Energy Research & Social Science 88 (2022) 102625

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Review

A systematic review of social innovation and community energy transitions

Alaize Dall-Orsoletta, Jorge Cunha *, Madalena Araújo, Paula Ferreira

ALGORITMI Research Center, School of Engineering, University of Minho, 4800-058 Guimarães, Portugal

ARTICLE INFO

Keywords:
Social innovation
Grassroots innovation
Inclusive energy transition
Renewable energy
Energy cooperatives
Community energy
Global south

ABSTRACT

For the energy transition, Social Innovation (SI) has been defined as innovations that contribute to the low-carbon energy transition, civic empowerment, and social goals through initiatives such as new forms of governance, social configurations, supportive policies and regulations, and new business models. This work systematically reviews the literature to identify (potential) impacts of SI and bottom-up initiatives on sustainable energy transitions. Based on bibliometric and qualitative content analysis, works were classified by the type of SI, related renewable energy source, and geographical context. Associated sociotechnical changes, obstacles, and enabling factors of SI are also indicated. Main findings show that SI has an important role in local transitions but limited power to challenge the regime and scale-up. For just energy transitions, it can facilitate energy access, co-production, energy democracy, and participatory processes besides bringing regional socio-economic development and building community capacity. SI can contribute to renewable energy deployment through co-ownership and community finance. Also, community-led actions are in a unique position to access local tacit knowledge, influence individual behavior, and use them to build more sustainable cities. Finally, research limitations and directions towards future research are presented.

1. Introduction

Confronted by the negative impacts of traditional energy sources (e.g., fossil fuels) on the environment, countries have been adopting measures to reduce greenhouse gas (GHG) emissions and disseminate sustainable practices. This implies the increased use of renewable energy sources (RES) and, simultaneously, the decreased use of more polluting alternatives, a process known as energy transition [1]. However, this process poses important socioeconomic challenges, which have to be properly addressed by policy-makers if a just energy transition ought to be achieved [2,3]. In this context, it is argued that social innovation initiatives might play an important role to enable a faster transition to sustainable energy systems [4].

Social innovation (SI) is a relatively recent topic of academic research that has emerged in different contexts to address social challenges in new and innovative ways [5]. According to the European Commission, SI can be understood, in broad terms, as "new ideas that simultaneously meet social needs and create new social relationships or collaborations. They are innovations that are not only good for society but also enhance society's capacity to act" [6], p. 33. Whereas [7] states that SI relates to aspirations of social actors that, when proposing a solution for a problem, also create opportunities for the development of new social relations and/or cultural orientations in a way that improves life quality and living standards in society. In other words, SI is a socially innovative practice that provides socially fairer and more inclusive results by developing innovative solutions through collaborative networks, which create social value by promoting social change, and the development and empowerment of the community [8].

In the context of the energy transition, SI has been defined as "innovations that are social in their means and contribute to the low carbon energy transition, civic empowerment and social goals pertaining to the general wellbeing of communities" [9], p. 4. Nevertheless, as there are many definitions of SI, its abridgment under a single interpretation is difficult, which can result in its instrumentalization [10]. In an attempt to address this, Marques et al. [11] differentiate SI in structural, targeted (radical or complementary), and instrumental. According to Marques et al., structural SI refers to changes in the structures of society that are related to new economic and political systems. Radical SI challenges the status quo and is often limited to small niches, whereas complementary SI aims to include a wide range of actors but without radically changing current institutions and social structures. Finally, instrumental SI refers to the common rebranding of initiatives under a certain nomenclature

* Corresponding author at: Campus de Azurém, 4800-058 Guimarães, Portugal.
E-mail addresses: alaize.orsoletta@gmail.com (A. Dall-Orsoletta), jscunha@dps.uminho.pt (J. Cunha), mmaraujo@dps.uminho.pt (M. Araújo), paulaf@dps.uminho.pt (P. Ferreira).

https://doi.org/10.1016/j.erss.2022.102625
Received 12 August 2021; Received in revised form 28 March 2022; Accepted 14 April 2022
Available online 28 April 2022

without fundamentally altering current practices [11]. Similarly, Haxeltine et al. [12] developed a framework, the Transformative Social Innovation (TSI), to evaluate how transformative a certain SI can be in terms of affecting the regime level. Generally, "transformative change is understood as a persistent adjustment in societal values, outlooks and behaviours of sufficient 'width and depth' to alter any preceding situation in the social and material context" [12], p. 13. Among the propositions for transformative changes in the status quo, one could cite, for example, 'new economics', which proposes a socio-economic system that prioritizes quality of life instead of economic growth per se [13], and 'degrowth', one of the most controversial perspectives of change that can be found in the literature [14]. However revolutionary and filled with good intentions, the interpretations of degrowth are highly criticized as they cannot be clearly translated to policies nor propose a comprehensible way to "scale the economy down" [15]. Therefore, the combination of SI and degrowth, two easily instrumentalized concepts, is dangerous for it can inhibit progress and the changes that are needed for the energy transition.

Concerning these necessary changes, some agreement has been reached at COP21 where global targets for reducing CO2 emissions and achieving a net-zero world by 2050 were established. Trends in decentralization, decarbonization, and digitalization [16] have been conducting technological innovation as they may provide a way forward towards a low-carbon economy. Nevertheless, one of the biggest barriers to making progress towards emission targets continues to be the availability of funding. According to the International Renewable Energy Agency (IRENA) investments in renewable energy (RE), for instance, have not been as high as they should and advancement has been slow [17]. Therefore, considering this problematic, the contribution of community-based initiatives to financing the energy transition has started to be evaluated, e.g., [18,19]. Nonetheless, the discussion on community's contribution has not been limited to financial aspects involving other perspectives such as governance and participatory decision-making. The involvement of other actors is enabled by niche environments as indicated by transition management arguments as "[…] socio-technical change opens transition management to include a set of actors beyond innovating firms and their immediate locus between suppliers and customers" [20], p. 13. In this regard, the terms "co-production" and "co-design" have emerged in energy systems and the envisioning of sustainable futures [21]. As the empowerment and engagement of communities is pointed out as key for attaining an inclusive transition [22], initiatives that address new forms of energy governance can be framed as SI [23]. The influence these initiatives have can also be an indicator of how much the civic society can contribute to the energy transition.

In addition to these perspectives on the transformative potential of SI, and contribution of SI to financing the energy transition and making it more participative, another key framing relates to justice. The Global Commission on People-Centered Clean Energy Transitions asserts that successful transitions imply considering equity, affordability, and fairness issues. Social aspects in energy research have been commonly related to energy justice, e.g. [24], affordability, e.g., [25], and the Sustainable Development Goal 7 (SDG 7), e.g., [26]. SDG 7 highlights the need for combatting energy poverty as millions still lack access to modern, renewable, and sustainable energy especially in developing and least developed countries located in the Global South [27]. In attempts to address the North-South divide in energy development, a growing number but still minority of works have addressed new business models in vulnerable countries, e.g., [28,29]. Researchers have analyzed SI through the aforementioned lens, but, considering the interdisciplinary and broad nature of SI and the energy transition, other perspectives can also be employed (e.g., technological innovation systems, multi-level perspectives, and strategic niche management [30–32]).

From this background, the present work aims to better understand the contribution of SI to the energy transition through a systematic literature review. From the best of the authors' knowledge, this is the first extensive literature review to be conducted on the subject. On related works, Hoppe and de Vries [9] through an editorial comment, analyzed 20 articles of a special issue on the same theme. Wierling et al. [33] evaluated the role of energy cooperatives for the energy transition in Austria, Germany, Denmark, and the UK, and concluded that "energy cooperatives are important enablers of the energy transition" but have been having their role shrinking due to "a tightening or removal of supportive schemes" [33], p. 1. Galende-Sánchez and Sorman [21] performed a literature review on co-production and participatory processes in climate and energy fields. Pellicer-Sifres [34] evaluated the potential of two grassroots innovations, the renewable energy cooperative Som Energia and the citizen organization alliance against energy poverty (APE), to the energy transition in Spain. Hewitt et al. [4] investigated community energy in Europe from 1970 to 2018 through the SI perspective. Seyfang and Haxeltine [35] analyzed grassroots innovations, which can be seen as SI, in community energy in the United Kingdom (UK). And, as a final example of related scientific works, Tomasi and Gantioler [23], through a literature review, evaluated new forms of energy governance as SI developments. Alike to the mentioned papers, this work contributes to the literature on SI and just energy transitions through the characterization of energy transitions as socio-technical processes and investigating the support of civic society to a low carbon and inclusive economy be achieved by 2050. Nevertheless, this work differs from the previous because it presents a systematic review of the literature on the relationship between SI and the energy transition considering a wider range of initiatives and contexts, and it focuses on both bibliometric and qualitative content analysis to characterize (potential) impacts of the former.

Therefore, this study developed around two main Research Questions:

1. How has SI contributed and can contribute to achieving sustainable energy transitions?
2. What is the role of community-based initiatives in a transition to a low-carbon sustainable economy?

This work is organized as follows: Section 2 refers to the research methods employed in this study. Section 3 presents the results of the bibliometric and content analysis. Section 4 presents the work's discussion concerned with answering the proposed research questions. The first research question is answered through a discussion generated around three perspectives judged highly relevant to evaluate SI contribution to the energy transition, namely, its transformative potential and ability to challenge the regime (Section 4.1), its relation to financing and co-producing transitions (Section 4.2), and its contribution to just and inclusive energy transitions (Section 4.3). Section 4 ends discussing the second research question (Section 4.4) and pointing to possible limitations and future research agenda (Section 4.5). Finally, Section 5 summarizes the conclusions drafted by the authors.

2. Materials and methods

This section reports the approaches adopted to data collection, followed by content and data analysis. In order to demonstrate transparency, guidelines proposed by Sovacool et al. [36] were followed.

2.1. Data collection

At first, a research plan was established to determine which databases, exclusion criteria, and research questions would be employed. To establish an appropriate search string, an initial search looking for the terms "social innovation" AND "energy transition" in titles, abstracts, and keywords resulted in 30 documents on the Scopus database (books and book chapters excluded). The assessment of these 30 documents helped to identify terms related to SI in the context of the energy transition. The identified terms form the second part of the query below:

TITLE-ABS-KEY ("energy transition") AND ("social innovation" OR "energy cooperatives" OR grassroots OR "bottom up initiative" OR "community energy" OR "community renewable energy" OR "community based" OR "community led").

The inclusion criteria limited the results to peer-reviewed scientific work, written in the English language, all years of publication, and indexed in the most relevant databases in the matter, Science Direct, Scopus, and Web of Science. Books and book chapters, working reports, and grey literature, e.g., reports and non-academic research, were not included. The scientific impact of publication sources was not considered as an exclusion criterion because the intention was to capture the broadest perspective of scale and influence of SI, and, by restricting publication sources, small-local initiatives analyzed by works published in less popular journals could be left aside. This search provided 222 results on 6th May 2021 (duplicates removed). The reference manager Mendeley was used to organize the retrieved documents. At the next step, titles and abstracts were assessed. 9 documents were identified as not in line with the topic, while two others were working reports, and were, therefore, excluded ($n = 11$). In addition, five documents could not have their full texts accessed and were also removed ($n = 5$). The subsequent step consists of reading the remaining 206 records, filtering and excluding items that do not demonstrate adherence to the topic under investigation. Here, seven other documents ($n = 7$) were excluded because they did not approach SI and grassroots initiatives in a way that shed light on their impact on energy transitions (e.g., mathematical modeling and optimization schemes for energy storage). This search resulted in 199 scientific works as shown in Fig. 1.

2.2. Qualitative content analysis

The qualitative content analysis comprised the establishment of categories and the classification of articles in these categories, i.e., coding [38,39]. The categories were established after reading the full text of the 30 articles covered in the initial search described in Data Collection (Section 2.1). The coding process was manually implemented. Articles were read one after the other and had information regarding the categories from Table 1 extracted from them. Categories, subcategories, their definitions, and reasons to be included are presented in Table 1.

It is also suitable to clarify that the term 'initiatives' refers to "associations of actors engaged in energy system transformation through collective, participatory and engaging processes, seeking collective outcomes" [49], p.3. They are interpreted here as cases of SI and concern the following: grassroots innovations or initiatives, bottom-up initiatives, community-based or community-led actions, niche innovations, community energy, community-owned energy (storage) systems, renewable energy cooperatives, local energy transitions, social movements, local energy initiatives, co-creation, co-production, shared renewable energy systems (SRES), and collective energy initiatives. Because of a lack of clear-cut definitions, some terms seem to be used interchangeably (e.g., bottom-up, grassroots, community-based, niche). However, the differentiation of these terms and the adequacy of their utilization are not discussed here.

2.3. Data analysis

For data analysis, Microsoft Excel was used to analyze both bibliometric and content information. Here, the bibliometric analysis encompasses authors, authors' institutions and countries, years of publication, citations, publication type (i.e., journal or conference proceedings), source, and database. Fig. 2 shows the distribution of registers by database, where 59 works could be found in all three databases, and most of the works ($n = 86$) could be found in at least two databases. Web of Knowledge, Science Direct, and Scopus contributed with 9, 12, and 33 exclusive works, respectively.

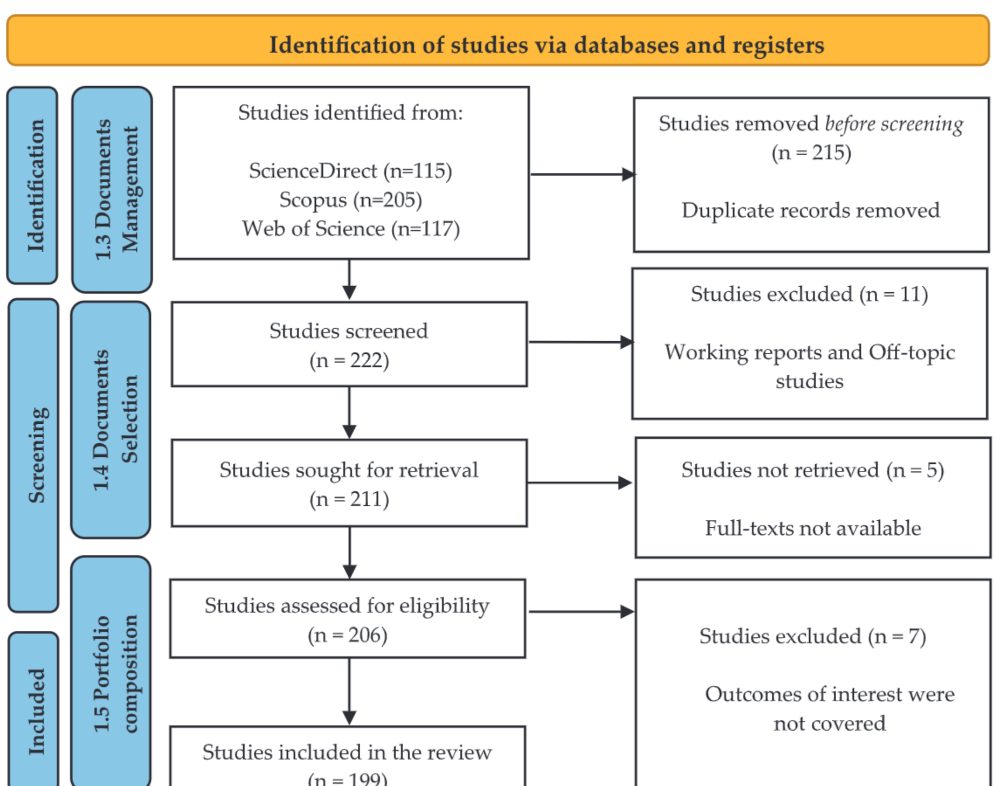

Fig. 1. Systematic literature review process.
Source: Adapted from [37].

