Energy communities—lessons learnt, challenges, and policy recommendations

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Vignette

Energy communities—lessons learnt, challenges, and policy recommendations

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Abstract

Energy communities (ECs) are considered important in transitioning the energy system. They are of particular interest due to their potential to empower citizens and support a more just energy transition. However, experiences from ECs remain limited and vary across countries, thus raising questions on potential future advancements. In this article, we explore experiences from ECs in several European countries to inspire discussions on further evolvement and improvements. Insights into lessons learned and key challenges within the selected countries have been collected and analysed, and recommendations for advancing these efforts are provided to policy makers. The results indicate that ECs are making progress in producing and sharing renewable energy while supporting a more just energy transition by engaging a variety of actors within local communities. The challenges, however, often stem from limited national support and difficulties in fully achieving diversity within engaged local communities. The recommendations stress the importance of building on early learnings in community energy and further strengthening local anchoring to achieve a just transition. This in turn, generates fertile ground for discussions on how to localize energy policy and reinforce a multi-level policy approach beyond the European and national levels.

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Graphical Abstract

Lay summary
Energy communities (ECs) are considered important for transitioning the energy system, and empowering citizens to support a more just energy transition. This article focuses on experiences in ECs across several European countries indicating progress in ECs supporting renewable energy and engaging a variety of actors. However, challenges often stem from limited national support and difficulties in achieving full diversity within engaged local communities. To enable further progress, it will be important to build on early learnings in community energy, strengthen local anchoring, and adopt a multi-level policy approach.

Key words: energy communities; Europe; best practice; challenges; policy recommendations

Introduction

(Lena Neij, Jenny Palm, and Henner Busch)

The transformation of our energy systems requires innovative approaches that go beyond traditional solutions. One promising development in this context is the concept of energy communities (EC). ECs represent a new form of financing and organization of local energy systems (LES) involving a wide range of actors, from local government and businesses to individual citizens. ECs provide an important potential for creating sustainable LES as it allows communities to take control of their energy production and consumption, often leading to more resilient and sustainable local energy practices. Research has shown that they also open the door for increased public acceptance of renewable energy technologies in general.

ECs are of particular interest because they have the potential to empower citizens to become active participants in the energy transition. Traditionally, energy systems have been dominated by large, centralized utilities that control both energy production and distribution. In contrast, ECs decentralize this control, giving citizens and local actors a central role in the process. This shift not only democratizes energy production but also fosters a stronger sense of ownership and responsibility among community members. By involving a diverse set of stakeholders, ECs can ideally address local needs and set other priorities compared to traditional top–down models.

The EC concept has developed under various names over time, and has captured variations in terms of energy technologies, institutional settings, and business model alternatives [1–3]. There is no strict definition of ECs, even so the emphasis is on local participatory governance [4].

Through the Clean Energy for All European package, adopted in 2019, the concept of ECs was introduced in the European Union (EU) legislation to strengthen participatory governance. The EC concept has then been further defined in terms of citizen energy communities (CECs) by the internal energy market directive (IEMD) and renewable energy communities (RECs) by the renewable energy directive (RED). Still, the term community energy (CE) is often used when describing initiatives with a strong focus on social movements, and within areas outside the EU. (In this vignette-article the focus is on the EU, but we have also included the non-EU countries UK and Norway to examine community within their legal frames.)

Over the past decades, many countries have gained valuable experience in developing and implementing different types of ECs. These experiences differ depending on each country's specific context and focus. Learning from experiences will be crucial for supporting future ECs in restructuring the energy system and achieving targets such as the REPowerEU plan's goal of establishing one EC per municipality by 2025. However, these lessons must be nuanced and based on experiences from several countries.

In this vignette-type of article (A vignette paper is a multi-authored perspective or review article on compelling, topical issues in energy, coordinated by an Oxford Open Energy editor who will invite and assemble contributions to the paper in the form of several sections. The vignette article will provide insights on the topic as well as inspire discussions on further evolvement and improvements on the topic.), we collect experiences on ECs from a range of countries aiming at articulating the experiences of ECs in Europe, within as well as outside the EU, to highlight the lessons learned so far. By examining these cases, we provide valuable insights into the opportunities, best practices, and key challenges that can help decision-makers and stakeholders to succeed with ECs. Based on this, we offer recommendations to policymakers and local communities on how to support and promote the growth of ECs. At the end, we also raise challenges, limitations, and questions to be further discussed both in research and practice.

We have invited several experts to write about their insights on ECs in the EU, the Netherlands, Germany, Austria, Italy, Greece,

Denmark, Sweden, Norway, Finland, and the UK. We have asked them to address the following three questions:

1) *what can we learn from best practices and opportunities in the different countries?*
2) *what are the key challenges with ECs?*
3) *what recommendations can be offered to policy makers and local communities?*

By addressing these questions, we hope to contribute to the ongoing discussion about the role of ECs in the broader context of the energy transition.

Energy communities in the European Union

(Thomas Hoppe and Frans Coenen)

Before embarking on discussion regarding best practices, challenges, and policy recommendations concerning ECs in Europe, it is important not to treat them as a homogeneous entity. Let us assume that there are roughly two types of ECs that are also dominantly present in two different contexts. The first type would be rather mature ECs in Northwestern (NW) EU countries with a history of institutional support, and CE as an acknowledged social movement (e.g. in The Netherlands, Germany, Belgium, the UK). The second type would refer to immature ECs in Central and Southeastern (CSE) EU countries without a (long) history of institutional support, whilst CE is not—or only recently—acknowledged as a social movement (e.g. Greece, Croatia, Italy, Serbia). However, the contrast between ECs in NW and CSE-Europe should not be viewed too strictly, given that limited maturity and experience can also be observed in other parts of Europe such as in Nordic counties like Sweden, Norway, and Finland.

European Union—opportunities and best practice

CE is mostly known as a social innovation in the green energy transition empowering the role of citizens in several distinct ways [5]. ECs are organizations that can be seen as a formalization deriving from CE (although this not hold for all EU regions). CE mobilizes citizens and local communities to give them a more proactive role, both as producers and consumers of locally generated renewable energy, and in decision-making on energy projects and infrastructure. However, the role of CE goes beyond this and also touches upon providing other energy services like ECs raising awareness and implementing incentives to trigger energy efficiency, energy sobriety behavior to encourage energy savings, demand response, offering education to their members. In a related vein, CE embodies innovation and experimentation, with particular ECs setting up experimental pilots for energy innovation; for example, distributed generation, smart grids, sustainable heat, neighborhood batteries, demand response, energy sobriety incentives, and flexible transport tariffs [6]. Since its emergence the CE movement has grown substantially, and has currently >1.5 M members in the EU, with >2250 ECs [7]. The movement is supported by CE federations at both the regional, national, and EU levels, which have effective lobbying power.

Whereas CE has flourished in several countries in NW-EU it is recently also starting to emerge in CSE-EU (in part, supported by successful CE federations in NW EU) [7]. This in part due to programmatic effort by national and EU CE federations (notably, REScoop.eu) that are funded by EU framework programs to scale CE. Next to scaling the CE movement both in terms of size and geographical scope success stories also contain fostering transformative change, like developing community owned wind, solar and heat plants, generating large amounts of renewable energy, hence mitigating carbon emissions. Regarding community wind energy, some of the largest onshore wind farms are among them (e.g. Zeewolde, The Netherlands). Here, wind ECs often work in partnerships with energy sector incumbents and public government [8]. Within these project ECs engage local communities and act as a key intermediary to gain social support. Another way CE brings about transformative change is by lobbying for institutional change, pushing for adoption of CE definitions and supportive policy in EU directives as well as in nation states, and at decentral levels of government. A milestone was achieved in 2018 with adoption of CE (as and CEC) in the REDII and IEMD EU directives, which are currently in the process of being transposed to national legislation in EU member states [9]. For example, in The Netherlands, CE federation 'Energie Samen' managed to get 50% local ownership adopted in national government regulation on planning and development of local renewable energy projects [10].

European Union—key challenges

Despite setting best practices and success stories the numerical impact of CE contributing to green energy transitions in the EU is still unclear, lacks hard evidence, or is considered limited. There are several reasons limiting CE's impact, which we subdivide between the two types of ECs introduced at the start of this section.

