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New clean energy communities in polycentric settings: Four avenues for future research

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ABSTRACT

Given the gaps between EU ambitions regarding energy community development and the current reality of clean energy communities in Europe, we explore a research framework enabling viable multi- and interdisciplinary research into new clean energy communities. We offer a definition of new clean energy communities, discuss their potential for wider dissemination and identify four factors that contribute to the current mismatch between ambitions and reality in energy community development. As a broader framework for interdisciplinary research into the field of new clean energy communities, we propose polycentric governance theory, considering the fact that the area of community energy systems is essentially multi-scalar, and that the rules of engagement in such systems are of great significance. This opens up four avenues for research on energy communities, which we outline in terms of enabling institutional contexts, potential for learning and transferability, business models and value propositions, and evaluation of outcomes and processes.

1. Introduction

In the 'Clean Energy for all Europeans' package [1], great hope rests on citizen as well as renewable energy communities to make energy systems more sustainable. This is reiterated by 'The European Green Deal' that emphasises the need for empowering energy communities [2]. Yet, energy communities are still considered a niche phenomenon and their development depends on access to capital, technical knowledge and entrepreneurial skills [3–6]. Their potential for replication or scaling up, and for engaging more widely with society to bring about clean energy transitions, has been limited so far.

Against this background, this paper explores the gaps between EU ambitions and reality regarding energy community development, as well as the potential for the development and wider dissemination of new forms of such communities. While doing so, it proposes polycentric governance theory (e.g. [7,8]) as a theoretical entry point to better understand the interactions between diverse actors as well as processes of social innovation, learning and value creation. Addressing these issues requires contributions from various fields. To enable viable multi- and interdisciplinary research, this perspectives paper proposes a

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research framework, starting from four factors that contribute to the mismatch between ambition and practice, and proposing associated research avenues and research questions.

Giving a more prominent role to clean energy communities implies a change to more decentralised electricity systems [9,10] that rely increasingly on distributed energy resources (DER). DER can take the form of distributed supply (predominantly renewable), distributed demand that can be flexed/shifted in time (demand response) and distributed storage. Flexibility has become increasingly important for system operation, requiring new features to enable demand that is responsive to the availability of supply in real time [11,12]. In decentralised energy systems, if designed in an inclusive way, energy communities will experience more opportunities for their engagement and empowerment [13]. In fact, new social arrangements and technologies that encourage energy users' engagement have stimulated the emergence of new types of energy communities, including distributed renewable energy generation, distributed storage, electricity trading, and opportunities to create value through demand response [14]. With appropriate support, these communities can change the energy landscape from the bottom up [15]. Apart from their potential in relation to renewable generation and demand response management, they offer an opportunity to engage members in energy conservation [10,16].

We consider the emergence of such new forms of clean energy communities to be a form of social innovation [17]. While there are some examples of successful new forms of energy communities [18], the phenomenon is still in an early stage and its potential to support and accelerate clean energy transitions is still to be assessed. Transitions towards more decentralized energy systems often take place in an unguided, uncoordinated way. Consequently, ambition and reality may not coincide when it comes to the spread of energy communities. Four factors contributing to this mismatch are:

1) Transitions take different forms in different places (e.g. [19–21]). In many countries, there is still a lack of clear regulatory frameworks for community or local energy [10]. Moreover, national physical, cultural and social conditions are shaping institutions and processes of change.
2) Most energy communities evolve in niches and consequently there are limited opportunities for them to connect and to learn from each other, especially as existing knowledge networks and mechanisms are often still fragile and bound by a limited amount of resources [22].
3) Emerging community business models include new activities and value propositions and call for new regulatory frameworks and governance [6,23]. For example, markets for small-scale demand-side participation are still struggling to be established in most regulatory regimes.
4) Scaling up energy community business models requires that their financial and non-monetary benefits for members and society can be demonstrated, along with guidance on how to achieve benefits and avoid failures.