Table 1
Categories and subcategories considered in the Content Analysis, their definitions, and reasons to be included.

Categories	Definition	Subcategories	Reasons
Geographical Context	It refers to countries/ continents where SI takes place	–	To evaluate where SI has developed and how it relates to energy poverty discussions and the North-South divide
Sociotechnical change	It refers to sociotechnical changes towards decentralization, digitalization, and decarbonization (3-D)	**Decentralization:** "drawing power from multiple, localised energy networks, through the deployment of low carbon technologies such as local solar plants […]; and increasing the number and type of energy providers (such as domestic and business prosumers)" [40], p. 5 **Digitalization:** it "has been enabled by creation and use of computerised information and processing of the vast amounts of data generated at all stages of the energy supply chain and at all scales" [40], p. 5. **Decarbonization:** "The decarbonization of the energy system as part of global climate change reduction efforts has resulted in the development of variable renewable energy sources (VRES) such as wind and solar energy." [41], p. 1	To evaluate if and how SI responds to 3-D trends in the energy industry
Types of SI	In the realm of energy transition, SI may relate to new organizational forms, new forms of governance and social configurations, novel policies and regulations, social incentives [9], and mixed initiatives.	**Organizational Forms:** new business models that stimulate low carbon energy services (e.g., renewable energy cooperatives) [9] **Governance and Social Configurations:** new forms of governance and development of social networks to stimulate transitions to low carbon economy (e.g., social networks supportive to RE, co-creation to co-design) [9] **Policies and Regulations:** policies and regulations that enable and empower social groups to engage in low carbon energy activities [9] **Social incentives:** incentives to change human behavior (e.g., to lower energy consumption) [9] **Mixed:** combination of different types of SI where no category stands out from the others	To understand the types of SI and initiatives that have developed for the energy transition and how they contribute for the latter
Obstacles	Conditions that hinder the establishment and development of SI	**Regulatory:** policies or regulations that hinder the establishment and growth of SI, (e.g., non-supportive legislation [42]) **Economic:** financial aspects that deter or delay the establishment and growth of SI (e.g., high upfront investments [43]) **Technical:** operational and efficiency issues that make difficult the establishment and growth of SI (e.g., need for automatization of local energy transactions [44]) **Social:** aspects linked to human behavior, social acceptance, and life in community that inhibit the establishment and growth of SI. (e.g., lack of social cohesion [45])	To determine the potential contribution of SI to the energy transition based on obstacles faced by initiatives
Enabling factors	Key factors that enable initiation or development of SI [46]	**Initiation:** factors that enable the initiation of SI (e.g., the liberalization of energy markets [47]) **Development:** factors that enable the development and continuation of initiatives (e.g., financial benefits [48])	To determine the potential contribution of SI to the energy transition based on conducive factors for SI establishment

3. Results

This section presents the results concerning the bibliometric analysis (Section 3.1) and the content analysis (Section 3.2) covering the geographical contexts of initiatives, associated sociotechnical changes, types of SI, obstacles, and enabling factors. A brief synthesis of the results is presented in Section 3.2.6.

3.1. Bibliometric analysis

Thanks to the inclusion criteria applied, from the total 199 works, 191 are journal articles and 8 are conference proceedings. Table 2 displays the ten sources with the highest numbers of works published. Due to the integrated socio-technical nature of the present topic of

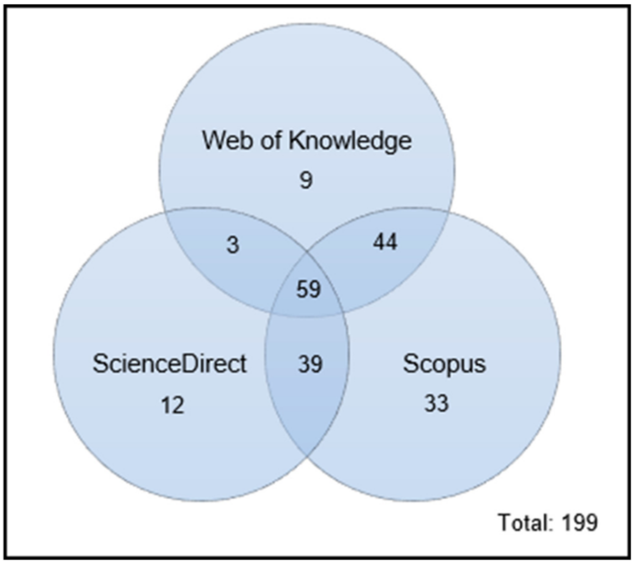

Fig. 2. Distribution of registers by database.

Table 2
Number of works per publication source.

Publication source	Number
Energy Research and Social Science	45
Energy Policy	26
Sustainability	20
Energies	8
Renewable and Sustainable Energy Reviews	7
Innovation: The European Journal of Social Science Research	5
Energy, Sustainability and Society	4
Journal of Cleaner Production	4
Renewable Energy	4
Local Environment	3

investigation, Energy Research and Social Science [50], was responsible for the publication of 45 out of the 199 works. Followed by Energy Policy ($n = 26$) [51] and Sustainability ($n = 20$) [52].

Table 3 shows an overview of the ten most-cited publications according to the Scopus database. The number of citations can be used as an indicator of the impact of research on the scientific community. Although it should be realized that most recent papers tend to be least cited than older ones for an obvious reason (shorter availability), which may partially explain the high number of citations of the first title presented in Table 3.

The number of publications on the topic has grown substantially since the first publication in 2012, as shown in Fig. 3, where the year 2021* encompasses the period from 1st January to 6th May 2021 when the search on the databases was made.

Fig. 4 displays the percentage of published works by continent or country of origin. It takes into account the countries affiliated with all authors, not only the first author of each publication. Such geographical perspective helps to identify the regions where SI and the energy transition have been mostly discussed by the scientific community. As it can be seen, an overwhelming majority of publications come from Europe, totalizing 77% (18% Netherlands, 13% Germany, 13% UK, 6% Spain, 27% other European countries). North America accounts for 8% of the publications, Oceania 7%, and the African and Asian continents account for 4% each. Scientific works published by authors affiliated with South American institutions were not represented in the sample, which can be explained by the English language inclusion criteria that exclude works in Spanish and Portuguese. In addition, South America, as part of the Global South, probably has fewer cases of community-based initiatives

Table 3
Overview of the ten most cited publications.

	Title	Year	Publication source	Citations[a]
[35]	Growing grassroots innovations: exploring the role of community-based initiatives in governing sustainable energy transitions.	2012	*Environment and Planning C: Government and Policy*	452
[53]	Grassroots innovations in community energy: The role of intermediaries in niche development.	2013	*Global Environmental Change*	271
[54]	A grassroots sustainable energy niche? Reflections on community energy in the UK.	2014	*Environmental Innovation and Societal Transitions*	197
[55]	Renewable energy cooperatives as gatekeepers or facilitators? Recent developments in Germany and a multidisciplinary research agenda.	2015	*Energy Research & Social Science*	160
[56]	Citizens' willingness to participate in local renewable energy projects: The role of community and trust in Germany.	2016	*Energy Research & Social Science*	149
[57]	Making the most of community energies: Three perspectives on grassroots innovation.	2016	*Environment and Planning A*	134
[58]	Financing renewable energy infrastructures via financial citizen participation – The case of Germany.	2014	*Renewable Energy*	129
[59]	An interdisciplinary review of energy storage for communities: Challenges and perspectives.	2017	*Renewable and Sustainable Energy Reviews*	118
[60]	Local governments supporting local energy initiatives: Lessons from the best practices of Saerbeck (Germany) and Lochem (The Netherlands).	2015	*Sustainability*	88
[61]	Collective ownership in renewable energy and opportunities for sustainable degrowth	2015	*Sustainability*	76

[a] Number of citations retrieved from Scopus database on July 16th, 2021.

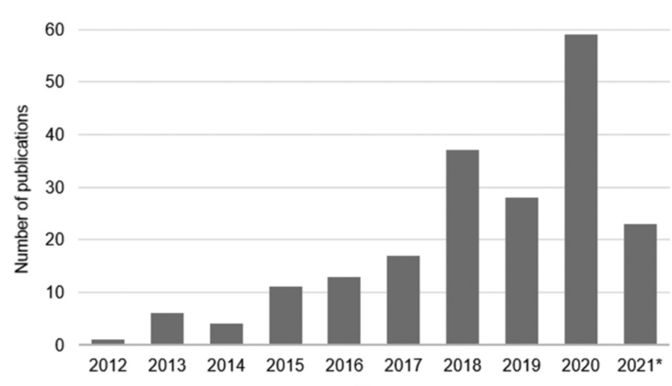

Fig. 3. Number of publications per year.

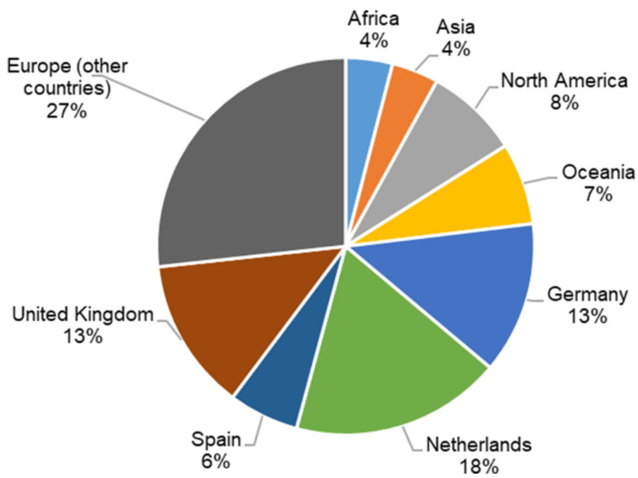

Fig. 4. Geographical distribution of publications by continent or country of origin.

involved in energy transition projects in comparison to other continents, which may discourage data gathering and research.

3.2. Content analysis

The results shown in this subsection are structured around the following topics: article's geographical context (Section 3.2.1); socio-technical changes (Section 3.2.2); types of SI and initiatives (Section 3.2.3); main regulatory, economic, technical, and social obstacles (Section 3.2.4); enabling factors for initiation and development of SI (Section 3.2.5); and synthesis of results (Section 3.2.6). It is worth mentioning that most of the works collected data on barriers and enabling factors for the development of bottom-up initiatives by reaching out to organizations and communities and gathering data through interviews (e.g., [62,63]), surveys (e.g., [64,65]), meetings and workshops (e.g., [42,66]).

3.2.1. Geographical context

Scientific works were grouped by the geographical context they were confined to (Table 4). Europe has been the focus of 128 studies. This number includes single-country and multi-country studies provided they included European countries only. Germany, UK, and the Netherlands were the single focus of 27, 20, and 16 articles, respectively, because of their large number of community energy initiatives and favorable cultural, socioeconomic, and institutional aspects. These numbers go up when cross-country and multi-countries analyses are included, going from 27 to 42 works for Germany, 16 to 27 for the UK, and 20 to 27 for the Netherlands. Among other European countries addressed by the remaining 65 works within the European context, there is Austria [43,67,68], Denmark [69,70], and Italy [71–75]. Additionally, a highlight is given to Spain that, even though presenting a political environment that is not so favorable to the development of community energy [76], received the attention of energy researchers because of the successful Som Energia Cooperative [77–79]. Asia is the second most studied continent with 18 works, followed by North America ($n = 11$), Oceania ($n = 10$), and Africa ($n = 6$). The category "Others" ($n = 26$) includes the Global South, which is directly investigated by three works [80–82], and the North-South divide [83,84]. It also comprises studies that analyze more than one continent such as Europe and North America [85], Europe and Asia [86], and Europe, North America and Australia [87], provide a global perspective [88], or do not have a specified context. Seventeen works fit in the latter case mostly because they investigate a particular type of SI, such as community wind energy [89,90] or energy governance [23], without explicit geographical boundaries. The results are displayed in Table 4.

Table 4
Geographical context of works.

Geographical context	Number	References[a]
Europe	128[b]	[33,44,91]
Germany	27	[92–94]
Netherlands	20	[45,95,96]
UK	16	[35,97,98]
Asia	18	[99–101]
North America	11	[102–104]
Oceania	10	[105–107]
Africa	6	[28,66,108]
Others	26	[21,109,110]

[a] The list of references is not exhaustive.
[b] Including Germany, Netherlands, and the UK.

3.2.2. Sociotechnical changes

This section highlights the sociotechnical changes that have been recognized in the reviewed articles in association with technological developments, according to decarbonization, decentralization, and digitalization trends [16].

3.2.2.1. Decarbonization. Actions towards decarbonization are broad in nature but usually regard energy efficiency, increasing RES share, and decarbonizing the transport sector. As decarbonization is one of the goals of the energy transition, all investigated works could be somehow cited herein. Concerning RES, from the 199 articles, 55 did not explicitly address any RES. The remainder analyzed a particular aspect of RE initiatives such as policies and regulations associated with the establishment of wind energy cooperatives, case studies such as community energy enterprises specialized in the generation of solar energy or the utilization of biomass. Intending to have a global perspective over RES and SI, Fig. 5 presents the number of times that each RES was investigated in the articles, e.g., multi-case studies that address two solar developments would count as two occurrences. Solar and wind comprise more than 50% of the RE employed in SI initiatives with solar being the single RES addressed by 41 papers.

The reasons for solar predominance can be its capacity adequacy to household and community needs, the possibility of rooftop installations, decreasing costs of solar photovoltaics (PV) technology, and FiT incentives. Yet, challenges for RE uptake remain, among which the development of energy storage systems, which are the main focus of seven of the reviewed works, i.e., [42,59,92,111–114]. Regarding transport sector, Zohar et al. [115] investigated through the middle-out perspective how intermediaries are contributing to the diffusion of electric vehicles and the growth of solar share. Azarova et al. [43] analyzed an alternative business model for community-owned EVs charging stations. Besides transportation, the improvement of heating

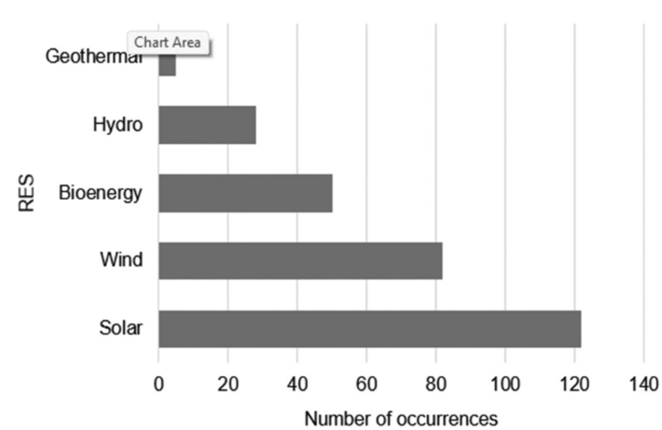

Fig. 5. Occurrences of RES.

technologies (see [116,117]) and thermal energy systems (see [48]) can contribute to reducing energy consumption through increased energy efficiency. Furthermore, a combined development of heating, fuel, and electric technologies can usher in the development of integrated community energy systems (ICES) [118]. Cost allocation in ICES is reviewed in Li et al. [119] arguing that "costs should be allocated fairly among the members of a local energy community", p. 1.

