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Review

Addressing the gaps in understanding and assessing energy communities

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ABSTRACT

Since their explicit mention in the recast of the European Renewable Energy Directive (Directive 2018/2001) and the Internal Electricity Market Directive (Directive 2019/944), energy communities in Europe are gaining increased attention. Nevertheless, despite the increasing literature coverage, their true functioning and needs as well as more technical elements such as their meticulous mapping and an all-encompassing definition of their performance are aspects that still need to be studied, highlighting the complexity of assessing them comprehensively. In this paper, we discuss the various elements that are needed for a proper understanding of energy communities as ever increasingly multifaceted energy actors and try to touch upon various contextual parameters in order to end up with a better understanding of their complexity. In particular, we discuss the need to review the historical and socio-cultural context in which energy communities emerge, the assumed benefits (e.g. inclusion, energy democracy and energy justice) and whether they are justified in practice, as well as the need to thoroughly map them. We conclude with recommendations on how to achieve a more comprehensive understanding of energy communities.

1. Introduction

People have organized themselves collectively all throughout history, including in citizen participated energy initiatives. However, their broad acknowledgment as relevant players to effectively achieve a sustainable and just energy system is a relatively recent phenomenon. First of all, they break the compartmentalized consumer-producer roles and open the system to other actors, thus giving back citizens agency and increase their role in the energy system. Moreover, they bring enhanced modes of participation for citizens in two ways. On the one hand, citizens are offered a broadened range of ways and moments to participate, i.e. financially and in decision-making, as consumers in the energy sector. On the other hand, citizens can now act as service providers, prosumers and promoters/initiators. Finally, their heterogeneity, alternative functional structures, and devised focus on social benefits provides a generous sample pool for exploring new synergies in an energy system that becomes more complex. Therefore, new arrangements could be investigated between actors that "could" better uphold sustainability, fairness, and democracy as values highlighting the relevance of citizens as active actors in the energy system.

Energy communities are gaining more attention since their explicit mention in the recast of the European Renewable Energy Directive (Directive 2018/2001) and the Internal Electricity Market Directive (Directive 2019/944). Prior to the introduction of the concepts of Citizen Energy Communities (CECs) and Renewable Energy Communities (RECs) in the European directives, only a limited impact assessment was carried out [1]. In practice, member States show wide variations in their effective implementation, as national or regional impact assessments are still ongoing in some countries or have not yet been initiated in others [2,3]. Energy communities, and community energy in general, are however a well-known and long-established concept. There is a wide variety of community energy projects in Europe, with different legal, organizational and financial forms [4–8]. Hewitt et al. further elaborate on the diversity of community energy projects covering a wide range of initiatives that are not limited to a particular class, project or decision-making structure.

The true functioning and needs of energy communities as well as more technical elements such as their meticulous mapping and an all-encompassing definition of their performance are aspects that still need to be studied, highlighting the complexity of assessing them comprehensively. The diversity of aspects that are to be taken into account in order to provide the needed insight is broad, and requires input from a variety of actors. Opinions of energy communities, their members as well as non-members [9], grid operators, cities/municipalities and service providers, are all providing different insights of relevance to present the currently lacking multi-dimensional picture. It is further

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important to understand that such a multi-dimensional picture becomes even more complex when taking into account the historical dimension of the phenomenon. Although recently there is an increasing number of studies reporting on new initiatives [4], the first of a kind demonstrations do not necessarily present viable, representative, and replicable cases as such due to the fact that they evolved in specific conditions (e.g. excessive funding). It is only by studying such pilot cases in more depth that their intricacies become apparent. For instance, the often referred examples of the energy transition project of Samsø (Denmark), and De Ceuvel (Netherlands) turn out to be largely dependent on unique framework conditions or creative and non-replicable structures. In particular, the former benefited from a number of specific external framework conditions, including among other subsidies for home owners for energy efficient refurbishments, investments subsidies for conversion to a heat pump, subsidies for the off-shore wind turbine, decommissioning certificates when replacing a wind turbine with a new one on any other location, fixed price additions for the first 22,000 peak hour of production by the wind turbines, and a compensation in case of low spot market prices, that were present shortly before and during the implementation of the project [10]. The latter is a microgrid that is allowed to share electricity behind the common meter based on creative ownership structures. This unique ownership structure allowed the set-up to be considered as one connection, and hence no grid fees apply opposite to cases where each user is connected to the grid separately. Therefore, referring to them as success stories without adequate context simplifies the picture and hinders a more comprehensive assessment of energy communities as a whole.

This paper aims to touch upon several elements in order to identify possible interrelations with respect to various contextual parameters that could help us better understand the intricacies and externalities[1] of energy communities. The need to assess the historical context of community energy projects is tackled first since such a process ensures a more robust approach on better understanding and designing them. It gives the basis to understand their origins taking into account social and cultural factors as well as economic and financial models along with environmental-related events that affected their evolution and success. The historical evolution of energy communities is discussed in particular, manifested as different waves of appearance following various growth and degrowth cycles. Some observations on the relevance of research on the topic are then summarized, emphasizing the need for a systematic and objective approach. The need for meticulous mapping is also highlighted to further emphasize the complexity of assessing energy communities. Additionally, the often assumed benefits that usually surround energy communities such as inclusion, energy justice and energy democracy are examined with a critical mindset in order to evaluate whether they are justified or not. Also, the need to create business cases that benefit members and the society are discussed. Furthermore, since the performance of energy communities is a criterion used to check the success of the initiative, the need for an all-encompassing definition becomes apparent. Finally, relevant suggestions and recommendations are given in the conclusion.

