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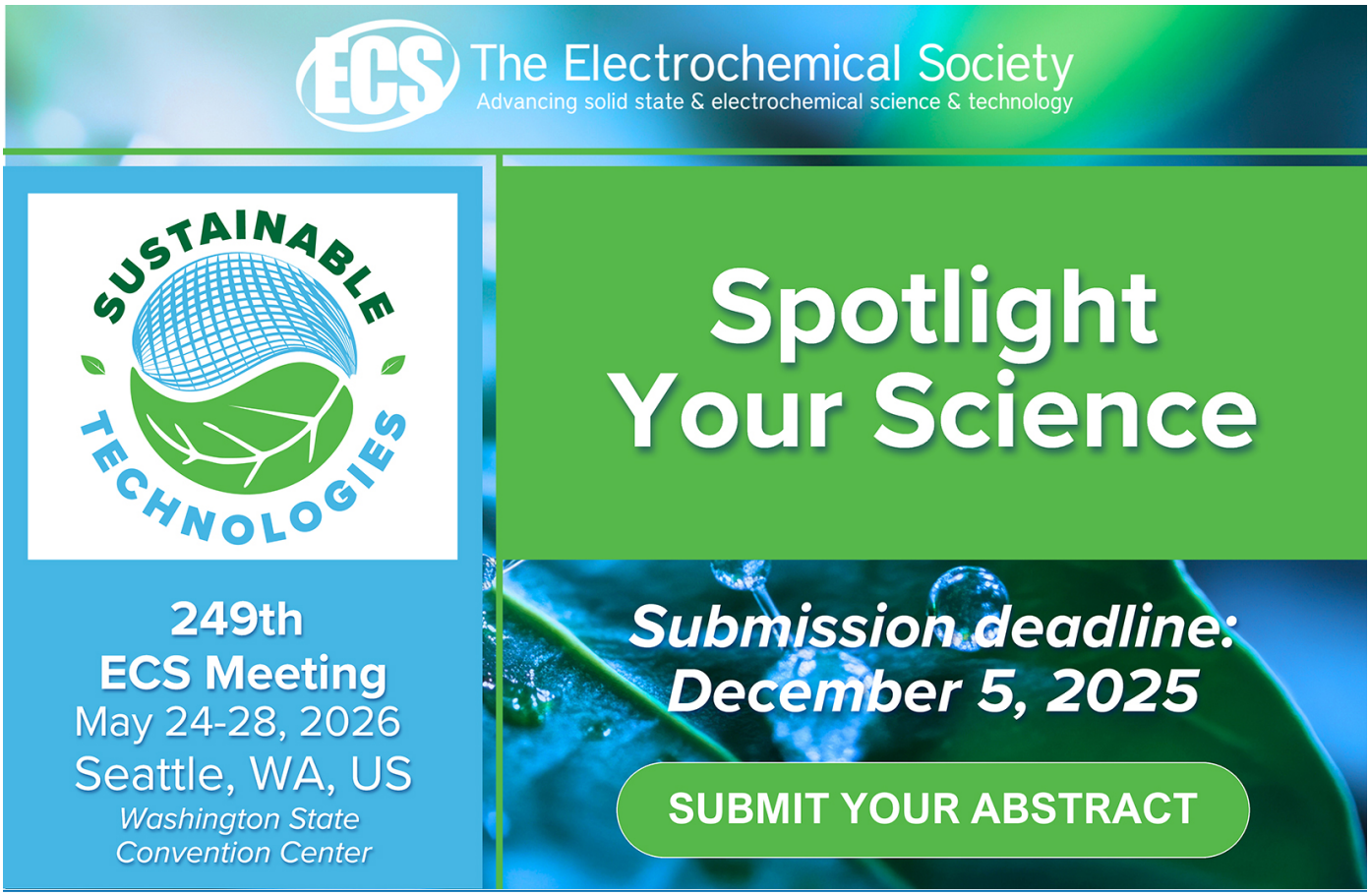
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PAPER

Participation in energy communities: the COM-B model as a framework for exploring motivations through living labs

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Abstract

Forming energy communities and the governance structures needed to facilitate their development is proving more difficult than previously foreseen. This is evidenced by the rather uneven development of sustainable energy communities in Europe and beyond. Living labs offer a useful pathway for co-creating the dynamic renewable energy ecosystems needed to foster user-driven innovation, particularly with regards to integrating digital technology into the engagement practices of citizens in new energy communities. This paper uses the COM-B Model of behaviour to explore the potential of living labs in facilitating more active participation and co-creation among stakeholders, particularly in terms of integrating demand response strategies that foster collaborative end-user engagement. Indeed, it is this interplay between information and communication technology (ICT) and innovation which emerges from living labs that can empower participants to co-design solutions that are more responsive to real-world needs. Also, it should lead to fostering more sustainable changes in behaviour and improve the efficacy of the technical solutions available to us. This paper presents recent findings from multinational European research utilising the living lab model and the collaborative environment it provided for citizens to vision the types of participation they prioritise in bridging the gap between technological potential and user-centric innovation. Such collaborative, co-learning opportunities offer a means towards ensuring current ICT advancements align with the practical demands of the low-carbon societies we wish to create.

1. Introduction

Over the past two decades, living labs have grown in popularity as both a methodology and milieu for real-life testing and scientific inquiry. Initially primarily concerned with user-centred testing of technology in real-life settings, the use-case of living labs has expanded into co-creation and participatory design. Accordingly, it has received growing recognition within academic research communities in recent years. Living labs practitioners have identified its usefulness as a tool for establishing 'innovation ecosystems' whereby users and experts can collaborate on co-developing new products and services, or as a policy tool for driving innovation within communities, particularly in urban contexts across different spatial scales (Paskaleva and Cooper 2021). A key challenge for information and communication technology (ICT) providers has been, and continues to be, how best to involve users at every stage of the innovation process. This also holds true for demand response practitioners, who must contend with ever greater levels of technical complexity—found within the hybrid, digitised systems needed to improve energy efficiency—and a certain reluctance by most (community) energy users to engage with this aspect of the energy transition.

