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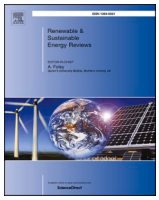

A transition perspective on Energy Communities: A systematic literature review and research agenda

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ABSTRACT

The advantages of Energy Communities (ECs) range from giving energy end-consumers an active role in the energy market to the increase of renewable energy sources and increased efficiency. Yet, the emergence of ECs is not taking place across countries and regions at the same scale or speed. Reasons for this were studied but remain fragmented, as a comprehensive overview of these studies is missing. This study aims to identify the studied factors for the emergence of ECs. We used the Multi-Level Perspective as a framework to structure EC literature. Therefore, a systematic literature review was conducted to identify the gaps. The review consists of a 1) bibliometric analysis, 2) content analysis, 3) geographic analysis. Building on this overview, the authors highlight the current research gap and propose potential pathways for future research to facilitate the diffusion of ECs. It was found that although ECs are studied context-specific, generic factors have contributed to the emergence of ECs independently from their location, such as appropriate policy schemes and support for practitioners. Factors, such as the geographies of the transition, and cognitive-cultural factors remain less studied.

1. Introduction

Initiatives for collective energy self-consumption and community energy are emerging across the globe [1]. The phenomenon has given rise to a wide field of study causing numerous terms, such as “community (renewable) energy”, “energy sustainable communities”, “integrated community energy systems”, or “renewable energy clusters”, which are describing similar concepts. Bauwens et al. [2] have identified and analyzed 183 of such concepts. Along the emergence of initiatives, new regulatory frameworks for their implementation are evolving. An example for such a framework are Energy Communities (ECs) that were defined by the European Commission as legal entities that take part at any stage of the energy supply chain building on voluntary participation of their members or shareholders for mainly environmental or social reasons [3,4].

Because of the diversity of the conceptualizations, the factors contributing to the transition towards ECs have been studied from different standpoints and with different foci. For example, Wolsink [5] focused on the aspect of social acceptance of smart grids as a common pool resource and how it is shaped by various factors, also Walker et al. [6] studied aspects of trust for community renewable energy and sense of community and their effects, while Wirth [7] contributes to the understanding of institutional preconditions for the development of community renewable energy. Most of the existing case studies have a certain geographic focus and draw caution to the limited applicability of their conclusions to other contexts (e.g. Refs. [8–10]). Although the authors can identify common facilitating and hindering factors in literature that affect the development of ECs across different scales (time, location), this fragmentation is limiting replicable and common conclusions to deeper understand the transition towards ECs. Brummer [11] and Berka et al. [12] have written comparative reviews on facilitating and hindering factors on the emergence of ECs but their geographic scope and number of compared initiatives remain limited. They are exemplary for previous literature reviews on the emergence of ECs that usually follow one single definition (e.g., community energy [11]), study single factors (e.g., institutional preconditions [12]), and address a limited number of case studies, regions, and/or countries (e.g., Samsø Island [13]).

In contrast, this literature review aims to provide an overview on the transition dynamics towards ECs with a global perspective building on findings that encompass different understandings of ECs.

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List of abbreviations

EC	Energy Community
MLP	Multi-Level Perspective
RES	Renewable energy source
R&D	Research and Development

To display the transition developments affecting ECs, the authors chose to apply the Multi-Level Perspective (MLP).

The authors followed the research question: What are the studied factors that influence the transition towards ECs? To answer this question, the authors followed a three-step approach; the first step was to compile an overview of the key research foci under which factors for the emergence of ECs were studied, then, in step 2, a detailed overview of the studied factors is given, and in the third step a transition perspective is developed based on step 2. For step 1, a systematic literature research was conducted applying a bibliographic coupling analysis to explore the major research branches on the topic. Then, for step 2, the authors conducted a qualitative content analysis. The authors apply the transition framework called MLP [14] on the factors to understand the transition dynamics of the studied factors, add a geographic overview to the analyzed studies, and see which factors have been studied the most and least. As ECs are socio-technical developments that are considered to bring a paradigm shift from a monopolized to a small scale and co-owned energy system, the MLP is a suitable tool to analyze the emergence of ECs. The MLP conceptualizes and facilitates the understanding of transition dynamics of different nature (e.g., social, technical, historical), and has also been applied to the energy transition in various studies [15,16].

Building this MLP on ECs, the objective is to provide researchers, policymakers as well as practitioners with a holistic overview of the factors influencing the transition to ECs which can help to facilitate its further upscaling and diffusion. Further, the authors highlight the factors that are understudied and provide a research agenda.

2. Studying the emergence of Energy Communities

2.1. What are energy communities?

Although building on different social and socio-technical concepts, ECs are the results of a transition process from a more centralized energy system, towards a more decentralized and democratized one. ECs are also considered a potential mean to achieve a more just and inclusive energy transition by enabling citizens to have a vote and share in the local energy system [17].

Bauwens et al. [2] have analyzed 183 concepts surrounding community energy researching their meanings, activities, and objectives. They concluded that these concepts cannot be deconstructed to one clear, overarching definition which makes it necessary to explain the different concepts surrounding ECs.

Walker & Devine-Wright [18] have studied the diversity of understandings, especially among policymakers, around the term of "community renewable energy". They found that the prime example for "community renewable energy" is implemented in an open and participatory way (process aspect) aiming at a specific output, e.g., increase of renewable energy, for the local collective (output aspect). The initiatives they have analyzed were often labelled as "community renewable energy" although fulfilling either the process or output aspect. "Energy sustainable communities" as studied by Schweizer-Ries [19], addressed the topic from a socio-technical system perspective taking into consideration the connection and interplay of technological and social aspects surrounding community renewable energy (considering different types of energy such as electricity, heat and different forms of usage, such as consumption, and for mobility). Building on that, the definition by Koirala et al. [20] of "integrated community energy systems" further developed the different conceptualization and define them as "locally and collectively organized energy systems […] capable of effectively integrating energy systems through a variety of local generation of heat and electricity, flexible demand as well as energy storage" (p. 724).

The more recent conceptualization of "renewable energy cluster" by Lowitzsch et al. [21] advances the term of "integrated community energy systems" and directly addresses the European definition of ECs as a "renewable energy cluster". They define ECs as socio-technical systems characterized by the complementarity of different energy sources, flexibility, interconnectivity of different actors and bidirectionality of energy flows. When using the term of EC, the authors align with their definition as an example of a "renewable energy cluster" but applying it beyond the borders of the EU and taking the process/output aspect as a criterion.

Fig. 1 shows the criteria to decide what to consider an EC.

2.2. The Multi-Level Perspective

Because the MLP is widely applied for the analysis of socio-technical transitions for sustainability [14,22], the authors chose to use it as a framework for the analysis the transition dynamics affecting the emergence of ECs. The MLP is an analytic and heuristic approach to understand different aspects of sustainability transitions in a simplified manner. The MLP differentiates between three main levels of analysis, namely the landscape, socio-technical regimes and the niche level [14].

