The role of local energy communities to reduce carbon emissions in the urban built environment

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Abstract. In recent years, a rapid increase in the adoption of renewable energy sources and in the transition from a centralized electricity generation system to an increasingly distributed one has occurred. Within this scenario, in line with the European directives for achieving the objectives in the field of energy transition and climate change, energy communities are seen as potential contributors. [1] The article is analyzing the role of energy communities in combating climate change and transitioning to a low-carbon economy. These communities significantly contribute to reducing carbon emissions by replacing fossil fuels with renewable energy sources. Community-managed projects reduce energy consumption and promote sustainable practices through awareness programs and investments in energy savings. Technical, financial, and social innovations are essential for an efficient transition to sustainable energy. Rising energy costs highlight the instability of the current system and the need to transition to renewable sources. EU legislation adopted in 2019 supports these initiatives, facilitating the co-production and distribution of renewable energy.

1 Introduction

Energy communities represent a step in fighting climate change [1], and they are part of the economy that tends to eliminate carbon emissions. Energy communities can help find a new balance between local economies and the economy overall and represent a society based on cooperation.

Community-managed renewable energy projects significantly reduce carbon emissions by replacing fossil fuels. Many projects implementing energy communities aim to reduce amounts of energy used, considering that we must not decrease energy consumption to make the transition to renewable sources. Members of the energy communities are encouraged to reduce their energy consumption, through awareness programs and investments in energy saving [1].

The energy community refers to a wide range of collective energy actions that involve citizens' participation in the energy system. The Clean Energy Package recognizes certain categories of community energy initiatives as 'energy communities' in European legislation. Energy communities can be understood as a way to 'organize' collective energy actions

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around open, democratic participation and governance and the provision of benefits for the members or the local community [2]. Energy communities can be instrumental for facilitating the energy transition at the citizen and at the local level. In addition to fostering greater citizen participation and acceptance of renewables projects, they also provide other socio-economic benefits such as the encouragement of local investments and engagement of vulnerable customers. [2].

2 Methodology

Several articles were studied to establish a definition of energy communities and to compare the legislative framework in Romania with European directives. Articles presenting case studies were also examined to determine the efficiency of energy communities and to find a way to conduct the simulation of energy communities.
Energy communities represent a transformative approach to managing and distributing energy resources, driven by the collaboration of local stakeholders and residents. European Union policies, such as the Clean Energy for all Europeans package, provide a regulatory backbone that supports the establishment and growth of these communities. This framework promotes energy democracy, allowing citizens to actively participate in energy generation and decision-making processes.

3 Results

Community energy reflects a growing desire to find alternative ways of organising and governing energy systems (Van Der Schoor et al., 2016). It is a new form of social movement that allows for more participative and democratic energy processes. Until recently, community energy lacked a clear status in EU and national legislation, taking different forms of legal arrangements. [2].
Energy communities are collaborative initiatives involving local stakeholders and residents to manage and distribute energy resources. Supported by EU policies like the Clean Energy for All Europeans package, these communities promote energy democracy, allowing citizens to participate actively in energy generation and decisions [3]. Energy communities in Europe have enormous potential: half of EU citizens – including local communities, schools, and hospitals – could produce their own renewable energy by 2050, covering 45% of the EU's energy demand [4]. The policy emphasis is on enabling citizens to generate, consume, store, and sell renewable energy without disproportionately burdensome regulations. This shift not only empowers communities but also fosters local economic growth, resilience, and sustainability by reducing dependence on large-scale utility providers and fossil fuels. Comparative analysis of renewable energy systems helps communities optimize setups for self-consumption and economic viability, reducing costs and environmental impact. Energy modeling guides low-carbon strategies, supporting policy decisions and community engagement. Citizen participation is crucial for project acceptance and success, facilitated by governmental and non-governmental organizations [3]. The use of photovoltaic energy reduces primary energy demand by approximately 11%, while the addition of the energy community configuration allows for a reduction in emissions by nearly 12% without additional investments [1].
The case studies the Joint Research Centre (JRC) [2] analyzed what community energy projects exist in diverse forms across Europe. The most widespread involves energy generation. Examples include school buildings or farm roofs equipped with solar panels, or windmills installed by residents in a village. Further, small biomass installations, heat pumps, solar thermal and district heating networks are popular technologies for some community

groups. While their overall proportion as investors in renewables may remain small (Yildiz et al., 2015), citizens and communities have a huge potential to invest in renewables. An increasing number of projects is also getting involved in energy efficiency and energy services that return profits to the community.