3.2.2.2. Decentralization. In comparison to large power systems, in which power is generated at central power plants for national to neighborhood scales, integrated community energy systems generate electricity through local distributed energy resources that provide for local communities [119]. Decentralized energy generation is associated with the small-scale deployment of solar, wind, geothermal, biomass, and hydropower energy. In this context, Muhoza et al. [120] evaluated household-level transitions through the employment of mini grids in rural Zambia, highlighting the struggles of mini grids achieving financial sustainability after initial project funding ends. Pasimeni [73] investigated the community acceptance and diffusion of mini grids exploring different scenarios through agent-based modeling. Whereas Kirchoff et al. [81] focused "on the successful implementation of microgrids supplied by renewable energies in very diverse environments", p. 1, mentioning the importance of swarm electrification for increasing access to RE. As a last example, Sareen et al. [121] evaluated the challenges related to achieving energy autonomy in the eco-community of Tamera, Portugal.

3.2.2.3. Digitalization. Migrating from centralized energy systems to decentralized ones requires changes in infrastructures and grids. Part of grid upgrades concern digitalization processes and technologies such as smart bidirectional meters, smart equipment, the integration of information communication technologies (ICT), and digital tools, which are linked to the innovative role of consumers as prosumers that produce and consume energy. On this matter, the work of Labanca et al. [109] treated of innovative low-carbon technologies, such as ICT, that support smart networks. Hansen et al. [122] on smart management evaluated how the use of digital technology affects energy systems governance concluding that it enables energy share but also increases the system's complexity. Snape [123] focused on smart community energy schemes, while van Summeren et al. [124] focused on the role of virtual power plants (VPPs) for community energy. Similarly, Ford et al. [110] analyzed smart local energy systems, and, even though focused on citizen participation, Sguglio et al. [75] analyzed the case of RES NOVAE related to establishing a smart city in Italy.

The work of Fernandez et al. [105] also focused on peer-to-peer (P2P) trading for local energy systems involving consumers with renewable energy units. Ehrtmann et al. [125] evaluated regional electricity models for community energy in Germany. Crespo-Vazquez et al. [126] designed a community-based local energy market based on P2P, smart grids, meters, and demand-side management. Howind et al. [127] evaluated the impact of demand-side management on rural communities' energy balance, whereas Boait et al. [111] assessed the impact of demand response technology on local trading employing both thermal and electrical energy storage. Lastly, Lavrijssen and Parra [44] identified "the main radical innovations in the electricity market", p. 1, which relates to P2P and blockchain technology.

3.2.3. Types of social innovation and initiatives

This section is concerned with classifying SI in different categories with the aim to facilitate the display of the diverse range of initiatives presented in the reviewed literature. However, since a combination of fronts is often necessary for the successful establishment of innovative social practices (e.g., policies and regulations must be in place to allow new forms of governance and new organizational forms to flourish), and most works bring this multifaceted perspective, the classification is not exclusionary, and works were arranged by their principal target. The classification of SI in the context of the energy transition process followed what was presented in [9]:

> "In the realm of energy transition this [SI] may relate to issues like social incentives (including 'green nudges') to stimulate behavioral change (e.g., to lower energy consumption), new social configurations (e.g., using social entrepreneurs or intermediaries to build social networks supportive to renewable energy), new organizational forms to stimulate low carbon energy services (e.g., renewable energy cooperatives), new forms of governance to stimulate transitions to low carbon economy (either at the local or regional scale; e.g., citizen self-governance or co-creation to co-design low carbon policy), novel policies and regulations to empower social groups to engage in low carbon energy activities." [9], p. 4.

As there was an overlapping between the initiatives that focused on governance and social configurations, they were grouped in one single category. Therefore, each work was classified according to its focus: Governance and Social configurations, Social Incentives, Organizational Forms, Policies and Regulations, or Mixed. When the work under investigation equally analyzed different aspects of SI and no aspect stood out from others, it was defined as "Mixed". Examples are Adesanya et al. [128] that investigated several aspects of 100% RE grassroots transition in cities in the United States (US) and Lenhart et al. [129], which approached evenly governance, social configurations, organizational forms, and policies for electric cooperatives in the US. The result of this categorization is shown in Table 5. Within the category "Organizational Forms", papers that referred to financing aspects were highlighted in Table 5 as this is one of the main lines of discussion in Section 4.2.

3.2.3.1. Organizational forms. Within SI, new organizational forms refer to a diverse set of community initiatives and business models that enhance access to and public ownership of low carbon energy services, such as renewable energy cooperatives. The work of Braunholtz-Speight et al. [19], for example, evaluated business models and financing characteristics of community energy in the UK. De Brauwer et al. [132] analyzed the potential of citizen-financed community renewable energy to drive the energy transition in Europe. Thapar et al. [144] presented a new business model in which the community is seen as a shareholder of RE projects in India getting up to 15% equity participation in turn of providing their land. Proka et al.'s [42] work "explores the opportunities and constraints for a collaborative business model for the neighbourhood battery in the Netherlands [...]", p. 1. De Bakker et al. [145] observed "the rise of a new hybrid form of energy company combing commercial and cooperative" in the Netherlands, where cooperatives were forging alliances with other energy market players. In addition to innovative business models and financing gates, SI initiatives focused on organizational forms also refer to: local energy markets and peer to peer trading [44,105,126]; industrial community energies [146,147]; renewable energy cooperatives, e.g., [147–149]; community energy storage [42,59,92,113,114]; and the integration of smart and digital tools to innovative community energy developments, e.g., VPPs [124].

Table 5
Types of SI and related initiatives.

SI	Number	References[a]
Organizational forms	72	[18,130,131]
Financing aspects	*10*	[43,58,132]
Governance and social configurations	64	[101,115,116,133–135]
Mixed	30	[90,136,137]
Policies and regulations	22	[138–140]
Social incentives	11	[141–143]
Total	199	

[a] The list of references is not exhaustive.

3.2.3.2. Governance and social configurations. Concerning new forms of governance, initiatives are centered on the importance of bringing new kinds of actors to the energy discussion. According to the reviewed literature, new forms of governance point to: co-design for mediating energy transitions [28,71]; co-production of energy services [21,134,150–153]; shared governance of community energy [122]; participatory development of tools to support local energy transitions [154]; co-creation for unlocking sustainable transitions and envisioning energy pathways [1,117,155,156]; public participation [99,157]; and self-governance [118,158]; innovative social configurations related to the presence of intermediaries [53,54,159], local entrepreneurship [98,160], the development of social networks [45,112,135,159,161], and new actors coalitions [162]. Out of the 64 papers on this category, eight also connect new forms of governance and social configurations for the energy transition to the discourse of energy democracy [63,153,162–167].

3.2.3.3. Policies and regulations. In a nutshell, works in this category focused on regulatory schemes and taxes, e.g., [168,169], subsidies and price guarantee schemes, e.g., [33,170–172], and legal definitions and compliance that somehow support or hinder SI development, e.g., [169,173]. These policies and regulations are further discussed as Obstacles (Section 3.2.4) and Enabling Factors (Section 3.2.5). On supportive regulations, three works focused on the Postcoderoos (PCR) scheme in the Netherlands [139,174,175], and the work of Roberts [138] analyzed the CEP, which established a supportive legal framework for community ownership at the EU-level. Also focused on EU directives, Horstink et al. [169] investigated nine European countries and identified, for instance, a mismatch of policies with the needs of different RE prosumers, which led the authors to offer recommendations for the transposition of EU directives into national legislations. On local policies, one work addressed the “Positive Energie Territories” (TEPOS) in France [176]. The work of Muza and Debnath [108], on inclusive renewable policy, investigated household-level appliance uptake in Rwanda. Gabaldón-Estevan et al. [177] evaluated the implications of Spanish energy policy for sustainable energy development concluding that changes in regulations have also affected SI. On supportive schemes, Nolden [172] compared the development of wind community energy in the UK and Germany and analyzed the role of FiT for so. Wierling et al. [33] performed a statistical analysis of energy cooperatives' activity in four European countries and observed that their role “is shrinking in recent years due to a tightening or removal of supportive schemes”, p. 1. Pinker et al. [47] explored how local and community energy initiatives' trajectories are “shaped by and entangled with the institutional and regulatory landscapes in which they operate”, p. 1.

3.2.3.4. Social incentives. Differently, social incentives are linked to behavioral changes to promote renewable energy [142,143,178,179], and social movements calling for reducing the world’s reliance on fossil fuels [141]. For instance, Meiklejohn et al. [179] investigated Australian local community engagement programs to reduce GHG at household levels and how these programs have changed with rooftop solar PV. Similarly, Kim et al. [180] analyzed how the Seoul Metropolitan Government created enabling conditions for promoting community energy initiatives including through various educational programs. Shabdin and Padfield [181] evaluated energy behavior in relation to gender in rural communities without twenty-four-hour electricity in East Malaysia. Still, among social movements, one could cite the Transition Towns movement, which has been addressed by three of the reviewed works [22,54,182] that, stemming from the UK, has reached an international level being “oriented to local grassroots citizen-led efforts that prepare for and support a societal energy transition to a low-carbon future” [182], p. 180.

3.2.4. Obstacles

The main obstacles identified from the content analysis are presented below as Regulatory, Economic, Technical, and Social obstacles. Lists of references are exhaustive in this section, i.e., all works that refer to that particular aspect are cited.

3.2.4.1. Regulatory. From the literature review, the main regulatory obstacle to the development of SIs in the realm of energy transition has been the lack of or hampering legislation [22,42,70,92,93,100,103,113,118,134,136,138,148,177,183,184], which has been highlighted by around 10% of all reviewed works. Among these, three specifically refer to the lack of legislation concerning community energy storage [42,92,113]. For instance, Özgül et al. [100] concluded that one of the biggest obstacles in the development of renewable energy cooperatives in Turkey was the insufficiency of the legislation and “the uncertainty about whether or not the necessary regulations will be made”, p. 115. Moreover, even though not an complete list of obstacles, other regulatory obstacles referred to were: legal and regulatory uncertainty in regards to policies and subsidies [18,42,92,100,106,118,146,183]; complex legal frameworks [47,74,125,138,143,169]; regulations that favored large-scale projects, centralized energy systems, and big energy companies [82,138,139,185,186]; competition against energy incumbents [85]; uncertainty concerning the most appropriate cost allocation method [119]; energy taxes and fees (e.g., double fee for energy storage [114], “normal” tax regime imposing energy tax and Value Added Tax for PCR [139]); inconsistency between policy levels (municipal, national and international levels) [93]; vested political interests (e.g., Spanish context [177]); and lack of institutional support [29,74,82,134,136,143].

3.2.4.2. Economic. On the economic side, it has been reported: difficulty in securing funding [35,67,134,136,158,187] due to the communal aspect of most initiatives; lack of financial resources within the community [18,33,45,47,100,103,144,148,172,188,189] and absence of financial support schemes [144,189,190]; split-incentive issues (e.g., in social housing [187]); availability of cheaper non-renewable energy [185]; lack of or low profitability of business models [59,125,148]; high grid connection and infrastructural upgrade costs [74,113,140,172,185,191,192]; risk capital (e.g., development of community wind energy schemes [172]); economic burden from taxes and levies (e.g., in CES [92]); high upfront investment (e.g., Solar PV [1,142]); and payment scheme not suited to local socio-economic conditions (e.g., household energy transitions in Zambia [120]).

3.2.4.3. Technical. Within technical issues, Nolden [172] noticed that planning requirements and bureaucracy for small-scale developments can be similar to large-scale ones. Lack of local technical expertise [42,74,100,106,125,144,183,193], communal capacity in terms of personnel, skills, leadership, and finance [10,22]; a volunteer-based workforce [45,169,183,188,191]; technical complexity and restrictions [18,33,74,148,183,193]; limited grid and infrastructure capacity [2,47,169,183,194]; limited customer base due to regional boundaries of some legislations (e.g., PCR [174]); and difficulties to scale up [83,195] and replicate projects due to contextual characteristics have also been pointed out as obstacles to be overcome. When integrating smart equipment and digital tools, Hansen et al. [122] reported on the challenge of data acquisition and management, and privacy issues together with increased technological complexity. In terms of RE generation, assessing regional particularities in terms of RES potential are key for effective regional strategies as proposed by Lutz et al. [196].

3.2.4.4. Social. In addition, social barriers are connected to lack of or limited environmental awareness [74]; entrenched habits concerning energy systems [74,183,197] and resistance to change

[44,60,114,118,129,154,198]; lack of social cohesion and trust [22,118,174,199]; restricted agency [2,190]; a non-unified vision of future energy systems [114,185,194]; unclear or unfair cost-benefit distribution [42,152]; passive citizenship [2,82,114,185,191]; exclusionary tendencies of some organizational forms [10,120]; lack of knowledge and communication [122,166,183,199]; and low community engagement [22,66,186]. Another challenge reported in the literature concerns truly involving communities in the creation of future energy landscapes (see [129,152]), as past experiences with energy projects may create resistance towards new developments, e.g., resistance of indigenous communities to energy developments in Canada [104,162,190].

3.2.5. Enabling factors

The aim of this section is to highlight the range of factors that commonly enable the Initiation and Development of SI initiatives. Here, lists of references are also exhaustive.

3.2.5.1. Initiation. Regardless of the type of SI, for its initiation, the literature has highlighted the importance of having a favorable legal framework, political will, and commitment of municipalities towards sustainability [48,74], but also a supportive constellation of actors and the active role of key personalities from the local community [1,81,137,185,200,201]. According to Klöckner [200], a decisive factor for the initiation and further development of initiatives is "having charismatic and socially skilled persons at key positions in the social network", p. 10. For initiatives that involve RE generation, the initial enabler is of a regulatory nature since energy markets must be liberalized and allow the participation of new prosumers and flexible electricity purchase as mentioned by [42,45,47,185]. Moreover, the ability to get loans and grants at better conditions [2,138,158,169,188], the decreasing cost of solar PV and wind technologies [19,67,100,137,185], the presence of social capital [4,202], and the involvement and empowerment of the community from early stages, i.e., co-creation [1,75,81,114,152], are emphasized by the aforementioned references. Initiation can be facilitated by the presence of national-level directives and debates as highlighted by Refs. [138,185,194], but even when these are not in place, local government participation and support can financially, technically, and legally back up initiatives as pointed by Refs. [10,45,60,118,188,203].

3.2.5.2. Development. For the development and growth of SI, Refs. [45,143,148,169,188] mention the importance of collaborating and cooperating with different actors such as local schools, universities, governmental and environmental institutions, and other community-based organizations. In favor of such collaborations, the importance of effective organizations of actors, strong networks, and local entrepreneurship has been recognized by Refs. [142,160,200,204]. According to the literature, in successful i.e., well-established, cases of SI, members are highly committed and held a common vision built on social and environmental awareness [73,76,87,158], there is a culture of local participation, trust, strong leadership, lack of NIMBY sentiment, and knowledge-sharing opportunities [134,156,201,205,206] that allow for continuous improvement and resilience building [53,76,164], which are prerequisites for SIs to navigate complex socio-technical transitions. The ability of keeping financing means within the region, building local capacity, and promoting regional socio-economic development are also highlighted by Refs. [18,45,60,66,87,129,207]. For new organizational forms involved in energy generation, the existence of long-term policies [81,186,208] and supportive tariffs [81,136,138,191,204], as well as financial benefits [67,111,120,142,144,179,185,209] are deemed essential for the creation and growth of initiatives. In the case of communities with low disposable income, the absence of or accessible upfront joining fees to local projects [29,66,120] are a requirement for the long-term sustainability of projects.