Challenges to immature energy communities, Central and Southeastern Europe

New ECs tend to lack necessary skills and capacities relying on volunteers, whilst lacking contact and support from professional organization [10]. Professionalizing their own organization is challenging, because they are not recognized or acknowledged by formal institutes, which also has to do with ECs in these contexts lacking a legal definition and associated rights in national legislation [11]. In addition, novel ECs often miss out on intermediary support, and not being connected to translocal networks, and therefore miss key knowledge and capacity building support to mature as organization, adopt vital strategies, adapt organizational governance, while lacking knowhow on how to build a viable business cases, and run operations. Another challenge is over-dependence on volunteers and key persons (e.g. champions), which comes with substantial risks, as key member turnover may lead to novel ECs ceasing operations altogether, a phenomenon that was previously (and still is) also observed in countries in NW-Europe such as the UK [12].

Challenges to mature energy communities, Northwestern Europe

Problems the CE movement encounters in this context to a large extent have to do with incumbency. In many contexts ECs are still not considered professional, trustworthy organizations, (formally) accepted by public government, DSOs and energy sector industries [13]. As the emergence and fruition of CE was to a large extent driven by public policy (i.e. financial and tax policy incentives) encouraging adoption of selected renewable energy technologies, many ECs became dependent on them, relying too much on supportive policy frameworks. When several of these were terminated ECs encountered challenges in their (renewable energy) projects' business cases) and their overall number, particularly in Germany, decreased [14].

Replacements of these policy incentives also proved challenging, as this went along with the introduction of market incentives in an unfair level playing field, benefitting incumbents at the expense of ECs (cf., auctions for wind farm siting in Germany) [14]. In most NW-EU countries uncertainty among the CE movement grew as termination of favorable policy incentives was coming, with national CE federations lobbying at national government level for maintaining of effective incentives. In a similar vein, the transposition of the EU REDII and IEMD directives was critically observed and handled by policymakers at nation state level, often backed by incumbent lobbies and interests. Not surprisingly, transposition into national legislation was seriously delayed and turned out less ambitious and favorable to supporting ECs than what was initially planned for at the EU level [7]. Moreover, ECs experience their relationship with public administrations at different levels of government a double-edged sword [15]. More recently, this got worse with increasing right-wing populist resistance to RE plans and projects, resulting in public sector budget cuts (especially at the local and regional level). Finally, over the last decade ECs, but also the EC movement in general, have been criticized for not being inclusive, being seen as predominantly featuring highly educated, above average age and wealth, autochthone, males with an engineering background, while excluding women, youth, allochthone, and underprivileged people [16]. Quite similar, the sector has been criticized for being seen as a mere 'policy tool' which merely provides a service to neoliberal political agendas by gaining local support for large-scale renewable energy projects [17].

European Union—recommendations

(The suggestions we present to high degree correspond with policy recommendations made by REScoop.eu and national CE federations, being part of the *Horizon 2020 SCCALE 20–30-50* project.)

Recommendations regarding immature energy communities, Central and Southeastern Europe

First, we advise continuing awareness raising among policy makers and formal institutes about the benefits CE can offer. Secondly, we suggest to monitor sound transposition of REDII and IEMD into national legislation and policy frameworks, to assure that ECs earn a legal definition, and CE initiatives receive the policy support they need to start up, and are officially allowed to develop and run RE projects of their own (REScoop.eu s monitoring this on behalf of the European CE movement). Third, we suggest to support local capacity building among EC initiatives, and continue aid provided by the EU and CE federations in NW-Europe to countries with less CE (social) capacity in CSE-European countries. This includes assuring knowledge and capacity transfer.

Recommendations regarding mature energy communities, Northwestern Europe

We recommend policymakers to maintain policy incentives that encourage ECs and are key to their business models, hence to their survival (e.g. net metering, renewable energy, generation tax incentives, low VAT rate on certain renewable energy and energy efficiency measures, subsidy to home/neighborhood batteries). We emphasize assuring a fair level-playing field in wind/solar energy auctions and related spatial affairs. We suggest to provide at least clear guidance how public funding for the energy transition for capacity building of local government also could be used to finance ECs (who can co-produce public services at 'arm's length of government). We suggest policy makers and implementing agencies provide more clarity in the implementation of community ownership arrangements (like the 'wind mill principle'; i.e. local ownership). Finally, we stress the importance of having a thorough monitoring system in place to measure performance of the CE sector, following-up a recent EU funded CE data project [18], and use of EU funded monitoring tool development.

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Energy communities in the Netherlands

(Daniel Petrovics and Thomas Bauwens)

ECs have emerged as key players in the Dutch energy transition, enabling decentralized, citizen-led control over energy production and consumption [19]. In the Netherlands, the rise of ECs presents valuable lessons on best practices and obstacles, especially regarding how ECs can better serve diverse populations [20] and integrate new technologies like collective heating into their operations [21]. Moreover, regulatory frameworks remain pivotal in shaping their potential.

The Netherlands—opportunities and best practices

The Netherlands has proved to be a fertile ground for the development of ECs, supported by its evolving legal framework. One notable feature is the inclusion of ECs in the 'Energiewet' (Energy Law), which formalizes their role in the national energy landscape. This provides a degree of legitimacy and protection for ECs, enabling them to operate more effectively within the energy system.

Another opportunity for ECs lies in stakeholder representation across multiple scales [22]. Dutch ECs often engage with diverse actors, from individual households to local businesses and municipalities, across multiple scales from neighborhood through energy regions to national institutions. This enables them to harness both 'bonding' and 'bridging' social capital [23]. Bonding social capital refers to the strong connections between individuals within the same community, which fosters trust and shared goals [24]. Bridging social capital, on the other hand, enables ECs to form alliances and partnerships across different social, economic, and geographical groups [24]. This dual dynamic has enabled ECs in the Netherlands to scale their impact and ensure they cater to the needs of wider populations, while enhancing their resilience and adaptability in a rapidly changing energy landscape [25].

The Netherlands—key challenges

Despite these opportunities, ECs in the Netherlands face several critical challenges. One major hurdle is engaging diverse populations [20]. Although ECs offer the potential for greater public participation in the energy system, they often struggle to attract members from varied demographic and socioeconomic backgrounds. This can lead to unequal access to the benefits of ECs, limiting their ability to foster inclusive energy transitions [16].

Another significant challenge for ECs in the Netherlands is developing collective heating systems, which face unique obstacles compared to electricity [26]. Heating infrastructure often requires deeper engagement with households, especially around behavioral changes and installing new equipment, such

as heat pumps. Furthermore, collaboration with municipalities and installation companies is crucial due to the spatial scale of these solutions [27]. As collective knowledge in this area is still developing, ECs need to build their capacity to address these challenges effectively.

Moreover, the regulatory environment poses further limitations. Collective self-consumption and energy sharing, central features of energy systems that fully integrate ECs, are not yet adequately supported in the Netherlands. Current regulations prevent ECs from sharing energy behind the meter, restricting their ability to provide grid services and fully integrate renewable energy sources into the local grid. This regulatory gap hinders ECs from scaling up their operations and delivering the full benefits of decentralized energy systems, including balancing supply and demand and sharing surplus energy with marginalized communities [28, 29].

The Netherlands—recommendations

To address these challenges and unlock the full potential of ECs in the Netherlands, we offer the following recommendations:

Build an enabling framework tailored to the legal form of energy communities

The dedicated judicial form for ECs gives them a clearer legal identity, simplifying their navigation of regulations and participation in energy markets. However, an 'enabling framework' as outlined in EU legislation, is needed to fully realize their potential and ensure they stay focused on local communities' needs rather than market-driven profit.

Engage interest representation organizations and intermediaries

Policy makers should collaborate with interest representation organizations and intermediaries that can bridge ECs and the broader energy market. National organizations such as Energie Samen, and municipal networks like Energie van Utrecht or Energie van Rotterdam, for example, play a critical role in advocating for the needs of ECs and facilitating their interaction with larger energy actors, including regulators and grid operators. Strengthening these relationships can help integrate ECs into the national energy system while maintaining their local focus.

Encourage engagement with diverse populations

To reach their full potential, ECs must prioritize outreach to diverse populations to ensure equitable sharing of the benefits of local energy production. This could include targeted awareness-raising campaigns in underrepresented communities, engaging with social housing agencies and designing financial incentives that reduce participation barriers for low-income households. Energy sharing could further support this effort by providing marginalized communities access to surplus renewable energy [28].