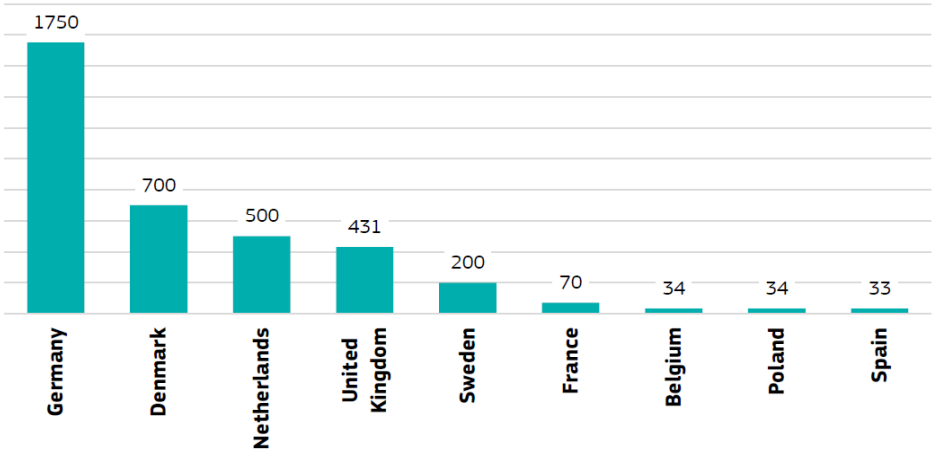

Fig. 1. Approximate number of community energy initiatives from the nine countries of the 24 case studies Source: JRC based on various sources, 2019 [2]

Another case is Repowering London is a non-profit organization that was founded in 2013 with the goal of creating energy communities in social housing in London. The organization supports communities in creating energy projects that produce renewable energy for people and a better future for their community. Repowering London believes that it is important to encourage cooperatives where community members have a say in the direction they want to develop the projects.

The local population sees solar panels as something that is accessible and supports renewable energy.

Financial support provided by Repower London to the Loughborough Community Centre has contributed to the funding of 4,494 lunches for children.

The project supports those facing energy poverty by allocating 20% of the income from Brixton solar to the Community Energy Efficiency Program (CEEF). This program directly helps community members facing energy poverty by renovating homes with better insulation, other improvements in energy efficiency, and education on energy saving practices.

Repowering London trains young people from a socially vulnerable neighborhood and makes them energy experts. After being trained for a few weeks in the energy sector, young people can offer specialized energy consulting or develop their own renewable energy projects (RES).[5]

The Eeklo project in Belgium, where the local authority launched a tender for the construction of a district heating network with a 100% renewable energy target, with 30% owned by citizens through a partnership with Ecopower, a Belgian energy cooperative, highlighted the importance of developing decentralized and citizen-controlled solutions, both for heating (bioenergy, surplus heat from local industries, waste infrastructure) and for mobility (car-sharing schemes, electric vehicle charging stations) and the need for citizen involvement in the heating and transport sectors, in addition to electricity.

It is important to consider and plan for all three sectors (electricity, heating, transport) to create a more sustainable, local, and efficient energy system.[5]

Ecopower, an energy cooperative in Belgium, was born 30 years ago from a local initiative with the goal of producing renewable energy. Starting with an old watermill, the cooperative has grown, installing wind turbines, solar panels, and other renewable energy projects, today powering over 50,000 homes. Ecopower does not profit from its energy supply activities, reinvesting the surplus in new projects. Cooperative members hold shares and have the right to vote at the general assembly.
The cooperative provides about 1.64% of residential electricity in Flanders and has helped members reduce their electricity consumption from the grid by half. Ecopower has also been a forerunner in collaborating with cities and municipalities, discovering the potential for collaboration between cooperatives and local administrations. Dirk Vansintjan, the founder of the cooperative, believes that the cooperative model helps build an economy that serves people and society, with a priority on ecological and social impact over profit. [5].