The landscape level consists of slow-changing socio-technical structures composing the wider environment (material, spatial, cultural conditions) in which transitions take place. The landscape cannot be actively changed by actors within the system, but it adapts slowly according to developments and triggers (e.g., the climate, finance, or COVID crisis) and it influences socio-technical and niche level. The socio-technical regimes describe common practices and rules (e.g., cognitive, normative, formal, and regulative rules) across and within different sectors and socio-institutional networks (technological, policy, science, socio-cultural, market regimes) [23]. On the niche level, considered to be shielded and protected from the market selection of the socio-technical regimes, innovations emerge. They also provide a space for experimentation and learning. Over time, niche developments can move from experimentation, stabilization, diffusion to institutionalization, but the success of niche developments to achieve radical and structural change on the regime and landscape level is highly uncertain.

Niche developments, socio-technical regimes, and socio-technical landscapes differ in their degree of rigidness to change. While niche developments are the most dynamic level and most uncertain in their development, the socio-technical regime level is more averse to change. The landscape level is the most rigid level in its structures and opportunities for change. Yet, there are dynamics among all the three levels, the landscape influences the regime and niche level and vice versa [14].

While the MLP is a common approach to analyze socio-technical transitions, it has also been subject to criticism. The main critics address the underrepresented importance of politics and power, culturally dependent discourse and framing of problems (e.g., climate change), the local embeddedness of grassroot innovations, the uncertainty of transition pathways, the steering of transitions, incumbents, and decline of dominant socio-technical regimes [24]. Further, a stronger focus on the geographies of transitions, so analyzing how and why transitions are the same or differ across different places in terms of their development and scales, is evolving [25].

Whereas most research has focused on how transitions differ across different places, this study aims to highlight the commonalities in the transition process towards ECs while taking specifically the critics concerning grassroot innovations, incumbents, and the geography into account.

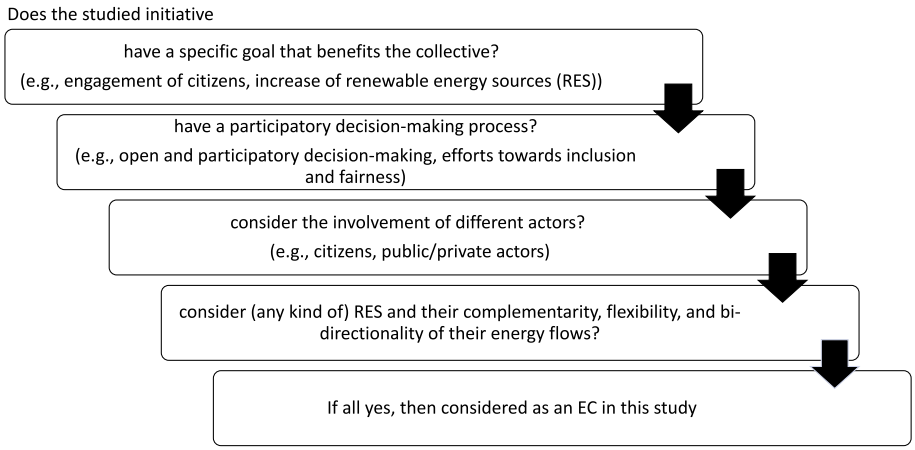

Fig. 1. Summary on decision-making on what is considered an EC.

3. Data and methods

The research was based on a systematic literature review using a bibliometric analysis (bibliographic analysis), followed, and supported by a qualitative content analysis. Fig. 2 summarizes the general approach.

In the first step, an extensive set of articles was retrieved combining sets of search queries containing articles that have "energy* community*" and "emergence", "reason", "trigger", "driver", "condition", "diffusion", or "factor" in the title, abstract, and keywords, no date range was specified. This search resulted in 1,203 articles (last updated May 2021) on Web of Science. Web of Science was used as it provides all data for the bibliometric analysis and is among the most renown citation databases [26], also because this study focused on English peer-reviewed publications. The 1,203 articles were then scanned according to their relevance to ECs. The authors considered the overlaps of the above-mentioned definitions and included studies on ECs that fulfill the criteria specified in Fig. 1.

Because they do not comply with the criteria, articles were excluded in which large scale projects were implemented by a single for-profit company and addressing purely the technical optimization of local energy systems. All types of renewable energy sources (RES) were considered in the selection of articles, but empirical studies of purely retrofitting and implementation of energy efficiency measures were excluded when aspects of interconnectivity and bidirectionality were missing. After applying the inclusion and exclusion criteria, 75 articles remained from the initial set, they were published between the years 2012 and 2021. To explore if there are main studied themes for the emergence of ECs in the selected literature, a bibliographic coupling analysis was conducted using the opensource software VOSviewer [27]. Bibliographic analyses allow to organize bigger samples of scientific literature into clusters according to shared authorship, co-occurrence of documents, shared citation, bibliographic coupling, and co-citation links. We conducted a bibliographic coupling analysis as it is considered the most appropriate method to distinguish clusters in literature both for small and very large literature samples [28]. For the bibliographic analysis on the bibliographic data of the selected 75 papers, the software creates literature clusters and citation networks based on how strong the papers are connected to each other determined by how many references they share. We applied a resolution of 0.8 (determines the detail of the clusters/number of clusters) and association strength as the normalization method to obtain a feasible number of clusters. The resolution must have a positive value, apart from that, it is adapted to the purpose of the research. Since we used a relatively small sample of literature a value below 1 resulted in the most distinct clusters to show the key research themes. The results of the bibliographic coupling analysis are of exploratory nature. In contrast to the very specific content analysis of the studied factors for the emergence of ECs, the