2. A theoretical framework for studying energy communities

Before setting out our 'four avenues' for research into new forms of energy communities based on the factors identified above, we offer a reflection on how to define the emerging communities under consideration, followed by an introduction to polycentric governance theory and its main themes, with the latter serving as the basis for our proposed research avenues.

2.1. Defining energy communities

Although there seems to be a considerable degree of consensus on the characteristics of energy communities, it simultaneously hides a wide variety of interpretations and meanings that are evolving over time (e.g. [24–27]). The flexible [28], elastic [29] and vague [30] nature of the term is widely recognised, and is reflected in the variety of compound terms used in the literature, which encompasses for example *community energy (initiatives)* [15,16,31,32], *integrated community energy systems* [33], and *clean energy communities* [34]. Building on the interpretations of diverse stakeholders, Walker and Devine-Wright [25] proposed a differentiation between projects' process and outcome dimensions (who by and whom for, respectively). This led to three broad interpretations of community: projects that are open and participatory in their process, projects that seek local and collective outcomes, and projects that do both, with the latter allowing for a wide range of possible configurations [25].

Explicitly and implicitly, reference to these process and outcome dimensions has become a common way of describing community action on energy. For example, building on Walker and Devine-Wright [25], Seyfang et al. [15] used the term community energy to refer to projects that yield collectively beneficial outcomes, and that feature a high degree of community ownership and control. Other common ways of describing renewable energy projects implicitly acknowledge process and outcome dimensions, through reference to joint ownership, participatory and/or democratic decision-making, and collective benefits (e.g., REScoop[1] definition of renewable energy cooperatives; [35]).

Notions of community are also often associated with the organisation of energy systems based on local (decentralised) resources (e.g. [33,34]). While some have suggested to reserve the 'community' label for bottom-up initiatives that involve active citizen participation (demarcating it from other, locally-based, modes of energy generation and management) [35], others have taken a broader approach based on organisational structures designed to meet collective interests. For example, Moroni and Tricarico [36] argued that a 'non-ideological' way of understanding community is to define it in terms of shared interests and an organisational system for the operation of the community. This approach places more emphasis on project outcomes rather than processes, and avoids the ambiguity of 'local'. Viewed in such a way, models such as peer-to-peer trading, community microgrids and integrated community energy systems may all be considered types of energy communities [33,34].

The myriad ways in which energy communities manifest themselves may also be explained by considering how context and the motivations of involved actors shape projects [27]. Using context and motivations as main influences, Hicks and Ison [27] proposed to consider 'community' on different spectrums (e.g., from only local individuals, to alliances, to only non-local organisations), rather than relying on a single definition.

The importance of considering diverse types of actors involved in energy communities has grown in relevance as energy policy and innovation have shifted towards more decentralised, locally rooted energy systems [35]. Despite the growing use of partnerships between communities and others, the types and roles of actors in different configurations is, thus far, not well understood [27]. Similarly, it is unclear to what extent context, including for instance national legislative frameworks, influences the types of actors involved [27,37]. For example, the development of a 'local energy' discourse in the UK is of increasing interest to large, incumbent energy utilities seeking to diversify their business models [38–40], as well as to new entrants seeking to profit from emerging market opportunities to be found in increasingly distributed, 'smart'[2] and often localized configurations of demand, supply and storage [30,41]. Historically, municipalities and other state actors have also contributed to the formation of energy communities [42,43]. These actors will likely differ in how they interpret the concept of community [25]. The diversity of interpretations and forms – practically and theoretically – associated with energy

[1] See: https://www.rescoop.eu/the-rescoop-model

[2] By 'smart', we mean 'employing information and communication technology (ICT).

communities may be considered a key feature of the term [27]. To accommodate this diversity, 'energy communities' is here used as an umbrella term that is sufficiently broad to encompass the variety of possible forms of community-oriented initiatives engaging in energy systems. In order to maintain coherence with prior work, and for the scope of this paper, we define them as *associations of actors engaged in energy system transformation through collective, participatory and engaging processes, seeking collective outcomes*.