3.2.6. Synthesis

The pattern encountered in the bibliometric analysis (Section 3.1) concerning the number of publications from Europe (Europe 77%, North America 8%, Oceania 7%, Africa 4%, Asia 4%) repeats itself for the geographical context of SI, as around 70% of approached initiatives take place in Europe (Table 4). The main reason behind a much larger number of publications coming from the Netherlands, Germany, and the UK (Fig. 4) can be explained by the respective larger presence of bottom-up initiatives in these countries and their relative maturity. These national contexts are marked by enabling factors such as favorable policies and governmental recognition of decentralized approaches' importance to meet RE targets. The Energiewende, in Germany, a national commitment to the energy transition, allowed unprecedented levels of public participation and, by the end of 2012, almost 50% of the total RES capacity in Germany was owned by citizens and cooperatives [210]. This advancement was due to a widely supported nuclear power phase-out and the presence of FiT schemes that associated community engagement with financial benefits [208]. Nevertheless, this dominant 'European perspective' can also be felt in the most cited publications as eight out ten focus on Europe (four works are focused on the UK [35,53,54,57], three on Germany [55,56,58], one on Germany and the Netherlands [60]), whereas the other two do not have a specific geographical context [59,61].

Nonetheless, in places where FiT has been phased out, there has been a reduction in the development of new energy associations by communities [93] due to more constrained investment conditions. In the Netherlands, on the other hand, even though the country chose to adopt a net metering scheme instead of FiT, the establishment of the PCR model allowed citizens to successfully generate energy from solar PV from collective rooftops [139]. In the UK, policies such as the Shared Ownership Policy of 2014, which facilitate the development of industry-community projects due to their non-commercial nature that could combat NIMBYism ("not in my backyard" attitudes), have fostered the advancement of community-based initiatives [98]. Even though the country has experienced a reduction in FiT schemes, the increasing price of electricity has motivated civic society to continue to invest in RE [98]. EU-level debates and commitment towards carbon mitigation targets can also help raise environmental awareness and motivate organizations and the civic society to pursue more sustainable behaviors and innovative business models.

Additionally, publication trends show that interest in the topic has grown, which happens in parallel to increasing efforts towards fighting energy poverty in the Global South. This can be a result of technological development towards decentralization and downward trends in the costs of solar and wind technologies. Solar PV power costs have declined by 82% from 2010 to 2019, onshore wind by 40%, and offshore wind by 29%. The price per kilowatt-hour of solar and wind energy has experienced a yearly decrease of 13 and 9%, respectively, for the same period [211]. Accordingly, solar PV and wind energy are the technologies most applied to SI. Nevertheless, "[a]lthough technologies might be technically and economically viable, they must also meet the energy needs and practices of the community in question", [212], p. 157. This leads to the second point, the envisioning of new business models that start to allow the participation of once excluded actors, e.g., low-income households [179]. Concerning exclusionary aspects of energy developments, the North-South disparities regarding energy access and the uneven distribution of burdens and benefits has raised concerns about energy justice and the unfair quality of the energy transition [213]. Hence the necessity of co-creating and designing transitions, so local needs are met, and socioeconomic conditions are fairly improved as highlighted by Marquardt and Delina [101].

Nevertheless, even in Europe, obstacles for the development of SI remain (Section 3.2.4). For new organizational forms, the main barriers are regulatory and economic, as they must compete with well-established large players provided with enough financial resources to balance risk and market uncertainty, as documented by works on energy cooperatives (e.g., [192,203,214]). According to the literature review, RE cooperatives, the most common initiative among new organizational forms, are studied by 34 works, of which 10 study initiatives developed in Germany and only three investigate cooperatives not in Europe. One of the reasons for cooperatives being largely addressed is the broad range of services that is provided by them such as electricity provision and district heating suitable to the European context [33]. Furthermore, some European countries already have a local culture of cooperativism, e.g., Italy [72]. For governance and social configurations, difficulties concern but are not limited to lack of trust, an absence of a shared vision, and poor leadership within the community. Social incentives, innovative policies and regulations are also a matter of governance associated with local government aspirations, long-term planning, and the alignment between levels of public administration. Nonetheless, each initiative must deal with a set of political, social, technical, and economic obstacles to establish itself, which emphasizes the complex nature of SI for the energy transition and the need for integrative approaches to foster its development. The obstacles and enabling factors gathered in the previous sections (Sections 3.2.4 and 3.2.5, respectively) are linked to the ability of SI to transform local energy systems and contribute to the energy transition as it will be discussed in Section 4. Fig. 6 graphically represents the aspects considered for the content analysis.

4. Discussion

The first research question (How has SI contributed and can contribute to achieving sustainable energy transitions?) is addressed through three lines of discussion: the transformative potential of SI and degrowth (Section 4.1); SI contribution to financing and co-producing energy transitions (Section 4.2); and SI, access to energy, and just energy transitions (Section 4.3). The second research question (What is the role of community-based initiatives in a transition to a low-carbon sustainable economy?) is discussed in Section 4.4, followed by research limitations and future research agenda (Section 4.5).

4.1. Transformative potential of SI and degrowth

Even though a controversial theme, at least eight of the reviewed works, i.e., [14,34,61,76,83,168,182,215] utilize the concept of degrowth. Community renewable energy (CRE) has some similarities with the degrowth movement in regards to recognizing the importance of public participation and governmental incentives towards local development [215]. However, few CRE projects are truly aligned to the degrowth movement in terms of transformational agendas, as they do not take distance from market-based capitalist approaches, excessive energy consumption, and fossil fuels, i.e. exnovation of fossil fuels [14]. SI has problematic aspects from a degrowth perspective, because it

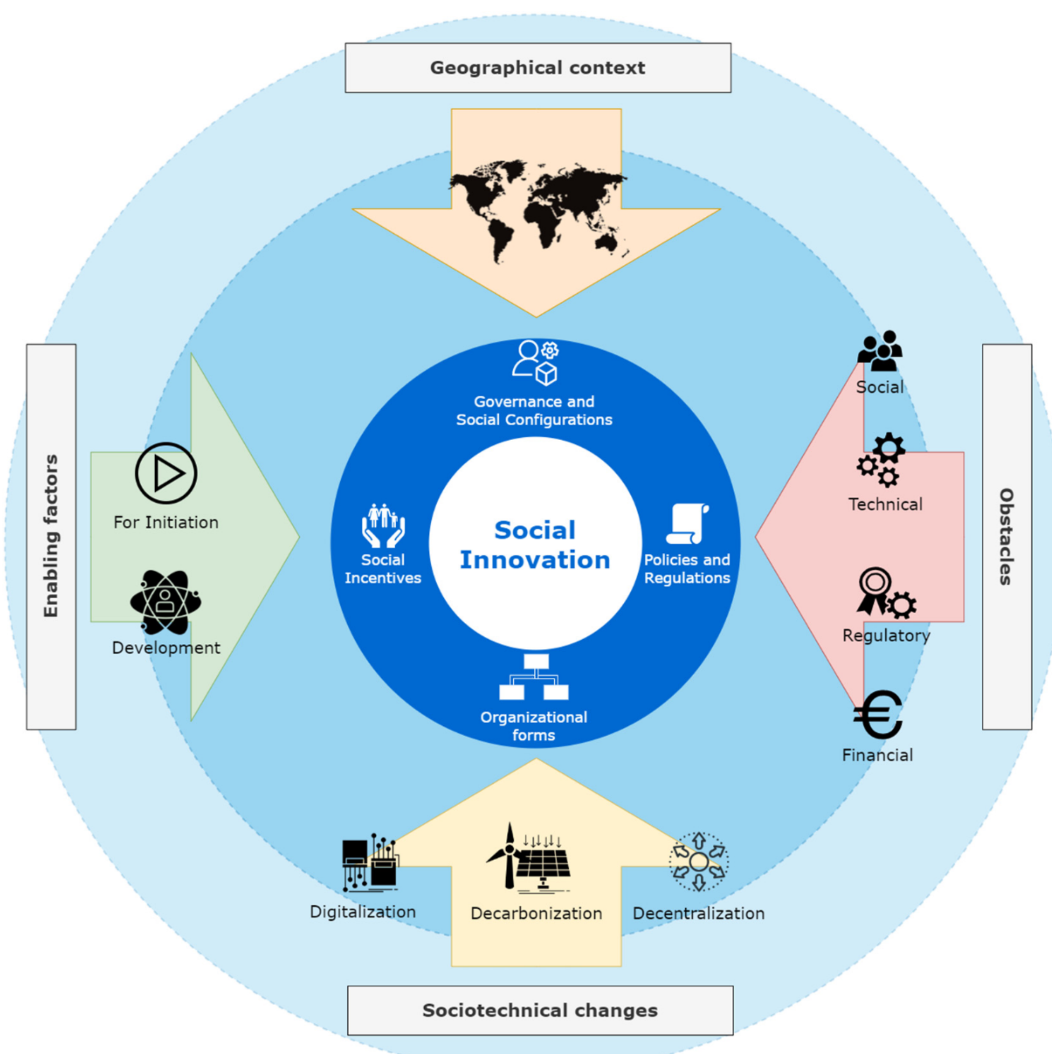

Fig. 6. Graphical representation of the Content Analysis.

seems to favor incremental rather than transformative approaches [14]. Selvakkumaran and Ahlgren [156], for instance, employed the TSI to investigate three cases of SI in Sweden and Denmark and found that none of the initiatives induced narratives of change into the regime. The challenges of grassroots diffusion have already been highlighted by classical works on grassroots innovation, e.g., [216], as “small-scale and geographical rootedness makes scaling up difficult”, [216], p. 596. It has been also argued that the identification of community-based initiatives as mainstream alternatives indicate that such initiatives do not want to diffuse themselves but rather remain ‘outliers’ for the regime [216].

Although SI may not provide the radical changes needed for degrowth, evidence from the literature shows that some initiatives have the potential to overcome scaling up issues. With local boundaries set aside, “collective and politically motivated renewable energy projects” (CPE) [61] can be seen as degrowth initiatives seeking for reducing energy consumption per capita and integrating sustainable practices. To sustain this view, Magnani and Osti [74] referred to the development of unions of energy cooperatives that have started to operate at a national level in Italy as promising. Even though uncertain and complex to manage and operationalize, they may pose a real threat to the centralized power system by diverting a considerable number of customers from energy incumbents. On the other hand, if activities remain restricted to local levels and exclusive local identification, grassroots innovations “can be easily tolerated by the dominant energy system” as they do not “provoke shifts towards a more sustainable and innovative way of producing and distributing energy” [74], p. 156. Innovative organizational forms such as energy cooperatives may escalate if they can diversify their customer base and form alliances at national levels (e.g., Som Energia [47,177]). In other words, “small-scale initiatives can reproduce elsewhere by ensuring groups are well connected regionally and nationally” [216], p. 596. Nevertheless, the ability to scale up depends on socioeconomic aspects and regulatory frameworks, as policies and regulations can either hinder or foster the development of alternative approaches to energy provision.

Following the classification of Marques et al. [11], alternative and collective approaches to energy provision through energy cooperatives and community energy (new organizational forms) can be considered targeted at radical SI as they can bring significant changes to local energy systems. From the literature review, it can be inferred that most grassroots initiatives do propose systemic alternatives and offer alternatives to the centralized power system [34]. Yet, without a large support network at national and/or international levels, SI transformative potential remains conditioned by broader politico-economic contexts at different policy levels [217,218]. Be that as it may, requests for radical rethinking will always struggle when facing institutions that benefit from the status quo [57].

4.2. *Financing and co-producing energy transitions*

Financing and access to funding were pointed as a big barrier to the establishment of grassroots innovation (Section 3.2.4). Therefore, in terms of financing, Broughel and Hampl [18] stated that “engaging small-scale investors through CRE projects offers an alternative and promising source of private funds”, p. 133, towards increasing the share of RE in the energy mix. The work of de Brauwer and Cohen [132] supports this statement once their results indicated a social potential of €176 billion could be obtained from European citizens to co-finance community-based wind energy cooperatives. However, groups that do not have enough disposable income may be excluded from participating in co-ownership schemes. Thanks to their membership-based operations and higher electricity costs, RE cooperatives are often dominated by the middle class [215] Furthermore, people are driven to invest in these innovative collective organizational forms if it is considered a stable investment with adequate rates of return [18,92,184,202]. To reduce the chance of people making decisions based on portfolio building, individual benefits should be aligned with larger social objectives headed for the decarbonization of the economy and the inclusiveness of marginalized and vulnerable communities [68,207,219].

Pertaining co-production, Galende-Sánchez et al. [21] reviewed 183 works on participatory processes within the climate and energy domain and concluded that a majority of co-production initiatives were limited by top-down approaches to consultation and did not include citizens in the decision-making process nor give them power over the outcomes. Nevertheless, the authors claimed that “despite not being a silver bullet, meaningful citizen participation constitutes a viable alternative to tackle today's complex problems” [21], p. 1. One reason for such limited power could be the current model of public communication, which gives weak visibility to grassroots and social movements [157]. On the other hand, one should bear in mind that “direct participation or better representation of stakeholders […] do not necessarily coalesce social and environmental benefits” [84], p. 307, as interests may be conflicting. Fischer et al. [214], when investigating citizens' willingness to join renewable energy cooperatives in Germany, identified a substantial potential for citizen participation, but, in face of legal reforms and increasing complexity of energy business models, considered that professionalized energy cooperatives might prevail over bottom-up volunteer-based initiatives in the future [214]. However, organizations must direct efforts at maintaining local ties and building local capacity as professionalization may lead initiatives to drift away from initial shared vision and communities' interests [60,183].

Therefore, as co-production and co-design seem to have limited influence over projects, they can be seen as targeted incremental SI [11]. Although restricted in power, co-production is still relevant from a broader perspective of educating communities, energy democracy, and knowledge and experience sharing [28]. In developing countries, it can inspire citizens to engage in public issues [164]. Furthermore, it can prompt the development of new coalitions and collaborations among different actors such as academics, civilians, private and public organizations, i.e., quadruplex helix [112]. Recent attempts to include the wide society in energy decisions can be seen as the first steps towards a governance shift from top-down to bottom-up approaches, but self-governance can add “more complexity to the already complex governance arrangements found in the liberalized energy sector”, [220], p. 9. Finally, financing energy projects through civic capital looks promising for developed and high-income nations but does not seem applicable to the reality of developing and least developed countries.

4.3. *Energy access and just energy transitions*

Concerns towards energy access concentrate mainly in the Global South, where solutions towards grid expansion, micro-grids, and off-grids have been employed. These solutions are often dependent on international cooperation and funding, e.g., decentralized community-based micro-hydropower plants (MHPs) in Ethiopia that were implemented by the German Development Cooperation (GIZ) [29]. In comparison to developed countries, energy projects in poorer nations often experience a lack of resources at implementation or operation stages, which requires more flexible business models and a combination of funding sources. As stated by Vanegas Cantarero et al. [82], “[t]he energy transition comprises presumptions of energy efficiency, affordability, reliability, and energy independence. And in developing countries, in particular, it also entails expectations of economic development, social inclusion, and environmental sustainability”, p. 1. Therefore, in poor communities, especially in rural areas, energy provision must also trigger community development and empower end-users [120]. Thapar et al. [144], for example, in pursue of accelerating RE deployment in India, proposed a new business model in which community members provide land and support in activities in place of 15% equity participation.

Even though techno-fixes are not the answer for transitioning to a low carbon economy, ICT, smart equipment, and digital tools undoubtedly support local energy markets and decentralized production.