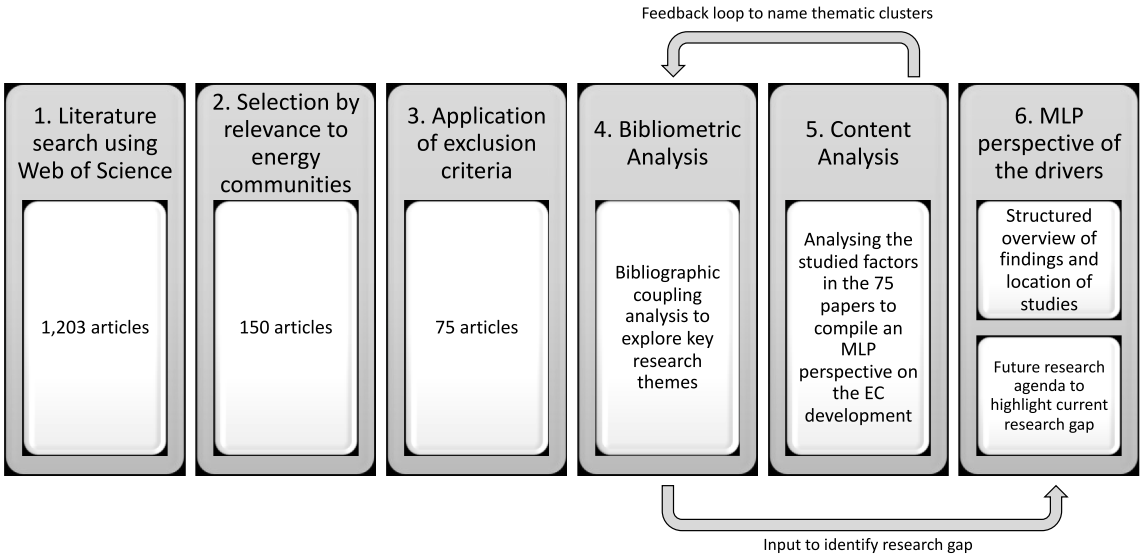

Fig. 2. Approach for systematic literature review.

bibliographic coupling was conducted to obtain a general overview of the main research foci in the selected publications.

The qualitative content analysis was conducted reading and analyzing all 75 papers to study in detail the studied factors. The authors used the software for qualitative data management "NVivo" to gradually identify re-occurring topics in the selected publications [29]. To identify the most studied aspects affecting the emergence of ECs, the mentioned factors (e.g., a specific tariff) in each publication are attributed a so-called node. Then, the nodes are grouped according to occurring topics (codes) (e.g., financial policy) in literature. The qualitative data analysis was conducted as described by Hilal and Alabri [30]. Using the number of the nodes for each of the codes, it is highlighted which aspects were studied most in the selected literature and deduct pathways for future research. The information from the qualitative content analysis was then used to feed back into the results of the bibliometric analysis to verify if the literature clusters share common themes or foci. The bibliographic coupling analysis feeds into the content analysis by showing broadly under which research considerations the specific factors were studied.

With both the information of the bibliometric and content analysis, a structured overview of the factors was compiled and conceptualized using the MLP [14]. An important aspect of analyzing factors for the emergence of transitions, such as ECs, are the geographic conditions for their emergence. While not specifically accounted for in the original MLP, recent research has stressed the importance of the question of *where* transitions occur [31]. Although the authors do not analyze in detail the geography (place and the spatial relation of the local activities) of ECs in this work, they aim to provide this perspective with showing where country studies and single case studies were conducted and where ECs were shown to exist in the literature.

In summary, the authors first provide a general overview of the foci that publications share, then study in detail the identified factors. With the input of both the general and specific overview of studied factors in literature, a transition perspective using the MLP is developed and highlighting the most studied factors and providing a future research agenda.

4. Results

4.1. Bibliographic coupling analysis

As a first result, a general overview of the topics studied in the selected research is provided. Using VOSviewer, Fig. 3 shows the clusters (green, red, blue, yellow) resulting from the bibliographic coupling analysis, the lines show how the publications connect to each other based on the references they share. Fig. 3 used all 75 papers, papers with none or a low number of shared references (0–2) do not appear due to the choice of resolution.

With input of the content analysis, the authors attributed titles (actors and network dynamics, motivations, social acceptance, action research) to the clusters resulting from the software analysis. The authors named the titles according to the shared research focus in the clusters. The researchers discerned the four main clusters: the motivations to set-up and join an EC (red), the social acceptance of ECs and of the specific technology assets installed in the ECs (blue), the actors and social networks active needed for ECs (green), and dedicated collaboration on transition between actors, sectors, and systems, which were named action research (yellow).

Because the bibliometric analysis is based on bibliographic data from which the foci of the research papers can merely be explored and deducted, the content analysis, so analyzing all publications, was used to 1) confirm if the clusters are distinct (if the resolution setting is appropriate) and 2) to title the topics of the clusters (feedback loop from the content analysis). The chosen resolution of 0.8 resulted in thematically distinguishable clusters according to the dedicated focus of the papers. Some papers thematically relate to each other, yet they are displayed in different clusters (e.g., motivations and social acceptance). The distinction is based on a demarcation the authors found insightful after the content analysis. The authors consider social acceptance as a prerequisite for the active motivation to join an EC. They distinguish between the acceptance of ECs, which does not require active involvement, and the reasons and motives to join an initiative, which requires active involvement. The cluster titled "Actor and Network Dynamics" encompass studies focusing on actors and actor networks influencing the development of ECs. In contrast to the first three clusters, which were titled according to a shared theme, the papers within the last cluster relate to each other based on the methodology the papers used (action research approaches). The main research foci are explained in the following.

4.1.1. Motivations

The first cluster contains literature relating to the topic of individual and communal motivations to set-up and/or join an EC. Bauwens [32] studied the heterogeneity of motivations to join an EC. [33], for

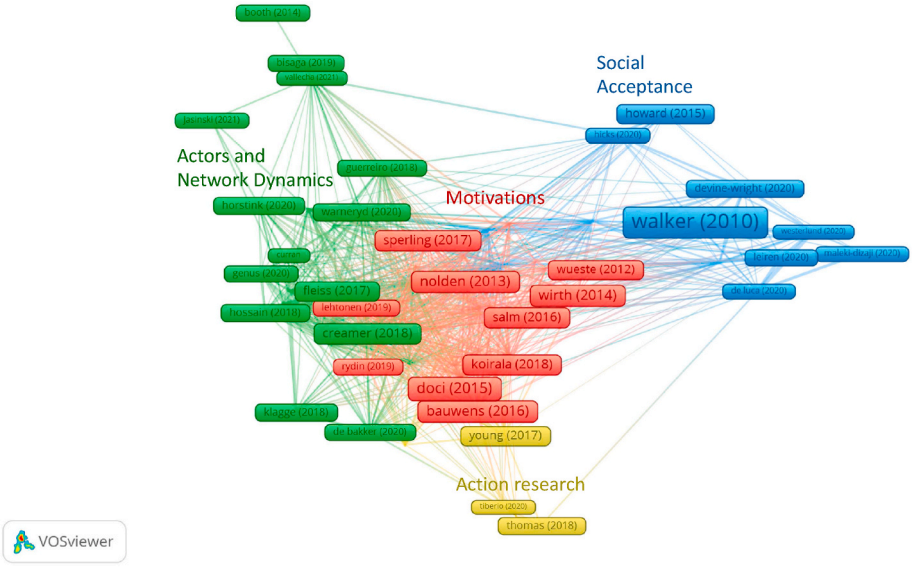

Fig. 3. Clusters resulting from the bibliographic coupling analysis using VOSviewer.

example, studied individual motivations to invest ECs and showed that both economic incentives (lower energy costs), and normative motivations (e.g. combat climate change) were most important. Holstenkamp and Kahla [34] researched more in detail the motivations resulting from beneficial investment opportunities in ECs, and also Curtin et al. and Salm et a [35,36]. studied financial motivations. Several studies researched how motivations are fostered by incentive creations through the institutional settings (for example [37,38]). Haf and Parkhill [39] stressed how the cultural identity, language, and history can affect the motivations of citizens. Mundaca et al. [13] added that (energy) justice aspirations can be a motivation to implement EC schemes and exemplified it with the energy island Samsø in Denmark.