Support learning and knowledge sharing for collective heating systems

Given the complexities of collective heating infrastructure, policy makers should invest in capacity-building initiatives to enhance ECs' understanding of these systems, while municipalities should directly support local stakeholder engagement. This could involve funding pilot projects and creating platforms for knowledge sharing between ECs already experimenting with collective heating solutions.

Clarify the role of collective self-consumption in energy regulation

Finally, the regulatory framework needs to evolve to allow collective self-consumption and energy sharing, enabling ECs to provide grid services. This would allow individuals to invest in renewable energy in congested grid areas, create new revenue streams for ECs, and enable them to play a more active role in balancing LES, contributing to grid stability while promoting renewable energy use. Furthermore, energy sharing could provide a means for ECs to distribute surplus energy to marginalized communities, such as energy-poor households, even for free or through non-monetary compensations [28].

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Energy communities in Germany

(Sören Becker)

In Germany, citizen energy entails different forms of organization and technologies. The sector was fueled by the opening of the European energy market and favorable investment conditions, above all generous feed-in tariffs and priority for renewable energies [30]. 30.2% of the German renewable capacity installed were held by private citizens in 2020 (figures include household installations, data by trend:research, in [31], 4). This renders CE in Germany a front-running and diverse sector.

Germany—opportunities and best practices

Several shared ownership schemes exist, organized around renewable energy sites, like electricity from wind and solar plants or heat and electricity from biomass. Some CE initiatives deliberately target ownership in energy grids. Often these projects would form as cooperatives, due to their equitable internal structure, but liability companies and partnerships are also common [32].

Prominent examples of ECs exist across the different regions of Germany. Noteworthy, the Schönau community, located in a town of ∼2500 inhabitants in the Black Forest mountains, already emerged out of activism for alternative energies just after the Chernobyl catastrophe. Not feeling supported by the regional utility, activists realized a referendum to buy the local electricity grid through a citizen cooperative (EWS Schönau). Later, EWS Schönau got active as a nation-wide retailer for renewable electricity. As an iconic project, the Schönau 'energy rebels' played an important role in supporting citizen-driven energy projects, acting as advisers and business partners for similar cooperative energy projects across Germany.

Energy cooperatives also emerged in cities, where projects target shared ownership in the surroundings or ownership in the urban grid. Two examples, BürgerEnergie Berlin and Energienetz Hamburg formed part of broader campaigns towards re-instituting local ownership, proposing a community-based alternative to traditional state ownership [33]. However, urban CE projects face high financial needs for investing in complex urban energy grids and a number of regulatory challenges for small-scale projects (see below). Besides realizing smaller projects, urban community projects developed a pragmatic approach, acting as knowledge brokers, think-tanks and intermediaries between different stakeholders [33].

Currently, two developments are worth noting: first, rising public interest in decarbonizing heat provision pushes 'thermal ECs' as an alternative to traditional fossil-fuel district heating and household-scale solutions [34]. Here, communities are built towards providing heat to neighbors from small-scale generation or storage. While there is optimism towards the potential of this approach, community heat projects rely on community support to an even greater extent as a high number of stationary costumers is necessary for effective operation [34]. Neighborhood-based electricity storage is a second emerging field, set around models of virtual power plants, digitally coordinating the flows of renewable energy from private generation [35].

Germany—key challenges

As elsewhere, declining price levels for renewable energy technologies have positioned the German CE sector in a paradoxical position between the growing interest of private households in green investment and the rising capacity of commercially driven renewable installations (for solar energy, see: [36]). With the trend towards larger and investor-owned renewable energy projects, it has become difficult for community projects to secure land or community shares in larger energy projects. Concurrently, participation in terms of benefits and decision-making are recurrent factors in German energy conflicts [37]. To ensure investment opportunities, the 2023 amendment of the Renewable Energy Act has introduced the priority for municipalities or citizen collectives to sign shares of planned installation in their territory (an option not necessarily resulting in active ECs).

Membership in German ECs is, possibly more than in other countries, constituted through formal membership and investment, sparking recurrent debate on their inclusiveness and openness. And indeed, Radtke and Ohlhorst [31] state that typical CE members are male, white and well educated. In their words: 'a remarkable share of projects' members may be described as wealthy, [while] those with lower income show high levels of involvement in terms of membership' ([31], p.4). This, in turn, does not mean CE projects were generally insensitive towards socio-economic imbalances. Hanke and Guyet [38] found that up to 20% of CE projects were reaching out to underrepresented groups like low-income households, women and young families.

Complex legal frameworks are a third, very practical, challenge for German ECs, especially those active in developing new projects. These refer to the complexities of auction models introduced in the mid-2010s, to the license requirements for energy trade and the complex patterns of land and property ownership. Especially in urban contexts with a dominant share of rental housing, it is difficult to navigate the various legal requirements, for instance, for shared roof-top solar plants in multi-family houses. Currently, exchange of electricity between neighbors is considered a regulated market transaction instead of 'prosuming' among neighbors [39], inhibiting this potential for energy neighborhood communities.

Germany—recommendations

Germany is a case in point for the diversity of the CE sector, in terms of how projects adapt to various spatial contexts and organizational requirements. The development of CE projects in Germany mirrors a history of seizing opportunities, while navigating unfavorable legal conditions and reshaping the space for initiatives to maneuver [40]. While project journeys rest on the endurance of motivated pioneers, some legal issues have been resolved, for instance the option for financial participation in affected municipalities, while others are still pressing like the issue of sharing locally produced electricity. The further development depends on the openness of policy processes to CE.

For ECs, the exchange of knowledge is of high importance, as are tailored strategies to overcome specific barriers. In this regard, the contribution of networks for CE and energy cooperatives must be stressed. Lastly, whether CE projects target vulnerable populations, is a matter of retaining capacities on their own. Here, CE projects could become integrated with public advice campaigns for energy saving in disadvantaged households.

Energy communities in Austria

(Patrick Scherhaufer, Jana Plöchl, and Aron Buzogány)

In terms of growth or fast development Austria could be seen as a success story in the field of ECs. In 2021 the conservative-green coalition implemented the EU requirements from the Clean Energy for All Europeans Package - particularly through the Renewable Energy Expansion Act [41]. The legal framework has supported the formation of ECs by simplifying administrative processes and providing financial incentives.

Austria—opportunities and best practices

To further develop ECs an independent coordination center was established in 2021, which pools activities and develops knowledge. This organization is supported by regional advisory centers in each Austrian federal state. Since then, the number of foundations has grown tremendously, so that at the beginning of 2024 1171 RECs and 147 CECs were in place [42]. The generation structure of these ECs consists of 75% PV systems, 9% PV systems and hydropower plants, 4% PV systems and biogas plants, and 3% PV systems and geothermal energy [42]. Overall, this administrative and legislative backing, which was pushed by the Green Party in the government, was essential to reduce entry barriers, making it easier for different actors to establish ECs and access the energy market.

The initial phase of ECs in Austria was driven by three key factors. First, on the procedural level, involving diverse actors in the decision-making process was important especially for municipalities, cooperatives, local businesses, and households. Companies advising ECs often built on existing local or regional partnerships to ensure success [43]. Second, from an economic perspective, ECs served as financing tools for (small-scale) power plants and helped prosumers reduce costs. They also offered financial benefits like lower grid tariffs due to geographical proximity or contributed to local economic growth by keeping energy revenues in the region [42]. Third, ecological motivations also played a role, because ECs support generating and consuming locally produced renewable energy [44]. Since 62% of Austrian energy consumption comes from oil, gas, and coal [45] often sourced from politically unstable regions, ECs enhance energy security and help achieve climate goals. On the individual level, ECs provide opportunities for effective climate action and personal involvement in sustainability efforts.

Austria—key challenges

There are five main challenges for the development of ECs in Austria. The first challenge is establishing a cohesive and coordinated effort among stakeholders. Effective partnerships between local governments, energy providers, citizens, and businesses should ensure that ECs are well-organized, financially sustainable, and aligned with local needs. Fischer et al. [42], Friederichsen [46], and Kaineder [43] identify several barriers to participation in ECs: long setup times (typically 6 to 12 months), varying tariff expectations, gender inequality, limited supply capacity, an imbalance between

energy producers and consumers, and excessive management effort with poor compensation. Therefore, trust, efficient resource sharing, expertise, and public sector support are essential for successful collaboration within ECs.