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This growing interest in living labs has also corresponded with a paradigm shift towards open innovation thinking (West and Bogers 2014), which argues the importance of including both external and internal resources for innovation (Chesbrough *et al* 2006). In an energy transition context, the focus on the 'lead user' framework of methods (e.g. see Lüthje and Herstatt 2004, von Hippel 2005) offers potential given that members of an energy community[6] are very often ahead of most, particularly in terms of adopting renewable energy solutions. Indeed, lead users have long been recognised as being capable innovators who are able to provide the external ideas needed as a resource in innovation (Bergvall-Kåreborn *et al* 2009), especially for knotty issues like improving energy efficiency while also impacting behaviour change at scale.

Matschoss *et al* (2024), for example, investigated the long-term effects of a practice-based living lab intervention into laundry and heating practices in Finnish households (2018–2023). Comparing how new or changed practices through societal changes (e.g. the COVID-19 pandemic and recent energy crisis, both of which occurred during this period), they note respondents attributed participating in the living labs to establishing novel ways towards adopting persistent, more sustainable energy practices. Matschoss *et al* (2024) also note that while living labs are often laborious, time-consuming ventures—especially in trying to keep participating households engaged—it is in this effort that one sees persistent, positive, long-term change to energy practices at the household scale.

The living labs informing this paper occurred over a similar period (2021–2024) within the ACCEPT project[7] and were also impacted by same societal shocks. The research involved a suite of community engagement activities in four European countries (a citizen-led energy cooperatives in Spain and the Netherlands, a company-led smart village in Greece; and a distribution system operator (DSO) -led community in Switzerland) engaged in the co-design and implementation of appropriate demand-response tools required for scaling up renewable energy projects. As O'Donnell *et al* (2025) suggest, collaborative processes like co-design are increasingly important to fostering change within complex adaptive systems and for resolving complicated issues such as attitudes to demand response and its impact on energy community formation. Also, it is important to note that deploying qualitative methods, which invariably are applied within living labs, is not as is sometimes portrayed always the easiest option. Rather, engaging with people involves a complex framework of theoretical and/or philosophical underpinnings (Hammarberg *et al* 2016) that must consider the complex, sometimes contradictory experiences of human participants.

Considering this, living labs provided us with an opportunity to move beyond traditional user-centric approaches and to incorporate a more layered, multi-contextual assessment of the kinds intersecting experiences the different citizens we engaged with had; and how these affected they perceptions and attitudes towards the demand response tools being developed. As Feurstein *et al* (2008) suggest, the living labs provided us the space to interact with stakeholders, whether they were service users, technical developers, or citizens within each of the energy communities, while keeping any perceptions of intrusiveness (on our part) to a minimum. Within this framework, we were keen to understand the causal factors linked to behaviour change and how behaviour affects practice, especially by citizens operating within (new and established) energy communities.

In this paper, we also explore the potential of the COM-B model as a tool for assessing the drivers and barriers to energy community participation within the living lab framework from the perspective of three different stakeholder groups through four co-designed, qualitative workshops. As such, these workshops formed part of a wider living lab framework developed for the project and were aligned with local requirements (Franz 2015).

1.1. Utilising the COM-B model within the living lab framework

First presented by Michie *et al* (2011), the behaviour change wheel offered a means for improving evidence-based behaviour related interventions in the public health sector. Their key aim was to better understand an increasingly recognised problem of rising numbers of ineffective health related interventions that tended to rely on patient willingness and their predisposition to change/adapt their behaviour. Mitchie *et al*'s review of the literature identified three prerequisites for the performance of a certain behaviour namely, 1.) The necessary skills to perform said behaviour; 2.) The intention; and 3.)

[6] While an 'energy community' can be quite an amorphous term, with a variety of meanings depending on who is using it, we apply Tobin and Lennon's (2025, p 1) definition of it as being any initiative 'where citizens, local organizations, and stakeholders collaborate to produce, manage, and consume energy, often from renewable sources'.

[7] ACCEPT (2021–24): ACtive Communities & Energy Prosumers for the energy Transition. Research Project funded by the EU Horizon 2020 Programme for Research and Innovation https://doi.org/10.3030/957781.

The lack of environmental constraints that would make the behaviour impossible or too difficult to perform. Based on these findings—and familiar with the requirement in (US) criminal law to prove capability, opportunity and motivation to determine guilt—devised the COM-B (capability, opportunity, motivation—behaviour) model of behaviour change. This model is further contextualised by subcategories describing the underlying mechanisms that frames each pillar. Under *capability*, they differentiate physical and psychological capabilities, referring to physical skills versus knowledge, memory, and any other psychological resources needed for a behaviour. Under *opportunity*, they list physical opportunity referring to the material conditions in our environment. In addition, they introduce social opportunities, indicating interpersonal influences, social, and cultural norms that impact our behaviour. Finally, they differentiate automatic and reflective *motivation*. While reflective motivation refers to volitional intentions, automatic motivation indicates the non-volitional mechanisms of behaviour, e.g. habits, impulses, *etc.*

Since its creation, the COM-B model has proved a versatile tool when it comes to understanding the drivers and barriers that can lead to success or failure when undertaking behaviour change interventions, though its primary focus remains in the field of healthcare. The model has been found useful in designing interventions focusing on diabetes prevention in urban South Africa (Murphy *et al* 2023). Aside from awareness raising, a recent study into improving indoor air quality study highlighted how the COM-B model was also successfully applied in helping change behaviours ensuring the associated improvement in air quality was sustained in the longer term (Kureshi *et al* 2023). One study examined engagement with contact tracing for COVID-19 by analysing interview transcripts organised around COM-B themes (Shelby *et al* 2022). From this, they were able to identify the key engagement barriers leading to physical and psychological incapabilities, based on which interventions were recommended. Another study used the model to organise motivational interviews (e.g. see Hettema *et al* 2005, Rubak *et al* 2005, Colvara *et al* 2021) on engagement among the elderly regarding fall prevention and to promote evidence-based safety strategies (Kiyoshi-Teo *et al* 2024).