4.1.2. Social acceptance

The literature within the blue cluster relates to each other through the focus on social acceptance. Walker et al. [6] showed that trust among the local initiators of the EC and other members, as well as to higher level authorities, is a crucial condition for the success and social acceptance of an EC. Wolsink [5] specifies between socio-political, community, and market acceptance of ECs. The author highlights that electricity from RES is becoming a common good by creating acceptance through co-ownership. Hicks et al. [40] and Maleki et al. [41] studied in detail the community acceptance of ECs showing that by providing active, passive, and financial ways for participation to citizens increases their acceptance of ECs, while Howard [42] is an exemplary study for the socio-political acceptance. Policies should address removing barriers to participation and sharing of benefits of ECs. Further, social acceptance was studied with an energy justice perspective [43,44]. Energy justice considerations and dedication to a just transition in these case studies supported the acceptance of RES.

4.1.3. Actor and network dynamics

Literature within the green cluster shares the focus on actor and network dynamics for the development of ECs. Hyysalo et al. [45] for example, highlight the need to differentiate actors and their roles as users for ECs. Fleiβ et al. [9] investigated which actors are most likely to join and adopt ECs and showed that those with the highest financial benefit are more likely to join. Horstink et al. [46] and Meister et al. [47] connected the institutional setting with the emergence of specific actors (prosumers and collective prosumers) for the development of ECs. Certain types of stakeholders (e.g., capacity builders, innovators, and municipalities) are highlighted as key drivers for the emergence of ECs ([48,49]. Apart from looking into specific stakeholders, this cluster also studies the dynamics and networks of actors between each other (e.g. Refs. [50–52]).

4.1.4. Action research

The studies belonging to the yellow cluster represent dedicated action research studies. Approaches under the umbrella of action research methods aim, according to Clark and Dickson [53], at fostering transitions towards more sustainable practices in a collaborative manner involving different stakeholders, sectors, and disciplines. Thomas et al. [54] exemplifies this type of research by conducting a transdisciplinary and participatory approach to study the transition towards an EC in Indonesia. The publications in this cluster aim to bring together different types of knowledge (local/academic), engage various stakeholders (e.g., local community, authorities, commercial entities), and concluded that common understanding and a shared transition goal is needed for the successful transition towards an EC.

4.2. Analyzed factors affecting the emergence of ECs

While the clusters showed under which focus the factors were studied in the selected literature (general overview), this section summarizes the studied factors in detail applying a qualitative data analysis using NVivo (specific overview). Individual factors were attributed a node, if several nodes related to the same factor they were coded together and named after the aspect they addressed (code). Then the authors titled them and connected them with the levels of the MLP they can be attributed to (see Table 1). The original MLP determines three main levels (niche, socio-technical regime, landscape), this summary further specifies aspects that cannot clearly be attributed to one of the levels, but that are rather shaped at their intersection. The codes were summarized to the following main aspects and were attributed single or several levels: individual and community aspects (added as a new level to the MLP), socio-cultural (landscape), economic and financial (regime and niche), commercial (niche and regime), technical (landscape and regime), institutional (regime), and geographic factors (landscape).

The individual and community level was added as an additional layer the original MLP to account for the critics on local particularities and embeddedness of grassroot innovations.

This table is the base for the new MLP visualization on ECs, seen in Fig. 5. In the third and fourth column, the mentioned factors (nodes) with their respective reference are shown. The codes are the resulting key themes that emerged from the summary of the nodes. The codes can be seen as influencing factors for the emergence of ECs, while they can be both hindering and facilitating for their development. As an example, trust among key actors (e.g., policy makers, investors, local groups) affects the emergence of an EC. The lack of trust would be hindering while the existence of trust supports the development of ECs.

The individual and community level is influenced by cultural, historical, and psychological factors such as the local norms and values (that affects and is affected by the perception of locality). While such landscape factors cannot be changed by intervention, the emergence of ECs can benefit from history of and experience with energy cooperatives or other cooperative business models. Energy cooperatives are the most common organizational form of ECs [84]. Pressures on the landscape level (events such as an economic crisis, war, extreme weather events, or a health crisis) can push the emergence of ECs by creating the need for a transition away from dominant practices.

Other landscape factors that influence the emergence of ECs are the general physical environment and geographic location. The lack of and the distance to RES can hinder the emergence and feasibility of ECs. The current state of RES infrastructure or other required infrastructure for ECs (transport and communication) can further impede EC developments through technical difficulties.

The lack of one of the identified factors could also push for the development of ECs. For example, the scarcity of clean energy in the local energy mix and the distance to central grid infrastructure were identified as driving factors for the development of local grids [63].

On the individual and community level, trust in policy makers, individual and community motivations to join ECs fostered the willingness to participate and acceptance of ECs. Such communities were characterized by a strong community spirit and identity. A key aspect for the actual mobilization towards an EC was the presence of enabling actors, who could be engaged and/or entrepreneurial individuals that collaborate between several levels of authorities and governance.

For the transition of the energy system, supportive institutional settings encompassing policy, laws, and practical assistance for innovative initiatives and research institutions are needed. The regime level is affecting how resources and other forms of support encourage initiatives, research, and other actors to transition towards a low-carbon energy system. Also, it affects the commercialization of such initiatives and actors (intersection of niche and regime level). The survival of business models for ECs is dependent on their capability to sustain their pool of members/investors. Economic and financial aspects, which are also influenced by the institutional setting, connect with this aspect. The availability of financing, funds, and other financial sources to overcome high investment costs facilitate the EC emergence. Tax schemes, subsidies, and tax incentives as well as social tariffs and feed-in tariffs were mentioned as drivers from a market perspective. The support to finance ECs was mentioned in many studies (e.g. Refs. [10,49,67,69]) and can be

Table 1
Results of content analysis.