This conceptualization seeks to recognise the interpretive flexibility with which the term is currently employed whilst specifically acknowledging the wide array of actors embroiled in contemporary activity. In this regard our conceptualisation differs from that proposed within EU legislation, which is, at the same time, prescriptive and vague [30]. To date, ambiguity within the term has allowed for a flourishing of activity. To what extent this can continue is, however, debatable. The increased penetration of incumbent and new public and private actors into the arena, combined with rapid changes to energy markets, service offerings and technologies, indicates the flexibility of the term will be tested further. Differentiating types of activity through developing and refining shared definitions and concepts for energy communities (vis-à-vis local energy, amongst others) will become an increasingly prominent priority for research and policy.

2.2. Polycentric governance theory and its central themes

Given the emergence of energy communities at various locations and scales, we propose polycentric governance theory as an entry point to better understand their emergence and operation, as well as associated processes of learning, organising and creating individual and collective value. The concept of polycentric governance emerged from studies in the 1960 s and 1970 s on collective action problems and the provision of public goods and services. Seminal papers [44,45] showed that multi-actor, multi-scale approaches to public policy problems often led to better outcomes than monocentric governance [46]. Polycentric governance is typically defined as a system with distributed decision-making in which multiple, independent or semi-independent governing units interact [47]. It can be seen as a form of multilevel governance, which draws attention to governance initiatives from the bottom-up, geared towards a common goal, and is also related to concepts such as network governance [48] and experimentalist governance [49].

Elinor Ostrom [7] brought the concept of polycentric governance in connection with climate related issues, suggesting that they could be solved by new and more dynamic forms of bottom-up, dispersed, and multi-level governance. She argued that polycentric governance can work well when central goals - such as fighting climate change - are shared, when actors develop trust because of their continued mutual interactions in local initiatives, and when systematic evaluations take place and translate back to the identification of best practices that can be scaled up. In line with Ostrom's suggestion to study the strengths and weaknesses of polycentric governance empirically, this paper proposes to use polycentricity as an analytical lens to examine how interactions around the particular issue of decentralised energy systems are structured and socially organized, with a specific focus on institutional arrangements developed and used by the actors involved [7] and the processes that influence them.

Among the themes that require attention when studying these interactions are those identified by Jordan et al. [8], including local action, mutual adjustment, experimentation, trust and overarching rules. In their book, these themes have been refined into research propositions, with local action referring to governance initiatives that are likely to take off at a local level through processes of self-organisation and may result in collective changes to the overall governance system through the accumulation of marginal changes by each initiative. Mutual adjustment is seen as spontaneously developing collaborations between the individual units of governance, producing more trusting relationships, which may also lead to mutual adaptation. Experimentation within these governance initiatives may be capable of introducing innovative approaches and may stimulate learning about what works. Trust is considered an important basis and likely to build up more quickly when governance units can self-organise, thus creating collective ambitions, and even more so at the local scale as actors then have the opportunity to interact face-to-face. The theme of overarching rules refers to the setting of common goals and the creation of mechanisms for conflict resolution, which may help to make governance function more effectively.

3. Four avenues for energy community research

As explained above, it is our view that polycentric governance theory offers a framework flexible enough to address the issues arising in evolving European energy systems at different scales from ultra-local (e.g. building and neighbourhood level) to supranational. This section sets out an agenda for research on energy communities (see Table 1), framed in terms of polycentric action and governance, that addresses the factors contributing to the mismatches between ambition and reality as identified in Section 1, and links them to the research propositions as formulated by Jordan et al. [8].

3.1. Avenue 1: Enabling institutional contexts

Seeing that bottom-up community-led action is a key element in polycentric governance theory [7,8], questions arise as to how to understand the evolving nature of energy communities in relation to their institutional frameworks.