2. The need to assess the historical context of community energy projects: waves, growth and degrowth

Citizen participation (in both its financial aspect and its decision-making facet) in energy projects has experienced four distinct waves over the past 50 years, each driven by different external factors. The first wave was triggered by the oil shocks of the 1970s with the first mention of scarcity, where pioneers started eco-villages and self-sufficiency initiatives. It was also the time that anti-nuclear networks formed across Europe, with some leading to cooperative investments in clean energy, including in Denmark. A second wave came later with government support for renewable energy. Examples include the many, private or small-scale collective investments in wind energy projects in Denmark that began to emerge in the mid-1980s to 1990s. Government support for wind energy projects helped to leverage private capital and increase acceptance [11]. A third wave can be observed starting around the global financial crisis and the Fukushima nuclear disaster in 2011. Confidence in large companies, including large and often international producers, declined. De Moor [12] observes the rise of citizen-led initiatives around this time to have a larger focus than energy, including healthcare and financial services. A current fourth wave can be observed today: the new policy, following the recast of the European Renewable Energy Directive (Directive 2018/2001), and the Internal Electricity Market Directive (Directive 2019/944) with extensive financial support from European, national, regional, and local funds, combined with the energy crisis related to the war in Ukraine. While effective data is not available, trends in the number of communities established as function of time, such as shown by Schwanitz et al. [13], emphasize the growing interest in, and uptake potential of, energy communities.

Understanding the cultural and historical context in which energy communities emerge is essential for assessing and guiding their development. Trends observed in both the past and in long-established communities provide valuable insights for today's energy community initiatives. The emergence of energy communities can benefit from the history of, and experience with, energy cooperatives or other cooperative business models [14]. The connection between new community energy initiatives and previous collective efforts (whether on energy, health, food, or others) has also been highlighted by De Moor [12] in her Inauguration speech. Similarly, Shaw [15] emphasizes the value of drawing on historical resources to better understand current community-building efforts. This perspective is strengthened by Lode et al. [7] and Renn et al. [16], who highlight the relevance of history on the organization of the (energy) market [7,16]. Lode et al. in particular also emphasize the individual and community level to be influenced by cultural, historical, and psychological factors such as the local norms and values [7]. Despite their importance, cultural and cognitive factors remain understudied, leaving a gap in the understanding of how such dynamics influence the formation and resilience of energy communities.

The socio-cultural dimension includes several interrelated elements, such as justice considerations (e.g., how fairness, equity, and rights are perceived and valued), sense of community and responsibility, norms and values (e.g., entrepreneurialism, communal values, traditions, perception of locality). These are not only shaped by broader historical contexts, including economic crises and the legacy of cooperative movements, but also depend on the energy community's development stage. Capellán-Pérez et al. refer to apparent key factors being the historical influence of the ecological and anti-nuclear movements, the experience with, and spread of, publicly-owned municipal utilities, the impact of the oil shocks in the 1970s and the respective derived policy-responses, as well as more generally the particular socio-political-cultural context of post-socialist countries [17].

Trust, particularly interpersonal trust, plays a foundational role in the development and success of energy communities. Palm [18] and Walker et al. [19] both emphasize that trust in others is a crucial condition for community-based energy initiatives to emerge. Interestingly, citizens in all EU Member States were surveyed in 2020 and 2021, which led to the composition of a map summarizing the trust in others at NUTS2-level [20]. This map could help understanding, at least partially, the currently lower uptake of energy communities in Eastern European countries, where lower levels of interpersonal trust may be a limiting factor.

While communities may demonstrate strong internal trust and cooperation, a parallel trend of mistrust towards governmental institutions is often observed. This mistrust is largely rooted in perceptions

[1] Externalities are costs or benefits that arise from the production or consumption of a good or service, but are not reflected in the market price and are borne or enjoyed by individuals or society who are not directly involved in the transaction.

of corruption and a lack of transparency. In some cases, such doubts extend to concerns about whether the energy transition can be accomplished fairly and efficiently, as discussed by Končalović et al. [21]. These dual dynamics (i.e. trust among community members and scepticism towards the political system), along with a region's socio-cultural and political history, are essential for understanding the development trajectories of energy communities.

In recent years, there has been growing interest among local authorities, citizens, NGOs, and other actors in becoming actively involved in the energy transition, both as individuals and through collective efforts [107]. The rise in the number of energy communities over the last five years reflects this trend. However, the development of these communities does not follow a linear path. Instead, they experience growth and degrowth cycles, which are closely tied to the attractiveness of the initiatives to their participants. The full understanding of this attractiveness, i.e. the answer to the question of the drivers for participation and non-participation, is not self-evident [22–24]. Conradie et al. explored this aspect in more detail for Flanders, Belgium. They looked specifically at individuals' intentions to participate in a community energy project. They found that social norms and attitudes have a similarly significant impact on intention.