According to Cuesta-Fernandez et al. [221], community-owned energy cooperatives can provide “the platform to nurture major technical and managerial innovations”, p. 154. In particular, it is expected that smart local energy systems (SLES) deliver various benefits towards achieving SDG7 and a just transition [110,222]. Nevertheless, community energy research should avoid techno-economic narrowness and determine how local energy developments impact on inclusivity of vulnerable groups [86]. In spite of all social, political, technical, and economic constraints, SI has the potential to facilitate energy transitions in the Global South through its community mobilization potential [101], as “a more active role of provinces and municipalities would facilitate greater attention to employment and community empowerment outcomes” [223], p. 6. In deprived areas, new energy infrastructures should bring benefits for locals in terms of employment and income for a just transition to occur [224]. Bottom-up initiatives in the energy transition have the potential to politicize the energy discourse towards equity, participation, and diversity [28,34,162,163,169]. As pointed out by Revez et al. [166], “as we move toward low-carbon alternatives, there is an opportunity to refashion a more inclusive and democratic form of public engagement with energy”, p. 10. This is in agreement with a recent work of Wittmayer et al. when investigating prosumerism as a social movement in seven European countries, as they conclude that collective prosumer initiatives such as RE cooperatives “can contribute to procedural and distributional justice in that they open up the involvement in energy systems and its benefits to new groups”, p. 10 [225]. Nevertheless, exclusionary tendencies through financial or technical requirements, for instance, can merely reproduce existing inequalities [225].

Despite calls for energy to be controlled in a public or cooperative way and for citizens to take control of their own energy investments, followed by suppositions that community-based consumption could reduce energy use [83], it seems that a coordinated top-down and bottom-up approach will be more efficient in delivering energy services and justice across the world.

4.4. Community-based initiatives and a low-carbon sustainable economy

When comparing top-down to bottom-up approaches to the energy transition, community-based initiatives have advantages in terms of accessing local resources and influencing individual behavior, and disadvantages as to restricted power and influence, difficulty in accessing funding, and dependence on public support. Diving deep into the advantages of community-led actions, as part of available local resources, there are human resources, which can contribute to networking and management skills [186], tacit knowledge [54,192], community mobilization [91,134], and financial resources (Section 4.2). In addition, environmental awareness and community trust can be enhanced through information-sharing campaigns, local meetings, and participatory processes [103,106,214,226,227]. By working towards improved life quality and more sustainable energy systems for native communities [228], these community-based initiatives can create “green jobs”, employ locals, and build local capacity [18,66,140]. Some cases also refer to the possibility of extra income for households and communities [147,229], as the case of implementing community bioenergy initiatives in rural areas in the Philippines and Vietnam [199]. Therefore, although mainly constrained at niche levels, grassroots can improve the diffusion and acceptability of RE and associated technologies, and significantly change local energy systems [230]. It can also empower communities, a feature considered essential for initiatives to achieve their transformative potential, besides the ability to scale up and represent sustainable and social needs [79].

Regarding disadvantages, it seems that new business models and local energy markets can only develop under favorable regulations [22] and effective policy strategies, especially in complex urban environments [231], since peer-to-peer trading, energy selling, distribution, and, in some cases, storage must be allowed by law. However, tariffs and tax exemptions, unless restricted to small-scale RE generation and orchestrated in combination with other policies, can end up favoring large energy suppliers and impairing the development of community-based initiatives [172,198]. As highlighted by Nolden [172], “[FiT] alone do not provide greater opportunities for multi-scalar energy transitions”, p. 1, which calls for niche protection measures. Among policies that should be employed in combination with FiT, there is the need for reducing bureaucratic burdens and the establishment of a level playing field for new market participants [93,110,232].

Therefore, both financial and institutional support are key for grassroots to be implemented and achieve operational levels. It lies with policy-makers the responsibility to balance a flexible institutional environment with stable regulations necessary to maintain initiatives functioning in a democratic way [233]. Furthermore, public or private bodies can play the role of umbrella organizations that provide consultation and help community-based initiatives overcome regulatory and technical barriers during project planning and execution [125,133]. Therefore, cooperation between top-down and bottom-up seems the most adequate approach in terms of the dimension and direction of community-led initiatives' impact [69,234]. This is in line with a recent work of Coy et al. on community empowerment, which characterizes the latter as both a process and outcome that requires a combined effort from communities and governing entities to thrive [235].

From this perspective, community-based initiatives have an important role to play in sustainable transitions, but they have restricted power because of the influence that energy incumbents have in decision-making processes [60,185] and restricted agency in centralized conservative governments [99]. In comparison to household-level solar generation, community schemes can increase efficiency [42,108,126,197] and lead to the reduction of emissions from a lifecycle perspective [22]. Additionally, they can improve resource allocation as community projects tend to better understand local needs and develop tailored solutions, assumed technical knowledge is available [216]. For isolated and rural communities, they can enhance inclusivity by co-production and the establishment of off-grid and mini-grid systems that allow access to electricity, e.g., micro-hydro in Ethiopia [29], solar energy in Zambia [120] and Rwanda [108]. In less developed countries, these arrangements could contribute to leapfrogging [80] and help to achieve SDGs.

4.5. Limitations and future research agenda

Since initiatives are highly context-dependent, case studies are the most suited approach to investigate the true impact of SI at local levels. However, the extensive nature of this work aimed at answering the research questions as comprehensively as possible within this work's limitations. Among the limitations of this research, there is the fact that the review did not include grey literature and actual examples of SI from platforms such as participedia.net or rescoops.com. Nevertheless, insights from practical case studies could be drawn from the literature review, as many works collected information directly from SI participants and stakeholders through interviews, surveys, and workshops. A second point concerns the search strings and inclusion criteria that may have limited the work coverage, as only few papers were retrieved from Asia and none from South and Central America. However, IRENA’s RE Market Analysis of Southeast Asia shows that there are opportunities for research in the region as it draws on several decentralized and off-grid projects to highlight the importance of local entrepreneurship and strong community participation [236]. Thirdly, there is the subjectivity of the analysis of content, that even though performed systematically, is still susceptible to bias as it depends on researchers' interpretation and categorization. As pointed by Sovacool et al. [36], “a systematic review is not guaranteed to be comprehensive or unbiased—the inclusion and coding of articles is still sensitive to the researcher’s selection of criteria and concepts”, p. 23. Similarly, the conclusions on the contribution of SI to the energy transition derives from the perspectives selected, namely, transformative potential of SI and degrowth, financing and co-production, and energy access and just energy transitions.

As a final contribution, three main directions for future research are presented. Firstly, concerning policies and regulations, for better alignment between municipal, national, and supranational policy levels, cross-level policy analysis could identify conflicting points to be resolved. On request for legal definitions, it is still to be seen how institutionalization impacts the development of bottom-up initiatives. As an example, would the EU's CEP, after defining community renewable energy and citizen renewable energy, hinder the development of small community-scale projects as it may add a layer of difficulty to scale up, push towards professionalization and lead to fewer members?

Secondly, in regards to collaboration and means to increase participation in community initiatives, new business models should continue to be investigated as ways to diversify – no gender, age, income, or color bias - and increase the number of memberships. Within vulnerable communities, projects should incorporate local technical training and accessible entry requirements as means to ensure a continued positive effect on life quality and access to opportunities. Nevertheless, financing to develop energy projects will continue to be a big obstacle in low-income regions, which draws attention to the importance of collaboration and cross-sectoral and country partnerships. Even though there are concerns about removing the communal aspect of grassroots when bringing big players to the table, these alliances may prove to be essential for accessing technical skills, knowledge-sharing, stimulating research and development, and financing. That is why the means to ensure sustainable and inclusive regional socio-economic development while creating these alliances must be studied, particularly when large energy companies are involved.

Thirdly, there is a clear uneven distribution of research and initiatives as most works focus on developed countries and European contexts. Nonetheless, countries in the Global South would be the ones to benefit the most from SI, as natural resources and populations have been historically exploited in this part of the globe. Related to this matter, it is still unclear how to measure the impacts of SI, which calls for quantitative indicators of social and economic impacts mainly in terms of job creation, community engagement, environmental awareness, acceptability of RE, change in consumption levels, and GHG emissions.

5. Conclusion

In conclusion, this work aimed at investigating the role of SI in energy transitions and how community-based initiatives contribute to achieving a low-carbon economy. From the literature review, we could conclude that SI, when hand in hand with technological innovation and enabling regulatory frameworks, can help achieving decentralized and inclusive energy systems. This has been evidenced by the role of SI for local transitions in regards to accessing local knowledge, raising social and environmental awareness, building local capacity an trust, accessing finance, democratizing energy discourses, and increasing energy access. The latter is especially relevant for the Global South, as SI can effectively contribute to just energy transitions through inclusive business models for low-income households, regional socioeconomic development, and community capacity building. On the other side, SI is at risk of being instrumentalized due to their broad nature. Also, it does not seem transformative enough for degrowth objectives as it faces several challenges to scale up. Few initiatives stemming from European countries reached national and international levels by growing memberships, increasing services, and demonstrating financial stability. Yet, initiatives may want to remain restricted to niche levels as alternatives to dominant regimes.

For dealing with economic barriers, one of the main impediments of the energy transition, co-ownership and community financing are promising in medium and high-income localities and can increase RE deployment. In terms of participatory decision-making, even though co-production and co-creation seem instrumental in most cases, they can still mobilize communities to pursue energy justice and local socio-economic development. In efforts towards inclusivity and justice, a combination of top-down and bottom-up approaches seems key for SI to flourish, as bottom-up approaches are particularly relevant for raising environmental awareness and influencing individual behavior thanks to their roots in local contexts. The risk of leaving behind the privileged understanding of local needs and communal resources must be addressed when these initiatives plan to be institutionalized and scaled up. Gaps in the literature point towards a need to better understand how policy levels interconnect, how to increase the richness and outreach of initiatives, and how to support the development of SI in the Global South as well as socio-economic indicators that enable quantitative analysis of SI's impacts towards a just energy transition.

Declaration of competing interest

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

Acknowledgments

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the Project Scope: PTDC/EGE-OGE/31635/2017.

References

[1] S. Selvakkumaran, E.O. Ahlgren, Impacts of social innovation on local energy transitions: diffusion of solar PV and alternative fuel vehicles in Sweden, Glob. Transit. 2 (2020) 98–115, https://doi.org/10.1016/j.glt.2020.06.004.
[2] B.B. Lennon, N.P. Dunphy, E. Sanvicente, Community acceptability and the energy transition: a citizens' perspective, Energy Sustain. Soc. 9 (2019) 1–18, https://doi.org/10.1186/s13705-019-0218-z.
[3] R. Hölsgens, S. Lübke, M. Hasselkuß, Social innovations in the german energy transition: an attempt to use the heuristics of the multi-level perspective of transitions to analyze the diffusion process of social innovations, Energy Sustain. Soc. 8 (2018) 1–13, https://doi.org/10.1186/s13705-018-0150-7.
[4] R.J. Hewitt, N. Bradley, A.B. Compagnucci, C. Barlagne, A. Ceglarz, R. Cremades, M. McKeen, I.M. Otto, B. Slee, Social innovation in community energy in Europe: a review of the evidence, Front. Energy Res. 7 (2019) 1–27, https://doi.org/10.3389/fenrg.2019.00031.
[5] J. Cunha, P. Benneworth, How to measure the impact of social innovation initiatives? Int. Rev. Public Nonprofit Mark. 17 (2020) 59–75, https://doi.org/10.1007/s12208-019-00240-4.
[6] BEPA, Empowering People, Driving Change: Social Innovation in the European Union, EU, 2010, https://doi.org/10.2796/13155.
[7] M.J. Bouchard, Innovation and the Social Economy, University of Toronto Press, Toronto, 2013, https://doi.org/10.3138/9781442695092.
[8] P. Benneworth, J. Cunha, Universities' contributions to social innovation: reflections in theory & practice, Eur. J. Innov. Manag. 18 (2015) 508–527, https://doi.org/10.1108/EJIM-10-2013-0099.
[9] T. Hoppe, G. de Vries, Social innovation and the energy transition, Sustainability 11 (2018), https://doi.org/10.3390/su11010141.
[10] J.M. Wittmayer, T. de Geus, B. Pel, F. Avelino, S. Hielscher, T. Hoppe, S. Mühlemeier, A. Stasik, S. Oxenaar, K.S. Rogge, V. Visser, E. Marín-González, M. Ooms, S. Buitelaar, C. Foulds, K. Petrick, S. Klarwein, S. Krupnik, G. de Vries, A. Wagner, A. Härtwig, Beyond instrumentalism: broadening the understanding of social innovation in socio-technical energy systems, Energy Res. Soc. Sci. 70 (2020), 101689, https://doi.org/10.1016/j.erss.2020.101689.
[11] P. Marques, K. Morgan, R. Richardson, Social innovation in question: the theoretical and practical implications of a contested concept, Environ. Plan. C Polit. Space 36 (2018) 496–512, https://doi.org/10.1177/2399654417717986.
[12] A. Haxeltine, B. Pel, A. Dumitru, F. Avelino, R. Kemp, T. Bauler, I. Kunze, J. Dorland, J. Wittmayer, M. Søgaard, Towards a TSI theory : a relational framework and 12 propositions, in: TRANSIT Working Paper 16, December 2017, TRANSIT Work. Pap. Ser, 24, 2017.
[13] J. Robertson, The new economics of sustainable development a briefing for policy makers, A Rep. Eur. Comm. (1997) 0–110. www.jamesrobertson.com.
[14] T. Krueger, V. Pellicer-Sifres, From innovations to exnovations. Conflicts, (De-) Politicization processes, and power relations are key in analysing the ecological crisis, Innov. Eur. J. Soc. Sci. Res. 33 (2020) 115–123, https://doi.org/10.1080/13511610.2020.1733936.
[15] J.C.J.M. Van den Bergh, Environment versus growth - a criticism of "degrowth" and a plea for "a-growth", Ecol. Econ. 70 (2011) 881–890, https://doi.org/10.1016/j.ecolecon.2010.09.035.
[16] G.G. Dranka, P. Ferreira, Towards a smart grid power system in Brazil: challenges and opportunities, Energy Policy 136 (2020), https://doi.org/10.1016/j.enpol.2019.111033.