In earlier research, the institutional setting of the energy sector has been identified as important for whether energy communities emerge or not, with countries pursuing more decentralized energy pathways providing more supportive conditions for community participation [8]. Sovacool [46] discusses how different constellations of scales, mechanisms, and actors can enhance responses to energy and climate issues in a polycentric manner. His approach highlights that there is no one-size-fits-all approach to institutional arrangements, and that the complexity of these arrangements should be appreciated when assessing what institutional conditions support the emergence of energy communities.

These insights raise the question of which European countries provide supportive regulatory, technological and social environments for new forms of energy communities, and which contain major barriers that hinder their diffusion; and ultimately how these national settings link with local initiatives and EU-level ambitions. Although the potential of energy communities to contribute to a transformation of energy systems has been acknowledged in earlier research [50], attention from research as well as policy makers has been rather instrumental and selective [51]. Research is dominated by case studies and only a few comparative studies between different national settings exist (e.g. [37,52]). Comprehensive overviews of the developments of energy communities, nationally and internationally, are scarce [53]. *What is lacking so far is research that compares and contrasts national institutional settings to better understand the predominant characteristics of energy communities and the business models that are evolving in different national contexts.*

Key research questions are: What institutional contexts enhance the emergence of energy communities and their projects? What are the formal and informal 'rules' that support or inhibit energy community development and how do they emerge? What forms of energy communities work best in different institutional settings, what factors lead to their emergence, and how can they be diffused?

3.2. Avenue 2: Processes and mechanisms of learning

Polycentric governance involves multiple governing centres, which, according to Jordan et al.[8], might be an ideal setting for learning and experimentation of what works best in different contexts and domains. Ostrom [7] argued that polycentric governance can work well when

Table 1
Proposed research avenues for studying energy communities based on polycentric governance theory.

Proposed research avenues	Factors contributing to mismatch between aspiration and practice	Related polycentric governance propositions	Research questions
Enabling institutional contexts	Limited- or overly complex - regulatory frameworks	Overarching rules enshrine goals to be achieved and/or allow conflicts to be resolved.	• What institutional contexts enhance the emergence of energy communities? • What are the formal and informal 'rules' that support or inhibit energy community development and how do they emerge? • What forms of energy communities work best in different institutional settings, what factors lead to their emergence, and how can they be diffused?
Processes and mechanisms of learning	Few opportunities for learning and building networks	Willingness and capacity to experiment are likely to facilitate governance innovation and learning about what works.	• How does learning within and between energy communities and other stakeholders take place? • How do learning processes develop, and which types of learning are involved? • How and to what extent does learning improve collective outcomes?
Business models and value propositions	Misalignment between emerging business models and existing regulatory frameworks	Initiatives by energy communities are likely to lead to the emergence of new energy service business models in the field of low carbon energy.	• What are emerging community business model components and arrangements? • What is the potential value of energy communities to system operators and end-users? • How could new business models enhance the economic viability and future deployment of more distributed energy resources?
Evaluating processes and outcomes	Limited evidence of financial and non-financial benefits for community members	Trust is more likely to build up through processes of self-organisation, collective vision forming and value creation.	• What types of value (creation) do community members perceive in relation to new forms of clean energy communities? • How do different features of energy communities affect the behaviour of community members in terms of energy conservation and load shifting? • Which interactions with other pro-environmental behaviours can be observed?

certain goals – such as mitigating climate change – are shared, when actors develop trust because of their continued mutual interactions in local initiatives (such as energy communities), and when systematic evaluation takes place and translates back to the identification of best practices that can be upscaled. Hence, learning is of central importance in polycentric governance thinking and is expected to drive innovations in socio-economic, technological and institutional domains (ibid).

Actors involved in energy communities may include private individuals, citizen organizations, civil society groups, businesses, municipalities and government agencies. The types of actors in terms of technical knowledge, entrepreneurship skills and access to resources may differ in each context, affecting the activities undertaken and the actual processes of learning in and between the communities [27,54]. Various types of learning may be involved, notably *cognitive* learning (the acquisition of new factual information), *normative* learning (a change in priorities assigned to certain norms and values), and *relational* learning (a change in levels of trust and understanding between actors) [55].