The growth and degrowth cycles of energy communities could therefore be affected by shifts in behaviours, governance and collective action in general. In other words, while positive attitudes towards renewable energy and sustainability encourage individuals to support the concept, participation and involvement could decline if norms shift. After all, energy communities consist of members that are part of the general socio-economic and political system that could influence their views. In particular, while growth is driven by optimism, collaboration, and supportive policies, degrowth can result from economic shifts and governance issues. Interestingly, the financial benefits have been identified as an important driver compared to other relevant drivers such as social, behavioural and attitudinal variables [22], something also discussed by Heurinckx et al. and Panagiotou et al. [25,26].

To sum up, mapping the history of communities could bring valuable information on aspects impacting the further development of existing and emerging initiatives. By tracing the history of energy communities, we can get a view on the reasons behind their emergence, their evolution patterns and the reasons they ceased to exist. Therefore, we could identify the success factors, recurring challenges and the cycles of growth and degrowth. As a result, such a historical perspective could be used as a tool and enable us to replicate successful projects, avoid past mistakes and overall understand how an energy community should be designed based on a given set of conditions. The impact of the socio-cultural and political history is not to be underestimated. On the contrary, it should be taken into account when developing energy community projects that consider the engagement of citizens and local actors. As discussed by Defourney and Pestoff, the history of citizen movements influences the uptake of, and interest in, grassroot and citizen-led initiatives [27]. Finally, the aspect of continuity should be highlighted: it is important to keep in mind that communities can change over time because of migration, changing values, or simply because the next generation replaces the existing one, emphasizing the importance to understand from past growth and de-growth cycles of initiatives what influenced their continuity.

3. The need for a systematic and objective research, including a meticulous mapping, to properly understand the intricacies around ECs

While the challenges and barriers faced by diverse types of energy communities are elaborately covered in the literature (e.g., [24,28–31]), the proper understanding of energy communities as ever increasingly complex energy inputs is yet to be realised. As argued by Labanca et al., ignoring the intricacies of collective energy initiatives will further perpetuate the demand-supply dichotomy [32]. Furthermore, the dichotomy remains stagnant in its classification of citizens as final consumers with little control power, and in its disregard of non-traditional closed resource cycles. Consequently, perpetuating this outdated and misleading approach to the functioning of the energy system results in the hampering of decarbonization efforts, and will continue to do so unless (until) a mindset change takes place.

The intricacies of energy communities are what make the research conducted around them challenging. In order to better understand trends and challenges, typologies of energy communities have been developed, otherwise defined as categories. Categorization can be done based on activities, location, and organizational form, among other criteria. It is hence not surprising that various typologies/categorisations have been reported in the scientific literature (e.g., Tuerk et al. who refers to 7 categories [33], Reis et al. discussing 8 categories [34], Schwanitz et al. mentioning 9 [13], Uihlein and Caramizaru who refer to 24 though are not explicit about the characteristics [108], and Mlinarič et al. who refer to 5 types for new and innovative communities [35]). Given the difficulties in collecting data on the number of energy communities in the different Member States, it is challenging to select and use a categorization as no statistically relevant trends can be extracted.

The conducted research often seems to mainly focus on the advantages and potential of energy communities (e.g., [36,37]). While such an optimistic framing can be attributed to the enthusiasm surrounding decentralized energy solutions, it also creates a somewhat skewed perspective that assumes energy communities are inherently beneficial. The prevailing narrative frequently highlights their contributions to energy democracy and a just energy transition, positioning them as a key pillar of the sustainable energy future. This trend in research is further reinforced by the way information propagates through academic citations and references. Once a positive framing is established in early (or influential) research, subsequent studies tend to build upon those foundations, sometimes lacking a balanced and critical assessment. The cumulative effect is that the “optimistic bias” becomes self-reinforcing, influencing not only academia but also policymaking. As Uihlein and Caramizaru [108] note, this bias has permeated through increasingly influential layers of research, particularly among scholars and institutions that heavily rely on scientific publications as a basis. The result is a feedback loop in which research builds on previous work that already assumes the benefits of energy communities, thereby marginalizing or underexploring more critical perspectives.

Furthermore, as Seyfang et al. [38] point out, intermediaries, lobbyists, and policymakers play a crucial role in shaping the transmission of research findings, often selectively emphasizing aspects that align with their interests or policy goals (consciously or not). This creates a twofold problem. First, if regulatory, legislative, and financial authorities base their decisions on incomplete, biased, or insufficiently cross-checked evidence, they risk misidentifying key challenges and stakeholders, ultimately reducing the effectiveness of their policies and interventions (in short, be effective in attaining their objective: the energy transition). Second, these institutions are one of the main reference points for research and information purposes. Therefore, their publications are welcomed with little scepticism. Once institutional reports present a particular viewpoint, it tends to be reproduced and disseminated through more accessible media channels (such as LinkedIn, blogs, newsletters, etc). These platforms often simplify and amplify research findings for broader audiences, further entrenching the prevailing narrative. Consequently, the original bias is not only perpetuated within academic and policymaking circles but also reaches the general public, shaping perceptions and discussions around energy communities in a way that downplays complexity.