The second challenge concerns the existence of clear and transparent governance structures. By establishing rules for decision-making, ownership, and risk-sharing, ECs can avoid conflicts and guarantee fair participation. Well-defined governance structures also help to ensure long-term stability and attractiveness for new participants.

A third challenge are the differing viewpoints and expectations of stakeholders, adding complexity during an EC's initial phase [43]. Municipalities often experiment with ECs on their properties to enhance their public image. They benefit from past experiences with local participation and strong connections to community stakeholders. Private initiators vary greatly in their preferences and knowledge about ECs. However, many of them are interested in building social connections in their neighborhoods. Owners of large generation plants, such as farmers, seek stable sales opportunities, while small and medium-sized enterprises with large roof spaces suitable for PV production often have low self-consumption and need customers.

Fourth, certain technical and organizational challenges still persist – e.g. the number of smart meters in operation, grid connection barriers and administrative burdens for creating an EC [44]. Finally, Vogler and Kump [47] argue that the influence of ECs on the Austrian energy transition should not be overestimated as the development and impact of such enterprises mostly depend on individuals performing different roles like 'grassroots, entrepreneurial, local hero, and techno-centric' and each role varies significantly in its performance and transformative potential.

Austria—recommendations

From the EC's perspective, there are four key expectations to make ECs more successful in Austria: lower start-up costs, improved communication and cooperation with grid operators, simplification of the legal framework and digital tools for billing [42]. Investments in terms of time and costs involved in establishing ECs should also be financially supported by public authorities. In addition, Fina and Monsberger [48] argue that if ECs should become a fully integrated actor in the energy landscape, new business models have to accompany their activities.

A process-oriented framework for understanding public engagement [49] and continuous awareness-raising efforts [50] are vital for sustaining the energy transition and ECs. These efforts increase support of renewable energy, encourage broader participation in energy projects, and can foster a culture of energy responsibility and sustainability.

However, the future development of ECs should not only be characterized by economic, ecological, or community-building factors but also by an increasing focus on social impact [51]. For example, initial ideas in Austria propose solidarity-based energy tariffs in ECs to support low-income households and reduce energy poverty. Research shows that including vulnerable households and marginalized groups in ECs can foster energy democracy and a just transition [16].

In summary, ECs in Austria are an opportunity to achieve environmental, economic, and social benefits by promoting decentralized renewable energy production, citizen participation and empowerment. Best practices, including long-term collaboration, transparent governance, administrative support, financial incentives, and a broader public awareness, are essential to their success.

Energy communities in Italy

(Chiara Candelise and Gianluca Ruggieri)

The Italian CE initiatives began already in the early 1900s; a new wave of communities framed as ECs developed around 2008, characterized mainly by very few and rather small collective photovoltaic initiatives [52]. Collective approaches regained momentum with the introduction of RECs (as per EU Renewables Directive 2019/944) including only electricity and not thermal energy. A number of initiatives emerged, characterized by an unprecedented and cross-cutting mobilization of stakeholders including citizens, energy sector companies and utilities, local administrations, national institutions, associations and non-governmental organizations.

Italy—opportunities and best practices

The main driver behind these initiatives is the REC support incentive implemented as part of the transposition of the EU Directive 2019/944. It is a feed-in premium granted to each kilowatt-hour of electricity consumed at the same time as its production through 'virtual energy sharing', i.e. consumers participating in a REC continue to use existing distribution networks keeping their supplier, while producers sell to the grid the energy produced and not physically self-consumed [53]. RECs are designed as legal entities which should maximize environmental, economic and social benefits to its members and the local areas in which they operate. Local members must own the power plants or otherwise retain control over those owned by third parties including energy companies. RECs are free to decide on the internal allocation of economic benefits: they can be shared among participants or collected to finance community activities with social impact. Given this context, different models are emerging: community-based approaches, which imply a greater focus on community engagement and benefits allocation, and market-oriented, turnkey solutions which tend to favor consultants, installers and producers [54]. In many cases, there is a trade-off between these two approaches [55].

The transposition of the EU Directive 2019/944, begun in 2020, has been initially provisional, limiting plants size to 200 kW and requiring REC members to be connected to the grid via the same MV-LV transformation substation. This has supported the development of first-generation RECs, typically including only a few dozen users (none exceeds 100 participants). Since spring 2024, the full and final transposition allows more consumers to be involved and higher investments in renewable generation to be triggered, by expanding the scope (from MV-LV to HV-MV substation) and the size of installations (up to 1 MW). In fact, there are ∼2000 HV-MV substations in Italy and on average each serves ∼30 000 inhabitants. This opens up new opportunities for larger, second-generation RECs.

In addition to the feed-in premium, RECs can benefit of several other support measures. The National Recovery and Resilience Plan (NRRP) has allocated 2.2 billion euro for capital grants covering up to 40% of the investment cost of plants built in municipalities under 5000 inhabitants. Several regional governments and bank foundations introduced various support mechanisms, usually to finance the REC development phase (feasibility studies, legal and management support).

Thanks to the first-generation RECs, legal structures and implementation models have been developed and tested and are now available for implementation in second-generation experiences as well. Although the RECs developed under the provisional regulation were smaller in size than those possible today, they have proven to be credible territorial hubs on energy

issues, informing and engaging citizens. They have also been a test base for municipalities, which in most experiences have been both promoters and funders, as in the small municipalities of Ussaramanna and Villanovaforru in Sardinia, or Ferla in Sicily region, or Magliano Alpi, in Piedmont region, one of the first national initiatives and best practices. More recently, larger projects are also emerging, such as the one promoted by the City of Milan and the Milan Politechnic, which will be soon active in four neighborhoods and aims at including hundreds of participants that will forgo incentives to finance a public social fund.

Italy—key challenges

Despite expectations, the development of RECs has been slower than expected to date, mainly due to delays in the policy transposition process (in particular a wait of almost 2 years for the final implementation decree). Moreover, the available NRRP funds, due to expire in March 2025, are at risk of not being fully allocated, due to the very short time left to small municipalities to benefit from the capital grant offered, since they struggle to apply due to lack of expertise. In addition, this often leads them to rely on turnkey bids from third parties, who tend to be more interested in facility development, rather than community engagement. This tendency is exacerbated by the fact that formally the legal entity applying for the subsidy is not the established REC, but the owner of the generation facility. Thus, this measure supports new installed renewable energy capacity, but does not necessarily facilitate significant citizen participation, as there is no requirement for the minimum number of members of the REC, nor a limit on physical self-consumption by the producer.

Additional challenges include the fact that banks have not developed dedicated financing tools, partly because the total feed-in premium collected depend on the consumers' behavior, thus causing uncertainty in the business plan design and reducing the bankability of the projects.

Italy—recommendations

Overall, these initial steps have highlighted the complexity of RECs development, which requires technical, legal, aggregation and management skills. It is advisable for small municipalities, considered to be among the key actors for the implementation of community-based RECs, to seek help from properly selected facilitators and intermediaries to ensure successful deployment.

Several national research institutions are working with the goal of monitoring the benefits to local communities from the development of RECs to inform possible future policy making decisions so that more attention is paid to increasing the social impact of RECs, rather than focusing on metrics such as installed capacity or energy fed into the grid. In addition, the development and evolution of a stable and clear policy framework for CECs (as defined by EU Directive 2018/2001), thermal RECs and RECs as ancillary services providers is of paramount importance to ensure a healthy growth of the EC sector in Italy in the years to come.

Energy communities in Greece

(Konstantinos Pantazis, Foivos Palaiogiannis, and Maria Margosi)

Greece introduced ECs in 2018 with Law 4513/2018 to address energy poverty and promote CE investments [56]. The EC law provided a comprehensive framework and incentives for EC activities [57]. In March 2023, Law 5037/2023 replaced Law 4513/2018, aligning Greek policy with EU Directives 2018/2001 and 2019/944. The new law introduced two types of ECs: RECs and CECs. Thus, three types of EC exist in Greece: ECs under the law 4513/2018, REC, and CEC. Only RECs or CECs can form new ECs from 2023 onwards.