Main aspects and relating MLP level	Codes	Factors (Nodes)	Exemplary reference
Socio-cultural (landscape)	Justice	Fairness and justice consideration as drivers for change	[13]
	Psychological factors	Sense of community, responsibility	[10,55]
	Cultural factors	Norms and values (e.g., equal rights, entrepreneurialism, communal values, traditions, perception of locality)	[7,39,44,56]
	Historical factors	History of energy cooperatives and cooperative projects	[7,13,57]
		Window of common opportunity (e.g., an economic crisis)	[13]
Geographic (landscape)	Physical environment and geographic location	Condition of physical environment (e.g., landscape, protected areas, biodiversity, and wildlife, urban/rural divide, availability of renewable energy sources)	[56,58,59]
		Development of other infrastructure (transport and communication)	[56]
		Closeness to RES assets	[60,61]
		Feasibility of RES assets	[62]
	Energy Mix	Low RES ratio in energy mix	[63]
Technical (landscape and regime)	Infrastructure	Grid infrastructure (e.g., unbundling of generation, transmission, and distribution)	[56,59]
		Availability of other infrastructure (transport and communication)	[45,56,64]
		Availability of data, availability of technology	[59,65]
	Sizing and assessment of feasibility	The sizing of the EC is influenced by many non-technical factors (e.g., feed-in-tariffs) and assessment of feasibility requires local data	[35,58]
		Consideration of different energy vectors as well as socio-technical aspects	[66]
Individual and community (regime, Niche, individual and community level)	Trust	Trust in key actors (policy makers, investors, local groups)	[56]
	Acceptance	Local ownership, distance, size, and visibility of RES assets, effect on local business (e.g., agriculture)	[56]
		Acceptance by key stakeholders (citizens, and institutional enablers)	[5,67]
		Regional (or national) share of renewables in the electricity sector	[56]
	Motivations	Motivations are very heterogeneous and vary from anthropocentric motives (social), over egocentric (individual motives) to biocentric (environmental) motives	[8,68]
	Participation	Presence of "frontrunners" or key enabling actors, presence of entrepreneurial individuals	[10,58,69]
		Presence of intermediating individuals, organizations	[44,70]
		Active participation and consultation during development and implementation process	[56]
		Willingness to participate which is affected by various factors, such as age, income, social norms, trust, satisfaction, acceptance, education, environmental concern	[65,71]
	Community Aspects	Sense of place, self-identity, place attachment	[56]
		Community spirit, size, involvement, awareness to technology, strong civil society	[10,59]
		Bridging and bonding social capital (the connection within and among societal groups)	[67]
	Networking and intermediaries	Connection of civil society to governments and local authorities, collaboration between different levels of authorities and governance	[55,67,72]
		Presence of alternative energy movements in politics and civil society	[7]
		Experience in collective work and collaboration, presence of existing networks (especially with local agencies)	[33,49,73]
Institutional (regime)	Policy	EC emergence, development and success are depending on suitable, and consistent policies (financial support schemes, environmental regulations)	[37,55,56,59, 63,64]
	Laws	A reliable legal framework (e.g., rules on grid connection, rules on cooperative entities, regulations on feed-in)	[7,74]
	Innovation	Institutional settings that foster innovative projects and policies (e.g., change management, adaptable governance approaches, space for experimentation)	[67,75]
	Research and development	Support and funding of research institutions	[59]
	Support	Support of governments, non-governmental and international institutions (e.g., supporting RES, subsidies, energy initiatives)	[7,58,76]
		Support specific for local projects and initiatives	[58]
		Guidelines and point of contact to understand current legislation, facilitation, and coordination of development process	[42,67]
	Planning and Permission	Resources (knowledge, time, money) needed for permission and planning processes	[56,77]
	Transparency and information	Access to information and transparency of permission process	[56]
	Fossil fuel incumbents	Degree of embeddedness and lobbying power of established regimes (e.g., fossil fuel incumbents)	[77]
	Public discourse	Public discourse on RES	[56]
Commercial (niche and regime)	Business	Economies of scale, upscaling, and diffusion of business models of social enterprises	[74,76]
		Protection and encouragement of investors	[78]
		Availability of experienced staff and knowledge base	[37,77]
		Experience with community initiatives/projects, innovation processes	[59]
	Cooperative	Validity and viability of the business model (motivations of members, their commitment)	[8,62,79,80]
	Business	Strategic networking among cooperatives, professionalization of community groups	[50,79]
	Models	Strategic networking of local initiatives with other groups, formation of alliances	[50]
Economic and financial (regime and niche)	Local profits and income	Local jobs, improvement of local economy	[56]
	Costs	Declining costs of (RES) technology	[76]
	Market	(Local) economic crisis	[13,81]
	Conditions	Re-municipalization trends, active local utilities, presence of generation-based industry	[74,82]
		Openness of the energy market (influenced by monopolies and regulation) and stability of the market	[47,59,63]
		Market acceptance of ECs (influenced by incumbents, investors, tariff structures),	[5]
	Financing		

(*continued on next page*)

Table 1 (*continued*)

Main aspects and relating MLP level	Codes	Factors (Nodes)	Exemplary reference
		Availability of and access to a diverse source of funding and financing on different regional and institutional levels to different stakeholders (by government, community investments, bank loans to communities and the public)	[10,49,56,58, 64,73]
		Availability of supportive tax schemes (tax subsidies for RES, tax incentives)	[7,49]
		Appropriate tariff structures (e.g., social tariffs, feed-in-tariffs)	[63,74]
		Appropriate funding and financing options according to the project development phase: First phase regional support, loan schemes, second phase: soft loans and grants, third phase Feed-in-tariffs, feed-in-premiums, local ownership criteria, access to technical knowledge and advice, quota-based auctioning	[35]

considered as a key influencing factor. Curtin et al. [35] have highlighted that difference phases of the EC development benefit from different types of funding and financing. This could also be the case for other factors. Across all levels, aspects of collaboration, boundary spanning through intermediation of different actors, and networking were found as beneficial for the EC development.

4.3. Geographic location of the case and country studies

To address the critics on the MLP, a general geographic overview of the existing studies is given in Fig. 4. The dots indicate where single case studies could be identified, the color range from white to dark blue shows where country studies were conducted. The darker the blue, the more studies were found per country. The location of the case studies and research focus of these case studies are summarized in the Annex Table A1.

This section aims at highlighting that the geographic scope of the case studies in the selected papers concentrates around the European countries Denmark, the Netherlands, Germany and the United Kingdom. With a few exceptions in non-European countries such as Australia and Korea. Denmark and Germany have a long history of Energy Co-operatives and co-ownership of RES [10,85].

The geographic overview shows that studies fulfilling the proposed criteria are lacking in the context of non-European countries and for low-income countries. This might be because information on local initiatives is covered by non-peer-reviewed publications, and in regional languages. Also, the countries to which the institutions of the authors are affiliated with are mainly Germany, the Netherlands, and the United Kingdom.

In contrast to studies in the EU, the study conducted by Biasaga et al. [86] highlights the uncommon practice of participation of the broader public, lack of governmental support and financial resources as key barriers to ECs. Also, Guerreiro and Botetzagias [70] highlights for the context of Indonesia, exemplary for a low-income country, that participatory and community approaches towards the organization and development of RES projects are uncommon. For the success of such projects, they highlight the need for skilled, experienced, and connected intermediaries who develop partnerships among public and private organizations.