Another challenge for understanding the intricacies around energy communities is having a global view on their number, participants therein, renewable energy generation and storage assets and other relevant information. The effective number of energy communities along with relevant information that could help us understand and study them better is hard to assess. Wierling et al. and Schwanitz et al. assess a

substantial number of community energy projects and consequently make a comparison with data of advocacy platforms [11,13]. They conclude that the lower numbers found compared to those of advocacy platforms, might suggest that terminated energy cooperatives were not removed from the database. However, in Wierling et al. the data for Denmark are limited to wind energy cooperatives and do not include solar energy initiatives, something that makes the overview incomplete [11]. The recent publication of Koltunov et al. holds a more critical selection as compared to the database of Wierling et al. [39]. Though, again, only a limited number of data on the initiatives are presented leading to the rather generic conclusion that distinct geographical, institutional, and policy context-specific conditions stimulate diversity rather than conformity.

To develop a comprehensive and accurate mapping of both existing and past energy community initiatives, it is therefore essential to ensure that databases undergo rigorous data quality checks and systematic data cleaning processes. Without these measures, inconsistencies, missing data, and inaccuracies could compromise the reliability of research and policy decisions based on these records.

Beyond improving data accuracy, expanding the scope of recorded information is equally crucial. Incorporating additional details, such as the historical evolution of each initiative, variations in membership composition, governance structures, and decision-making processes over time, would provide a much more meticulous assessment of energy communities. These aspects are often overlooked in conventional mappings, yet they are essential for understanding the long-term sustainability, adaptability, and effectiveness of these initiatives.

For instance, documenting fluctuations in membership could shed light on factors influencing participation, such as economic conditions, policy changes, or internal dynamics. Moreover, there is no evidence on whether financial or publicly funded technical support to energy communities leads to more renewable energy compared to support for other forms of renewable energy implementation. Specifically, while studies were found that mapped increased renewables as a function of the type of support (through subsidies or other incentives) [40,41], there is no research that includes and compares different schemes with the support for energy communities. There is even no assessment of which support to energy communities causes what impact. All these examples could be investigated through a complete mapping with expanded datasets and a subsequent analysis.

To achieve this level of depth in mapping, it is imperative to engage with a broad and diverse range of stakeholders. While existing initiatives and their members are valuable sources of information, a holistic approach should include insights from emerging and terminated energy communities, as well as from individuals and groups who have not participated in such initiatives. Engaging with emerging initiatives allows for real-time observation of the motivations, opportunities, and early-stage obstacles that communities face when establishing energy projects. These insights can help identify what enables the successful launch of new energy communities. On the other hand, studying terminated initiatives is particularly insightful, as it reveals the practical challenges that lead to failures. Understanding the reasons behind dissolution, whether due to financial instability, lack of community engagement, governance issues, or excessive reliance on external subsidies, can help refine future policies and support mechanisms. Additionally, terminated initiatives may highlight gaps in expertise or resources that were not initially apparent, thus helping to mitigate similar risks in future projects. Equally important is the inclusion of perspectives from non-members or groups representing them, such as poverty associations, religious organizations, or other community advocacy groups. These voices can provide critical reflections on the accessibility and inclusivity of energy communities, particularly concerning the principle of "open and voluntary participation." In some cases, economic barriers, social exclusion, or cultural factors may prevent certain populations from joining energy initiatives, even if they are theoretically open to all. Understanding these dynamics is essential for ensuring that energy communities truly serve the broader public interest rather than reinforcing existing inequalities. Furthermore, examining the financial impact of energy communities on non-members, such as whether they experience increased or decreased energy costs as a result of nearby initiatives, adds another layer of insight into the overall socioeconomic effects of these projects.

By adopting a meticulous approach to mapping energy communities, a more accurate and meaningful understanding of these initiatives can be developed. This, in turn, will enable better-designed, more resilient and inclusive energy communities as well as more effective support structures.

4. The need for real inclusiveness, energy justice and energy democracy in energy communities

There is an overuse of certain well-sounding expressions that imbue energy communities of an aura of goodness, but that there is actually little focus in the factual reality behind them and general misinformation when it comes to their risks, challenges and needs. In this regard, the history of energy communities and the cycles of growth and degrowth of community projects, discussed in section 2, have not necessarily led to their effective democratization and inclusiveness throughout the years.

The way energy communities are described and promoted actually reflects idealistic levels of inclusivity, democracy, justice, fairness, etc. that are not evidently met in a substantial share of these energy communities. Although energy democracy refers to a concept that promotes a shift from centralized, corporate-controlled energy systems to ones governed by people, cases of non-democratic governance practices and the professionalization of energy communities leads away from such a definition. Similarly, although inclusivity means ensuring all community members participate for a fair and equitable energy system, in practice historically marginalised members of the community or those facing energy poverty are rarely included. Both of the above lead to reduced energy justice, i.e. an equitable access to affordable and clean energy, when not taken into account when designing energy communities. To this end, concepts such as recognitional and restorative justice could be used in order to counter balance current inequalities which could enable more and diverse kind of citizens to participate in the energy transition process by engaging in an energy community [42].