Outside of the health and wellbeing sector, references become somewhat scarcer, particularly relating to energy and especially regarding the topic of citizen engagement in energy communities. Having said that, there are several notable contributions. For example, the COM-B model has been used to assess the barriers to energy efficiency in Portugal, finding that the lack of capability (both physical skills and knowledge) poses the greatest obstacle to efficient energy consumption behaviours amongst citizens (Barreto *et al* 2023). Another study applied the COM-B model to examine energy behaviour in the military and concluded that the three pillars of the model apply better to the collective behaviour of the unit rather than the individual (Smaliukiene *et al* 2020). In Northern Ireland, Paden *et al* (2022) developed a framework for supporting consumers in energy transitions, based off the COM-B model. While in the Netherlands, a study there highlighted that the main challenge to the energy transition is not technical but social; using the COM-B model to design interview questions for uncovering the factors that could best activate change in household energy behaviours (Onencan and De Koning 2022).

A key takeaway from these studies is that they all point to the COM-B model's usefulness in examining the societal and behavioural factors impacting engagement in energy communities. A potential limitation to the COM-B model lies with approaches taken to recruitment and sampling (e.g. see Howlett *et al* 2019). This is important since, as Ballon and Schuurman (2015) point out, living labs have primarily been seen as very much a practice-driven phenomenon and consequently, remain somewhat underresearched and possessing several theoretical and methodological gaps[8]. A key foundational element of the approach they contend is the notion of *stigmergy*, which is used to describe how complex problems can be addressed through uncoordinated collective actions (e.g. using ICT and in particular online social media platforms) to generate 'spontaneous' innovations (see also Wang and Di Carlo 2023, Zheng *et al* 2023). While widely used to describe generic coordination approaches within animal societies, where traces left by individuals in the environment act later as guides to the same or different individuals, stigmergy—in a human context—is increasingly applied to describe phenomena arising from the digitisation of society. An illustrative example for this include new forms of stigmergic processes emerging from online services that exploit the digital footprints left by users (Bassanetti *et al* 2023). Similarly, blockchain management in demand response in electric energy grids (e.g. see Junaidi *et al* 2023) can benefit from deploying stigmergic processes.

In terms of engagement and maximising the demand response potential within energy communities, the living lab approach combines these strands to allow space for co-creating innovations with users

[8] While there are alternative frameworks to COM-B and Behaviour Change Wheel (e.g. see Luan *et al*'s (2025) treatment of one such alternative, the Fogg Behavioral Model), its usefulness lies with its ability to allow practitioners diagnose the complex factors affecting behaviour and then to devise collaborative design approaches to reaching tailored solutions specific to each group.

(*i.e.* energy community members, business stakeholders, *etc*) by deploying mixed methods within hybrid environments—usually a combination of offline and online engagements. This approach allows for a productive tension to emerge between the characteristics of the real-life environment and the research space grafted onto it (Ballon and Schuurman 2015). Indeed, it was this productive tension along with various external impacts (e.g. the COVID-19 pandemic and energy crisis) that saw participants engage in the workshops with a high degree of openness and consideration. Reflecting what Soeiro and Ferreira Dias (2020) point to being the most and least important motivations for people when considering joining an energy community, participants in our living labs shared similar sentiments which will be presented in more detail later in the paper.

2. Methodology

This paper reports on a key strand of living labs activity comprising a series of workshops to assess and trial several community participatory methods. While the living labs were deployed across the four participating energy communities in the project, the engagements discussed in this paper focus on two, Spain and Switzerland. In Spain, we sought to gather the perspectives from ordinary 'energy citizens' (for a more detailed appraisal of the concept, see Dunphy *et al* 2025) who were members of, or about to establish, their own energy community. In Switzerland, participants were drawn from professionals within the energy industry and we were keen to learn what they prioritised as being important when engaging with ordinary energy citizens. Especially important to this work was uncovering the (sometimes imperceptible) barriers and drivers participants identified as having the most impact on individual and collective decision-making around energy community formation. Between January and June of 2024, we facilitated four workshops engaging different stakeholders in the energy transition with the workshop programme divided into two phases, where participants were asked to reflectively assess the suitability of the approach across different contexts.

The first phase involved a preparatory workshop with project partners engaged in both the technical and social aspects of the project, using the COM-B model framework to assess the participatory methods trialled in the living labs. This first workshop, along with associated analyses of the community engagement outputs (e.g. see Lennon *et al* 2021a, 2021b, Tobin *et al* 2023, Hajdu *et al* 2024), then informed the second phase of engagements with the energy communities, where we conducted three workshops. Two workshops were organised for Spain where we engaged with citizens at different stages of participation in their local energy cooperative (the first in Murcia with citizens already part of an energy community and the second in Bullas involved citizens in the process of establishing their own energy community). While in Capriasca, Switzerland, we were able to learn the perspectives of professional stakeholders working in the energy sector there.

An initial researchers' workshop confirmed the COM-B model template as a useful tool for uncovering participant perspectives on energy community formation, the findings from which we were able to further test in the community workshops. There, participants were asked to deliberate on which community engagement approaches they considered most effective and supportive of their needs. From the beginning, we acknowledged the commonly accepted key drivers to motivate participation comprising a combination of social, economic, environmental, and political factors (Lennon and Dunphy 2024). Given the hybrid nature of the living labs organised, we found Ørngreen and Levinsen's (2017) perspectives on understanding complex work and knowledge processes particularly useful. Long a standard of qualitative research, the workshop has been used for everything ranging from software development to co-creation and innovation (Thoring *et al* 2020). As such, workshops are particularly useful for fostering collaborative discussions and securing constructive feedback between participants and researchers (Lain 2017, Ahmed and Asraf 2018). As Sofaer (2002) suggests, applying rigorous qualitative research methods can greatly enhance high-quality engagements across multiple categories and experiences.

