Local governments' ecosystem roles in different energy communities

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***Abstract*— Local governments play a critical role in initiating and implementing energy communities. The existing literature acknowledges their role but focuses on production-based energy cooperatives, and there is a need for a more comprehensive understanding of the potential roles within the ecosystems. This study deploys an ecosystem approach to provide an overview of different energy communities and the roles that local governments play in them. Mostly, the local governments have a supportive and reactive role, but especially in more complex settings like microgrids, they also can have a proactive ecosystem leadership role in coordinating and facilitating energy communities.**

***Index Terms*- Energy communities, microgrids, municipalities, local governments, ecosystems**

I. INTRODUCTION

Energy communities (ECs) are promoted in Europe by the European Union, member states, and local governments. ECs have the potential to boost renewable energy (RE) capacity, facilitate customer empowerment, provide flexibility services, and support the financing of the energy transition [1]. The evolution of ECs is heading from rather simple production-based systems towards more complex ones, including functionalities like self-consumption, energy usage optimization, flexible loads, and real-time energy monitoring [2]. The emergence of activities related to sector coupling, energy aggregators, flexibility markets, and peer-to-peer markets present a complex value proposition that differs from the traditional energy cooperatives investing in stand-alone power plants, for example [3]. This evolution challenges citizen participation as the new EC types are technically advanced and require professionals to manage and oversee the entire creation process, including administrative, technological, and financial aspects [4].

The crucial role in their implementation falls on local actors, including local governments like municipalities and councils, utilities, and local businesses and communities. Recent European directives concerning ECs acknowledge the possibility of local government's participation in ECs but leave their specific role open for interpretation [5]. Local governments are well-placed to take action because they can provide access to key resources, enjoy the trust of citizens, oversee urban planning process, and, in some cases, even own utilities [1], [6]. Furthermore, they have set ambitious climate targets as exemplified by networks like ICLEI and C40 [7]. Although recent studies have explored the roles of local governments [8], [9], there remains a gap in understanding their strategies for governing different types of energy communities, particularly concerning the integration of urban planning and energy matters [10], [11]. Also, the cross-sectoral nature of ECs is not sufficiently addressed. Cities and municipalities vary in their available resources, expertise, regional networks, and political ambitions regarding ECs, and the lack of knowledge and expertise on EC creation is a significant barrier [8]. This paper aims to expand upon existing studies, with the research question being: *"What are the different ecosystem roles local governments can play in different energy communities?"*

II. METHODOLOGY

The local government's role in different ECs was examined through case studies. We chose exemplary cases for different types of roles with the specific criteria: (1) the EC includes a substantial role for the municipality or the city, including different municipal entities like their utilities; (2) the ECs include an ecosystem structure, meaning that the EC does not have a purely top-down development approach. The success of the EC depends on other actors' investments and commitments; (3) EC members as owners, decision-makers, or active participants, play a significant role in the EC's value creation. We collected the available secondary data with stakeholder role descriptions, including existing comprehensive case studies, news articles, announcements, and other data. From this data, we identified the local government's role and connected it with the definitions of various ecosystem actor roles in the ecosystem genesis phase [12].

III. RELEVANT LITERATURE

A. Ecosystem roles

Business ecosystems are often coordinated by a central actor, also known as the keystone actor, the orchestrator, or the ecosystem leader [12], [13]. Studies of ecosystem leaders aim

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to answer the challenges of creating a shared vision, coordinating and incentivizing investments, and creating rules for problem-solving and maintaining stability within the ecosystem [14]. While private actors generally coordinate the business ecosystem, public actors may also take on that role [15].

ECs fit the ecosystem concept as they have stark similarities: ECs are based on open and voluntary participation, much like ecosystems, where members are hierarchically independent actors. ECs rely on reciprocity and interdependences, similar to ecosystems, as the economic viability of ECs is jeopardized if EC members leave [16]. Other essential ecosystem features, technological interoperability and complementarity, are crucial for the EC as they seek self-sufficiency while optimizing the usage of local assets. Based on this, we posit that ECs emerge in the form of business ecosystems [17, p. 201]. The different ecosystem roles are summarized in Table 1. Ecosystem emergence encompasses phases of preparation, formation, and operation, and the roles can be appointed to each phase [12]. The preparation phase includes discovering new value, providing resources, and securing actors' commitment. The ecosystem leader deciphers actor roles, builds a platform, or otherwise links partners. In the formation phase, interactions between different roles become more apparent. The ecosystem leader coordinates interactions and tries to enhance trust between ecosystem members while resolving tensions. In the operation stage, the ecosystem leader aims to introduce new complementary and value-adding offerings to the ecosystem.