Greece—opportunities and best practices

Although the 2018 law allowed for various energy activities, only two have attracted most ECs. The first, which drove ECs' rapid growth, involved investments in renewable energy (primarily solar) through an operational support scheme (feed-in tariff/feed-in premium). Incentives like guaranteed tariffs, grid connection priority, and reduced bank guarantees made this a highly appealing investment option. The second activity, favored by citizen-initiated ECs, focused on collective self-consumption via virtual net-metering. This scheme, particularly valuable in Greece's volatile energy market, protects members from price spikes, builds resilience against market fluctuations, and offers solid investment returns.

In Greece, several ECs have successfully implemented projects, particularly for collective self-consumption, showcasing the effectiveness of citizen-driven initiatives. Notable examples include Hyperion and Collective Energy in Athens, with solar projects of 500 kW and 100 kW, respectively. The 'Minoan Energy Community', the largest in the country with >600 members, has developed two collective self-consumption projects totaling 1.4 MW. This initiative has brought together public bodies, small and medium-sized enterprises (SMEs), and vulnerable households to produce and share energy, focusing on combating energy poverty. The success of the 'ESEK community' in Karditsa underscores the critical role of local cooperative banks, which have provided low-interest loans, enabling ESEK to launch Greece's first EC focusing on biomass and pellet production in 2010, in collaboration with local farmers and the municipality. The role of intermediaries is also crucial in facilitating the energy transition. 'Electra Energy' is a prime example, offering technical and advisory support to many ECs across the country. Furthermore, citizen-initiated ECs have recently formed a union, DESMI, comprising 20 members, aimed at political advocacy and mutual support, see Figure 1 [58].

These examples, as highlighted in the literature [25, 59], show the importance of networking, cooperation between grassroots initiatives and local authorities, and the role of intermediary organizations in supporting EC initiatives.

Greece—key challenges

Despite significant progress in developing ECs in recent years, several challenges persist. Many EC projects face grid connection issues, with 2341 canceled and 2476 remaining pending or unconnected. Only 1487 (34.3%) out of 6304 applications have received approval [60]. Grid space scarcity is a primary obstacle, accounting for nearly half of canceled and pending requests [61]. Additional factors include missed deadlines, incomplete documentation, and automatic agreement terminations. Furthermore, frequent policy changes and poor management of the transition between the 2018 and 2023 laws exacerbate uncertainty and hinder project progress [62].

Another significant challenge is the misuse of the concept of EC. Many investors exploit the advantages that law provides to ECs, including guaranteed tariffs for solar and wind projects, to bypass standard procedures like permitting, grid connections,

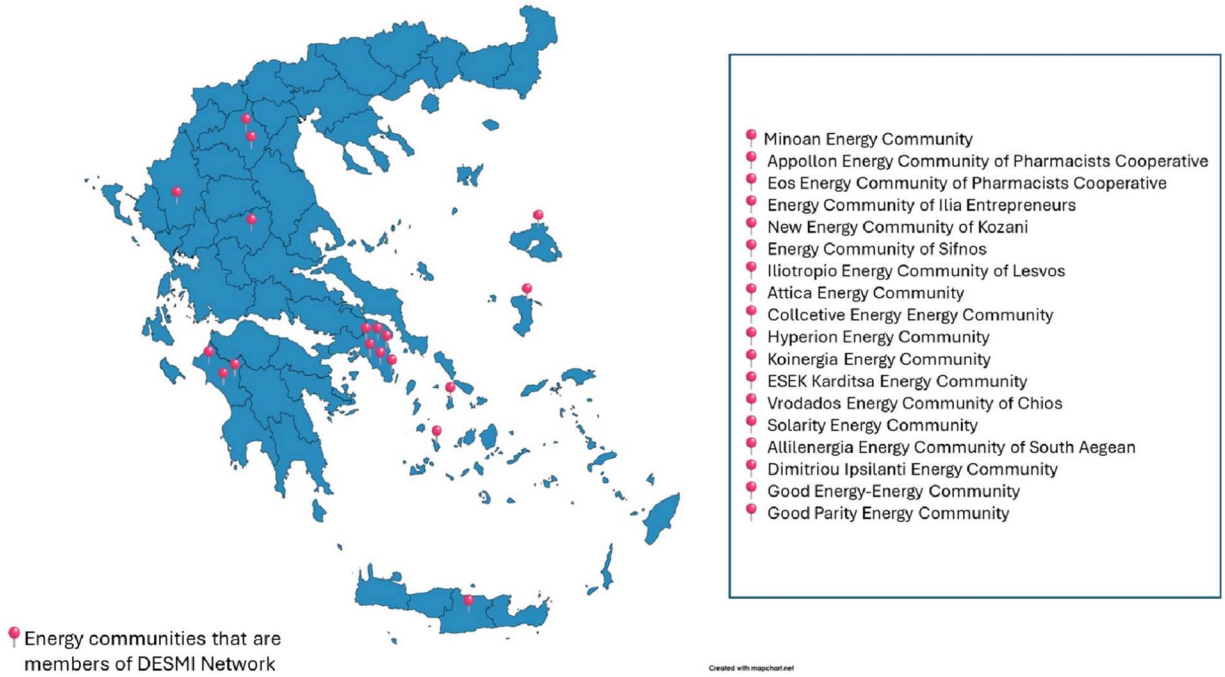

Figure 1. DESMI Coalition of Energy Communities, the most active EC network in Greece, aims to democratize the country's energy system and promote a just energy transition.

or competitive tenders. This issue is evidenced by two key indicators:

- ECs transfer projects to private companies; between 2021 and August 2023, ECs transferred 105 guaranteed tariff projects, each ~90 MW, to private firms [61].
- The disparity between commercial and self-production projects (1164 MW and 14 MW, respectively). Only 3.9% of self-production projects by ECs, SMEs, and individuals have been electrified, highlighting a clear bias towards commercial ventures.

In response, the Greek state gradually eliminated most incentives for ECs' RES commercial projects, thereby weakening their attractiveness to communities and underscoring the increased uncertainty resulting from policy changes.

For most entities, including ECs, Law 5106/2024 (Article 110) replaced virtual net metering with virtual net billing in 2024, encouraging energy use in line with renewable production. However, this shift is less attractive to household ECs. Despite broader regulatory opportunities, few ECs have expanded beyond renewable energy projects.

A central issue is a lack of common vision. Diverse motives and insufficient support policies prevent ECs from reaching their full potential. Greece ranks low on nearly all energy poverty indices in the EU [63], yet <5% of the population is well-informed about the EC concept [62]. This lack of awareness undermines ECs' core purpose in the energy transition—promoting citizen participation and democratizing the energy system, focusing on social and environmental benefits over profit.

Greece—recommendations

To support the development and success of ECs, we propose a set of policy recommendations. First, while Greece's National Energy and Climate Plan recognizes the role of ECs, there are significant gaps. We must also set more ambitious targets, such as raising the 600 MW self-consumption goal [64] and mandating at least one EC per municipality. Second, policy consistency and coordination are vital. A smooth transition from Law 4513/2018 to 5037/2023 must be ensured for existing ECs, and well-organized 'one-stop shops' should be established to provide technical and administrative support. Third, funding mechanisms should evolve to support innovative EC business models beyond energy production, such as demand response and grid flexibility services. The 'Apollon' program that aims to support ECs from local authorities that incorporate vulnerable households under the scheme of virtual net metering is a good initiative but needs to be expanded for virtual net billing from citizen-initiated ECs, possibly by funding the battery-storage costs. Emphasis should be placed on activities that raise awareness and disseminate knowledge. Finally, in the current landscape of limited grid space availability, the 2GW network allocation must be expanded, ensuring equitable distribution among the different types of self-producers, ECs, SMEs, and individual households. ECs could receive grid connection priority, particularly when implementing virtual net billing.

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Energy communities in the Denmark

(Henner Busch)

Denmark has a long-standing history of ECs [59, 65]. The country has great potential for wind power development with lots of places with excellent conditions due to topography. In addition, collective solutions for heating (e.g. district heating) are widespread and socially accepted. Like its Scandinavian neighbors, Denmark has strong social capital with high levels of trust in

society which opens opportunities for cooperative solutions in the energy sector [66].