In Romania, the dominant technology preferred by the initiators of energy communities photovoltaic panels. Thus, 20 of the 21 identified initiatives use solar panels for electricity production, and 3 of them intend to develop heating solutions, also using electricity.[6]
Despite the early stage, the energy community movement in Romania is characterized by great enthusiasm, multiple ideas, a good anchoring in the local context and community needs, networking with similar initiatives in Romania and abroad, but unfortunately, a weak advocacy and representation capacity. The most recent encouraging development in this area is the establishment, at the beginning of 2024, of the Association of Prosumers and Energy Communities.[6]
GRĂDINA APUSULUI, a 4-story apartment building in Sector 6, Bucharest, has become a pioneer in Romania's energy community movement. This initiative, spearheaded by the "ÎntreVecini" (Neighbors) association, has brought a sense of unity and purpose to a previously isolated community.

Inspired by Nadia, a resident who returned from Australia, the project blossomed from a shared desire to care for the building's green area. Recognizing the potential for change, Nadia sought to foster collaboration and a sense of belonging among residents. The "ÎntreVecini" NGO provided technical and financial support for the installation of photovoltaic panels on the building's roof in 2021. This led to the community becoming a prosumator in December 2022, generating green energy and injecting it into the grid. The initiative has brought numerous benefits, including a reduction in energy bills and a strengthened sense of community. Residents have come together to create a vibrant garden, a symbol of shared ownership and collaboration. This green space has fostered social connections and fostered a sense of pride among residents. The success of GRĂDINA APUSULUI has inspired other communities, with 10 projects in various stages of development across Romania. The majority of these projects rely on photovoltaic panels, showcasing the growing interest in solar energy. While 10 projects are purely private, others involve local public authorities, demonstrating a broader engagement in this sustainable energy approach. GRĂDINA APUSULUI serves as a beacon of hope for other communities seeking to embrace a more sustainable and collaborative future. It demonstrates that collective action and community spirit can transform urban spaces into vibrant and empowered hubs of change.

Buteni, a municipality located in Arad County, is a vibrant example of a rural community that has adopted a proactive approach to achieving climate neutrality. Governed by mayor Mircea Braiți, Buteni has benefited from a development strategy based on a solid team, an entrepreneurial spirit, and a constant involvement in promoting European standards. The main reason for this transformation is the desire to reduce energy poverty among residents and to support small entrepreneurs, contributing to the community's economic development. This goal has been achieved through securing European funds, implementing infrastructure and energy efficiency projects, and promoting the "Casa Verde Fotovoltaice"

(Green House Photovoltaic) program. As a result, Buteni has become a municipality with a high rate of prosumers, with approximately 20% of households having photovoltaic panels installed. Additionally, the administration has provided support and guidance to residents in the process of installing panels, ensuring optimal absorption of funds and raising awareness of long-term benefits. The impact of the projects is visible: a significant reduction in energy bills, a cleaner environment, and a more united community, proud of its involvement in the green transition. Buteni is now a model of good practice for other rural communities, proving that climate neutrality is an achievable goal through involvement, initiative, and collaboration between authorities and residents.