[17] IEA, IRENA, Executive Summary - Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System, 2017.
[18] A. Ebers Broughel, N. Hampl, Community financing of renewable energy projects in Austria and Switzerland: profiles of potential investors, Energy Policy 123 (2018) 722–736, https://doi.org/10.1016/j.enpol.2018.08.054.
[19] T. Braunholtz-Speight, M. Sharmina, E. Manderson, C. McLachlan, M. Hannon, J. Hardy, S. Mander, Business models and financial characteristics of community energy in the UK, Nat. Energy 5 (2020) 169–177, https://doi.org/10.1038/s41560-019-0546-4.
[20] F. Berkhout, A. Smith, A. Stirling, Socio-technological regimes and transition contexts, in: B. Elzen, F. Geels, K. Green (Eds.), Syst. Innov. Transit. to Sustain. Theory, Evid. Policy, Edward Elgar Publishing, Camberley, 2005.
[21] E. Galende-Sánchez, A.H. Sorman, From consultation toward co-production in science and policy: a critical systematic review of participatory climate and energy initiatives, energy resSoc. Sci. 73 (2021) 94–99, https://doi.org/10.1016/j.erss.2020.101907.
[22] A.L. Berka, J.L. MacArthur, C. Gonnelli, Explaining inclusivity in energy transitions: local and community energy in aotearoa New Zealand, Environ. Innov. Soc. Transit. 34 (2020) 165–182, https://doi.org/10.1016/j.eist.2020.01.006.
[23] S. Tomasi, S. Gantioler, Innovative approaches to energy governance: preliminary quantitative insights from the literature, Green Energy Technol. (2021) 277–290, https://doi.org/10.1007/978-3-030-57764-3_18.
[24] B.K. Sovacool, A. Hook, M. Martiskainen, L. Baker, The whole systems energy injustice of four european low-carbon transitions, Glob. Environ. Chang. 58 (2019), 101958, https://doi.org/10.1016/j.gloenvcha.2019.101958.
[25] A.B. Setyowati, Mitigating inequality with emissions? Exploring energy justice and financing transitions to low carbon energy in Indonesia, Energy Res. Soc. Sci. 71 (2021), 101817, https://doi.org/10.1016/j.erss.2020.101817.
[26] P. Munro, G. van der Horst, S. Healy, Energy justice for all? Rethinking sustainable development goal 7 through struggles over traditional energy practices in Sierra Leone, Energy Policy 105 (2017) 635–641, https://doi.org/10.1016/j.enpol.2017.01.038.
[27] United Nations, The Sustainable Development Goals, 2020, https://doi.org/10.4324/9781003099680-3.
[28] A. Ambole, J.K. Musango, K. Buyana, M. Ogot, C. Anditi, B. Mwau, Z. Kovacic, S. Smit, S. Lwasa, G. Nsangi, H. Sseviiri, A.C. Brent, Mediating household energy transitions through co-design in urban Kenya, Uganda and South Africa, energy resSoc. Sci. 55 (2019) 208–217, https://doi.org/10.1016/j.erss.2019.05.009.
[29] K. Wiese, Energy 4 all? Investigating gendered energy justice implications of community-based micro-hydropower cooperatives in Ethiopia 33 (2020) 194–217, https://doi.org/10.1080/13511610.2020.1745059.
[30] F.W. Geels, Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective, Res. Policy 39 (2010) 495–510, https://doi.org/10.1016/j.respol.2010.01.022.
[31] J. Schot, F.W. Geels, Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy, Technol. Anal. Strateg. Manag. 20 (2008) 537–554, https://doi.org/10.1080/09537320802292651.
[32] J. Markard, M. Hekkert, S. Jacobsson, The technological innovation systems framework: response to six criticisms, Environ. Innov. Soc. Transit. 16 (2015) 76–86, https://doi.org/10.1016/j.eist.2015.07.006.
[33] A. Wierling, V.J. Schwanitz, J.P. Zeiß, C. Bout, C. Candelise, W. Gilcrease, J. S. Gregg, Statistical evidence on the role of energy cooperatives for the energy transition in european countries, Sustainability 10 (2018) 3339, https://doi.org/10.3390/su10093339.
[34] V. Pellicer-Sifres, Transformative energy transition from the bottom-up: exploring the contribution of grassroots innovations in the spanish context, innovEur. J Soc. Sci. Res. 33 (2020) 124–139, https://doi.org/10.1080/13511610.2019.1705146.
[35] G. Seyfang, A. Haxeltine, Growing grassroots innovations: exploring the role of community-based initiatives in governing sustainable energy transitions, environ. Plan. C govPolicy 30 (2012) 381–400, https://doi.org/10.1068/c10222.
[36] B.K. Sovacool, J. Axsen, S. Sorrell, Promoting novelty, rigor, and style in energy social science: towards codes of practice for appropriate methods and research design, energy resSoc. Sci. 45 (2018) 12–42, https://doi.org/10.1016/j.erss.2018.07.007.
[37] M.J. Page, J.E. McKenzie, P.M. Bossuyt, I. Boutron, T.C. Hoffmann, C.D. Mulrow, L. Shamseer, J.M. Tetzlaff, E.A. Akl, S.E. Brennan, R. Chou, J. Glanville, J. M. Grimshaw, A. Hróbjartsson, M.M. Lalu, T. Li, E.W. Loder, E. Mayo-Wilson, S. McDonald, L.A. McGuinness, L.A. Stewart, J. Thomas, A.C. Tricco, V.A. Welch, P. Whiting, D. Moher, The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, BMJ 2021 (2020), n71, https://doi.org/10.1136/bmj.n71.
[38] K. Krippendorff, Content Analysis: An Introduction to its Methodology, 2nd ed., SAGE Publications Inc., Thousand Oaks, 2004.
[39] H.F. Hsieh, S.E. Shannon, Three approaches to qualitative content analysis, Qual. Health Res. 15 (2005) 1277–1288, https://doi.org/10.1177/1049732305276687.
[40] R. Hiteva, T.J. Foxon, Beware the value gap: creating value for users and for the system through innovation in digital energy services business models, Technol. Forecast. Soc. Change. 166 (2021), 120525, https://doi.org/10.1016/j.techfore.2020.120525.
[41] M. Karami, R. Madlener, Business model innovation for the energy market: joint value creation for electricity retailers and their customers, Energy Res. Soc. Sci. 73 (2021), 101878, https://doi.org/10.1016/j.erss.2020.101878.
[42] A. Proka, M. Hisschemöller, D. Loorbach, When top-down meets bottom-up: is there a collaborative business model for local energy storage? Energy Res. Soc. Sci. 69 (2020), 101606 https://doi.org/10.1016/j.erss.2020.101606.
[43] V. Azarova, J.J. Cohen, A. Kollmann, J. Reichl, The potential for community financed electric vehicle charging infrastructure, Transp. Res. Part D Transp. Environ. 88 (2020), 102541, https://doi.org/10.1016/j.trd.2020.102541.
[44] S. Lavrijssen, A.C. Parra, Radical prosumer innovations in the electricity sector and the impact on prosumer regulation, Sustainability 9 (2017), https://doi.org/10.3390/su9071207.
[45] T. Van Der Schoor, H. Van Lente, B. Scholtens, A. Peine, Challenging obduracy: how local communities transform the energy system, energy resSoc. Sci. 13 (2016) 94–105, https://doi.org/10.1016/j.erss.2015.12.009.
[46] IRENA, Community-ownership Models. Innovation landscape brief, Innov. Landsc. Br. (2020) 169–178.
[47] A. Pinker, L. Argüelles, A. Fischer, S. Becker, Between straitjacket and possibility: energy initiatives and the politics of regulation, Geoforum 113 (2020) 14–25, https://doi.org/10.1016/j.geoforum.2020.04.016.
[48] J. Fouladvand, N. Mouter, A. Ghorbani, P. Herder, Formation and continuation of thermal energy community systems: an explorative agent-based model for the Netherlands, Energies. 13 (2020), https://doi.org/10.3390/en13112829.
[49] J. Blasch, N.M. van der Grijp, D. Petrovics, J. Palm, N. Bocken, S.J. Darby, J. Barnes, P. Hansen, T. Kamin, U. Golob, M. Andor, S. Sommer, A. Nicita, M. Musolino, M. Mlinarič, New clean energy communities in polycentric settings: four avenues for future research, Energy Res. Soc. Sci. 82 (2021), https://doi.org/10.1016/j.erss.2021.102276.
[50] Energy Research & Social Science., (n.d.). https://www.journals.elsevier.com/energy-research-and-social-science/ (accessed October 28, 2021).
[51] Energy Policy., (n.d.). https://www.journals.elsevier.com/energy-policy (accessed October 28, 2021).
[52] Sustainability., (n.d.). https://www.mdpi.com/journal/sustainability (accessed June 26, 2021).
[53] T. Hargreaves, S. Hielscher, G. Seyfang, A. Smith, Grassroots innovations in community energy: the role of intermediaries in niche development, Glob. Environ. Chang. 23 (2013) 868–880, https://doi.org/10.1016/j.gloenvcha.2013.02.008.
[54] G. Seyfang, S. Hielscher, T. Hargreaves, M. Martiskainen, A. Smith, A grassroots sustainable energy niche? Reflections on community energy in the UK, Environ. Innov. Soc. Transit. 13 (2014) 21–44, https://doi.org/10.1016/j.eist.2014.04.004.
[55] Ö. Yildiz, J. Rommel, S. Debor, L. Holstenkamp, F. Mey, J.R. Müller, J. Radtke, J. Rognli, Renewable energy cooperatives as gatekeepers or facilitators? Recent developments in Germany and a multidisciplinary research agenda, energy resSoc. Sci. 6 (2015) 59–73, https://doi.org/10.1016/j.erss.2014.12.001.
[56] B.J. Kalkbrenner, J. Roosen, Citizens' willingness to participate in local renewable energy projects: the role of community and trust in Germany, energy resSoc. Sci. 13 (2016) 60–70, https://doi.org/10.1016/j.erss.2015.12.006.
[57] A. Smith, T. Hargreaves, S. Hielscher, M. Martiskainen, G. Seyfang, Making the most of community energies: three perspectives on grassroots innovation, Environ. Plan. A Econ. Space 48 (2016) 407–432, https://doi.org/10.1177/0308518X15597908.
[58] Ö. Yildiz, Financing renewable energy infrastructures via financial citizen participation – the case of Germany, Renew. Energy 68 (2014) 677–685, https://doi.org/10.1016/j.renene.2014.02.038.
[59] D. Parra, M. Swierczynski, D.I. Stroe, S.A. Norman, A. Abdon, J. Worlitschek, T. O'Doherty, L. Rodrigues, M. Gillott, X. Zhang, C. Bauer, M.K. Patel, An interdisciplinary review of energy storage for communities: challenges and perspectives, Renew. Sustain. Energ. Rev. 79 (2017) 730–749, https://doi.org/10.1016/j.rser.2017.05.003.
[60] T. Hoppe, A. Graf, B. Warbroek, I. Lammers, I. Lepping, Local governments supporting local energy initiatives: lessons from the best practices of saerbeck (Germany) and lochem (The Netherlands), Sustainability 7 (2015) 1900–1931, https://doi.org/10.3390/su7021900.
[61] C. Kunze, S. Becker, Collective ownership in renewable energy and opportunities for sustainable degrowth, Sustain. Sci. 10 (2015) 425–437, https://doi.org/10.1007/s11625-015-0301-0.
[62] A. Forman, Energy justice at the end of the wire: enacting community energy and equity in Wales, Energy Policy 107 (2017) 649–657, https://doi.org/10.1016/j.enpol.2017.05.006.
[63] L.L. Delina, Can energy democracy thrive in a non-democracy? Front. Environ. Sci. 6 (2018) https://doi.org/10.3389/fenvs.2018.00005.
[64] S. Soeiro, M. Ferreira Dias, Renewable energy community and the european energy market: main motivations, Heliyon 6 (2020), e04511, https://doi.org/10.1016/j.heliyon.2020.e04511.
[65] S. Soeiro, M. Ferreira Dias, Community renewable energy: benefits and drivers, Energy Rep. 6 (2020) 134–140, https://doi.org/10.1016/j.egyr.2020.11.087.
[66] S. Bloem, M. Swilling, K. Koranteng, Taking energy democracy to the streets: socio-technical learning, institutional dynamism, and integration in south african community energy projects, Energy Res. Soc. Sci. 72 (2021), 101906, https://doi.org/10.1016/j.erss.2020.101906.
[67] K. Reinsberger, A. Posch, Bottom-up initiatives for photovoltaic: incentives and barriers, J. Sustain. Dev. Energy, Water Environ. Syst. 2 (2014) 108–117, https://doi.org/10.13044/j.sdewes.2014.02.0010.
[68] K. Reinsberger, T. Brudermann, S. Hatzl, E. Fleiß, A. Posch, Photovoltaic diffusion from the bottom-up: analytical investigation of critical factors, Appl. Energy 159 (2015) 178–187, https://doi.org/10.1016/j.apenergy.2015.08.117.

[69] F. Mey, M. Diesendorf, Who owns an energy transition? Strategic action fields and community wind energy in Denmark, energy resSoc. Sci. 35 (2018) 108–117, https://doi.org/10.1016/j.erss.2017.10.044.

[70] L. Gorroño-Albizu, K. Sperling, S. Djørup, The past, present and uncertain future of community energy in Denmark: critically reviewing and conceptualising citizen ownership, Energy Res. Soc. Sci. 57 (2019), 101231, https://doi.org/10.1016/j.erss.2019.101231.

[71] A. Capaccioli, G. Poderi, M. Bettega, V. D'Andrea, Participatory infrastructuring of community energy, in: A.M. Kanstrup, J. Vines, L. Huybrechts, R.C. Smith, K. Bodker, C. Bossen (Eds.), ACM Int. Conf. Proceeding Ser, Association for Computing Machinery, 2016, pp. 9–12, https://doi.org/10.1145/2948076.2948089.

[72] S. Wirth, Communities matter: institutional preconditions for community renewable energy, Energy Policy 70 (2014) 236–246, https://doi.org/10.1016/j.enpol.2014.03.021.

[73] F. Pasimeni, Community-based adoption and diffusion of micro-grids: analysis of the italian case with agent-based model, J. Artif. Soc. Soc. Simul. 22 (2019), https://doi.org/10.18564/jasss.3950.

[74] N. Magnani, G. Osti, Does civil society matter? Challenges and strategies of grassroots initiatives in Italy's energy transition, energy resSoc. Sci. 13 (2016) 148–157, https://doi.org/10.1016/j.erss.2015.12.012.

[75] A. Sguglio, N. Arcuri, R. Bruno, Integration of Social Science in Engineering Research for Smart Cities, The Italian Case of the RES NOVAE Project, in: Proc. - 2018 IEEE Int. Conf. Environ. Electr. Eng. 2018 IEEE Ind. Commer. Power Syst. Eur. EEEIC/I CPS Eur. 2018, 2018, https://doi.org/10.1109/EEEIC.2018.8493774.

[76] I. Capellán-Pérez, Á. Campos-Celador, J. Terés-Zubiaga, Renewable energy cooperatives as an instrument towards the energy transition in Spain, Energy Policy 123 (2018) 215–229, https://doi.org/10.1016/j.enpol.2018.08.064.

[77] S. Soeiro, M. Ferreira Dias, Energy cooperatives in southern european countries: are they relevant for sustainability targets? Energy Rep. 6 (2020) 448–453, https://doi.org/10.1016/j.egyr.2019.09.006.

[78] J. Morandeira-Arca, E. Etxezarreta-Etxarri, O. Azurza-Zubizarreta, J. Izagirre-Olaizola, Social innovation for a new energy model, from theory to action: contributions from the social and solidarity economy in the Basque Country, Innov. Eur. J. Soc. Sci. Res. (2021), https://doi.org/10.1080/13511610.2021.1890549.

[79] V. Pellicer-Sifres, S. Belda-Miquel, I. Cuesta-Fernandez, A. Boni, Learning, transformative action, and grassroots innovation: insights from the Spanish energy cooperative som energia, energy resSoc. Sci. 42 (2018) 100–111, https://doi.org/10.1016/j.erss.2018.03.001.

[80] L. Holstenkamp, What do we know about cooperative sustainable electrification in the global South? A synthesis of the literature and refined social-ecological systems framework, Renew. Sustain. Energ. Rev. 109 (2019) 307–320, https://doi.org/10.1016/j.rser.2019.04.047.

[81] H. Kirchhoff, N. Kebir, K. Neumann, P.W. Heller, K. Strunz, Developing mutual success factors and their application to swarm electrification: microgrids with 100 % renewable energies in the global south and Germany, J. Clean. Prod. 128 (2016) 190–200, https://doi.org/10.1016/j.jclepro.2016.03.080.

[82] M.M. Vanegas Cantarero, Of renewable energy, energy democracy, and sustainable development: a roadmap to accelerate the energy transition in developing countries, energy resSoc. Sci. 70 (2020), 101716, https://doi.org/10.1016/j.erss.2020.101716.

[83] O. Akizu, L. Urkidi, G. Bueno, R. Lago, I. Barcena, M. Mantxo, I. Basurko, J. M. Lopez-Guede, Tracing the emerging energy transitions in the global north and the global south, Int. J. Hydrog. Energy 42 (2017) 18045–18063, https://doi.org/10.1016/j.ijhydene.2017.04.297.