Denmark—opportunities and best practices

The long-standing history of RECs in Denmark has brought about several well-known examples and best practice approaches. In particular, island communities such as Samsø and Ærø have become iconic cases of community engagement in and local ownership of the energy transition [67–69]. These cases often depended on individual leadership by local champions who invoked positive visions [70, 71] that mobilized the whole community. Many successful cases from Denmark show that it is essential to combine grassroot and top–down approaches [65]. This was often achieved by bringing local community and public planning authorities as well as businesses to the same table. A key factor for the success of RECs is the strong ownership base in the local community. Oftentimes, small ECs, and in particular CECs, are only open to local investors. In the same vein, larger projects often grant preferential treatment to local investors, such as investment models for households with limited funds. As a result, the high share of local ownership produces respective local economic benefits (energy savings, profits from selling energy to the grid, local jobs in the energy sector), and high levels of acceptance towards renewable energy and cooperative projects.

Research on ECs in Denmark highlights the importance of two actors: local banks and intermediaries. The case of Ærø shows how local banks can fulfil an important function as facilitator of ECs by providing cheap loans to local households who wanted to buy shares in a local community-based wind project [67]. The shares in the project were so economically attractive that the bank accepted the same shares for which they provided money as collateral for the loan. Previous research has underlined the important role intermediaries play in energy transitions [72–74]. This finding is echoed by experiences from EC development in Denmark. E.g. all three self-proclaimed 'energy islands' Samsø, Ærø and Bornholm have set up independent institutions who have the mandate to drive local energy transitions.

Denmark—key challenges

Denmark is the only country that reported the full transposition of the EU RED package by July 2024. While this puts Denmark ahead of all other EU member states, the transposition has only recently taken place. This means that it will take some time until the entire system has internalized the new legislation and before positive effects become visible. Another issue persists in the form of siloed policies. Currently, legislation for heat production on the one hand and electricity generation on the other hand follows two different strands. This makes it extremely difficult for EC initiatives to go into combined-heat and power, because of the legal hurdles and the very high information costs that come with navigating two different bodies of legislation.

Currently, the most pressing problem is a general lack of support for new ECs. Some seed funding is available for new initiatives but there is little to no support for such groups once they start working on their EC. In particular CEC initiatives struggle with a lack of support. Required know-how is hard to come by because professional consultants are too expensive for citizen initiatives that do not start off with considerable capital. This vacuum of support cannot be filled by municipalities because they do not have the necessary resources. Further, they would find themselves in a conflict of interests as they are supposed to both support new initiatives and ensure that rules such as planning regulations are observed.

A final challenge for ECs comes in the shape of power asymmetries. The involvement of municipalities and companies as partners in a REC means that professionals who are paid for their contribution to the project work together with citizens who sacrifice their free time in the project and thus perform unpaid labor. This can lead to dynamics in which a part of the project consortium feels undervalued and might start to question why they should contribute without compensation.

Denmark—recommendations

The situation in Denmark requires more targeted policies that provides a clear direction of the transition towards more decentralization and local ownership if ECs are to become a considerable part of the energy system. Part of this push could be to create funding schemes that compensate people for their contribution in EC initiatives. Another aspect of this is the harmonization of legislation pertaining electricity and heat production so that ECs can tap into the potential of combined heat and power on a local level.

Finally, the successful examples described above show that independent intermediaries (which are not identified as state-entities) can play a significant role in rolling out ECs in Denmark [67, 75, 76]. Therefore, we suggest financial support for intermediary actors who can function as one-stop-shops for citizens and organizations who are interested in setting up a REC.

Energy communities in Sweden

(Jenny Palm and Anna Bergek)

In the context of ECs, Sweden presents an intriguing case due to its historically dominant centralized electricity system. For decades, this centralized system, largely powered by nuclear and hydro energy, has provided a reliable supply of electricity at low prices, with minimal expectation of citizen involvement. However, since the early 2000s, there has been a gradual rise in interest in both becoming an individual prosumer and participating in ECs. There are however no law on ECs in Sweden.

Sweden—opportunities and best practices

In the absence of a uniform definition of an 'energy community' in Swedish legislation, it is difficult to determine what qualifies as an EC, and there is no official EC registry or similar system. The only existing mapping, completed around 2017, identified ~240 organizations resembling EC [77]. This and later studies show that there are several different variants of ECs in Sweden, for example, those focused on wind and solar energy.

It is noteworthy that successful ECs in Sweden often emerge from collaborations between municipally owned energy companies, local private companies, and local citizens. These partnerships have accelerated the development of ECs by enhancing knowledge-sharing, financial support, and access to sites. This model can be replicated to, for example, increase community buy-in and financial feasibility [78].

Sweden—key challenges

Earlier research has found that a conducive legal framework is important for ECs to emerge [79]. Sweden has not yet translated the EU regulation into Swedish law and lacks tailor-made policies for ECs. It is still more beneficial to be an individual prosumer (i.e, someone who both produces and consumes electricity). Electricity consumption from self-generated electricity is not subject to energy tax, VAT, network charges or electricity trading costs. Individual prosumers who generate their own electricity

can, therefore, benefit financially by optimizing their electricity use, thus reducing the amount that needs to be purchased. In contrast, in an EC where the shared electricity passes through the electricity meter before being distributed among members, energy tax, VAT and network charges are applied to all the generated electricity, creating a disadvantage for ECs compared to individual ownership (Swedish Energy Agency, 2024).

The framing of ECs in Sweden has, so far, been rather technocratic. ECs are often described in terms of the value they generate for the grid, such as grid stability and expansion of renewable electricity production [80, 81]. Moreover, the discourse on ECs is dominated by industrial ideals prioritize centralized large-scale energy systems. A challenge in the Swedish context, therefore, is to assign value to other aspects such as citizen engagement in energy production and distribution and an increased share of citizen ownership of electricity production resources [82].

As in many other countries, Swedish ECs rely heavily on volunteers, and a major challenge is finding citizens that have enough time to participate in running an EC. Another challenge is to find people with knowledge on how to set up and run an organization producing and distributing energy [83]. In Sweden, as in many other countries, there is also a lack of diversity among the members of ECs. Most members are rather well-educated men with middle-to-high incomes [78, 84]. Energy is perceived as a masculine domain, which further impedes women's participation in ECs [84].

Sweden—recommendations

Successful ECs in Sweden have often included municipally owned energy companies that set up the organization, mobilize resources, manage the construction process, and/or operate the EC's energy plant(s). A first recommendation, therefore, is to encourage stronger collaboration between municipalities (including municipally owned energy companies) and citizens.

As noted earlier, there are strong economic incentives to increase the self-use of self-generated electricity. One way for an EC to share its produced electricity among its members is through so-called virtual sharing. In this solution, the generated electricity is fed into the existing grid and only indirectly connected to the members' electricity use. However, under current regulations, members must pay energy tax and network charges even if they (virtually) use electricity generated by plants in which they own shares through the EC. From an economic standpoint, virtual sharing is, therefore, not justifiable at present. Regulatory changes that make virtual sharing of electricity equal to sharing behind the meter are thus an important policy measure to encourage further EC development. (Swedish Energy Agency, 2024).

Existing ECs raise justice concerns due to the lack of diversity among their members. To fulfill the EU's ambition of using ECs as a means to develop an inclusive and equal energy market, policymakers need to take action by adopting regulations and incentives that make ECs known and accessible to a wider range of social groups [84]. To further encourage this development, a third recommendation for policymakers is to introduce a law on ECs with a clear definition, which would enable the provision of more targeted subsidies, low-interest loans, or tax incentives to lower financial barriers for ECs [85].

It is important to raise awareness of the existence and benefits of ECs, ensuring that all citizens are informed, involved, and empowered to participate. It should also be noted that citizens in general likely do not have the same environmental motives as early EC members, which may affect their views on suitable EC models as well as their willingness to engage actively in EC organization and management [86]. To stimulate broader participation, policy needs to be flexible and allow for different organizational models to be used.

A final recommendation is to support the establishment of an umbrella organization, which can help put ECs on the political agenda [81, 87]. Such support could begin with some of the already existing voluntary initiatives that provide guidelines and information about current ECs (see e.g. https://www.sverigesenergigemenskaper.se/).

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Energy communities in Norway

(Karina Standal)

The concept of ECs is new in Norway, but there has been a small, but increasing trend towards rooftop solar PV in private homes or larger municipal or commercial buildings. There are also a few smart energy projects integrating a range of renewable technologies, storage and prosumer arrangements [109], like the Island of Utsira (see [88]). However, the interest in ECs in Norway is emerging.