The conclusion disseminated in specialized literature, and also reflected in the European definition of energy communities, according to which the vast majority of these initiatives are non-profit, is also confirmed in the case of Romania, the motivations of the initiators not being predominantly financial. Unanimously, the framework of the initiatives is a non-commercial one, the profit not being part of the context in which they were born or the motivation of the initiators. On the other hand, if at the European level the dominant motivation for establishing energy communities is the ecological one, in Romania it is rather a social one. About 60% of the initiatives place energy poverty or the reduction of energy bill costs in a central place in the context that gave rise to the initiative, the remaining 40% of the initiators being rather motivated by the desire for energy autonomy or the objective of contributing to the reduction of emissions. Obviously, this distribution of motivations is explainable through the prism of the national context, namely the prevalence of the phenomenon of energy poverty in Romania, a phenomenon that exerts great pressure on local public authorities.[6]

Fig. 2. Current geographical distribution of local energy community projects [6]

4 Conclusions

Energy communities are essential for an efficient transition to renewable sources and combating climate change, requiring innovations, appropriate legislation, and cooperation between citizens and authorities. Integration of renewable energy in smart cities includes technologies like solar panels, wind turbines, and geothermal energy, enhanced by IoT and AI for efficient resource management.

The analysis of the current legislative and public policy framework in Romania regarding energy communities highlights the gaps, confusion, and interpretability of the law.
In legislative context, Romania transposed the RED II Directive in December 2022 through OUG 163/2022, but the definition of energy communities remains general and unclear. National legislation does not provide a specific legal form for energy communities and does not provide additional clarification to the European definition.
The legal status of energy communities is not clearly defined in Romanian legislation, leaving room for interpretation. There is a lack of clarity in defining the responsibilities of institutions involved in the development of energy communities, leading to a lack of clarity in the establishment process. The legislation does not establish specific procedures for access to financing and information, leaving room for inequality and favoritism.
Also, OUG 163/2022 mentions a "favorable framework" for promoting energy communities, but these elements are not detailed. The National Integrated Plan for Energy and Climate Change (PNIESC) does not include specific aspects for energy communities. The National Energy Regulatory Authority (ANRE) has not organized information sessions on energy communities. The relevant ministry has not carried out an assessment of the obstacles and the potential for developing energy communities, as required by legislation.
The legislative and public policy framework in Romania regarding energy communities is fragmented, unclear, and confusing. The lack of clarity and the absence of a favorable framework can lead to inefficiencies, blockages in the establishment process, and the capture of communities by private interests. The lack of information and support from authorities can hinder the development of energy communities. There is a need to rethink current legislation to ensure a clear and favorable framework for energy communities, facilitating their establishment, development, and efficiency.
From the analysis of the articles it emerged that is an energy sharing limitations: Currently, energy sharing is not permitted between members of a geographically defined energy community. For example, residents of apartment buildings participating in the "ÎntreVecini" project cannot use the energy generated by communal photovoltaic panels to offset their individual consumption, only for common areas. Also there is restrictions on energy compensation: Compensation for energy produced by prosumers is not allowed between different consumption locations, even within the same supplier, let alone across different suppliers.
There is lack of legislation for microgrids: There is no legislation in place for microgrids, especially in new urban developments. Residents in these developments are often interested in managing their own microgrids, but lack of clear regulations hinders these initiatives.
Local authorities cannot concession the roof of a public building (eg school) to an energy community. The local public finance law is not clear enough regarding the conditions under which municipalities can contribute capital, land, etc. in an association with citizens / private entities, what an energy community is like, or how, as members of energy communities, municipalities can benefit from revenues and what they can do with them. The technical experts interviewed show that the most feasible energy communities from the point of view of balancing the network are those in which different public and private users coexist, having different consumption curves (individuals and legal entities such as small factories, shopping centers, etc. - with consumptions raised during the day).
It is not clear to local public authorities what legal form the community can take in order to comply with the thick legislation to which LPAs are subject. Some interviewees, taking into account the specifics of Romanian legislation regarding the establishment of different legal forms, consider the very necessity of having a legal form an obstacle for the expansion of energy communities in Romania. Studying the legal forms that energy communities can take, we find, indeed, that it is not at all clear what advantages and constraints each one has.

This detailed analysis identifies significant legal and regulatory challenges hindering the development of energy communities in Romania. Addressing these issues through legislative amendments and clarifications, along with improved communication and cooperation between relevant stakeholders, is crucial to fostering the growth and success of these initiatives. By tackling these obstacles and fostering an enabling environment, Romania can unlock the full potential of energy communities to contribute to a more sustainable and resilient energy future.

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