There is a widespread assumption that upholding citizen engagement in a renewable energy project will automatically result in its acceptance by the hosting community. In this regard, an aside should be made to clarify the interplay between the concepts of citizen participation in its decision-making and financial facets, also referred to as procedural and distributional justice, respectively [43–45], procedural and distributive fairness [46–48], interpersonal and intrapersonal fairness [49], energy democracy, and the effect they all have in diminishing local conflict by increasing community acceptability. Essentially, a fairer energy project will likely have increased local acceptability, and the more democratic a decision-making process becomes, the more procedurally fair it will be. However, that is not to say that all citizen participation is inherently democratic, procedurally fair, and would lead to acceptance. Furthermore, energy democracy is an umbrella term in itself, as there is currently no single understanding of its meaning [50], which ranges from a normative goal related to legitimacy, fairness and justice, to a more operational notion regarding decentralized and participative decision-making in actual energy initiatives. With the phenomenon of energy communities gaining momentum and increasing in size, the following questions therefore arise:

Are communities really democratic in their organization and, do members actually value higher democracy?

A challenge related to governance and fair/democratic decision making is observed. Hanke et al. emphasize the existence of male-dominated governance boards, while Hannoset et al. [51] points to social pressure when members have to participate in votes with raising

hands. Ranville, who assesses effective democracy in cooperatives, refers to the statute as being insufficiently clear on that matter, adding that cooperatives could be criticized for their lack of "real" democracy even when their statute is respected [52]. Ranville further refers to democracy as measures in "participation", though emphasizes that participation has several dimensions such as economic participation, control, ownership, perception of participation, and aspects such as trust, loyalty, and motivation. Ranville further proposes a definition that combines the membership rules, candidacy procedures and voting system, with more participatory aspects such as satisfactory outcome of a vote and sufficient candidates to elected positions. This, as the author claims, is to be combined with a measurement of subjective assessment of democracy. Wahlund and Palm further touch upon the lack of attention to representational democracy, and a bias towards decentralized energy systems in the literature on the matter [53].

As Liu et al. discovered, while citizens consider their engagement in the decision-making process as objectively fairer than the lack thereof, especially when the participation regarded major aspects of the project rather than minor, their perception of the participation process is not one of procedural fairness [54]. In fact, when factors such as possible bias, defence of local interests and ethical standards were taken into account in the context of citizen participation in decision-making, its perceived procedural fairness diminished. Interestingly, similar is the fact that, in the majority of the studies, the degree of acceptance of energy projects was not significantly altered by incorporating citizen participation in the decision-making, but was indeed greatly reduced when taking the perceived fairness of the process into account, and especially so when it concerned major aspects of the project [54].

A more democratic energy system can indeed be possible, though it is not self-evident [55]. In this regard, Renn et al. concluded that the most apparent democratic solution does not always result in the most beneficial outcome for citizens and that, indeed, a bottom-up approach to citizen participation in the context of citizen sustainability initiatives should not be understood in a literal sense of direct democracy, where every decision needs to be consulted and its majoritarian resolution adopted, but rather as a key pillar around whose best interest decisions should gravitate [16]. On the one hand, Dutch citizens regard professionalization as a necessary transformation for enabling the successful growth and subsidy securing of energy communities, as well as a way to compete with private companies in the sector [56]. In the end, professionalized energy communities might prevail over bottom-up volunteer-based initiatives in the future [57,58]. As Coy et al. noted, when looked at from the perspective of the individual initiative members, the transformation of citizens as energy professionals "in their own right" can be an empowering shift of power dynamics [59]. Members of citizen initiatives feel pressured to undergo their transformation towards professionalization if they want to be taken seriously, and currently this process leaves them in an inadequate regulatory framework full of impeding bureaucracy [56]. On the other hand, professionalized citizen energy initiatives frequently offer what Cornwall and Miraftab called "invited" participation [60,61], in which members are offered limited participation opportunities whose mode, content, and scope are predetermined by incumbents [62], and where there is no direct confrontation of authorities and the status quo but rather an "aim to cope with existing systems of hardship". While this participatory space is not inherently anti-democratic, the corporate tinge associated with professionalization still poses a risk for the focus of energy communities to shift from the interest of local members to the interest of a broader, more profit-based group. Therefore, Hoppe et al. and Gregg et al. stress the importance to keep in touch with local connections and building the local capacity [63,64], as well as to establish differentiated roles between the citizen members and professional/economic actors (if embodied by different individuals), so as to ensure that the ongoing citizen participation will still be meaningful and impactful [58].

Are energy communities inclusive?