Norway—opportunities and best practices

A major motivation among local authorities is how ECs can make communities more attractive by reducing costs and providing employment [89]. One example is an isolated rural municipality in Norway where EC models are planned to enable fish farming that provides tax revenues and employment, and thus counter depopulation. Local authorities' interest in ECs is also linked to political commitments in municipal climate action plans and energy security and self-sufficiency of heat and electricity [109]. The motivation for ECs as part of emergency preparedness is likely to grow as climate change increasingly puts grid supply under pressure.

Research has also shown opportunities for ECs in condominiums [90, 109]. Housing cooperatives are common in Norwegian cities and already have a membership model with shared investments and democratic decision-making. Further, several of Norway's property developers have engaged in pilot projects integrating local energy production and storage on office or residential buildings (e.g. [91]). Higher and more fluctuating electricity prices after the Russian invasion of Ukraine and changes to the grid tariff may increase the motivations for decentralized energy systems among a range of actors [109].

The opportunities for ECs are enabled by new regulatory changes. October 2023, the government extended the 'plus-customer scheme' (that grants rights and incentives as prosumers) to facilitate joint electricity production, sharing and consumption within the same property. Further, a recent white paper from the government (based on an appointed Energy Commission) has signaled the need to 'turn every stone' to contribute towards the low-carbon energy transition while sustaining adequate prices and security of supply [92]. Their recommendations include focus on solar PV and facilitation of local solutions producing, sharing and storing electricity ([92], 17). This is a shift of policy narrative from almost exclusive focus on hydropower and wind power in centralized supply, where other

technologies and decentralized models were viewed as disrupting elements [93, 109]. The size of energy systems (to be defined as prosumers), and distribution of extra costs for grid companies to all customers has been a continued debate.

Norway—key challenges

Despite emerging interest, ECs have yet to be significantly implemented. While the RED II have been instrumental in enabling ECs in Europe, Norway is not an EU member, only part of the European Economic Area. Norway has at present no legal definition of ECs and no plans for implementing an enabling framework pursuant to Art. 22 of the RED II to facilitate the development of renewable ECs [94, 109].

Relevant stakeholders have also pointed to inhibiting regulations, lack of support schemes and political focus from national and local governments as important barriers for ECs [109]. The need for reducing administrative burdens, increasing access to information, capacity development and financial support was highlighted. Preconditions in terms of financial resources, time, leadership skills, technical interest and personal motivation are necessary to mobilize municipalities, small businesses and individuals to engage in ECs [89]. Stakeholders expressed that the required knowledge and resources for engaging in RECs were too challenging and unavailable to a diversity of actors. Further, the existing financial support schemes (provided through the state enterprise Enova) entail high up-front costs and are not designed with the specificities of ECs in mind [89, 90].

Norway—recommendations

Taken the current framework conditions, ECs may not scale-up but remain a minor niche in the energy system, unless national and local governments take action. One pathway is to implement REDII's legal framework and enabling framework for renewable ECs on national level. This would provide guidelines concerning the organization and purpose of ECs, as well as conformity with Europe. Another pathway is for regional and local authorities to provide support and financial incentives that direct ECs towards 'solving' local needs, e.g. local energy security issues and financial, social and environmental benefits to the community. This would provide local distribution of benefits, increasing the likelihood of community acceptance of the energy transition and reduce the likelihood that commercial interest (who do not have local needs at heart) co-opt the EC model. Accompanied by measures to ensure that information and support schemes are available to a diversity of actors, the result would further enable an inclusive and just scale-up of ECs in Norway.

Energy communities in Finland

(Salvatore Ruggiero and Aki Kortetmäki)

ECs are an emerging practice in Finland. The full spectrum of these entities has not yet been transposed into Finnish legislation. Currently, defined terms include Citizen Energy Community (CEC), 'group of active customers' and 'local energy community'. The definition of EC largely follows the definition of a CEC but sets additional requirements for members' location. A 'local energy community' is restricted to members whose consumption points, production facilities, and storage are connected to the same grid connection point. Thus, the legislation enables communities within, e.g. apartment buildings and industrial sites but, in most cases, does not apply to communities of detached houses as in the case of REC. Furthermore, the definition of a local EC does not include the right to engage in distribution.

Finland—opportunities and best practices

Currently ECs or groups of active customers in Finland are predominantly operational among properties located on the same premises, as in the case of a solar PV system owned by a housing company. In Finland, a housing company is a legal entity established to own and manage residential buildings where ownership is typically divided among multiple private households (i.e. the housing company's shareholders). As part of the definition of active customers and local ECs, Finland introduced virtual net-metering ('hyvityslaskenta' in Finnish) in the form of a credit calculation model. Solar energy from a property's PV system is first used for shared areas like staircases, garages, and saunas. Any leftover electricity is then shared among the shareholders' apartments based on a set ratio, calculated every hour or every 15 minutes. If there is no corresponding consumption in a specific apartment during the metering period, the surplus is usually sold on the electricity market at the current market price.

Legislative changes have been made in Finland to ensure that various EC models can be implemented. In 2021, new legislation enabled the connection of a power plant built outside the property to the property's electricity grid via a separate line. However, this connection line must not link two consumption points; it is only allowed to connect generation to consumption. Virtual ECs are theoretically possible in Finland as a service offered by energy companies, but there is no separate incentive available for electricity transmission or taxation costs in this regard.

There are emerging examples of built or planned city areas piloting new forms of sector integration, where actors within the area share electricity, heat, cooling, and gas production as well as flexibility and storage opportunities among themselves. Examples of such areas include the LEMENE industrial area in Pirkanmaa and the Hiedanranta area, where technical and administrative innovations can be piloted.

Due to cold climates, heating energy constitutes a significant portion of energy consumption, primarily met through electricity (direct electric heating or heat pumps), local combustion-based boilers, or district heating. Electricity in Finland is among the cheapest in Europe, with only a small fraction of production based on fossil fuels. Consequently, there are numerous energy efficiency measures available including subsidies for transitioning away from oil heating and for household renovation costs. However, direct subsidies for the formation of ECs are not provided in Finland. Nevertheless, the Housing Finance and Development Centre of Finland does offer grants for investments in solar energy and other energy-related projects in multi-apartment buildings.

Finland—key challenges

Despite the opportunities ECs offer in Finland, they face several challenges. Regulatory gaps and the absence of clear operational models hinder their comprehensive development. For instance, current regulations do not allow the creation of ECs that extend across multiple properties connecting several production and energy consumption points through the electricity grid [95].

User engagement also presents a significant challenge. Although Finland has made great strides in renewable energy, many citizens remain unaware of the benefits of participating in ECs, or they are reluctant to engage in these initiatives. This disengagement hinders the success of decentralized energy systems, as active citizen participation is crucial for their effective operation [96]. Additionally, the alignment of interests among various stakeholders, including municipalities, businesses, and community members, can be difficult. Successful ECs depend on

strong collaboration between these parties, yet differing priorities and objectives can obstruct progress [97].

Finland—recommendations

To support the continued growth of ECs in Finland, several key recommendations can be formulated. First, public awareness and participation must be enhanced. One-stop shops should be open to facilitate ECs, while financial incentives could be provided to encourage broader citizen participation. Moreover, encouraging community-level investments will play a crucial role in advancing ECs. Cooperative financing models, particularly in housing companies, can facilitate joint investments in energy production and efficiency measures [98].

Second, policy makers should continue to support ECs by developing a regulatory framework that facilitate collaboration and innovation. While Finland's current legal framework allows for the creation of ECs within the premises of housing companies, further steps are needed to remove technical and administrative barriers to implement the full spectrum of EC models. In addition to simplifying regulations, Finland should establish clearer economic incentives, including subsidies and tax reductions, for communities that invest in renewable energy production and storage. Such financial mechanisms, including low-interest loans, will lower the entry barrier for communities, particularly those that lack significant upfront capital.

Finally, fostering collaboration and knowledge sharing among stakeholders is essential. Local authorities and energy providers should support the sharing of best practices and technical expertise with housing companies interested in creating ECs. By promoting the sharing of knowledge and resources, Finland can enable a more prominent role for ECs in the national energy transition [99]. In addition, the planning and implementation of local energy projects should involve a more inclusive set of stakeholders to ensure that the benefits of renewable energy are fairly distributed and citizens can actively participate in the energy transition. Placing ECs at the core of Finnish energy policy will foster social acceptance and contribute to a more just energy transition, while also supporting broader climate and sustainability goals.