Although the studies in low-income countries mention similar drivers, barriers, and facilitators for the development of ECs, the degree of importance they attribute to the drivers differ, e.g., the concept of public participation in general, the lack of financial resources of private entities, the need for organization and trained intermediaries, and the development of an institutional infrastructure.

Hansen and Coenen [31] summarize how the geographies of transitions relate with transition studies, and what aspects (e.g., geography of natural resource availability, proximity to existing industry, local technological and industrial specialization, formation of informal institutions/networks) could be studied with such a geographic lens. Within the selected research, no study was dedicated specifically to this research agenda.

5. MLP on the emergence of ECs

Using the input of both the general and specific overview of the studied factors, the authors apply the MLP on the emergence of ECs. The MLP on ECs allows to differentiate and structure the mentioned drivers. The overview systematizes and simplifies the dynamics of the broader system in which an EC is embedded. The aim of this overview is to provide a framework for analysis to assess ECs from a broader system perspective.

On the landscape level, unchangeable factors such as the availability of RES and the general geographic location are mentioned. The authors added the geography as a landscape factor in this overview, and consider the geographic landscape both in evolutionary and institutional economic geography terms [31]. Therefore, an influential factor are local technological and industrial specializations affecting what kind of innovations are more likely to emerge. Historic factors such as history of cooperative models and the historic organization of the (energy) market also account for the spatial distribution of ECs and represent landscape factors. The impacts and development of a (global) crisis count as a landscape factor impacting the development of ECs (e.g., the financial crisis but potentially also the impacts of the COVID-19 crisis) [13,81]. While landscape factors are changing slow, they influence both the socio-technical regimes and niche level.

The dominant institutional, market, industry and technical regimes compose and define the laws, policies, regulations, market rules and habits, industry settings (incumbents), and technical standards. Socio-technical regimes are influenced by landscape and niche developments, and they influence them vice-versa. The socio-technical regimes are interconnected and influence each other, also through representatives, intermediaries and incumbents interacting, contesting, and collaborating across the different socio-technical regimes. These dynamics are shown by the circle around the socio-technical regimes. At the junction to the niche level, research, and development (R&D) and innovation have been mentioned as factors driving the emergence of ECs. Both R&D and innovation are influenced by the governmental/industry support and other socio-technical settings. The development and success of ECs are therefore very dependent on favorable socio-technical regime settings and, in addition, from the drivers from individuals and the community. Among the favorable socio-technical settings, specific and adapted policies to the locality were mentioned [56]. Further, financial support schemes and funding availabilities to the general public foster the emergence of ECs [10]. Curtin et al. [35] highlights different financial options along the EC development phase. First, loans and regional funds can support the initiation of an EC, then soft loans and grants can support their implementation, while feed-in-tariffs and premiums as well as a high local ownership ratio can support their survival. Generally, a public dedication to innovation and adaptive governance principles can help the emergence of ECs [67].

The socio-technical regimes and niche level (with individual and community level) are difficult to separate from each other clearly, as ECs seem to succeed at their intersection. In literature, business aspects are highlighted in this context (see Fig. 5). Addressing the challenge to make a niche development economically (and environmentally, socially,

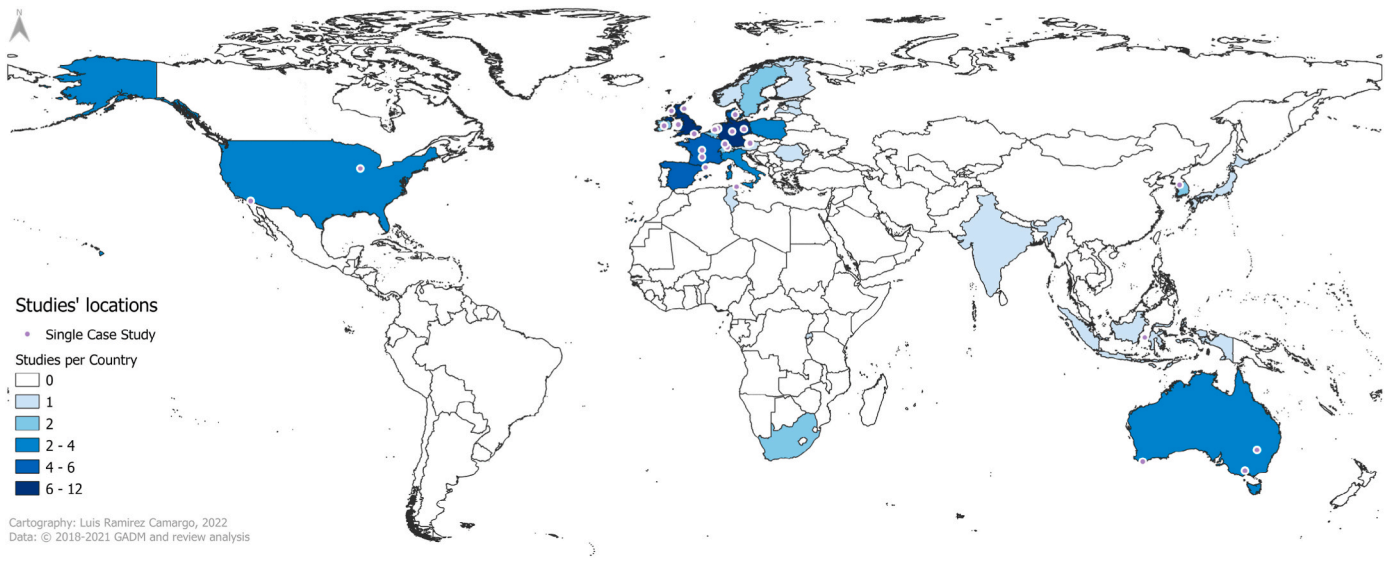

Fig. 4. Geographic overview of the studies compiled.