Focused on energy communities, polycentricity is considered to have the potential to facilitate the development of *cognitive learning*, by enabling the diffusion of relevant knowledge to be transferred to stakeholders [7]. Such knowledge transfer can facilitate fast-paced learning and result in up-scaling of energy projects in terms of the growth of members or project size, or the replication of projects in new locations, both of which may feed into the institutionalization of initiatives [15,56,57]. *Normative learning* can be facilitated, where stakeholders learn and embrace changes of new perspectives, goals, or priorities, which is important for developing collective action solutions as well as a strong clarity of purpose [55,58]. *Relational learning* may be facilitated in polycentric settings where actors can develop trust, and are enabled to cooperate with other stakeholders [55,59].

Much in this vein, Bauwens [60] argues that community-based energy initiatives foster the conditions for experimentation and creativity, exhibit informational benefits by encouraging the use of local knowledge, and enable feedback on the performance of rules. *What needs to be better understood is how energy communities develop their own knowledge base, how they disseminate knowledge amongst each other, and the ways in which different types of learning can be stimulated.*

Key research questions are: How does learning within and between energy communities and other stakeholders take place? How do learning processes develop, and which types of learning are involved? How and to what extent does learning improve collective outcomes?

3.3. Avenue 3: Business models and value propositions

Because polycentric systems are thought to exhibit high adaptive capacity and multiple, independent decision-making units [8,61], their potential for generating innovative business models appears high. The question then arises as to which new energy service business models are emerging in the field of low carbon energy and how they can be described and classified.

Business models describe how value can be proposed, created and delivered, and captured by business or other organizations [62,63]. Sustainable business models, or business models for sustainability, focus on *"how an organization creates, delivers and captures value for its stakeholders in a way that supports a safe and just operating space for humanity and all living entities to flourish"* 64, p. 2]. The business models of energy communities may be seen as a type of sustainable business model, which brings together social, economic, and environmental benefits to the stakeholders involved.

There is a lot of model-based work on the value and viability of DER, especially in relation to renewable energy generation and demand response, which brings together supply, demand and storage considerations [65]. But as yet, very little research has engaged with the role that new forms of energy communities could play towards enhancing the viability of DER. Also, current models do not yet address the distinct values that they may be able to offer. There is a clear need for a better understanding of emerging community business model components and arrangements, their potential value to system operators and their potential value to end-users.

Energy communities vary significantly according to the parts of the energy system they seek to influence, with different activities addressing

how energy is generated, how it is moved around (transmission and distribution), and how it is sold (supply) to end users for their purposes (demand). As Brown et al. [41] point out, nearly all of the innovative business models currently being developed can take on either community or business-orientated logics. *Understanding the breadth and diversity of business model activities being pursued by energy communities requires further work, including the development of alternative and potentially complementary typologies.*

Key research questions are: What are emerging community business model components and arrangements? What is the potential value of energy communities to system operators and end-users? How could new business models enhance the economic viability and future deployment of more distributed energy resources?

3.4. Avenue 4: Evaluating processes and outcomes

According to polycentric governance thinking, trust is an important condition for the emergence and well-functioning of polycentric systems and is more likely to build up through processes of self-organisation, collective vision forming and value creation [8]. With regard to the latter, many factors, such as value systems, familiar practices, and experiences, may affect the values perceived by consumers - members of the clean energy communities - which in turn influences social dynamics and mirrors citizens' willingness to get involved [66]. Moreover, particular types of value creation can be important from a polycentric governance perspective, especially as they relate to activities such as connecting and building relationships with others as well as transferring knowledge. These values can be perceived as benefits by individuals but also at the level of the energy system (e.g. reduced network cost).

3.4.1. Consumer value creation

The concept of value tends to be multifaceted and consumer experiences usually involve more than one type of value simultaneously [67]. From the perspective of energy communities, the "utilitarian" value might be the most obvious; however at least two other value types could be important and need to be better understood. First, there is the ecological value defined as "consumption-related issues regarding the natural environment and the impact made on it by humans" [69, p. 1157]. Second, there is the network value, which is a value co-created through social networks or groups of consumers, or in this case, energy community members [68].