[84] V.H. van Zyl-Bulitta, C. Ritzel, W. Stafford, J.G. Wong, A compass to guide through the myriad of sustainable energy transition options across the global north-south divide, Energy 181 (2019) 307–320, https://doi.org/10.1016/j.energy.2019.05.111.

[85] M.C. Brisbois, Shifting political power in an era of electricity decentralization: rescaling, reorganization and battles for influence, Environ. Innov. Soc. Transit. 36 (2020) 49–69, https://doi.org/10.1016/j.eist.2020.04.007.

[86] A. Kumar, G. Taylor Aiken, A postcolonial critique of community energy: searching for community as solidarity in India and Scotland, Antipode 53 (2021) 200–221, https://doi.org/10.1111/anti.12683.

[87] J. Hicks, N. Ison, An exploration of the boundaries of 'community' in community renewable energy projects: navigating between motivations and context, Energy Policy 113 (2018) 523–534, https://doi.org/10.1016/j.enpol.2017.10.031.

[88] Q. Wang, J. Lin, K. Zhou, J. Fan, M.-P. Kwan, Does urbanization lead to less residential energy consumption? A comparative study of 136 countries, Energy 202 (2020), 117765, https://doi.org/10.1016/j.energy.2020.117765.

[89] J. Baxter, C. Walker, G. Ellis, P. Devine-Wright, M. Adams, R.S. Fullerton, Scale, history and justice in community wind energy: an empirical review, Energy Res. Soc. Sci. 68 (2020), 101532, https://doi.org/10.1016/j.erss.2020.101532.

[90] H. Kopnina, The power to change: a brief survey of the wind power's technological and societal potential, barriers to use, and ways forward, Visions Sustain. 2020 (2020) 44–57, https://doi.org/10.13135/2384-8677/4370.

[91] M. Talandier, Are there urban contexts that are favourable to decentralised energy management? Cities 82 (2018) 45–57, https://doi.org/10.1016/j.cities.2018.05.004.

[92] S. Gährs, J. Knoefel, Stakeholder demands and regulatory framework for community energy storage with a focus on Germany, Energy Policy 144 (2020), 111678, https://doi.org/10.1016/j.enpol.2020.111678.

[93] J. Beermann, K. Tews, Decentralised laboratories in the German energy transition. Why local renewable energy initiatives must reinvent themselves, J. Clean. Prod. 169 (2017) 125–134, https://doi.org/10.1016/j.jclepro.2016.08.130.

[94] O. Akizu, G. Bueno, I. Barcena, E. Kurt, N. Topaloğlu, J.M. Lopez-guede, N. Topalöoglu, J.M. Lopez-guede, Contributions of bottom-up energy transitions in Germany: a case study analysis, Energies. 11 (2018) 1–21, https://doi.org/10.3390/en11040849.

[95] A. Proka, D. Loorbach, M. Hisschemöller, Leading from the niche: insights from a strategic dialogue of renewable energy cooperatives in the Netherlands, Sustainability 10 (2018), https://doi.org/10.3390/su10114106.

[96] M.A. Heldeweg, Normative alignment, institutional resilience and shifts in legal governance of the energy transition, Sustainability 9 (2017), https://doi.org/10.3390/su9071273.

[97] P.A. Strachan, R. Cowell, G. Ellis, F. Sherry-Brennan, D. Toke, Promoting community renewable energy in a corporate energy world, Sustain. Dev. 23 (2015), https://doi.org/10.1002/sd.1576 n/a-n/a.

[98] S. Saintier, Community energy companies in the UK: a potential model for sustainable development in "local" energy? Sustainability 9 (2017) 1325, https://doi.org/10.3390/su9081325.

[99] G.C.-L. Huang, R.-Y. Chen, B.-B. Park, Democratic innovations as a party tool: a comparative analysis of nuclear energy public participation in Taiwan and South Korea, Energy Policy 153 (2021), 112251, https://doi.org/10.1016/j.enpol.2021.112251.

[100] S. Özgül, G. Koçar, A. Eryaşar, The progress, challenges, and opportunities of renewable energy cooperatives in Turkey, ENERGYSustain. Dev. 59 (2020) 107–119, https://doi.org/10.1016/j.esd.2020.09.005.

[101] J. Marquardt, L.L. Delina, Reimagining energy futures: contributions from community sustainable energy transitions in Thailand and the Philippines, energy resSoc. Sci. 49 (2019) 91–102, https://doi.org/10.1016/j.erss.2018.10.028.

[102] M.C. Brisbois, Powershifts: a framework for assessing the growing impact of decentralized ownership of energy transitions on political decision-making, energy resSoc. Sci. 50 (2019) 151–161, https://doi.org/10.1016/j.erss.2018.12.003.

[103] J. MacArthur, Renewable energy and the social economy in Alberta, Int. J. Environ. Sustain. 8 (2013) 121–130, https://doi.org/10.18848/2325-1077/CGP/v08i04/55068.

[104] J.L. MacArthur, TradeTarsands and Treaties: The Political Economy Context of Community Energy in Canada, Sustainability 9 (2017) 464, https://doi.org/10.3390/su9030464.

[105] E. Fernandez, M.J. Hossain, K. Mahmud, M.S.H. Nizami, M. Kashif, A bi-level optimization-based community energy management system for optimal energy sharing and trading among peers, J. Clean. Prod. 279 (2021), 123254, https://doi.org/10.1016/j.jclepro.2020.123254.

[106] P. Hansen, Optimising shared renewable energy systems: an institutional approach, Energy Res. Soc. Sci. 73 (2021), 101953, https://doi.org/10.1016/j.erss.2021.101953.

[107] R. Proudlove, S. Finch, S. Thomas, Factors influencing intention to invest in a community owned renewable energy initiative in QueenslandAustralia, Energy Policy 140 (2020), 111441, https://doi.org/10.1016/j.enpol.2020.111441.

[108] O. Muza, R. Debnath, Disruptive innovation for inclusive renewable policy in sub-saharan Africa: a social shaping of technology analysis of appliance uptake in Rwanda, Renew. Energy 168 (2021) 896–912, https://doi.org/10.1016/j.renene.2020.12.091.

[109] N. Labanca, A.G. Pereira, M. Watson, K. Krieger, D. Padovan, L. Watts, M. Moezzi, G. Wallenborn, R. Wright, E. Laes, B.D. Fath, F. Ruzzenenti, T. De Moor, T. Bauwens, L. Mehta, Transforming innovation for decarbonisation? Insights from combining complex systems and social practice perspectives, Energy Res. Soc. Sci. 65 (2020), 101452, https://doi.org/10.1016/j.erss.2020.101452.

[110] R. Ford, C. Maidment, C. Vigurs, M.J. Fell, M. Morris, Smart local energy systems (SLES): a framework for exploring transition, context, and impacts, Technol. Forecast. Soc. Change. 166 (2021) 1–16, https://doi.org/10.1016/j.techfore.2021.120612.

[111] P. Boait, J.R. Snape, R. Morris, J. Hamilton, S. Darby, The practice and potential of renewable energy localisation: results from a UK field trial, Sustainability 11 (2019), https://doi.org/10.3390/su11010215.

[112] D. Boulogiorgou, P. Ktenidis, TILOS local scale technology innovation enabling low carbon energy transition, Renew. Energy 146 (2020) 397–403, https://doi.org/10.1016/j.renene.2019.06.130.

[113] B.P. Koirala, E. van Oost, H. van der Windt, Community energy storage: a responsible innovation towards a sustainable energy system? Appl. Energy 231 (2018) 570–585, https://doi.org/10.1016/j.apenergy.2018.09.163.

[114] B.P. Koirala, E. van Oost, H. van der Windt, Innovation dynamics of socio-technical alignment in community energy storage: the cases of drten and ecovat, Energies 13 (2020) 1–22, https://doi.org/10.3390/en13112955.

[115] T. Zohar, Y. Parag, O. Ayalon, Of agency, action, and influence: the middle-out mechanism for promoting a low-carbon energy transition, Energy Res. Soc. Sci. 72 (2021), 101900, https://doi.org/10.1016/j.erss.2020.101900.

[116] L. Edling, C. Danks, Supporting actors: the role of state policy and private programs in advancing local and renewable heating technology, Energy Policy 153 (2021), 112266, https://doi.org/10.1016/j.enpol.2021.112266.

[117] A. Itten, F. Sherry-Brennan, T. Hoppe, A. Sundaram, P. Devine-Wright, Co-creation as a social process for unlocking sustainable heating transitions in Europe, Energy Res. Soc. Sci. 74 (2021), 101956, https://doi.org/10.1016/j.erss.2021.101956.

[118] C. Acosta, M. Ortega, T. Bunsen, B.P. Koirala, A. Ghorbani, Facilitating energy transition through energy commons: an application of socio-ecological systems framework for integrated community energy systems, Sustainability 10 (2018), https://doi.org/10.3390/su10020366.

[119] N. Li, R.A. Hakvoort, Z. Lukszo, Cost allocation in integrated community energy systems - a review, Renew. Sustain. Energ. Rev. 144 (2021), 111001, https://doi.org/10.1016/j.rser.2021.111001.

[120] C. Muhoza, O.W. Johnson, Exploring household energy transitions in rural Zambia from the user perspective, Energy Policy 121 (2018) 25–34, https://doi.org/10.1016/j.enpol.2018.06.005.

[121] S. Sareen, D. Baillie, J. Kleinwächter, Transitions to future energy systems: learning from a community test field, Sustainability. 10 (2018) 4513, https://doi.org/10.3390/su10124513.

[122] P. Hansen, G.M. Morrison, A. Zaman, X. Liu, Smart technology needs smarter management: disentangling the dynamics of digitalism in the governance of shared solar energy in Australia, Energy Res. Soc. Sci. 60 (2020), 101322, https://doi.org/10.1016/j.erss.2019.101322.

[123] J.R. Snape, Smart community energy schemes: A case study-based model, in: Eceee Summer Study Proc, European Council for an Energy Efficient Economy, 2019, pp. 955–962. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85085182063&partnerID=40&md5=bf8702e0d3189a3cf52521550f1bc1fd.

[124] L.F.M. van Summeren, A.J. Wieczorek, G.J.T. Bombaerts, G.P.J. Verbong, Community energy meets smart grids: reviewing goals, structure, and roles in virtual power plants in Ireland, Belgium and the Netherlands, Energy Res. Soc. Sci. 63 (2020), 101415, https://doi.org/10.1016/j.erss.2019.101415.

[125] M. Ehrtmann, L. Holstenkamp, T. Becker, Regional electricity models for community energy in Germany: the role of governance structures, Sustainability 13 (2021) 1–24, https://doi.org/10.3390/su13042241.

[126] J.L. Crespo-Vazquez, T. Alskaif, A.M. Gonzalez-Rueda, M. Gibescu, A community-based energy market design using decentralized decision-making under uncertainty, IEEE Trans. Smart Grid. 12 (2021) 1782–1793, https://doi.org/10.1109/TSG.2020.3036915.

[127] S. Howind, V. Bauer, A. Wendt, G. Franzl, T. Sauter, S. Wilker, Prosumer and demand-side management impact on rural communities' energy balance, in: IEEE Int. Conf. Emerg. Technol. Fact. Autom. ETFA, Institute of Electrical and Electronics Engineers Inc, 2020, pp. 768–773, https://doi.org/10.1109/ETFA46521.2020.9212185.

[128] A.A. Adesanya, R.V. Sidortsov, C. Schelly, Act locally, transition globally: grassroots resilience, local politics, and five municipalities in the United States with 100% renewable electricity, Energy Res. Soc. Sci. 67 (2020), 101579, https://doi.org/10.1016/j.erss.2020.101579.

[129] S. Lenhart, G. Chan, L. Forsberg, M. Grimley, E. Wilson, Municipal utilities and electric cooperatives in the United States: interpretive frames, strategic actions, and place-specific transitions, Environ. Innov. Soc. Transit. 36 (2020) 17–33, https://doi.org/10.1016/j.eist.2020.04.006.

[130] S. Salm, S.L. Hille, R. Wüstenhagen, What are retail investors' risk-return preferences towards renewable energy projects?A choice experiment in Germany, Energy Policy 97 (2016) 310–320, https://doi.org/10.1016/j.enpol.2016.07.042.

[131] I. Tietze, Sharing economy in the german energy transition, Int. J. Bus. Glob. 24 (2020) 392, https://doi.org/10.1504/IJBG.2020.106466.

[132] C. de Brauwer, J.J. Cohen, Analysing the potential of citizen-financed community renewable energy to drive Europe's low-carbon energy transition, Renew. Sustain. Energ. Rev. 133 (2020) 1–12, https://doi.org/10.1016/j.rser.2020.110300.

[133] V. Brummer, Of expertise, social capital, and democracy: assessing the organizational governance and decision-making in german renewable energy cooperatives, energy resSoc. Sci. 37 (2018) 111–121, https://doi.org/10.1016/j.erss.2017.09.039.

[134] D.S. da Silva, L.G. Horlings, The role of local energy initiatives in co-producing sustainable places, Sustain. Sci. 15 (2020) 363–377, https://doi.org/10.1007/s11625-019-00762-0.

[135] P. Ocelík, L. Lehotský, F. Černoch, Beyond our backyard: social networks, differential participation, and local opposition to coal mining in Europe, Energy Res. Soc. Sci. 72 (2021), 101862, https://doi.org/10.1016/j.erss.2020.101862.

[136] I. Soloviy, M. Melnykovych, A. Björnsen Gurung, R.J. Hewitt, R. Ustych, L. Maksymiv, P. Brang, H. Meessen, M. Kaflyk, Innovation in the use of wood energy in the ukrainian Carpathians: opportunities and threats for rural communities, For. Policy Econ. 104 (2019) 160–169, https://doi.org/10.1016/j.forpol.2019.05.001.

[137] D.A. Heyen, F. Wolff, Drivers and barriers of sustainability transformations, Gaia 28 (2018) 226–232, https://doi.org/10.14512/gaia.28.S1.9.

[138] J. Roberts, Power to the people? Implications of the clean energy package for the role of community ownership in Europe's energy transition, Rev. Eur. Comp. Int. Environ. Law 29 (2020) 232–244, https://doi.org/10.1111/reel.12346.

[139] H.-J. Kooij, A. Lagendijk, M. Oteman, Who beats the dutch tax department? Tracing 20 years of niche-regime interactions on collective solar PV production in the Netherlands, Sustainability. 10 (2018) 2807, https://doi.org/10.3390/su10082807.

[140] A. Savaresi, The rise of community energy from grassroots to mainstream: the role of law and policy, J. Environ. Law 31 (2019) 487–510, https://doi.org/10.1093/jel/eqz006.

[141] R.M. Colvin, Social identity in the energy transition: an analysis of the "Stop adani convoy" to explore social-political conflict in Australia, Energy Res. Soc. Sci. 66 (2020), 101492, https://doi.org/10.1016/j.erss.2020.101492.

[142] R. Ford, S. Walton, J. Stephenson, D. Rees, M. Scott, G. King, J. Williams, B. Wooliscroft, Emerging energy transitions: PV uptake beyond subsidies, Technol. Forecast. Soc. Change. 117 (2017) 138–150, https://doi.org/10.1016/j.techfore.2016.12.007.

[143] D. Hill, S. Connelly, Community energies: exploring the socio-political spatiality of energy transitions through the clean energy for eternity campaign in New South Wales Australia, energy resSoc. Sci. 36 (2018) 138–145, https://doi.org/10.1016/j.erss.2017.11.021.

[144] S. Thapar, S. Sharma, A. Verma, Local community as shareholders in clean energy projects: innovative strategy for accelerating renewable energy deployment in India, Renew. Energy 101 (2017) 873–885, https://doi.org/10.1016/j.renene.2016.09.048.