Citizen initiatives, especially energy-related ones, face great obstacles in their ambition to be inclusive. The greatest hindrance to overcoming their biases comes from a lack of resources and knowledge, preventing these communities from effectively upkeeping inclusiveness in gender, age, ethnical and socioeconomical background, among others. For example, Jochemsen et al. reflect that inclusive participation is hardly ever present in the studied group of Dutch citizen sustainability (energy and other "green") initiatives, which is unexpected given its fundamental importance for their democratic legitimacy [56]. The same authors conclude in a more recent paper that communities are almost never completely undemocratic but a trade-off is present [65]. As discussed, ECs organise participation and decision making in a strategy way and prioritize certain legitimacy principles over others as a way to overcome these trade-offs and therefore uphold internal legitimacy.

One could argue that the increased subsidies that are currently allocated to setting up energy communities could enable broad participation of less privileged communities, a prerequisite to an effective and just energy democracy. However, today's business models focus on the community as such and do not sufficiently include the impact on the wider energy system [66]. Less contribution to the energy system's operational costs by community members implies a higher cost for the non-participants [67]. As Hanke [68], Bielig et al. [69], and Trahan [70] identified, the ones typically not included are people that are already in less economic prosperous situations. Bode confirms this, and adds the need to hinge on a collaborative multi-level and multi-actor environment [71]. New initiatives by (often larger) cities emerge, aiming to provide an answer to social inclusiveness and/or avoidance of the Matthew effect by having the public authority as main investor. City of Antwerp's "Wind voor A" is such an example. At the same time, an increasing number of newly formed energy communities do not centre around the generation of revenue through electricity feed-in, but instead focus on the promotion of local energy sharing solutions especially with a view towards lowering the electricity bills of participating households. Examples can be found e.g., in Magliano Alpi in Italy, the City of Vienna's and the City of Porto's neighbourhood energy sharing scheme, or the currently being developed energy community in the City of Larissa which allows for the participation of vulnerable households in the community via virtual net-metering.

How does the evolution of energy communities affect inclusiveness, justice and democracy?

The growth of projects may enable the professionalization of operations, and leverage more private capital to become less dependent (or even totally independent) on policy decisions with regards to funding and support. Furthermore, larger initiatives might attract more members as the growth reduces risks, enables professionalization in the operation, diversification of activities, and expansion of the services to become a viable and interesting actor on the market. However, with the close involvement of citizens in decision-making decreasing because of the increasing size and professionalization of the initiatives, the question whether members agree with this evolution arises.

According to Bauwens [72], it has been shown that increasing the size of the initiative also attracts different member profiles, which in turn affects the governance and output of the community. Hannoset et al. assess governance and democracy challenges in community projects that have grown significantly in size (e.g., the German Schonau) [51]. He observed that not all members consider this a positive aspect as it influences their potential to weigh on decisions. Similarly, smaller Dutch citizen energy initiatives also face democracy challenges (among others) stemming from inherent deficits (e.g., they are not sufficiently recognized as actors in the official municipal setting, communication shortcomings in the relevant material and procedural information provided to members and in their relation with the public administration), which can be observed in the interrelations of the citizen initiative with the municipality, the competing corporate actors, and between members themselves [56].

The need for more citizen engagement or a more democratic energy landscape is a topic that is also put in perspective of current

dissatisfaction (and distrust) of citizens with the political discourse and large corporations. Tarhan recalls the ordo-liberal position to energy democracy claiming that our current energy system brought us to the brink of ecological catastrophe specifically because corporate monopolies interfered with fair competition in the energy markets [70]. In response, by incentivizing community ownership of renewable energy systems, governments have a mandate to re-establish fair competition, all the while providing economic opportunities for local communities and individuals. Tarhan refers here to prior research by Morris and Jungjohann who claim that such increase in community projects can hurt energy corporations financially [55]. Nevertheless, as Morris and Jungjohann conclude, this democratization does not entail the disappearance of energy corporations from the market, but simply an increase in the number of community ownership of renewable energy projects. In reality, as Tarhan concludes, the engagement of bottom-up initiatives in the energy transition is happening at a very slow pace and only involves already-privileged communities.

Based on the above, there is currently insufficient evidence on the effective democratic aspects related to energy communities and insufficient understanding of what entails democracy in this context, to answer the question whether they effectively lead to meaningful democratic participation.

5. The externalities of ECs – creating benefits to members and to society

It is well-known that the business cases for energy communities in the concept of CEC or REC are challenging [66,67,73]. Selling energy to the grid (i.e., any electricity not consumed locally is exported to the grid) has historically been the most straightforward revenue model for energy communities even if the financial returns are often modest. More recently, also models of collective self-consumption and peer-to-peer energy trading emerged. In peer-to-peer energy trading, members of a community can buy and sell electricity directly among themselves. This model allows prosumers to obtain a higher price for their surplus electricity than they would by selling to the grid. At the same time, consumers within the community benefit by paying less than traditional retail rates. The result is a more economically efficient use of local renewable energy, which not only enhances members' savings but also reduces dependence on external energy providers. Several EU Member States have attributed beneficial tariff schemes for collective self-consumption. E.g., Spain has substantially reduced tariffs for exchanges within a 2 km distance, and Austria has reduced grid tariffs where the reduction is related to the part of the grid that is used (currently being 60 % for exchanges on the same low voltage network, and 30 % for exchanges on the same medium voltage network). These models allow prosumers and community members in general to optimize the economic value of their collectively owned renewable energy generation assets.