TABLE 1. ACTOR ROLES IN ECOSYSTEMS [12]

Leadership	
Ecosystem governance	Develops ecosystem by designing roles, coordinating interactions, and orchestrating resource flows.
Forging partnerships	Creates a network by attracting and linking partners and providing niche creation opportunities.
Platform management	Provides technical basis by building/ opening a platform or aligning complementors with the platform.
Value management	Creates and captures value by bundling offerings or stimulating value appropriation.
Dominator	Conducts mergers and acquisitions in related fields.
Direct value creation	
Supplier	Delivers key components by supplying materials, technologies, and services.
Assembler	Provides products and services and processes information supplied by other ecosystem partners.
Complementor	Delivers key complementary offerings.
User	Contributes to value creation by defining problems, developing ideas, and integrating complementarities.
Value creation support	
Expert	Supports primary value creators by generating knowledge, consulting, and encouraging tech transfer.
Champion	Supports ecosystem construction by building alliances and providing access to nonlocal markets.
Entrepreneurial roles	
Entrepreneur	Starts new ventures, visioning, setting up focused networks, and coordinating R&D and commercialization.
Sponsor	Supports new venture creation by giving resources, financing, purchasing and co-developing the offerings, and networking.
Regulator	Supports entrepreneurial activity and opens avenues for ecosystem emergence through political reforms.

B. Different energy community types

ECs are potentially very diverse [1], [18], [19]. There is no single definition of an EC, but in this paper, we understand it broadly as locally and collectively organized energy systems encompassing different activities [18]. The European directive for Citizen Energy Communities includes activities of generation, distribution (incl. district heating (DH)), supply, consumption, aggregation, energy storage, electric vehicle charging, energy efficiency, and other energy services [5]. In this paper, we follow these activities and identify seven types of ECs where municipalities can play an important role. As a basis, we use energy cooperatives, models where citizens often jointly invest with municipalities and local businesses in RE production facilities. Energy cooperatives may also propose energy supply services, having to fulfill the cooperative principles. The municipality's role in EC cooperatives is introduced in the next sub-chapter.

Collective self-consumption brings together producers and consumers who are typically co-located in a multi-apartment building, collectively producing and self-consuming renewable electricity. In some cases, self-consumption happens behind-the-meter, but in some countries like France and Spain, it is done using the public grid in between. In virtual power plants (VPPs), an aggregator controls a cluster of dispersed generator units, controllable loads, and storage systems as a single entity. Community VPPs are governed by community members, but they can use third-party aggregators to participate in demand response markets. They are not tied to a single location, although this is more likely in the case of an EC form.[20] The community VPP provides flexibility to the system operators, which means that the community acts as a service provider rather than just a customer. Distribution is listed as one EC activity, and microgrids are a prominent way to implement it. They are similar to VPPs but have clear electrical boundaries and the ability to operate in both grid-connected and islanded mode. Unsurprisingly, islands are at the forefront of microgrids and are managing flexibility issues, making them good examples of ECs in the future. Similarly, industrial microgrids are mentioned in the directives as an option for ECs (possibility to create closed distribution networks). Energy efficiency measures refer to different services, like Energy Service Company (ESCo) services, energy audits, insulation, retrofits, etc., governed within an EC [18]. In the agriculture sector, ECs are seen as an opportunity to enhance local resource utilization and security of supply, e.g., via biomethane production.

C. Local governments' policy instruments for supporting energy communities

Several projects have created their own guidebooks and reports for local governments on how to support and participate in EC creation. [7]–[9], [21]. According to [21], municipalities have four distinct roles in ECs: (1) a sponsor role, involving providing endorsement and visibility, and limited financial aid; (2) a contractor role, entailing purchasing energy or contracting services for public buildings: (3) a co-owner role, participating as co-owners in local projects; or (4) a municipal utility role, involving developing EC projects under a public-private partnership, for example.

Thorough presentations of municipality's role in cooperatives were presented also in [6], [22], [23]. During the project development phase, municipalities can offer expertise by providing or funding feasibility studies [23]. They can provide networking opportunties and organize events and workshops. For financing, municipalities can provide capital, loans, guarantees or assistance in the application processes related to national or international applications [23]. In the context of urban planning, they can provide available space for production units, and accelerate planning and permit procedures. They also legitimize projects in different ways and solve conflicts. One-stop-shops are a popular way of helping projects; they can have a facilitative, informative or integrative, similar to ESCOs [21]. They can provide data on the best locations for RE, including land ownership and energy demand. One efficient way for local governments to promote ECs is to include them in public tenders [24] and purchase community power and heat (e.g., PPAs) [25]. During the production phase, they can garner support for local acceptance, and in the selling phase, buy energy and facilitate negotiations with the stakeholders [6]. Figure 1 overviews the municipalities' ecosystem roles in energy cooperatives.