2.1. The COM-B model as method within the living lab framework

A key consideration for this work was to understand the causal factors linked to behaviour change and how behaviour affects practice within energy communities, especially in those we engaged with. Consequently, the usefulness of a range of behaviour models found in the literature were examined, from which emerged several key questions ranging from understanding the role of behaviour in effecting individual actions, to what factors coalesce to instigate changes to both. Michie *et al* (2011) have asked similar questions, pointing to the COM-B model as a framework for providing insights into three critical

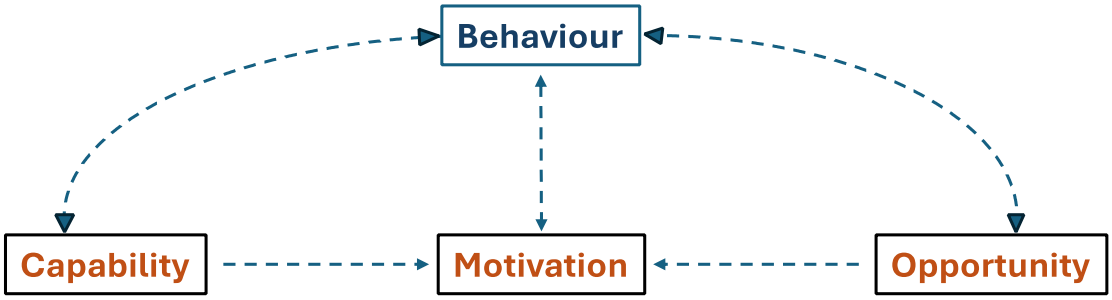


Figure 1. The COM-B system. Adapted from Michie et al (2011). CC BY 2.0.

components they identify as pivotal to producing, and subsequently changing, behaviour (see figure 1 below).

The rather simple schematic presented in figure 1 belies the complex, intersecting relationships between individuals within the energy system. However, its simplicity also succinctly demonstrates several key components determining one's behaviour, e.g. capability and opportunity can both affect motivation, with all three contributing to how an individual expresses behaviour[9], while the opposite is also true. For instance, someone may not see an opportunity to join an energy community in their area given the perceived financial and/or social constraints they experience. If, however, circumstances change, and the right financial incentives emerge or they are encouraged by a friend already in the energy community, their perceived *opportunity* to participate can change quite substantially. The same individual may also believe they do not have the appropriate skillset needed to participate in the energy community, which is understood in terms of one's *capability*, or capacity. However, if an opportunity arises whereby, they can upskill to the appropriate level, then their perception of their capability also changes as a result (Lennon *et al* 2024). As such, the COM-B model offers us an interactional approach to better understand the determinants of behaviour and consequently how they might impact long-term behaviour change (Michie *et al* 2011).

Keen to learn from the participants' personal experiences, a key question in each workshop was: what are the main drivers and barriers of engagement in the living labs? This is where the COM-B model for behaviour proved particularly useful. Living labs by their nature are best understood as amalgamations of different behaviours by citizens, who go to meetings, communicate across different media, and use technical appliances directly benefiting the energy community they are a part of. As such, the COM-B model for behaviour is a useful tool for examining the (behavioural) barriers to engagement in a workshop setting.

2.2. Overview of the four engagement workshops

For the workshops, we recruited energy community leaders, ordinary energy users, energy community members, local business leaders, and industry professionals who were subsequently organised in terms of affiliation and the role(s) they occupy within their organisation or energy community. A key outcome of the workshops was to gain a deeper understanding of what the participants see as the main drivers and barriers impacting their decision to join (or not) an energy community, see figure 2. Each workshop began by introducing the conceptual framework underscoring the COM-B model with workshop leaders providing tailored examples to the participants as they familiarised themselves with the six subcategories outlined in the behaviour change wheel. The participants were then asked to consider how their own experiences inform their understanding of each driver or barrier and how it might facilitate or hinder their engagement in an energy project.

Using colour coded sticky notes these were then placed within one of the six subcategories outlined in the model, depending on whether they considered the driver/barrier to be a capability, opportunity, or motivation in their decision-making. After this exercise, a group discussion took place with workshop leaders using these as points of departure and exploring the possible reasons why they made the choices they did.

[9] It should also be acknowledged that behaviour can also very much depend on temporal changes in addition to other external environmental, social, and financial determinants.

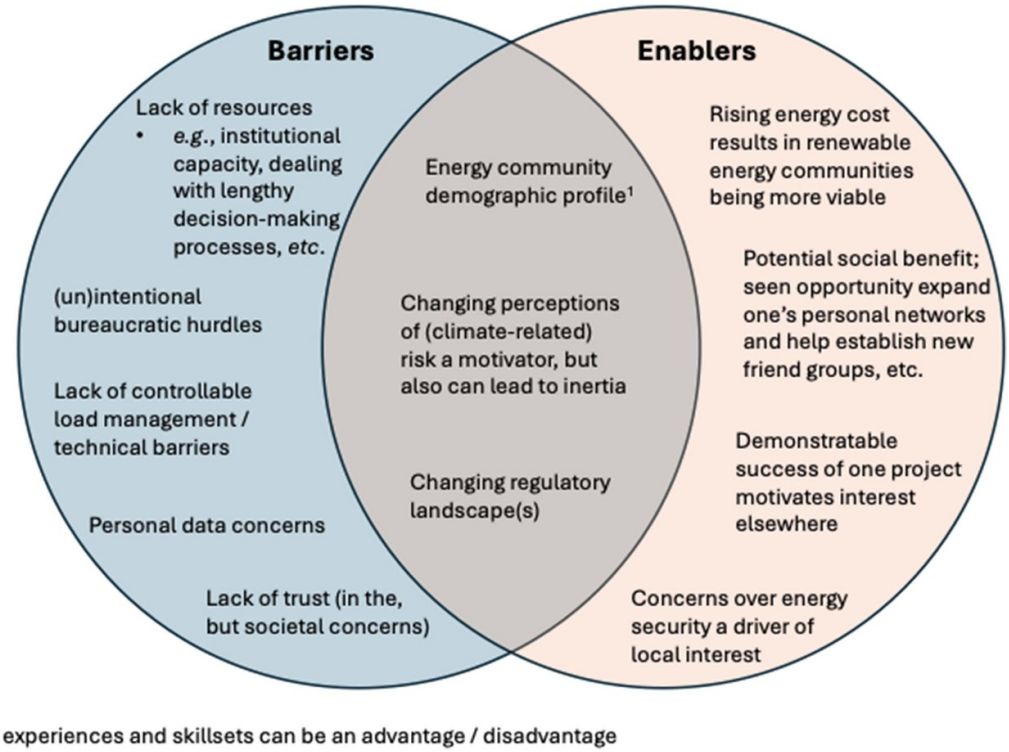


Figure 2. Synthesis of participants' perceptions of the barriers and enablers to energy community formation taken from discussions across the four workshops.