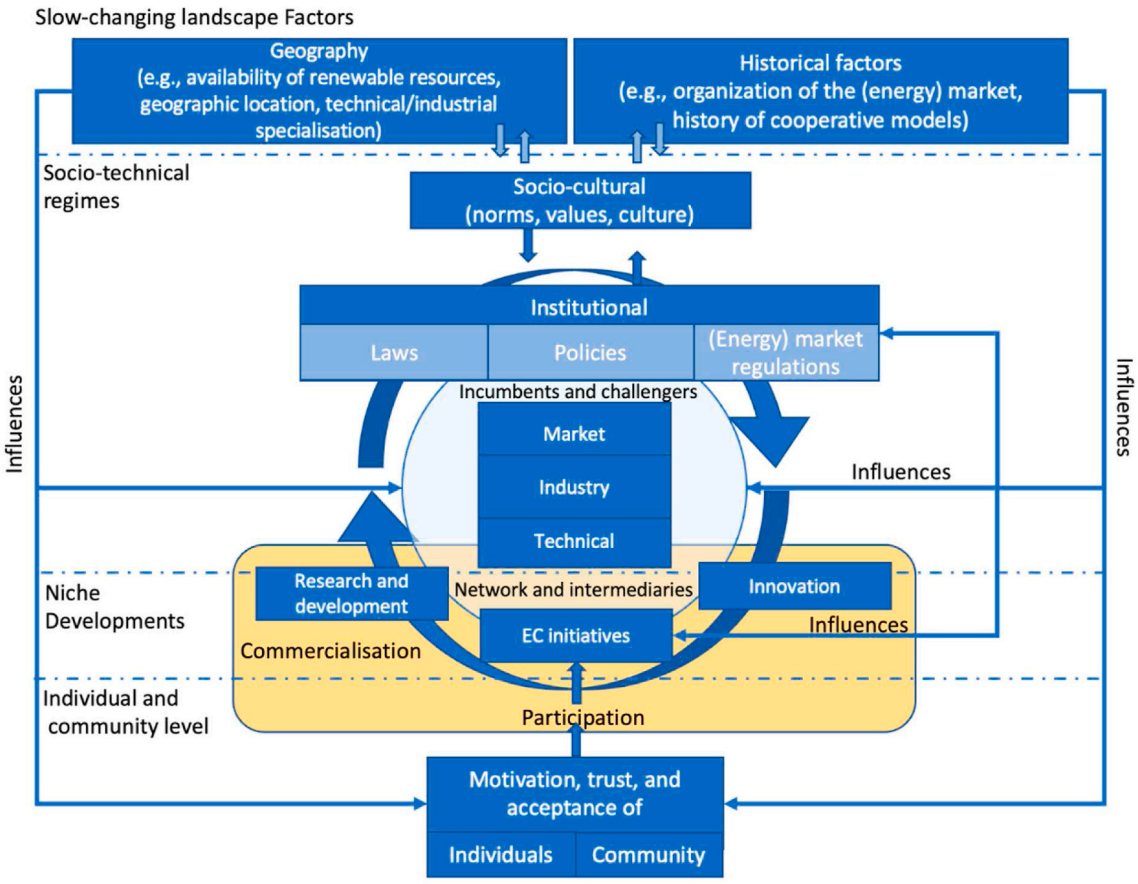

Fig. 5. MLP on EC development, figure compiled by author building on [24].

technically) viable. This is not only affected by the market design, policy support, but also depending on human and natural resources [62]. The collaboration among different sectors, innovators, active EC initiatives (so the interaction both of incumbents and new market players), were mentioned as a key factor to achieve such viability [72]. ECs also face the challenge to maintain non-capitalist ideals (e.g., focus on environmental and social benefits, shared ownership) in the process of commercialization [85].

On the individual and community level, that was added as an additional layer in the overview, is impacted both by landscape and socio-technical regime factors. Motivation, trust, and acceptance among the citizens and towards the socio-technical regime players were mentioned as decisive for the success of ECs. Public events for the community, the provision of workshops, trainings, and information, ownership building and cross-sector collaboration were mentioned as practical tools to engage individuals and the community to participate in an EC scheme

[59,69,70,83,87].

6. Towards a future research agenda

The authors identified factors as less studied based on the lower number of nodes for the factors and considered them as potential research agendas when they were mentioned as a gap in the selected literature. Three main research pathways were determined: 1) studying the innovation system with a focus on the proximity to industrial/technical systems, 2) studying socio-demographic, cognitive and cultural factors affecting individual and community level, and 3) consider the transition stage of ECs to differentiate which factors support their development stage.

The number of the nodes for each code of the content analysis shows that factors on the socio-technical regimes level are studied predominantly, which is also supported by the results of the bibliometric analysis. Here, especially the institutional settings, social acceptance, and motivations, and reasons to participate received most attention. On the contrary, factors attributed to the landscape level, specifically geographic aspects under which the factors; conditions of the physical environment (e.g., landscape, protected areas, biodiversity, and wildlife, urban/rural divide, availability of renewable energy sources), development of supporting infrastructure (e.g., transport and communication), proximity to RES, and the local energy mix were identified, are studied the least.

Considering the geography of transitions, only a few of the detailed case studies addressed some of the geographic factors falling under the landscape level, none of the articles that fulfilled the selection criteria has dedicated its focus on the geography of the innovation system from a quantitative and spatial perspective, yet such studies are needed to analyze shared characteristics and conditions across space and time. Asheim and Gertler [88] deepened the understanding of regional innovation systems and researched why the proximity to specific (industrial) clusters are important for the emergence of innovations, such a geographic perspective on ECs in this context are scarce. Examples of such research that did not fulfill the criteria of the review are Punt et al. [89] who studied the institutional relatedness with the spatial phenomenon of emerging energy cooperatives, and Lode et al. [90] who studied that phenomenon quantitatively but using different indicators assessing social cohesion.

Guerreiro and Botetzagias [70] stressed, and our review also confirms this, most studies are focusing on Europe, and on other high-income countries while studies focusing on other regions, especially on areas where access to electricity is still limited, need to receive greater attention and visibility. This also falls under aspects of geography.

Overall, quantitative studies that combine landscape factors with the emergence of EC initiatives are less represented in the selected research. Also, Šahović and da Silva [79] highlighted that especially demographic studies in combination with the local emergence of ECs are missing, here the aspects such the rural-urban divide may be an important aspect to consider. The low number of nodes for the cultural- and cognitive factors on the landscape level indicate that these are understudied factors. Factors mentioned under socio-cultural dimension were justice considerations, sense of community and responsibility, norms, and values (e.g., entrepreneurialism, communal values, traditions, perception of locality), and historical factors (e.g., economic crisis, history of cooperatives). These factors seemed to be strongly connected with the individual and community level, therefore, studies combining them with socio-demographic information from individuals and the community are a potential research pathway.

Apart from the low number of specific nodes, the transition stage of ECs (experimentation, stabilization, diffusion, or institutionalization), may influence what kind of factors are supporting their further development. The transition stage was not specified in the overview of the studied factors. But from a market and business perspective, detailed analysis of competitive business models for ECs are needed, especially for the stabilization and diffusion stage. The consideration of the transition stage and the supporting factors for each transition stage should be considered in future research. For example studies showed that, mentioned factors that can support the emergence of ECs (e.g., feed-in-tariffs), may not be supporting the operation or establishment of ECs as they proved to be not viable from a long-term perspective [91].

7. Conclusion

The current literature on ECs is fragmented and draws from different, yet similar, concepts and frameworks. To fully grasp the state-of-the-art and research gap of current research on factors that influence the transition to ECs, the authors conducted a systematic and content analysis-based literature review.

The authors determined four main research foci under which factors for the emergence of ECs were studied; social acceptance, motivations to join, actor and network dynamics, and dedicated action research studies.