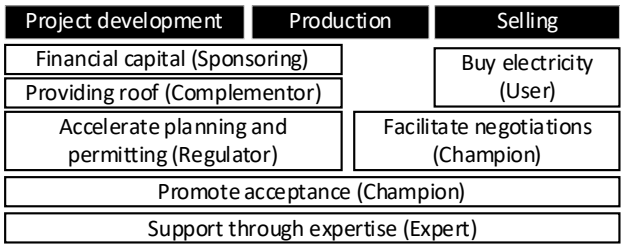

Fig. 1. Municipalities' ecosystem roles in cooperatives, modified from [22].

IV. Local governments' role in different Energy communities

A. Collective self-consumption

In Faverges, France, the municipality proposed land [complementor] for a 2,5 MW solar PV plant, which electricity is partially self-consumed by citizens. Additionally, a common tariff and advanced energy usage monitoring are included in the agreement [26]. The municipality also facilitated interactions with local citizens [champion] and co-developed an application to access energy data [expert].

B. District heating

In the context of DH, various models, including a cooperative model, can be applied. In Eeklo, Belgium [21], the municipality partnered with the EcoPower cooperative and infrastructure builder Veolia to construct and operate the DH network. The project initially started as a bottom-up movement, which the municipality capitalized on by establishing specific criteria. The DH network is part of the municipality's sustainable energy action plans (SEAP) [regulation]. Given that it relies on using waste heat, transparency on costs and benefits is crucial. The municipality enlisted an energy expert from the cooperative for planning purposes and engaged citizens in the development of a long-term heat plan, adopted by the council in 2020. The municipality initiated a tender for the concession to construct a DH network, serving, e.g., factories, offices, and a hospital [regulation]. This concession granted the consortium an exclusive right to use the public domain but included specific conditions, such as the requirement for over 30% citizen participation, market conformity heat price, commitment to energy efficiency, and future 100% RE use in the DH network [27]. Together, these requirements opened a floor for the chosen consortium. The municipality also committed to purchasing a portion of the heat produced [user].

C. Island communities

Samsø in Denmark is transforming into a carbon neutral island, thanks to community-invested wind turbines and biomass-fueled DH plants. The municipality set its first RE-island targets already in 1997 when it entered a competition for pioneering energy islands [regulator]. The municipality received funding for an energy plan that would shape the island's future by establishing the climate ambitions [sponsor]. Later, Samsø launched the Samsø Energy Company, its own office for energy and environmental issues (SEEO), and a municipal offshore wind company [ecosystem gov.]. The SEEO office actively mobilized people for CE investments through public meetings and information campaigns [expert], and it secured funding for households' energy investments [28]. The municipality also provided loan guarantees for constructing the power plants [sponsor]. The entire cooperative structure was organized and coordinated by the SEEO with a dedicated energy expert who had good connections to regional planners and other stakeholders [forging partnerships].[28]

Overall, Samsø has leveraged RE as a source of competitive advantage in its economy, including tourism, food production, and startup businesses [champion]. Samsø municipality actively participates in several climate networks with a focus on knowledge transfer and high climate ambition [expert]. [29] Also, the municipality initiated an Energy Academy to share its community-based success story.

D. Industrial microgrid

In Finland, a mid-sized municipality in the southern region and its utility initiated a project for building a self-sufficient microgrid for a new commercial/industrial district. The municipality pushed the project in many ways. It assisted in the funding process of a national grant [expert], provided a loan guarantee for the project [sponsor], and increased its visibility [champion]. The municipal council approved the creation of a new entity responsible for managing and operating the microgrid [ecosystem gov.]. The microgrid members are actively involved in its operation by sharing excess heat through the microgrid operator's coordination [ecosystem gov.].[30] During the operational phase, this operator brought the local energy assets together, established the tariffs and rules for the microgrid [value mgmt], and implemented them through a platform provided by a third-party service provider. The municipal entrepreneurship office managed the sales of plots in the area for the companies [complementor], and the operator assisted to identify complementary actors with suitable load profiles [forging partnerships]. The municipality is also constructing a swimming pool in the area, making it a user of the microgrid [user].

E. *Community-based virtual power plant*

In Loenen, the Netherlands, the rural village has a long-standing tradition of supporting clean energy projects, especially after winning €200,000 in a regional "Energetic Villages" competition. They have set a target of becoming energy self-supporting [regulation]. The village initiated a fund that invests in local insulation, solar PV, and heat pump projects [sponsor]. Additionally, the community initiated a cooperative in which citizens can become co-owners and use it for local energy management, capable of, e.g., controlling heat pumps [platform mgmt].[31]

F. *Energy efficiency*

Energy efficiency programs often face the challenge of securing funding. To address this challenge, the city of Bristol intends to issue community municipal bonds through a crowdfunding platform [platform mgmt.]. According to the plan, the platform will encompass many energy efficiency projects of the community buildings. The city council audits these buildings' energy usage to get the precise specifications for the energy efficiency projects [champion] [32].

G. *Biomethane production*

In the municipality of Aoste, France, the local government is engaging in EC formation due to the political will in the region to develop the local biogas sector [regulation]. The municipality plays a key role in facilitating coordination among various actors [champion] and providing a portion of the organic waste used in the process [supplier]. The produced biogas is injected in the gas network and the digest produced in the process will replace fossil fertilizers. [33]

V. Discussion and Conclusions

In the preparation phase, the most common roles for local governments were the regulator role, but the expert, champion, and sponsor roles were also common. The regulator role included the establishment of relevant sustainability targets, which indirectly support ECs. In the formation phase, local governments were less active but took an active role in the ecosystem leadership in the microgrid and DH cases. During the operation phase, the role shifted towards user and value support roles. The microgrid cases also included ecosystem leadership roles.

Compared to previous literature, this study adds both a strategic perspective and granularity to the local governments' roles in different ECs [7], [8], [21]. Compared to the usual energy cooperative cases ("coop" in Table 2), which mainly revolved around value creation support, sponsoring, or accelerating planning and permitting processes, the microgrid cases showed that the local governments could also play an ecosystem leadership role. Also, the roles as platform initiators in the VPP and energy efficiency cases provide examples of further possibilities. In brief, local government can either use cooperatives or other platforms as a vehicle for their targets through leader roles or support existing cooperatives through supportive roles.

Table 2 below provides a graphical summary of the results from this study. In general, findings indicate the bottlenecks that constrain EC diffusion. Financing can be a bottleneck, especially when EC models are less familiar by banks. This was addressed in many cases through loans or guarantees. Bureaucratic issues and marketing can also present major challenges in the projects. In the case of microgrid projects, the involvement of numerous stakeholders involved adds complexity. As a result, the local public entities play a relatively strong role in coordinating and integrating these diverse actors. It's worth noting that playing such a facilitator role may be challenging, as the business model for such facilitation is somewhat unclear.

TABLE 2 CASE STUDY RESULTS IN THE FRAMEWORK BY [12]

	Preparation	Formation	Operation
Leadership			
Ecosystem governance	decipher roles MG Isla	coordinate interactions MG Isla	orchestrate resource flows MG
Forging partnerships	attract & link parters	create collaboration Isla DH	stimulate complementarity MG Isla
Platform management	build platform VPP EE	open platform	orchestrate complementors
Value management		decipher bases of value	create & capture value MG
Dominator			integrate actors
Direct value creation			
Supplier			supply components Bio
Assembler			assemble components
Complementor	Coop SC	MG	provide complementarities MG
User	define need	provide ideas	purchase and use Coop MG DH
Value creation support			
Expert	generate knowledge Coop Isla EE MG	provide expertise Coop SC	transfer technology Coop Isla
Champion	Coop Bio MG SC	build connections Coop	provide access to markets Isla Coop
Entrepreneurial roles			
Entrepreneur	co-locate	set-up network	
Sponsor	give resources Coop Isla VPP MG	co-developing offering	link to other actors
Regulator	provide favourable cond. Coop Isla Bio VPP DH	DH	DH

The more stakeholders are involved, the more emphasis is given to value management. In the EC context, these issues have been discussed previously from the commons perspective, as presented by Ostrom [34]. Ecosystem frameworks for value appropriation can complement these theories. A local government as a trusted, long-term entity could help mitigate risks and promote complementarity, either through bilateral agreements or platforms with common rules, or both. In the industrial microgrid case, the municipality invested in the infrastructure, allowing it to attract complementary actors to the area. Additionally as a user, a publicly owned entity offers a flexible and complementary load for the EC. Aside from the microgrid case, the DH service aims to utilize excess heat but has a challenge of differing interests of heat consumers, producers, and the network operator [27]. An EC structure with high transparency on costs and profits is considered as a potential solution to this dilemma.

Overall, this work demonstrates that the ecosystem roles presented in [12] share many similarities in the EC context. However, certain specificities of the EC context make them different from other ecosystems. The non-profit nature of ECs sets them apart from many other ecosystems, especially from the perspective of the ecosystem leaders, who act from the business perspective and drive environmental and social values (e.g., voluntariness, community logic, equality). ECs are often closely tied to existing and new infrastructure, distinguishing them from digital ecosystems. Also, the traditional nature of energy networks as natural monopolies imposes an additional constraint on ecosystem creation, as the power is not equally balanced between incumbents and new entrants.

It is worth noting that having just one case per EC type naturally presents limitations, as well as relying solely on secondary data sources. Furthermore, some of the projects have not yet entered the operational phase, and project lifecycles cannot be analyzed consistently for all cases.

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