3. Results

3.1. First workshop in Thessaloniki, Greece

The first (researchers') workshop was held in Thessaloniki, Greece in January 2024. The workshop involved pilot leaders and technical partners from the four pilot sites: Murcia (Spain), Aspra Spitia (Greece), Culemborg (Netherlands), and Capriasca (Switzerland). The participants, divided into four groups based on their pilot sites, worked on identifying the drivers and barriers to engagement as they experienced them within the project, using the COM-B model of behaviour to structure their feedback. Each group was given a template to help them identify specific factors and recognise what component of the COM-B model they found most useful. Common themes to emerge from this workshop primarily centred on the barriers to citizen engagement and participation, with the discussions organised within the capability, opportunity, and motivation framework.

- Under the **Capability** theme, the lack of applicable technological knowledge (e.g. in how to use IT tools effectively) was noted as a significant obstacle, with participants acknowledging the communities they worked with often lacked the technical knowledge needed, hindering their ability to get the most out of the digital platforms and smart energy tools provided. This was seen as especially true for those more elderly citizens they engage with. Also, a common concern expressed by many within the communities they worked with centred on personal data, how it was to be stored, and who had access to it, suggesting a strong desire for clearer communication and training around data privacy and cybersecurity.
- Under the **Opportunity** theme participants highlighted a variety of barriers across different physical and societal contexts, ranging from safety concerns (e.g. fear of devices malfunctioning and/or posing a fire hazard) to financial and community-based considerations. Collective experiences of the COVID-19 pandemic was still fresh for many of the participants, who pointed to how it was illustrative of how disruptions to community-based initiatives and collaborative energy models can be addressed through effective communication and appropriate outreach. In addition, the issue of trust (e.g. in the development of digital tools and other supports) was a significant factor, not only with the technologies but also with regards to the wider social and political structures in place. Also, difficulties in accessing shared contact lists, due to General Data Protection Regulation constraints, was seen as a barrier to internal communication along with other practical challenges such as underdeveloped electrical assets,

unreliable IoT communication, and static electricity costs often limited people's capacity to participate, even when they have expressed a clear desire to do so.
- These all had an impact on **Motivation**, which was seen as contributing to questions within some communities as to the real, tangible benefits to participation (e.g. the absence of time-of-use electricity rates hinder participants' ability to adjust their consumption patterns and in turn lower their costs). Indeed, the lack of tangible incentives, including financial, was seen as a barrier by most. Moreover, lengthy project timelines, particularly the long 'idle' phases between technical developments can lead to citizens disengaging from their energy community.

While participants tended towards identifying the barriers to engagement, some did discuss certain drivers from the perspective of motivation and social opportunity. Also, the potential environmental impact and working for the sake of participation were mentioned with regards to reflective and active motivation, while the sense of being part of a group related to social opportunity was seen as a positive motivating factor.

3.2. Second workshop in Murcia, Spain

The second workshop held in Murcia, Spain, in April 2024, targeted citizens who were already part of an established energy community. These participants outlined their experience engaging in the living lab and challenges they faced within their energy community. After being divided into groups, participants used the COM-B model of behaviour to identify and prioritise several interrelated drivers and barriers to energy community formation and citizen participation. These include:

- **Capability**-related barriers including what some perceived to be a general ignorance stemming from difficulties in accessing suitable information on developing community energy projects (e.g. understanding the changing regulatory landscape, the types of technologies involved, etc). This was seen as a major psychological barrier with participants pointing to institutional and community related inertias that result in continued resistance to change.
- **Opportunity**-related challenges were also seen as significant, with several suggesting that privileged sectors remain intent on maintaining the 'status quo', either intentionally or unintentionally, often putting up obstacles that hinder the development of ECs. Also, access to reliable sources of information (linking back to the information deficit described in the first workshop) continues to perpetuate a knowledge gap for many citizens.
- **Motivational** barriers were also acknowledged here as emerging from socio-economic and perceptual issues that impact community cohesion (e.g. incorporating the needs of disadvantaged groups rarely considered when developing energy projects), significantly impacting neighbourly relations at the local level. Also, the cost of energy was a primary concern for most and can limit participation when renewable energy source (RES) projects are often seen as being more expensive than traditional fossil-fuel infrastructure, particularly at the earlier stages of a project. As such, the associated environmental costs are rarely considered accounted for in the overall costings.

While the factors that can drive engagement for the Murcia community comprised the following:

- **Capability** is further strengthened if the public has a full understanding of the threats posed by climate change (its risks, but also the potential opportunities associated with meeting those risks). This knowledge can have a significant positive impact to ongoing work within energy communities including increasing awareness of energy-related issues, strengthening the uptake of emerging technologies, and incentivising greater participation in community-based energy projects.
- **Opportunity** can arise within societies that are increasingly adept using new technologically adept society as long as these technologies are seen to benefit those communities within which is installed. Establishing active citizens groups, who are committed can have significant positive impact influencing others to form their energy community when done in conjunction with broadcast media to showcase successful projects and user experiences. Participants also pointed the potential benefits from standardising energy community implementation and evaluation processes, giving greater confidence to new ECs with regards to planning and organising projects, particularly at the more precarious early stages.
- **Motivation** comes from a growing recognition for proper sustainable energy management, though for lasting engagement societal trust is a key factor. Participants acknowledged a clear need for stronger regulation to facilitate more consistent and supportive conditions for energy communities.

3.3. Third workshop in Bullas

The third workshop in Bullas sought to capture the perspectives of citizens who were about to establish their own energy community and who were applying the lessons learned from the community in Murcia. The key barriers to engagement for these energy citizens comprise the same three themes:

- Under **Capability**, the participants shared concerns with the Murcia group, pointing to the knowledge gap most citizens have the bureaucratic structures and associated legal parameters underpinning the establishment of an energy community.
- Regarding the barriers to **Opportunity**, participants referred to lengthy decision-making timescales involved in setting up an energy community at the community level (given the number of meetings needed to pass decisions, etc). Together with the legal constraints and bureaucratic hurdles, the likelihood of members losing interest and the energy community potentially dissolving grows considerably. These can be summed up as follows:
  - Lengthy decision-making process at planning stage
  - Legal constraints
  - Bureaucracy linked to creating/joining a community
- While **Motivational** barriers stem largely from the continuing knowledge gap described above, which is often further compounded by distrust in bureaucratic/civic institutions and economic actors in the market. Together, participants agreed they struggled to motivate fellow citizens to join the energy community. While this can be understood a capability barrier, it is also a motivational one.

