacles to building and maintaining a resilient energy community. While at the more granular level, specific strategies have been identified and categorised within three levels of importance. This research contributes to the wider literature on EC focused on understanding how they are defined and the key motivating factors to be considered by communities embarking on their transition to more sustainable energy configurations. It also seeks to address a significant research gap we have identified relating to how DSOs and energy cooperatives can collaboratively work together to navigate the regulatory and operational challenges they both face.

The findings reported here can also advise project leaders and energy cooperatives on how best to build more resilient EC that take into account the dynamic relationships between emerging DSOs and energy cooperatives. The topic of this research is of special pertinence to those tasked with bringing different societal

actors together to exploit the beneficial potential of demand response within a wider energy community framework. A notable pathway for future research should be around how the energy community ideal can be utilised to strengthen democracy, particularly at the local level. Also, a much greater focus on energy poverty and how ideas around togetherness can foster strategies that bring along every energy citizen, not just those with greater socio-economic privilege should be considered.

Data availability statement

The data that support the findings of this study are openly available at the following URL/DOI: www.accept-project.eu/library.

Ethical Statement

This study was approved by the Social Research Ethics Committee (SREC) at University College Cork. All participants gave informed consent to participate.

Appendix

Workshop phase 1: question to participant
"What does 'community' mean to you?

Workshop phase 2: scenarios and questions posed to participants

Scenario 1: a renewable energy developer has identified a suitable location for developing a solar power park. However, she does not know the local area well and does not have existing connections within the local community. Her business model is to establish a local cooperative that will work with landowners and a technology partner to install the solar panels and generate an income stream for the project.

- *How could she create local interest in the park and recruit members into the cooperative?*
- *Identify what are the main challenges, and note them down in the first box*
- *Discuss what could be the main strategies to increase local interest, and note them down in the second box*

Scenario 2: a renewable energy cooperative has spent considerable time building up a successful business. However, energy prices have stalled in recent years and it is beginning to lose some of the income it needs to maintain operations. It must now diversify if it is to continue to grow. Some members do not see the value of diversifying and fear that 'their' coop will change beyond recognition. Some concerns expressed by these members include changes to membership rights, existing land access arrangements, etc.

- *What potential strategies can the coop leaders employ to convince members to adopt change and see the potential benefits of diversification?*
- *Identify what are the main challenges, and note them down in the first box*
- *Discuss what could be the main strategies to find solutions to the situation, and note them down in the second box*

Scenario 3: A project focusing on developing a community tool for the monitoring of energy use has been in operation for 12 months. In those 12 months, technologies have been developed and applications for the end user have been rolled out to the community at the business-to-business and business-to-customer level. However, the project leaders have monitored the use of the new app and realised that the community are not engaging with the application as much as anticipated. They have formulated some potential solutions for addressing this is issue.

- *Please select one primary (most important) and one secondary (second most important) strategy from the list of potential strategies for addressing this issue*

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