[145] M. de Bakker, A. Lagendijk, M. Wiering, Cooperatives, incumbency, or market hybridity: new alliances in the dutch energy provision, Energy Res. Soc. Sci. 61 (2020), 101345, https://doi.org/10.1016/j.erss.2019.101345.

[146] S. Eslamizadeh, A. Ghorbani, R. Künneke, M. Weijnen, Can industries be parties in collective action? Community energy in an Iranian industrial zone, Energy Res. Soc. Sci. 70 (2020), 101763, https://doi.org/10.1016/j.erss.2020.101763.

[147] M. Hentschel, W. Ketter, J. Collins, Renewable energy cooperatives: facilitating the energy transition at the port of Rotterdam, Energy Policy 121 (2018) 61–69, https://doi.org/10.1016/j.enpol.2018.06.014.

[148] C. Herbes, V. Brummer, J. Rognli, S. Blazejewski, N. Gericke, Responding to policy change: new business models for renewable energy cooperatives – barriers perceived by cooperatives' members, Energy Policy 109 (2017) 82–95, https://doi.org/10.1016/j.enpol.2017.06.051.

[149] N. Šahović, P.P. Da Silva, Community renewable energy - research perspectives -, Energy Procedia 106 (2016) 46–58, https://doi.org/10.1016/j.egypro.2016.12.104.

[150] S. Becker, M. Naumann, T. Moss, Between coproduction and commons: understanding initiatives to reclaim urban energy provision in Berlin and Hamburg, Urban Res. Pract. 10 (2017) 63–85, https://doi.org/10.1080/17535069.2016.1156735.

[151] L.L. Delina, A rural energy collaboratory: co-production in Thailand's community energy experiments, J. Environ. Stud. Sci. (2019) 83–90, https://doi.org/10.1007/s13412-019-00572-x.

[152] D.H. Llewellyn, M. Rohse, R. Day, H. Fyfe, Evolving energy landscapes in the South Wales valleys: exploring community perception and participation, Energy Policy 108 (2017) 818–828, https://doi.org/10.1016/j.enpol.2017.04.028.

[153] L.L. Delina, Energy democracy in a continuum: remaking public engagement on energy transitions in Thailand, energy resSoc. Sci. 42 (2018) 53–60, https://doi.org/10.1016/j.erss.2018.03.008.

[154] R.J. Hewitt, C. de Boer, J. Flacke, Participatory development of digital support tools for local-scale energy transitions: lessons from two European case studies, Glob. Transit. 2 (2020) 138–149, https://doi.org/10.1016/j.glt.2020.07.003.

[155] R.M. Pulselli, S. Broersma, C.L. Martin, G. Keeffe, S. Bastianoni, A., Van den dobbelsteen, future city visions. The energy transition towards carbon-neutrality: lessons learned from the case of Roeselare, Belgium, renew, Sustain. Energy Rev. 137 (2021), 110612, https://doi.org/10.1016/j.rser.2020.110612.

[156] S. Selvakkumaran, E.O. Ahlgren, Understanding social innovation in local energy transitions processes: a multi-case study, Glob. Transit. 3 (2021) 1–12, https://doi.org/10.1016/j.glt.2020.12.001.

[157] A. Wagner, T. Grobelski, M. Harembski, Is energy policy a public issue? Nuclear power in Poland and implications for energy transitions in central and East Europe, energy resSoc. Sci. 13 (2016) 158–169, https://doi.org/10.1016/j.erss.2015.12.010.

[158] N. Frantzeskaki, F. Avelino, D. Loorbach, Outliers or frontrunners? Exploring the (Self-) governance of community-owned sustainable energy in Scotland and the Netherlands, Lect. Notes Energy 23 (2013) 101–116, https://doi.org/10.1007/978-1-4471-5595-9_6.

[159] P. Buschmann, P. Moser, A. Nadaï, Y. Régnier, A-disciplinary considerations of two networks of local climate energy initiatives: paper part of the special issue entitled: "Unlocking energies, unpacking the entanglements and temporalities of local initiatives", Local Environ. 24 (2019) 1053–1072, https://doi.org/10.1080/13549839.2018.1520822.

[160] D. Süsser, M. Döring, B.M.W.W. Ratter, Harvesting energy: place and local entrepreneurship in community-based renewable energy transition, Energy Policy 101 (2017) 332–341, https://doi.org/10.1016/j.enpol.2016.10.018.

[161] C. Sebi, J. Doutre, A.-L. Vernay, Mapping the energy community cooperation chains, in: Eceee Summer Study Proc, European Council for an Energy Efficient Economy, 2019, pp. 797–803. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85085176502&partnerID=40&md5=6930f1fc20ed2973666e36ebd83bfe92.

[162] J.L. MacArthur, C.E. Hoicka, H. Castleden, R. Das, J. Lieu, Canada's green new Deal: forging the socio-political foundations of climate resilient infrastructure? Energy Res. Soc. Sci. 65 (2020), 101442 https://doi.org/10.1016/j.erss.2020.101442.

[163] E. Allen, H. Lyons, J.C. Stephens, Women's leadership in renewable transformation, energy justice and energy democracy: redistributing power, Energy Res. Soc. Sci. 57 (2019), 101233, https://doi.org/10.1016/j.erss.2019.101233.

[164] L.L. Delina, Climate mobilizations and democracy: the promise of scaling community energy transitions in a deliberative system, J. Environ. Policy Plan. 22 (2020) 30–42, https://doi.org/10.1080/1523908X.2018.1525287.

[165] K. Szulecki, I. Overland, Energy democracy as a process, an outcome and a goal: a conceptual review, Energy Res. Soc. Sci. 69 (2020), 101768, https://doi.org/10.1016/j.erss.2020.101768.

[166] A. Revez, N. Dunphy, C. Harris, G. Mullally, B. Lennon, C. Gaffney, Beyond forecasting: using a modified Delphi method to build upon participatory action

research in developing principles for a just and inclusive energy transition, Int. J. Qual. Methods 19 (2020), https://doi.org/10.1177/1609406920903218.
[167] A.H. Sorman, E. Turhan, M. Rosas-Casals, Democratizing energy, energizing democracy: central dimensions surfacing in the debate, Front. Energy Res. 8 (2020), https://doi.org/10.3389/fenrg.2020.499888.
[168] B. Klagge, T. Meister, Energy cooperatives in Germany–an example of successful alternative economies? Local Environ. 23 (2018) 697–716, https://doi.org/10.1080/13549839.2018.1436045.
[169] L. Horstink, J.M. Wittmayer, K. Ng, G.P. Luz, E. Marín-González, S. Gährs, I. Campos, L. Holstenkamp, S. Oxenaar, D. Brown, Collective renewable energy prosumers and the promises of the energy union: taking stock, Energies. 13 (2020), https://doi.org/10.3390/en13020421.
[170] T. Braunholtz-Speight, M. Sharmina, E. Manderson, C. McLachlan, M. Hannon, J. Hardy, S. Mander, Price support allows communities to raise low-cost citizen finance for renewable energy projects, Nat. Energy 5 (2020) 127–128, https://doi.org/10.1038/s41560-020-0556-2.
[171] B. Schmid, T. Meister, B. Klagge, I. Seidl, Energy cooperatives and municipalities in local energy governance arrangements in Switzerland and Germany, J. Environ. Dev. 29 (2020) 123–146, https://doi.org/10.1177/1070496519886013.
[172] C. Nolden, Governing community energy—feed-in tariffs and the development of community wind energy schemes in the United Kingdom and Germany, Energy Policy 63 (2013) 543–552, https://doi.org/10.1016/j.enpol.2013.08.050.
[173] K. Tews, The crash of a policy pilot to legally define community energyEvidence from the German Auction Scheme, Sustainability 10 (2018) 3397, https://doi.org/10.3390/su10103397.
[174] J. de Boer, C. Zuidema, A. van Hoorn, G. de Roo, The adaptation of dutch energy policy to emerging area-based energy practices, Energy Policy 117 (2018) 142–150, https://doi.org/10.1016/j.enpol.2018.02.008.
[175] N. Verkade, J. Höffken, Collective energy practices: a practice-based approach to civic energy communities and the energy system, Sustainability 11 (2019) 1–15, https://doi.org/10.3390/su11113230.
[176] A. Nadaï, O. Labussière, A. Debourdeau, Y. Régnier, B. Cointe, L. Dobigny, French policy localism: surfing on 'positive energie territories' (Tepos), Energy Policy 78 (2015) 281–291, https://doi.org/10.1016/j.enpol.2014.12.005.
[177] D. Gabaldón-Estevan, E. Peñalvo-López, D.A. Solar, The spanish turn against renewable energy development, Sustainability 10 (2018) 1–16, https://doi.org/10.3390/su10041208.
[178] K. Schumacher, F. Krones, R. McKenna, F. Schultmann, Public acceptance of renewable energies and energy autonomy: a comparative study in the French, German and Swiss upper Rhine region, Energy Policy 126 (2019) 315–332, https://doi.org/10.1016/j.enpol.2018.11.032.
[179] D. Meiklejohn, S. Bekessy, S. Moloney, Shifting practices: how the rise of rooftop solar PV has changed local government community engagement, Cogent Environ. Sci. 4 (2018) 1481584, https://doi.org/10.1080/23311843.2018.1481584.
[180] H. Kim, A community energy transition model for urban areas: the energy self-reliant village program in Seoul, South Korea, Sustainability 9 (2017), https://doi.org/10.3390/su9071260.
[181] N.H. Shabdin, R. Padfield, Sustainable energy transition, gender & modernisation in rural Sarawak, Chem. Eng. Trans. 56 (2017) 259–264, https://doi.org/10.3303/CET1756044.
[182] B. Poland, C. Buse, P. Antze, R. Haluza-DeLay, C. Ling, L. Newman, A.-A. Parent, C. Teelucksingh, R. Cohen, R. Hasdell, K. Hayes, S. Massot, M. Zook, The emergence of the transition movement in Canada: success and impact through the eyes of initiative leaders, Local Environ. 24 (2019) 180–200, https://doi.org/10.1080/13549839.2018.1555579.
[183] J.S. Gregg, S. Nyborg, M. Hansen, V.J. Schwanitz, A. Wierling, J.P. Zeiss, S. Delvaux, V. Saenz, L. Polo-Alvarez, C. Candelise, W. Gilcrease, O. Arrobbio, A. Sciullo, D. Padovan, Collective action and social innovation in the energy sector: a mobilization model perspective, Energies. 13 (2020), https://doi.org/10.3390/en13030651.
[184] P.D. Conradie, O. De Ruyck, J. Saldien, K. Ponnet, Who wants to join a renewable energy community in Flanders?Applying an extended model of Theory of Planned Behaviour to understand intent to participate, Energy Policy 151 (2021), 112121, https://doi.org/10.1016/j.enpol.2020.112121.
[185] H.-J. Kooij, M. Oteman, S. Veenman, K. Sperling, D. Magnusson, J. Palm, F. Hvelplund, Between grassroots and treetops: community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands, energy resSoc. Sci. 37 (2018) 52–64, https://doi.org/10.1016/j.erss.2017.09.019.
[186] D. Magnusson, J. Palm, Come together-the development of Swedish energy communities, Sustainability 11 (2019), https://doi.org/10.3390/su11041056.
[187] A. McCabe, D. Pojani, A.B. van Groenou, Social housing and renewable energy: community energy in a supporting role, Energy Res.Soc. Sci. 38 (2018) 110–113, https://doi.org/10.1016/j.erss.2018.02.005.
[188] J.A.M. Hufen, J.F.M. Koppenjan, Local renewable energy cooperatives: revolution in disguise? Energy. Sustain. Soc. 5 (2015) https://doi.org/10.1186/s13705-015-0046-8.
[189] J. Koch, O. Christ, Household participation in an urban photovoltaic project in Switzerland: exploration of triggers and barriers, Sustain. Cities Soc. 37 (2018) 420–426, https://doi.org/10.1016/j.scs.2017.10.028.
[190] C.E. Hoicka, K. Savic, A. Campney, Reconciliation through renewable energy? A survey of indigenous communities, involvement, and peoples in Canada, Energy Res. Soc. Sci. 74 (2021), 101897, https://doi.org/10.1016/j.erss.2020.101897.
[191] C. Sebi, A.-L. Vernay, Community renewable energy in France: the state of development and the way forward, Energy Policy 147 (2020), 111874, https://doi.org/10.1016/j.enpol.2020.111874.
[192] D. Wagemans, C. Scholl, V. Vasseur, Facilitating the energy transition-the governance role of local renewable energy cooperatives, Energies. 12 (2019), https://doi.org/10.3390/en12214171.
[193] B.P. Koirala, Y. Araghi, M. Kroesen, A. Ghorbani, R.A. Hakvoort, P.M. Herder, Trust, awareness, and independence: insights from a socio-psychological factor analysis of citizen knowledge and participation in community energy systems, energy resSoc. Sci. 38 (2018) 33–40, https://doi.org/10.1016/j.erss.2018.01.009.
[194] T. Blanchet, Struggle over energy transition in Berlin: how do grassroots initiatives affect local energy policy-making? Energy Policy 78 (2015) 246–254, https://doi.org/10.1016/j.enpol.2014.11.001.
[195] A.M. Koster, J.M. Anderies, Institutional factors that determine energy transitions: a comparative case study approach, in: Lect. Notes Energy, Springer Verlag, 2013, pp. 33–61, https://doi.org/10.1007/978-1-4471-5595-9_3.
[196] L.M. Lutz, D.J. Lang, H. von Wehrden, Facilitating regional energy transition strategies: toward a typology of regions, Sustainability 9 (2017) 1–17, https://doi.org/10.3390/su9091560.
[197] K. Klaniecki, I.A. Duse, L.M. Lutz, J. Leventon, D.J. Abson, Applying the energy cultures framework to understand energy systems in the context of rural sustainability transformation, Energy Policy 137 (2020), 111092, https://doi.org/10.1016/j.enpol.2019.111092.
[198] D.J. Hess, Industrial fields and countervailing power: the transformation of distributed solar energy in the United States, Glob. Environ. Chang. 23 (2013) 847–855, https://doi.org/10.1016/j.gloenvcha.2013.01.002.
[199] A.M. Minas, S. Mander, C. McLachlan, How can we engage farmers in bioenergy development? Building a social innovation strategy for rice straw bioenergy in the Philippines and Vietnam, Energy Res. Soc. Sci. 70 (2020), 101717, https://doi.org/10.1016/j.erss.2020.101717.
[200] C.A. Klöckner, Understanding the social dynamics of consumer energy choices - some lessons learned from two H2020 projects (ECHOES, SMARTEES), in: Eceee Summer Study Proc, European Council for an Energy Efficient Economy, 2019, pp. 3–12. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85085174879&partnerID=40&md5=1bb5c8072e66ba84a9f65129ddbc12fa.
[201] S. Yang, W. Chen, H. Kim, Building energy commons: three mini-PV installation cases in apartment complexes in Seoul, Energies 14 (2021) 249, https://doi.org/10.3390/en14010249.
[202] B. Prislan, T. Medved, J. Zupančič, V. Chable, A.F. Gubina, Financing of renewable energy installations, in: Mediterr. Conf. Power Gener. Transm. Distrib. Energy Convers. (MedPower 2016), Institution of Engineering and Technology, 2016, https://doi.org/10.1049/cp.2016.1057.
[203] T. Meister, B. Schmid, I. Seidl, B. Klagge, How municipalities support energy cooperatives: survey results from Germany and Switzerland, Energy. Sustain. Soc. 10 (2020) 18, https://doi.org/10.1186/s13705-020-00248-3.
[204] D.N. Mah, