A Conceptual Framework to Address Collective Energy Initiatives' Spatial Impacts at the City Level: An Ongoing Attempt

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Abstract. Energy is vital in sustaining human life and fostering development, yet the energy sector's significant contributions to greenhouse gas emissions and climate change necessitate transformative changes, commonly addressed as an energy transition.

As major energy consumers and greenhouse gas emitters, cities play a pivotal role in such transition. Urban plans and policy mechanisms offer a means to regulate urban processes and practices, influencing energy demand and emissions patterns; however, transformation processes also involve phenomena that extend beyond the confines of urban planning practices, for instance, collective actions.

Collective Energy Initiatives (CEIs) represent an emerging transformative social movement fostering the transition toward decentralized renewable energy production and consumption. The implementation of renewable energy technologies introduces spatial challenges, such as land competition and conflicting land uses, suggesting that CEIs practices may have spatial repercussions in urban areas. Yet, there is a lack of scholarly interest in the spatial impacts of CEIs.

This contribution presents early findings from an ongoing literature review aimed at identifying methodological approaches to study the spatial impacts of CEIs. Drawing upon existing publications on CEIs, a conceptual framework is formulated to stimulate new trajectories in understanding the complex interplay between energy transitions, collective actions, and their spatial implications. The resulting integrative framework highlights the multifaceted nature of CEI impacts and emphasizes the importance of a nuanced understanding of both internal dynamics and external contexts to effectively address spatial concerns at the city level.

Keywords: Urban Energy Transition · Urban Planning · Community Energy Initiatives

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1 Introduction

Energy is vital for the life and development of humankind [1–3], yet the energy sector has a great impact on GHG emissions and climate change [4]. To mitigate the energy sector's impacts and, at the same time, adapt to climate change pressures, a substantial change in the energy systems is necessary [4].

Energy systems are historically addressed as techno-economic frameworks defined by the energy flows and the technical activities required to collect energy sources and supply consumers energy demand [5]. More recently, energy systems are also understood as complex socio-technical-economic configurations [6, 7, 10, 11] resulting from the decisions and actions of a variety of agents [12] deeply influenced by cultural values, social norms and identity, traditions, common visions, and imaginaries [6–9, 12, 13].

Changes in the energy system are commonly addressed as an energy transition [5, 9, 14, 15]. As energy systems are (re)shaped by individual actors and institutions' choices, which are rooted in a broad fan of cultural values and social norms, the current energy transition goes beyond swapping technologies and fuels. Energy transition also requires a shift in cultural paradigm among agents who finance, create, and use those technologies and fuels as well as a change in their role within the energy system itself.

Traditionally, cities were merely considered the end point of the energy supply chain [16]. Being the main energy consumers and GHG emitters [17], cities are now perceived as a crucial instrument to maintaining the global average temperature increase within 2 to 2.4 °C above pre-industrial levels [16, 18–20]. Through the exercise of urban policies and plans (for instance, in Europe there are the SECAP, the Climate City Contract, and the Carbon Neutral Cities Alliance) cities can govern urban processes and practices to reach climate neutrality, however urban environments are also historically profoundly influenced by phenomena out of urban planning control.

The different forms of social energy mobilization and cooperation that are currently emerging at the local level [21–24] represent an example of these phenomena. Citizens acting in their personal capacity (e.g., leaders, consumers, voters), professional capacity (e.g., town planners, builders, teachers, investors), or collective capacity (e.g., the youth climate movement) are actively participating in the current energy transition [25]. The activities span from people becoming active consumers and producers, i.e. prosumers [26], to the more complex forms of collective prosumerism such as collective self-consumption multi-tenancy buildings [26], energy neighborhoods and districts [27, 28], and energy communities [29]. In this contribution, the umbrella term collective energy initiatives (CEIs) is used to consider all collective initiatives of prosumers.

The movement of CEIs is already playing an important role in the evolving energy landscape [30], bringing real change between society and energy [31] through spurring collaborations, mobilizing resources, developing context-specific technological mixes and governance structures, and influencing public consensus [19, 32]. CEIs have also gained increasing prominence in scientific literature over the past two decades [33, 34], and various terms have emerged referring to these initiatives (e.g., civic renewable energy, grassroots energy initiatives, civic energy initiatives, cooperative energy initiatives, local energy initiatives, local energy communities, renewable energy communities, community energy initiatives, community energy) [19, 26, 35–41]. The European context itself is witnessing a clear proliferation of these initiative: Wierling et al. (2023) identified

over 10,000 citizen-led energy initiatives across 29 European countries, while the European Federation of Renewable Energy Cooperatives (REScoop) counts 701 member cooperatives and about 1 500 000 citizens involved [42].

Their growth and number imply that CEIs can even be seen as a "transformative social movement" [43] that is upholding decentralized renewable energy production and consumption spurring the transition towards an electrified energy model. Nevertheless, the implementation of wind turbines, solar panels, sun boilers, thermal, and biogas systems needed to meet energy demands may require more land compared to fossil fuels-based technologies [44–46], exacerbating the global competition for land [47]. In the United States, for instance, the realization of renewable projects has already become one of the primary causes of change in land use [48]. Certainly, in urban areas physical space is both scarce and contested, urging for a proper understanding of where, how, and why it is changing.

In a recent investigation focusing on scenarios of solar penetration levels, Van de Ven et al. (2021) identified that the expansion of solar energy may primarily come to replace existing land use for commercial activities, including croplands or commercial forests utilized for timber products or biomass. According to the simulated solar penetration levels, for every 100 hectares of solar land in Europe, the extent of unmanaged forest clearance across the globe may range from 31 to 43 hectares. Whereas certain renewable energy sources may be considered inexhaustible, the land is limited [49]. Although the production of some renewable energies can be co-located with other land activities, such as installing solar panels on urban rooftops or integrating wind and solar infrastructure with agricultural land [45], the decarbonization process may lead to a series of conflicts [45, 46, 50]. The competition for land, arising from renewable energy projects, may result in conflicts with alternative land-use purposes such as agriculture, residential, commercial, and natural areas [46, 47, 50]. Additionally, conflicts may emerge among the pre-existing land uses in areas designated for renewable energy installations [45]. Concerns about property values also arise: the integration of renewable energy technologies on buildings may enhance their image and marketability [51] whereas, alternatively, the installation on land might lead to a depreciation of neighboring property values [45]. It is therefore reasonable to suppose that CEIs' practices may have spatial repercussions in our cities, although it's likely that the impacts vary depending on the specific type of initiative. Nevertheless, so far scholarly interest in the overall impacts of collective energy initiatives has been limited [52].

A question therefore naturally arises: spurring the upholding of renewable energies, how do CEIs impact at the city level from a spatial point of view?

This contribution presents early findings from an ongoing literature review aimed at identifying methodological approaches to study the spatial impacts of CEIs. Building on the existing work on the CEIs, the research develops an integrative conceptual framework, seeking to stimulate novel trajectories in understanding the complex interplay between energy transitions, collective actions, and their spatial implications.

2 Methodology

Because of the nature of the research question, the initial focus of the review regarded the strand of literature related to the impacts of collective energy initiatives (CEIs). The search process involved the selection and use of keywords (e.g., "energy initiative*" AND "impact*", "energy community*" AND "impact*", "energy project*" AND "impact*") within databases such as Scopus, Web of Science, and Google Scholar, and largely employed the snowballing technique[1] [53], encompassing both scientific and grey literature. The inclusion criteria did not have any time restriction. As the review progressed, it brought forth interconnected aspects that enriched the contextual understanding of the primary research subject. Consequently, supplementary thematic dimensions were incorporated.

The search has thus far yielded 39 publications, including 25 peer-reviewed articles, 5 review articles, 1 conference paper, 4 scientific reports, 1 policy brief, 1 Ph.D. thesis, and 2 master theses. The studies were subjected to thematic analysis and categorized based on the emergent themes.

To streamline the synthesis of ideas and promote innovative perspectives, an integrative review approach, as elucidated by Snyder (2019), is adopted [54]. The application of this approach to the emergent realm of CEIs does not seek to encompass the entirety of literature ever published on the subject. Rather, its objectives are (1) to draw a deductive conceptual framework combining different perspectives and (2) to provide a critical analysis of the literature [54, 55]. This contribution offers a preliminary version of the conceptual framework.

3 The Literature Review

The present contribution reviews 39 publications published between 2008 and 2023. The publications encompass a broad range of disciplines, spanning research areas from urban and social sciences to environmental and energy ones.

Five thematic dimensions were defined, and some publications cover more than one (Table 1). These dimensions are (1) CEIs' impacts; (2) CEIs' actors' participation; (3) CEIs' motives and ambitions; (4) CEIs' professionalization; and (5) CEIs' external context.

The analysis of CEIs' impacts included a total of 17 publications and revealed a widespread assumption among academia and policymakers that these initiatives have a vast array of impacts in advancing local energy transition [29, 32, 56–58]. Besides generating renewable energy [52], such impacts generally encompass social, environmental, and economic aspects. Literature reflects on many impacts, such as enhanced social cohesion, new job opportunities, acquisition of knowledge and skills [32, 57, 59, 60], reducing energy (fuel) poverty [61, 62], generating revenues from renewable energy systems [57], providing access to affordable energy [32, 57], increasing local support for renewable energy [32], enhancing communities' empowerment and involvement in the energy sector [19, 32, 63], reducing carbon emissions [64], impacts on social equity

[1] The "snowball sampling" method is a literature review approach that, starting from a set of articles, utilizes their citations to identify additional literature on the same topic [53].

Table 1. Thematic dimensions identified during the literature review process and included publications.

Dimension	Number of publications	Literature references
CEIs' impacts	17	19, 30, 33, 53, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 73
CEIs' actors' participation	11	19, 59, 70, 71, 72, 73, 69, 74, 75, 77, 76
CEIs' motives and ambitions	8	34, 53, 71,73, 77, 78, 79, 80
CEIs' professionalization	9	22, 78, 79, 81, 82, 83, 84, 85, 87
CEIs' external context	16	22, 30, 34, 65, 70, 73, 76, 77, 78, 79, 80, 81, 87, 88, 89, 90

[62], visual impacts [57], and impacts on the existent electricity and heating system [65, 66]. However, one category goes overlooked: the spatial one.

Over the last decade, numerous studies have been highlighting strikingly insufficient empirical evidence of the impacts of CEIs and call for further research to develop formalized impact assessments, systemic and evaluative frameworks that consider the holistic nature of the energy transition, longitudinal studies, statistical analysis, and (quasi-) experimental designs [19, 32, 52, 57, 59–61, 63, 66]. These studies also offer alternative and interesting lenses. In their research, Germes et al. (2021) advocate an approach that considers the motives, objectives, and ambitions of the initiatives to comprehend and assess their impacts, thereby analyzing the specific impacts the initiatives themselves aspire to achieve [52]. This approach stems from the conceptualization put forth by Hasanov (2022), who delved into Dutch local energy initiatives (LECs) employing an "inside-out" perspective, encompassing an examination of both the internal dynamics of community initiatives and their external factors [67]. These studies have also contributed to the literature by illustrating that CEIs differ greatly from one another, both in their motives and outreach, and in organizational aspects such as size, internal structure, and professionalization.

The analysis of the actors' participation in CEIs covered a total of 11 publications. Besides discussing the capacity of CEIs to offer a vast array of social benefits and services, such as enhancing communities' empowerment and involvement in the energy sector [19; 30; 33; 64; 69] and helping mitigating energy poverty [30; 62; 63; 69], the publications reflect on the societal groups and actors involved in the initiatives [58, 68–72], the roles they can play in a CEI [72], and how they participate [73, 74]. However, it is worth mentioning that there is limited empirical proof supporting the efficacy of collective energy initiatives in engaging underrepresented and vulnerable communities and addressing energy poverty [68, 75].

For the analysis of CEIs' motives and ambitions 8 publications were examined. Some research works focus on the key reasons that spur the development of energy initiatives, namely the starting motives [52, 76, 77], whereas others on the ambitions and the objectives [34; 53, 79, 80]. In both cases categorizations are proposed. For instance, the study by Germes, Wiekens, Horlings (2021), the most recent of the five publications

analyzed, firstly focused on the starting motives of Dutch local energy initiatives and subsequently noticed that in most cases motives were comparable with the objectives of the initiative [52]. Therefore, they delineated three main categories of local energy initiative's objectives: environmental (e.g., preserve environment, conserve, and produce energy, become independent of natural gas, etc.), economic (e.g., save money, strengthen local economy, generate income from local community), and social (e.g., increase social cohesion and awareness, take collective action).

The analysis of CEIs' professionalization included a total of 9 publications. Professionalization is recognized as one of the main success factors of collective energy initiatives [80]. Literature showcases various approaches in which energy initiatives are getting professionalized, together with some positive impacts and flipsides of the professionalization processes. For instance, Oteman et al. (2017) discuss the recruitment of professionals as permanent staff instead of relying on volunteers, along with collaboration with other initiatives [78]. Differently, Ahlemeyer, Griese, Wawer & Siebenhüner (2022) associate an initiative's professionalization with the level and difference of qualifications of its board members, linking it to the broader concepts of technical and economic professionalization [80]. Nevertheless, professionalization and its impacts are often poorly documented, making it challenging to develop a comprehensive framework [22, 77, 79–84].

For the analysis of CEIs' external context 16 publications were covered. Works explore different external contextual factors that may influence CEIs' development and some of them offer categorizations and definitions. A notable example is the study by Hicks & Ison (2018), which addresses four categories of the aforementioned factors [76].

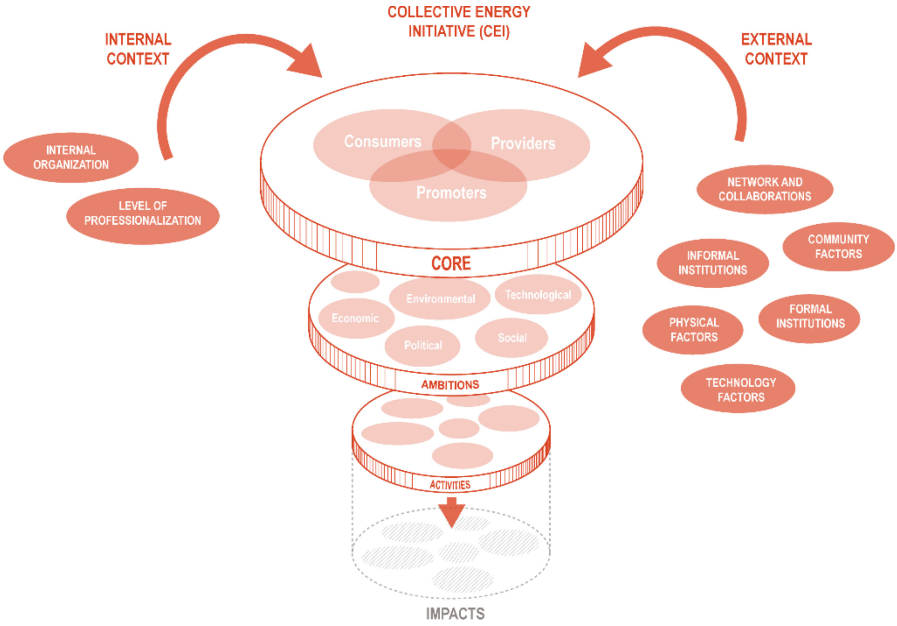

Fig. 1. The conceptual framework (Source: Authors own elaboration, adapted from [76]).

Institutional factors are a key factor, including both informal aspects (e.g. the culture within existing energy and other relevant institutions) and formal aspects (e.g. structure of the energy market, regulatory environment, laws governing legal structures, renewable energy policies). Community factors refer to aspects such as local history and culture, relationships or social capital, and skills and knowledge available, social perceptions of and appetite for certain technologies. Physical factors include topography, renewable resource availability, and existing energy infrastructure, whereas technology factors, are related the cost of different renewable energy technologies, the maturity and modularity of the technology, the energy needs and demand profile of the community/building). The authors conclude that whereas physical and technological contextual factors may be similar across different initiatives, the institutional and community factors are far more complex and nuanced.

The Integrative Conceptual Framework

Developing a framework for analyzing how the spatial impacts of collective energy initiatives (CEIs) take place first needs to acknowledge that CEIs themselves are complex systems[2] whose impacts are deeply influenced by multiple dimensions (Fig. 1).

CEIs have at their heart society [33]. Based on the collective action model, CEIs can involve a diverse array of actors, encompassing professionals, consumer cooperatives, academics, non-governmental organizations (NGOs), local authorities, national government, development firms, energy companies, financial institutions, and more [58, 68–72]. The actors involved (also called "members" or "project participants") assume different roles. According to Gjorgievski, Cundeva, and Georghiou (2021), three main roles can be identified: the initiators/promoters, the energy providers/practitioners, and the consumers [72].

Personal motives drive initiators to begin collective energy initiatives and people to join them and may span from financial (e.g., electricity cost reduction or investment opportunities) and environmental (e.g., lowering one's environmental footprint), to social (e.g., being part of a community, a movement addressing climate change), technological (e.g. engaging with new technologies), energy independence/security motives (e.g., independence from large power companies, contributing to energy security) [76, 77]. Studies have highlighted that, despite joining the same CEI, different stakeholders [70], as well as single individuals, may have different motivations and ambitions [52, 67].

Based on the motives, initiatives formulate joint ambitions (Fig. 1) [52] which, mirroring the heterogeneity of the motivations, may be only focused on energy, or embrace a wide range of topics, including political (e.g., community empowerment, influencing sustainability/energy policy, community leadership) and infrastructural ones (e.g., improving energy independence, community building refurbishment) [33, 52, 78, 79]. The ambitions are then translated into the implementation of an initiative's projects and activities [72], which generates impacts. In other words, impacts are the manifestation of different types of projects and activities, which are brought to existence by motives and objectives [52, 76].

Nevertheless, the path from motivations to the progression of activities is not linear; rather, it is shaped by both internal and external contexts. Being collective actions,

[2] A "complex system" can be defined as a "human-built world" that is beyond the comprehension of single disciplines and requires continuous interdisciplinary cooperation [85].

the effectiveness of CEIs heavily depends on civic participation and engagement [74]. However, as stated by Ison (2010), the level of internal participation and engagement is deeply shaped by the internal governance structure of the initiative, which may be hierarchical, a majority voting system, or based on a consensus approach [73].

The success, alias the impacts, of a CEI also deeply depends on its level of professionalization [80, 86]. Professionalization pathways encompass diverse trajectories, including the transition from volunteerism to remunerated employment, engagement with external consultants, and establishment of a well-organized internal structure [22, 77, 78, 80–84]. Higher levels of professionalization can help initiatives in better-attracting finances, customers, and members or in better supporting the members of the board [80]. Similarly, professionalization helps initiatives in managing increasing complexity following e.g., the augmentation of the projects, of the number of members, or of the services provided [80, 81, 83, 84]. Finally, professionalization may also enable the initiatives to play a greater role within the energy transition process [80]. It is through professionalization that collective energy initiatives can grow and take over utility services [22], which have been able to structure and optimize themselves over the past decades and now are not willing to see their investments deprecated. However, once they start professionalizing, initiatives can run the risk of "alienating their grassroots community" and losing the engagement of volunteers [77], they can "drift away" from initial ambitions, goals, and community's interests [77], or lose social credibility [80].

CEIs are deeply intertwined within their external context [67], which critically influences their development and their impacts [67, 72, 76, 87–89]. Firstly, the socio-cultural context may provide support in terms of knowledge, partnerships, or practical services. The professionalization of an initiative, for instance, deeply benefits from collaborations and networks. Local governments, organizations, businesses, and residents can assume significant roles as supporters, members, or also partners of an initiative [22]. Networks across various territorial levels also constitute a crucial element that supports the initiatives by facilitating valuable knowledge exchange [22; 34, 87]. An example at the European level is the REScoop organization, which promotes collaboration amongst European cooperatives, supports start-ups, and provides a vast array of services (e.g., community coaching, training sessions, financing services, advocacy services, etc.) [42]. The absence of support from the community or a constrained network can pose significant challenges to the cooperative's development [22], for instance in terms of limited community participation, limited expertise, and limited access to funds. It is reasonable to suppose that the higher the level of professionalization and size of an initiative, the more significant its impact becomes in the urban transformation process and the transition towards a more sustainable urban energy system.

The emergence and formation of community energy projects are also shaped by cooperative tradition and values, socially shared roles, and a strong sense of local responsibility, which have been proven to have influenced the willingness of citizens to start or join an initiative, and to have shaped cooperatives' decisions in terms of organizational form, and energy plant site and scale, helping better understand why certain regions display a higher density of community energy projects than others [87]. Alongside policies, laws, feed-in regulations, rules for grid connection, or tax incentives, energy market are factors conducive to the emergence of community energy projects [33, 76, 80, 87]. For

instance, a policy framework that tends to focus on renewable technology and finance elements and lacks to support the value and quality of community engagement may constrain the development of some CEIs [76], as well as the delays (and instability) of the legal frameworks to recognize these new forms of energy production [77].

Moreover, as highlighted by Leone et al. (2023) in their work on Positive Energy Districts' projects, strong influences may also come from the existent energy infrastructure, but also by the urban fabric on which the project intervenes, the architectural-landscape constraints, the final function of the district (e.g., residential, commercial, mixed, etc.), the geographic and climatic characteristics, the availability of renewable energy resources and technologies, and the socio-economic fabric [89].

4 Conclusions

Recognizing the spatial impacts of Collective Energy Initiatives (CEIs) is a critical step towards effectively addressing spatial concerns related to the urban energy transition. Nevertheless, the literature review revealed a lack of comprehensive insights into the analysis of CEIs' impacts [52] and a notable absence of references to their spatial dimensions.

With the aim of better comprehending how to address the study of CEIs' spatial impacts, the present study reviewed published works on different types of CEIs and applied a holistic approach to analyze them.

Existing research on CEIs tends to focus on specific configurations and delves into sectoral analysis. An example is Oteman, Kooij, Wiering (2017) who studied the development of Dutch grassroot energy initiatives and their local and national network connections [78]. In contrast, Ison (2010) examined the governance of community projects within the UK Community Carbon Network [73]. Besides focusing on specific aspects, some studies may include brief references to other topics. The publications related to the professionalization dimension are a demonstration of this: most studies do not directly address it but offer some reflections.

However, this focus on individual sectors can hinder a broader understanding of CEIs as a whole. By analyzing studies on PEDs [89], energy cooperatives [79, 80, 82], the so-called local energy initiatives [52, 83, 84], energy communities [68, 81], community energy projects [73, 74] among others, and by distilling and categorizing the information contained in the publications, the present contribution "connects the dots" and captures the interrelations among the various aspects that characterize and affect a CEI, showing that CEIs' spatial impacts are intricately shaped by a multitude of both internal and external factors.

The resulting conceptual framework (Fig. 1) depicts the complex nature of CEIs' spatial impacts, emphasizing the importance of a nuanced understanding of CEIs to effectively address the impacts that they have at the city level.

The relevance of the study is therefore twofold. First, it considers sectorial studies on different types of CEIs. Second, by applying a holistic approach to the sectoral studies reviewed, it builds an integrated conceptual framework that facilitates the visualization of the multiple dimensions involved in CEIs' development and their interconnectedness.

Researchers, practitioners, and urban planners can already benefit from this preliminary version of the framework to gain a "bird's eye view" on a key topic in the global

energy transition scenario. Moreover, the conceptualization lays the groundwork for further research to explore how and why CEIs generate spatial impacts.

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