Energy community concepts based on a private (though connected) microgrid are also proposed [34]. In such case, a group of consumers decides/aims to operate its own distribution grid and hence to not contribute to the cost of the overall distribution grid that serves the non-members. There is limited experience with privately operated grids part of a larger grid infrastructure. The local grid at the university and military hospital of Jette (Brussels, Belgium) is one, where the importance of a separate grid in the capital is considered to outweigh the excessive costs. The German Schonau is another case, where a group of private consumers decided to buy over the grid and act as cooperative distributor and supplier for the full village. In general, the costs of distribution of electricity are socialized over all consumers, ensuring services to people in poverty. The case of Schonau indicates that a community operating the grid can be done while providing services to more vulnerable consumers. Though for small private grids of the size of a neighbourhood, questions could arise on social segregation and inclusiveness.

Several scientific publications further refer to the lack of remunerable benefits to the energy system (operational and capital) when operating a smaller group of consumers as a microgrid or closed distribution system [67,74,75]. As also explained by the Regulatory Assistance Project [105], it is not the operation of the energy community itself that creates a cost saving or solves a congestion issue in a grid, it is the behaviour of a group of consumers or producers which could be organized in any way or could simply be individuals reacting to a price signal. Services such as related to grid congestion or energy market demands can be organized in many ways, e.g. through using dynamic pricing or aggregation. Interesting models are also offered by commercial parties such as Sonnen, using its community of owners of storage and PV to operate a virtual power plant, or Thermovault that uses the flexibility of sanitary hot water boilers to participate in commercial energy market services.

Several energy communities further try to diversify their services to members. Commercial offers include e-mobility with successful and less successful experiences, and attempts to offer a concept named “citizen led renovation” (i.e., energy communities offering renovation services to members (and often non-members alike), generally against payment but benefitting from the trust relation they can offer as compared to commercial renovation guidance services). With regard to the e-mobility services, a successful scheme is the UK's sharing of private EV charging points. It is not a traditional energy community offer, but has created its own community of EV-owners to create mutual benefits of using each other's private chargers. A less successful story is the Belgian e-car sharing Partago, which showed increasing and substantial financial losses year after year until it was ended in 2024. On citizen led renovation initiatives, the different cases mostly rely on publicly available funding accessible to all (member or not), or come with a payment to an external energy auditor where the energy community itself would only be the one contacting the commercial energy auditor and passing the report and payment [76]. However, Citizen-led renovation initiatives could create synergies, or even act as one-stop shops. Successful cases such as People Power Retrofit (Manchester, UK) and Energent (Gent, Belgium) effectively contribute to increasing the renovation uptake and creating local jobs. Additional examples of smaller scale bottom-up initiatives delivering interesting concepts for renovation are Hyde Farm, (London, UK), and Keuruu (Finland) for electrification of heating.

Apart from financial benefits, energy communities offer citizens greater autonomy/energy independence, energy security, agency, and empowerment in how they produce, consume, and manage their energy [77]. Instead of being passive recipients of electricity from centralized utilities, members become active participants with decision-making power over their local energy systems. This increased control can lead to more conscious (and reduced) energy use and stronger community ties since members often feel a stronger connection to their community and a greater sense of ownership and responsibility in the transition to a cleaner energy system.

When it comes to creating benefits to society, a small share of energy communities uses a model in which all profit is directed to social initiatives, focusing on inclusion or alleviation of energy poverty. Cooperatie Goed is one of the few that aligns with nearly all of its projects. The cooperation does not ask its members for a financial contribution. For investment projects, unless the owner requests a certain citizen participation, the cooperation will look for the financing with the lowest cost and organizes the project to deliver a maximum profit. All profit is then given to a local project on (energy) poverty. The organization further has well described and clear governance and decision making structures, with an atypically short period for participation in the governance until having to be re-elected, i.e. 4 years. Other initiatives use a more modest model for such societal contribution, such as Ecoob and the earlier mentioned Energent who can decide to allocate a part of their profit to projects on alleviation of energy poverty though it is neither structural nor impacts the ambitions of payment of dividends.

6. The need for an all-encompassing definition for the performance of energy communities

The performance of energy communities is a parameter often included in literature, as a criterion used to check the success of the initiative in question. However, there is currently no uniform definition of the term, which has traditionally been measured using quantitative criteria but now is also evaluated through a qualitative lens. Authors' understanding of the notion ranges from the most mathematical concepts [78] to a more abstract idea that focuses on community democracy, justice and fairness [79], and other social goals [80–83]. Nevertheless, the most common interpretations regard their technical [84–88] or economic [84,85,89–91] efficiency, self-consumption and energy self-sufficiency [90,92], or the effective attainment of their sustainability goals [81,85,93]. Some have even suggested them being "successful alternative economies" [94]. Kumar and Ng reflect the constellation of notions that hide under the terms of success(full)-performance of renewable energy projects [95]. A more flexible perspective would perhaps be provided by Lode et al. [8], which regards an energy community performance as successful as long as it respects its stakeholders' objectives.