On the other hand, the factors seen as helping to drive engagement are summarised as follows:

- In terms of **Capability**, participants acknowledged the importance of building institutional knowledge within the energy community with members understanding the different ways one can participate, and which role one can adopt or avail of, e.g. as an expert, having an advisor or technical role, etc.
- While **Opportunity** is enhanced when members are supported in adopting leadership roles that align with their level of expertise. Also, learning how other energy communities organise themselves is seen as particularly invaluable. Most importantly, access to energy- and energy planning advisors is a must.
- Participants also saw **Motivation** strengthened when members share similar ecological values and commitment to sustainability issues. Having a strong environmental conscience often sustains individual involvement through more difficult times. This is further strengthened by greater is transparency in decision-making, which helps foster trust, improve accountability, and instil a greater sense of shared ownership among members.

3.4. Final workshop in Capriasca

A fourth and final workshop was held in Capriasca, Switzerland, which sought the perspectives of energy industry and business stakeholders. We were particularly keen to learn of their experiences engaging with citizens. The importance of this group's perspectives was evident both for comparing the outlooks of industry professionals to those of citizens in the energy cooperatives in Spain and for identifying any tension or misalignment between the two. Several notable insights emerged from these discussions, including how certain attitudes and expectations of citizens aligned with those in industry. Also, we noticed an overall appreciation for the need to establish frameworks that work to encourage greater participation particularly among those citizens who are not immediately involved in, or knowledgeable of, energy communities *per se*. These are summarised as follows:

- In terms of **Capability**, participants agreed that the knowledge gap of citizens remained a key barrier to engagement and can have a knock-on effect with regards to establishing trust between different stakeholders, e.g. a basic understanding of the legal dimensions to energy communities, coupled with a poor understanding the climate crisis and the overall logic of the energy transition can limit people's ability to recognise the potential opportunities linked to joining an energy community.
- **Opportunity** is limited when legal barriers continue to stymie participatory investment, e.g. frequent changes to laws and regulations relating to RES supports, taxation (see Tomasi 2022, Regueiro-Ferreira and Cadaval Sampedro 2023) have significant negative impacts on potential energy community formation.
- In addition to the widely recognised knowledge gap, **Motivation** is hindered by the degree of technical knowledge needed to navigate the complex rules around energy. So much so that energy professionals sometimes struggle to explain/share important knowledge with non-technical experts. Also, the low

cost of electricity in Switzerland, coupled with the high salaries there, can remove an economic incentive for citizens.

Workshop participants also identified several potential drivers for DSOs in encouraging greater participant engagement. These include building:

- **Capability**. Two important aspects they found helped improve the psychological capabilities of those participating in an energy community being (1) end-user application (though this was qualified, with the app needing to be both intuitive and responsive, while also taking into account local geographic and socio-cultural contexts; and (2) partnering with a trusted entity can help with community relations, resolve potential conflict, and manage expectations.
- While **Opportunity** was presented in a number of ways, e.g. joining an energy community, when seen as a neighbourhood activity, can expand one's personal networks and help establish new friend groups. More direct contact with customers and better environmentally friendly profile was also seen as beneficial, with better citizen engagement seen as becoming increasingly important.
- In addition, citizen **Motivation** can be significantly improved through increased user knowledge, particularly relating to energy communities, and can be achieved using trusted and reputable groups, institutions, and companies. Also, new products and services that are more attuned to citizens' needs can potentially motivate greater participation in energy communities.

4. Discussion

As Lowitzsch (2019) posits, shifting from fossil fuels to RES involves a complex alignment of financial, technical and social innovations any one of which (if incorrectly applied) can potentially derail the whole process. We take this position a step further and argue that the current energy transition is at its core primarily a social challenge. While people already have (in theory at least) access to much of the necessary financial and technical tools available to them, they still do not have the appropriate tools needed to help them deliberate and then decide on where their interests best coalesce with the wider interests of the energy system. Indeed, Esteve-Jordà and de Armenteras Cabot (2024) note energy communities can be best understood as an intricate interplay between the public and the commons, offering citizens an opportunity to make a significant contribution to establishing greater energy security, reduce climate-damaging emissions, and stimulate local economies. However, this all still contingent on supportive regulatory frameworks provided by the state, a sentiment that was expressed repeatedly by participants in the workshop discussions. The state—whether through policy formulation, legislation, regulatory oversight, financial support, or in empowering citizens—is very much seen as having a primary role in the success or failure in both the long- and short-term viability of energy communities at scale.

For Miller *et al* (2013) three critical, intersecting aspects of energy transformation must be considered namely in terms of infrastructures, epistemics, and justice. Previously, energy systems often appeared relatively hidden from public scrutiny while at the same time they continued to deeply structure society—so much so that alternative arrangements seemed impossible. This was achieved through *energy epistemics* and the controlling of who knows what about energy systems, how do they know, and whose knowledge matters when it comes to governance and decision-making. Which brings us to the issue of energy justice, which is essential if we are to avoid perpetuating existing inequalities in the energy system or indeed contribute to establishing new ones.

Applying the COM-B model to their study of an energy community in The Netherlands, Onencan and De Koning (2022) demonstrate how people's behaviour and their ability to adapt to the different challenges are themselves shaped by psychological capabilities and motivational factors. These include beliefs, attitudes, social norms, and perceptions relating to behavioural control. Interestingly, they suggest homeowners there often view the short-term benefits of home renovations (e.g. improvements to thermal comfort and switching away from fossil fuel heating) as being quite separate from the longer-term goals of the energy transition. Consequently, they suggest prioritising interventions that align citizens' short-term goals to the wider societal level ambitions of the energy transition. More appropriate governance structures at the energy community level are therefore needed for establishing a more resilient and equitable energy transition, with energy communities occupying a central role in decentralised energy production. Despite the clear associated benefits ascribed to energy communities (e.g. see Lode



Figure 3. The COM-B model of behaviour template with example from the workshops. Adapted from Michie et al (2011). CC BY 2.0.

et al 2022), their rollout is not happening at the scale or speed required[10]. Reasons for this can vary, highlighting the importance of appropriate policy and more targeted supports mechanisms (as indicated by workshop participants), though geographic and cognitive-cultural factors continue to be under-examined. This paper acknowledges this gap and assesses the COM-B model for its potential in understanding the cognitive-cultural aspects at play during EC formation.