Tricarico [69] highlights a critical issue in the dynamics of community engagement. On the one hand, being part of a community can be a means to improve one's socio-economic conditions. On the other hand, it could also cause marginalization of specific social groups, create inequalities, and social conflicts. According to Lennon et al. [70], to achieve a sustainable energy transition, participatory and inclusive governance structures are necessary. *Exploring these aspects will allow finding answers to questions such as whether and how new forms of energy communities meet their members' (i.e. consumers' and citizens') needs for clean, secure and affordable energy in their everyday life settings (existing values and social practices).*

Key research questions are: What types of value do community members perceive in relation to energy communities and alternative energy service models?

3.4.2. Value creation through energy conservation and load shifting

Energy communities can vary in terms of owners and operators of new generating and storage assets and new ways of controlling these assets using ICT. They may involve aggregators who manage demand and trade electricity on behalf of many individual members, as well as new rules and tariffs to enable demand response. This could trigger new awareness of the value of conservation and load shifting, and develop community members' skills in achieving these. Energy communities may consequently create value at the societal level: how large this potential is and under what regulatory conditions it can be tapped remain important questions (see Section 3.2).

In this regard, energy communities may have several 'new' features (for a review, see [35]) that render them a very promising research domain for experimentation, as one main theme of polycentric governance theory. Experimentation within energy communities can build on the large body of behavioural science research that has demonstrated the role of social influence on energy use and energy-related investment decisions. One example is the finding that installations of solar panels on rooftops are potentially triggered by peer behaviour [71]. Positive spillover effects [72] between energy community members could therefore influence conservation behaviour, although community membership might also provoke negative responses such as moral licensing [73,74], if membership in a clean energy community is used as a moral justification for indulgence in behaviours with negative environmental impacts.

Based on the extensive literature on price-based [75–77] and non-price-based (e.g. [78–82] interventions to stimulate energy conservation behaviour - as well as their combination (e.g. [83]) - and load shifting, *future research should test interventions specifically in the context of energy communities.*

Key research questions are: How do different features of energy communities affect the behaviour of community members in terms of energy conservation and load shifting? Which interactions with other pro-environmental behaviours can be observed?

4. Concluding reflections

Energy communities represent a promising form of citizen participation in decentralised energy systems and have the potential to create value for their members and society. However, several factors related to institutional context, exchange of knowledge, viable business models, and perceptions about value creation are currently hindering energy communities to fulfil their promise. In this perspectives paper, it is argued that polycentric governance theory, with its emphasis on understanding how actors collaborate, establish trust, and build institutions suitable for resolving common pool resource dilemmas, is a promising theoretical entry point to studying the emergence and operation of new forms of energy communities. At the same time, it is evident that the applicability and relevance of polycentric governance theory needs to be thoroughly tested based on practical evidence. To contribute to this purpose, a number of research 'avenues' have been outlined that address the mismatch between EU ambitions and reality regarding energy community development.

The encounter between the issues that new forms of energy communities give rise to and this theoretical framework have led to a point at which research questions emerge that are, we hope, relevant and challenging to fellow-researchers. These questions fall into four separate but related categories, dealing in turn with: a) polycentrism itself and enabling institutional contexts for energy communities, b) the dynamic business of learning and replication, c) the pressing issue of establishing value propositions and viable business models and d) the need for evaluating outcomes and processes in energy communities, without which no effective learning will be possible at the scale needed.

This perspectives paper aimed to highlight the need to understand why and how energy community business models emerge, as well as their potential for accelerating sustainable development in the context of varied and changing regulatory landscapes, system needs and user practices. These questions are not just of academic interest: at stake are very practical issues of how the environmental impact of energy systems can be massively reduced while, at the same time, emerging new system models can become socially and politically viable.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

the work reported in this paper.

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