Although the studies were conducted with different foci, research approaches and at different locations, the identified factors are similar in many studies. Among the more prominent factors is the set-up of a supportive institutional setting encompassing laws, policy, regulation, and administrative support addressing market, industry, technology, and innovation players. A supportive institutional setting can cascade down on individual and community level where interpersonal (trust, individual motivation), and socio-cultural (values, norms) factors were studied as beneficial for the emergence of ECs. As the landscape factors (e.g., the geographic location or the historic factors) cannot be changed, the support of individuals and communities and especially of intermediaries that are at the intersection of the socio-technical and niche level showed to be beneficial for the emergence of ECs.

Within the selected literature, fewer studies were available on a cross-country level with a quantitative approach, or a focus on the geography of innovation systems. Quantitative research that combines landscape factors (e.g., the availability of RES, industrial clusters) and individual factors (e.g., the acceptance of RES) dedicated to analyzing the geography of EC innovations and innovation systems, also from the perspectives of low-income regions and countries could further develop the understanding of the factors influencing the emergence of ECs.

This study showed that the directionality of influences, so whether, for example, the niche level influences the socio-technical regime or vice versa, is not clear, it rather showed that ECs are embedded in a very complex environment with many factors influencing each other.

Credit author statement

Maria Luisa Lode: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Geert te Boveldt**: Writing – original draft, Writing - Review. **Thierry Coosemans**: Resources, Project administration, Funding acquisition. **Luis Ramirez Camargo**: Writing – original draft, Writing - Review, Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Table A.1
Single and country studies

Area/Country	Case Study	Researched focus	Reference
Australia	Hepburn Wind, and Denmark Community Windfarm	Beneficial community engagement practices, economic and governance structures	[40]
Australia	Two community wind farms in new South Wales	Studied the legal and non-legal requirements for the development of ECs	[42]
Austria	Two community funding projects of solar: HELIOS Sonnenstrom GmbH and MEA Solar	Studied which financial considerations are most decisive to join a community scheme	[9]
Baltic Sea Region	Sweden, Denmark, Germany, Poland, Estonia and Finland	Studied urban community energy initiatives	[51]
Belgium/Flanders	ReScoops	Studied the influence of insitutional factors on the size of energy cooperatives in Belgium	[92]
Channel Islands	Guernsey, Large scale community offshore windfarm	Studied the factors influencing the acceptance of a windfarm	[60]
Denmark	Samsø	Studied internal and external factors contributing to the success of the energy island Samsø	[10]
Denmark, Scotland and Ireland	Samsoe and Aero, Isle of Eigg, Cloughjordan (Ireland)	Assessing the effect of acceptance and participation on the emergence and success of ECs	[69]
France	Le Mené, a local energy initiative	Studied the processes that helped the initiative to emerge and grow and highlighted the hybridization of actors	[93]
France	240 community energy projects	Studied the facilitating and hindering factors of the EC developments	[49]
Germany and Denmark	Feldheim, Samsø	Studied fairness and equity aspirations as drivers for change	[13]
Germany	Energy Cooperatives	Studied the supportive governmental regulations leading to the development of Energy Cooperatives in Germany	[85]
Germany	Feldheim, a 100% renewable community	Studied and highlighted the importance of participation of stakeholders, sense of ownership, support of political actors	[87]
Germany	25 bioenergy villages	Studied the success factors for local transitions highlighting early stakeholder engagement and biocentric motivations of the villagers	[68]
Germany, Italy, Latvia, Norway, Poland, and Spain	Comparative country analysis	Procedural and distributional justice implementation for citizen engagement	[43]
Germany, Spain, Italy, Poland, Norway	Saxony and Thuringia in Germany, the Balearic Islands, Spain, Latium, and Abruzzo in Italy, Latvia, the Warmian-Masurian province in Poland and mid-Norway.	Studied the community acceptance of wind energy developments	[56]
India	Country Study	Studied grassroot barriers to communal solar, biomass and micro-hydro plants	[59]
Indonesia	Two hydro plants locally owned at Cinta Mekar, Kamangghi	Studied supportive factors and cultural, institutional, and economic conditions in the context of a developing country	[70]
Korea	Community energy initiatives	Studied the influence of policies developed by the Seoul Metropolitan Government on the development of urban ECs	[57]
Rwuanda	South-West Rwanda	Studied specific policies to encourage citizen participation in a photovoltaic roll-out under the "Vision 2020 Umurenge Program"	[86]
Scotland and Wales	Ynni Llanaelhaearn', Pen Llŷn (Lleyn Peninsula) in Gwynedd and 'Ynni Talybolion' in Llanfechell, Ynys Môn (Anglesey)	Studied cultural values as a driver of ECs	[39]
Scotland, Germany, Spain	Som Energia, Bürgerenergie, Huntly and District Development Trust	Studied regulatory and institutional barriers	[74]
South Korea	Seoul, Dongdaemun district	Studied mini-PV installation under community schemes	[73]
South-West France	Farming Houses and the Fermes de Figeac cooperative	Studied economic and territorial challenges for local community photovoltaic initiative	[94]
Spain	ReScoops	Studied the factors influencing the development of ECs in Spain	[81]
Switzerland	828 active Energy Cooperatives	Studied governmental support for energy cooperatives	[47]
Switzerland	Zürich	Studied the barriers and drivers of an urban community energy project in Zürich	[95]
The Netherlands	220 initiatives registered in "Hier Opgewekt"	Studied collaboration for and among energy cooperatives and other partnerships for ECs	[50]
The Netherlands	Stichting Betuwe Energie, BrummenEnergie	Studied the factors leading to the success and diffusion of energy cooperatives	[52]
The Netherlands	Overijssel and Fryslân	Studied the innovation processes of ECs and highlighted the importance of acceptance among key stakeholders	[67]
The Netherlands and Germany	AmesterdamZuid, Thermobello and Jühnde, Freiamt	Socio-psychological analysis of reasons to join an EC	[33]
Tunisia	Community energy project: Sidi Daoud Wind Park	Studied factors influencing the acceptance or rejection of community energy projects	[44]
United Kingdom	Hove and Brighton Cooperatives		[96]

(*continued on next page*)

Table A.1 (*continued*)

Area/Country	Case Study	Researched focus	Reference
		Studied the impact of trust and distrust within citizen led energy initiatives	
United States, Sweden, the Netherlands, Germany, Japan	Blue Lake Rancheria, Collins, Borrego Springs, Bronzeville, Brooklyn, Reynolds Landing, Simris MG, Aardehuizen, Feldheim, Steinweg, Mannheim Wallstadt, White Gum Valley, Sendai	Studied the implementation of community micro-grids and role of institutional support	[82]
Wales	Community Hydropower projects	Studied the governmental support, the benefit for local communities	[58]

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