The detailed discussions that took place in the four workshops allowed us to utilise the COM-B model framework to drill down into the participants' motivational perspectives and uncover the causal factors influencing their decision-making, while also assessing the project's approach in terms of capacity, opportunity, and motivation. Each workshop comprised of in-depth discussions on the implementation, challenges arising, and the perceived barriers and drivers linked to energy communities at different phases of their life cycle. Seven key themes emerged from participants' interactions with the COM-B model template (see figure 3) that very much align with the literature and are presented with illustrative translated quotations from the participants:

1. Participants often struggle to define what is an 'Energy Community': several participants in the workshops acknowledged they struggled sometimes with the energy community idea, suggesting it can feel somewhat amorphous with its assigned meaning changing depending on the context and to whom they are talking to. This was also echoed by some of the professional participants working in the sector who also indicated it can be difficult keeping up to date with current trends (not only in terms of the technologies involved, but also in relation to the roles and expectations assigned to the citizens they work with). Similarly, citizens within an established energy community often found it difficult to engage with others from the same community who might be less informed as to the benefits of RES and any potential opportunity for them to become more involved. A common theme across all four workshops was an acknowledgement that more education is needed at the societal level so that citizens have a better handle of the information being disseminated and consequently have more realistic expectations with regards to their own ability and what the energy community can deliver for them. An example of the types of experiences include:

> 'I myself did not know how to define an energy community. In other words, what it is or what it is for, or what advantage it would have over […] I don't know about economic or environmental advantage or any other type of advantage' (AHMP-3, 2024).

Similarly, another participant noted '…we found ourselves along the way in the energy communities and we invested a lot (of time and resources) in it, but it seems there are problems convincing the

[10] Despite emerging definitions of energy communities (e.g. see the definitions of 'Citizen Energy Community' and 'Renewable Energy Community' in the EU's *Clean Energy for All Europeans Package*), there remains confusion amongst practitioners as to the parameters of the term.

community so that an entire community, an entire united neighbourhood, is dedicated and onboard because perhaps people do not know what it is about…' (AHMP-1, 2024)

2. Operational and practical considerations are key priorities for most participants: Discussions on what are the practical steps needed to establish an energy community predominated all the workshops. Issues raised included the technical expertise required, the logistical challenges at different scales, and the sourcing of financial supports. For some, there was a clear preference for small and local RES plants over larger strategically important infrastructure projects, where issues of ownership and control are more easily coopted by the large energy incumbents and other equivalent stakeholders. Also, the issue of dynamic tariffs (particularly those with oversimplified band structures) dominated discussions particularly in Spain where it has led to greater pressure being put on smaller energy producers and cooperatives who find it harder to compete with existing energy incumbents better able to absorb such pressure. Also, the multifaceted roles taken on by individuals and the importance of clear communication was broadly acknowledged as essential for effectively managing energy consumption, balancing costs, and for implementing demand response during peak use times with users. A participant in the Murcia workshop highlighted the need for greater technical support from trusted sources:

> 'I don't know how there would be any possibility of providing these communities with a technician who would come to them and explain how they could do it. In their case, while it is not a main project for them it would help in reality. That is while the theory is very good, how to put the theory into practice does not come out of projects…' (AHMP-2, 2024)

Another participant, speaking about the complexities of financial arrangements available to energy communities, the danger of not understanding the details, and the different business models purportedly available to support ECs put it like this:

> '…even if you have an ESCO[11] [supporting the energy community], I read some articles on Italy where there is no limit [e.g. to the service fee] so it depends on the company that is helping you setting up your energy community, with service fee might end up even higher than incentive' (AHLP-1, 2024)

3. Engagement and motivational factors are central to establishing energy communities: Participants also engaged in considerable discussion on the importance of motivating members from the wider community. While this can be partly explained by Theme 1 above and the difficulty in negotiating different interpretations of what an energy community is meant to be, other factors were also noted including the social atomisation experienced by many (Marčenoka 2016, Naidoo 2023):

> 'I know that there are many difficulties in implementing an energy community, but I don't know if someone is a neighbour of mine, and they ask me, I couldn't tell you…' (AHMP-3, 2024)

In terms of motivation, the discussions highlighted that participants do not necessarily see it arising from economic incentives but rather position it within a wider constellation of tangible community benefits including fostering greater environmental responsibility and improvements to the quality of life for citizens this can bring. When considering what motivates her, one participant suggested:

> 'It's not very representative compared to the motivations of other people in my house. With the motivations of other people like, well, those younger than 30 years old who were right now going out into the world…' (AHMP-5, 2024)

While another participant, who acknowledged the importance of sharing information that highlight good practices from existing energy communities, described his own motivation journey as follows:

> 'A group of citizens who want a common goal of collective self-consumption, with a facility that is set up for you, and you benefit because you will save money on your electricity bill. While it is true that this [scenario] is not an energy community per se, it can be collective self-consumption, and you can save money. However, from what I now understand from being in the solar cooperative, is hey, what I actually want is an energy community.

[11] Energy Service Companies (ESCOs) provide a broad range of energy services including retrofitting, designing and implementing energy savings projects, energy infrastructure outsourcing, *etc*.

> It's just about uniting [people] because we have a certain environmental awareness and, in the end, I don't want to [just] depend on the company option' (AHMP-4, 2024)

4. Barriers to EC development: Participants in all four workshops pointed to a broad range of structural barriers they have faced when establishing their own energy community. These can comprise bureaucratic procedures, unstable legislative landscapes and/or regulatory environments that result from the ideological differences of new government administrations that may choose to de/prioritise prior legal frameworks, e.g. shifts in policy relating to governance, exploitative financing arrangements. Taking into account the not insignificant institutional bias towards maintaining an existing status quo that invariably favours the large energy incumbents, participants also acknowledged the strong potential for corporate capture to occur at any time during the process of establishing an energy community. Despite this risk, participants noted the role taken by government at each stage of the process being instrumental to the overall success or failure of their energy community.