Energy communities in the UK

(Iain Soutar and Patrick Devine-Wright)

Growth in the UK CE sector has slowed in recent years. As in several other European countries, a favorable renewable energy policy environment meant that the sector enjoyed considerable growth in the early 2010s, and the publication of a strategy for CE in 2014 appeared to signal government support. However, a stripping back of policy support for community-scale renewables such as onshore wind and solar and a discontinuation of direct funding streams, has created a hostile environment for the sector.

Policy attention on CE in the 2020s appeared to have shifted to LES as a new focal point for energy system decentralization [100]. (In the UK, the notion of 'Local Energy Systems' emerged from within policy and industry communities to reflect a place-based approach to energy system decarbonization through collaboration between private and public organizations, within discrete projects to achieve system goals. This can be contrasted with the concept of Community Energy, which typically involves grassroots, citizen-led initiatives to unlock collective (local) benefits.) The notion of the local energy system (LES) has become a key focal point for energy policy in the UK and further afield. LES are not isolated systems, but local experiments with combinations of social, technological and business model innovations to help overcome specific energy issues [101]. The increased attention on LES as energy system 'solutions' has been driven by a few key factors. First, transitions to low carbon power, heat and transport technologies will need to involve people in homes, businesses and communities, and as such, challenges and opportunities are specific to places. Second, electricity network constraints present barriers for electrification at the local level which require local solutions. And third, complementarities afforded by local system solutions provide an opportunity to stimulate energy industries, such as generation and storage developers, or organizations developing flexibility platforms [102].

While LES might be characterized as competing with CE in some ways, emerging evidence suggests that the two approaches may be mutually supportive. Here, we explore opportunities and challenges for the CE sector in the UK, and present some recommendations for policymakers seeking to support both LES and CE.

The UK—opportunities and best practices

Despite the otherwise unhelpful policy environment, some parts of the CE sector have been able to demonstrate resilience by attending to the challenges and opportunities presented by 'local energy'. Of the 147 local energy system projects surveyed by Rae et al. [103], almost a fifth (19%) involved CE organizations as funded project partners, with CE organizations acting as project lead for nine of the projects. This suggests that CE representation within LES projects is valued by both wider consortia, and funding bodies.

Qualitative research on public engagement by recent LES project partnerships explored how CE organizations offer several assets of value within wider partnerships [104]. First, the time and resource-limited nature of LES projects meant that developing relationships with host communities can be challenging. In this context, CE organizations were able to provide access to pre-established trusted networks with local communities. Indeed, having access to such social networks, through CE groups, may have been a critical step in accessing funding. Second, CE groups were valued in terms of the knowledge they held about LES challenges. This was particularly the case where long-standing CE groups had been able to generate learning from past projects.

Meanwhile, quantitative research on public perceptions of LES also demonstrates public support for CE groups being involved in LES projects, and high levels of trust in CE groups to ultimately manage future energy systems [105]. More broadly, the same research found evidence of strong public support for a shift to decentralized energy systems in the UK, providing a firm foundation for the future of both LES and CE [106].

The UK—key challenges

However, there remain significant challenges for the future of CE in the UK. Exit from the EU means that CE organizations are not afforded the same legal status as those in the EU. Meanwhile, and as discussed, UK energy policy has for the most part neglected the CE sector. Much of the direct support for CE has been stripped back, as has indirect support by way of the existence of, and access to, renewable incentive mechanisms. A reliance on volunteers has meant that much of the sector is supported by goodwill, rather than sustainable revenue streams. The sector has suffered from a lack of socioeconomic and cultural diversity, meaning that CE may not be able to represent the needs of the communities they serve. And more broadly, the patchy nature of the sector means that while CE may provide benefits to some local communities, other communities—particularly those less endowed with access

to natural resources, grid connections and social capital, may be left behind [107].

The UK—recommendations

These reflections lead us to several recommendations for policy and practice. First, future LES programs should be designed in ways that include CE organizations. Future programs could simply mandate that the CE sector is represented within project consortia. This would help ensure that CE groups are properly integrated - and adequately resourced - within projects as trusted delivery partners, provide much-needed funding to sustain CE initiatives, and unlock the value that CE can bring to LES projects.

Second, the UK Government should consider how the CE sector can help to implement wider energy policy. For example, policy support for onshore wind could favor involvement of CE groups; policy around low carbon heat could incorporate support for community-scale heat projects; and retrofit policy could seek to access economies of scale by targeting communities, rather than individual homes. Allowing CE groups to access policy support through such avenues would in turn help to generate revenue streams and ultimately sustain the sector.

Third, there is an opportunity for government to use the CE sector as a channel for public engagement around energy transitions, and the changes required within homes, communities, and wider energy systems. CE groups (and other community groups) tend to be firmly anchored in places, have well-established trusted networks within communities, and hold valuable experience and knowledge in effective community engagement. Providing they are well-resourced CE and other community organizations would be well placed to support public engagement policy.

To support these changes, creating a dedicated CE unit within government's civil service would be an important first step. Such units help bridge the divide between policymaking and practitioner communities, identify and realize mutual benefits therein, and streamline learnings from the sector into the policy decision-making process. Such policy support could also provide the impetus for the adoption of CE approaches in underserved areas.

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Conclusions

This vignette-article provides valuable insight in the development of ECs in Europe. Whereas ECs focus on expanding renewable energy generation and supporting a just energy transition, they come with a diversity of best practices and challenges. The country contributions shown here indicate that the progress of ECs has largely been policy-driven, relying on national policy tools such as guaranteed tariffs, grid connection priority, regional advisory centers, action plans, and net-metering. Building on this support, ECs have engaged and connected actors within a community, as well as realized important partnerships across actors such citizen, businesses, organizations and authorities. The results specifically indicate the strengths of engaging local actors such as municipalities, cooperatives, local businesses, local banks, non-profit organizations and intermediaries, to raise awareness, mobilize citizen, and to access trusted networks. The engagement in such trustworthy environments may not only support renewable energy but can also trigger energy efficiency and innovation in areas such as smart grids and energy storage.

Nevertheless, several challenges are highlighted in terms of the neglect of ECs in national energy policy, a delay in the translation of EU legislation into national legislation and a cumbersome bureaucracy. Several authors report that the support of EC (and CE) has been reduced and that regulatory environments prevent ECs from sharing energy behind the meter. There have been challenges in grid connection and in developing collective heating systems. Overall, there are a lack of necessary skills and capacity, as well as power asymmetries relying on volunteers and goodwill. It has been difficult to coordinate diverse actors within ECs and to find well-functioning processes of internal decision making with diverse actors. The EC initiatives have been criticized for not being inclusive, predominantly relying on highly educated males with an engineering background, and excluding women and underprivileged groups. In recent years, the uncertainty related to ECs seems to have grown, and policy appears to be biased towards commercial ventures. It has even been argued that the EC model has been co-opted by commercial interests, and several report on a trend towards investor-owned renewable energy projects which might be to the detriment of citizen values.

Overall, the researchers that were invited to contribute to this vignette stress the value of ECs in anchoring future energy systems in the local context and its actors. This is necessary for legitimacy and for a just energy transition in terms of inclusiveness and redistribution of benefits and burdens from the transition. The recommendations provided mainly focus on building awareness among policy makers and the support for a national law on ECs with a clear definition to enable the provision of more targeted policies. A special emphasis is given to the need to engage municipalities as well as local interest representation organizations and intermediaries. Moreover, ECs need to be accessible for a wider range of social groups. In general, the collection of lessons learnt, and the key challenges and recommendations presented here by the invited experts express the necessity to discuss how to use the learnings in ECs (and CEs) to achieve a just transition. This in turn, calls for a broader discussion at all policy levels on how to strengthen a multi-level policy approach with a special focus on local actors and local achievements.

The collective insights presented in this vignette-article inspire discussions and stress the need for further research. One topic requiring more focus in the future will be the regulatory environments in terms of sharing energy behind the meter and how to resolve challenges in grid connection. Another topic will be on the additionality of ECs in terms of how they contribute to energy justice (fairness, equity and cost distributed across stakeholders) in ways other energy arrangements do not, as well as the role of local actors in ECs from a multilevel governance perspective. A third topic for future research may be to assess the multi-level policy approach, as indicated above, and to advance knowledge on how to align policy at different levels. In all, the future role ECs in the European energy systems presents a rich and diverse research agenda for the coming years.

Author contributions

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