On top of that, as Haggett et al. highlight, one energy community undergoes as many as five stages in its life (six if we consider termination), and a successfully initiated project might not survive the long-term operational stage if it wasn't created with a view on self-sufficiency [96]. That is why considering some initiatives as successful merely because of their effective creation seems a foresight-lacking approach [97]. In this regard, Boulanger et al. studied factors for energy communities' success in the short (creation) and long (operational functioning) term [98]. Likewise, some energy communities which are considered exemplary as successful best-practices are not truly self-sufficient but survive through their operative phase, since they have enjoyed an inimitably high degree of support throughout all their existence [79]. Finally, a number of authors have begun considering a hybrid, all-encompassing notion of what a successfully-performing citizen energy initiative means: a citizen collective organization that meets its quintessential social (e.g., fostering community benefit) and sustainability (e.g., lowering carbon emissions) goals, while remaining self-sufficient and viable in the long term [99,100]. Even then, Smith, and Celata and Coletti defend that qualitative terms, rather than quantitative milestones, would be better to evaluate energy communities' performance [101,102].

Given the diversity in motivations to initiate an energy community (e.g. as discussed in [103]) and the changes of the initiatives' priorities over time, combined with the variation in reasons to join a community [22,69], it is unlikely that there will be a single definition on what entails a successful energy community. Conceptual definitions that include a variety of performance metrics, such as used in the energy community maturity framework [104], could be a way forward.

7. Conclusions

It is important to understand what has influenced the emergence, growth, and decline of (specific types of) energy community initiatives. This can happen through the process of setting the energy communities in their historical and socio-cultural context in which they were created, evolved and (when relevant) eventually terminated. This could help us understand how we position the complex current context with both threats of effective events (wars and climate crisis) as well as a policy push for the creation of a new organizational form without emphasis on the aim or realizations of such initiatives. Such insights, currently not available, could inform about the creation of a context where (specific types of) energy communities could contribute to achieving specific predefined goals (e.g., more on-shore wind turbines, more PV on residential buildings, or more energy efficiency improvements for private buildings).

There is a need for unbiased, objective, and facts-based research on energy communities. Since research feeds into policy making at any level (local, regional, national, and European) either directly or through it being picked up in more accessible media (such as LinkedIn, Blogs, Newsletters, policy-papers, or others), science-based insights can feed further developments on energy communities, better designs of enabling frameworks, and resilient initiatives.

The lack of accuracy and consistency in which energy communities are currently mapped is a major obstacle to understanding the spread and impact of these communities in the energy system. The full picture of the evolution patterns of energy communities and how they react to external stimuli is therefore not clear. This makes it difficult to identify essential data of energy communities, namely: (un)successful models, (de)growth spurts and their causes, impact of support measures, etc. An accurate mapping of currently existing energy communities in Europe would therefore become a relevant source to fully understand the present state and evolving patterns of energy communities by country or Member State, and to direct advice and support in an informed manner.

Energy communities promise certain social benefits such as inclusion, energy justice, and energy democracy. In fact, energy democracy is often used as a justification for setting up energy communities [107]. However, there is currently no agreement on what energy democracy is and to what extend current forms of energy communities align with potential concepts of energy democracy. This is an important element as the democracy argument is used to justify privileges and exemptions to energy communities as compared to other actors and participants in the energy system. A better understanding of what energy democracy is, how it is perceived by relevant stakeholders, and to what extent or in what form energy communities could contribute to that would enhance our understanding of energy communities and their contributions to a fair and just energy transition.

There is currently no overview of support measures (whether financial, fiscal, capacity building, or technical assistance) as provided by local, regional, national, and European authorities and agencies. Furthermore, current support measures show no link with performance aspects or avoidance of e.g. a Matthew effect or a specific uptake of technology. Support is hence not used as an instrument to achieve an additional goal aside from the emergence of energy communities as actors. When trying to design energy communities to be as resilient as possible, it is important to understand the intercorrelations between performance, support measures, and impact.

Finally, the assumed added value that energy communities can create is often not based on facts or scientifically-based assessments. Positive and negative externalities are not adequately mapped. In order to understand their true added value, it is important to gain insight in the different aspects that would define their performance. Such multi-faceted performance is expected to be different across different Member States. Diverse aspects that could define performance of energy communities, without making a judgement on the weight of the different aspects, should be defined.

Overall, scientific research could provide effective insights in what can be contributed by various flavours of energy communities by adopting an overarching and holistic approach of understanding their intricacies and externalities, keeping in mind possible interrelations with respect to various contextual parameters. After all, only by fully understanding such a complex phenomenon like energy communities could we transition from unjustified assumed benefits to a real bottom-up inclusive energy democracy.

CRediT authorship contribution statement

Leen Peeters: Writing – original draft, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization. **Laura Fernández López:** Investigation, Data curation. **Christos Trompoukis:** Writing – review & editing, Supervision, Investigation.

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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Data availability

No data was used for the research described in the article.

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