> '…we have noticed that some changes have to be made by both ourselves and others with regards to the environment. And not only from our neighbours, but from our local and regional governments, and those providing the infrastructure and knowledge support. I don't know, but I have come to the conclusion that [the administrative supports offered] it has to be more aggressive, more revolutionary [than is currently the case]' (AHMP-3, 2024)

Similarly, 'It makes sense to postpone grid investments, so that we can target engagement in certain areas since we have data available on RES production and also on consumption. However, the legal barriers right now, compared to the past, are pretty strict and it is actually limiting engagement especially when trying to expand the energy community' (AHLP-4, 2024)

5. Potential Drivers to EC development: While much of the discussion in each workshop focused on barriers and how to overcome them, participants did explore the drivers they saw helping with energy community formation. For example, they talked of the perceived benefit in receiving clearer more targeted guidelines that directly point to the financial incentives and local government supports they could avail of. This contrasts with the rather generic, technology-oriented information they receive at present. Such information could also focus on providing citizens with a variety of community-based solutions that take into account local contexts and capabilities. A participant from the second Spanish workshop noted the potential usefulness of the COM-B model in assisting their efforts to establish their own energy community:

> 'In the end, there will be situations that are not too strange or unmanageable, but there will be a few. Let's see if I can identify one. If I am not able to know what will likely fail and what will not, then nothing will happen. This [the COM-B model] can helps us to identify which options are best for us and what we are trying to do. For an energy communities project looking at how digital tools can help, what barriers we see, and or the facilitators that are needed, it can help with that? Then this is something that might help me' (AHBP-2, 2024)

For others, the potential return on investment through peer-to-peer trading is seen as a key motivating driver to join an energy community:

> 'I have already made my investment and now what I am going to do is I will sell that excess [electricity] to them [speaking about other members in the energy community]. Being part of a community helps me to recoup the initial installation costs and to pool resources' (AHBP-4, 2024)

6. Technology and Tools: Another key theme to emerge from the discussions centred on the types of technological tools available to participants that can facilitate their management and the day-to-day operating of their respective energy communities. Across the workshops, participants acknowledged the importance of having access to intuitive, user-friendly (digital) technologies that can assist with the various aspects to managing the oscillating demands of energy consumption and production. The issue of standardising how one accesses data and how it is subsequently presented to users was another common theme with concerns around how best to collate such data so that it is more useable to energy community practitioners. When discussing the demand response tool created for the project, one participant put it this way:

> 'In the end, this is why I do what I do: what are the reasons that drive me to behave in a certain way or not to do certain things. For example, when we talk about recycling what are the barriers for people to participate or not. [Referring to the COM-B model] this model helps you to identify barriers and structure them in a more organised way, okay? Then yes, we can shortcut them or address them in a simpler more effective way' (AHBP-1, 2024)

7. Community Building and Solidarity: Finally, the importance participants gave to establishing a strong community spirit that can help support collective actions was another recurring theme. Understanding the social dynamics within an energy community is also fundamental to the practical deployment and application of innovative energy solutions (Tobin and Lennon 2025). Indeed, it is the collective emotions expressed within the group that operate as a kind of 'social glue' bonding people together to work towards a common goal, and understood in terms of solidarity (Salmela 2014). As Frega (2021) points out, solidarity can be seen as social involvement and understood in terms of 'acting-for' and 'acting-with'. As such, this fostering of connections between energy community members and the promoting of mutual benefit, citizen empowerment, and the establishing of trust (e.g. between the manager of the energy community, the recruitment team or community leads, and members of the community who engage at different levels) all contribute to the cohesion of the group and the wider acceptability of the energy infrastructure at the centre of the cooperative. Essentially,

> '…the community includes how you act in one way or another, that is, it's a product of belonging' (AHBP-2, 2024)

In addition, the potential power collective action and solidarity brings to individual decision-making was also alluded to:

> 'Everyone's inconveniences can be compensated within a community [arrangement] that, when you are alone, there are no ways' (AHBP-3, 2024)

These seven themes from the workshops align with the literature on community identification and role interpersonal trust plays in establishing social acceptability. Indeed, they also contribute to the consolidating of those normative social behaviours that condition individual expectations and the willingness to participate in community energy projects. A notable sentiment shared across the workshops was that many of the participants wanted to 'do something' and joining an energy community was their way of contributing. This was repeatedly framed in terms of a type of personal 'journey' for some, emphasising the importance of story-telling and narrative to the decision-making process for many people (Baldwin 2009). Also, a definite correlation can be found with those who are concerned about the environment more generally and those who possess a willingness to participate in energy communities (Soeiro and Ferreira Dias 2020).

5. Conclusion

Our experience using the COM-B Model of behaviour to explore the potential of living labs in facilitating more active participation and co-creation among stakeholders suggests its very real usefulness for examining the underlying motivational drivers and barriers of citizens' towards participating in energy communities. While citizens may be inclined to join an energy community for a variety of reasons, certain commonalities can be found to explain how and why they frame their decision-making in the ways that they do. These include environmental concerns, concerns about security of supply, and the opportunity to reduce costs while at the same time also generating additional income. Consequently, we conclude successful community engagement is very much predicated on energy projects providing both the physical and the intellectual space for citizens to examine and then validate their own motivational reasons for engagement. Financial incentives (which tend to favour wealthier cohorts in society) have not resulted in a rapid uptake in participation around community energy projects (e.g. see Qadir *et al* 2021). Instead, we need to offer more hybrid, adaptive support mechanisms that address both the structural and behavioural contexts motivating citizens when engaging in local renewable energy projects.

Data availability statement

Under the conditions of ethical approval, the data cannot be made publicly available upon publication as consent has not been provided by the participants and there is a risk of reidentification.

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Conflict of interest

The authors declare that there are no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical statement

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

Author contributions

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Conceptualization (lead), Data curation (lead), Formal analysis (lead), Funding acquisition (lead), Investigation (lead), Methodology (lead), Project administration (lead), Writing – original draft (lead), Writing – review & editing (lead)

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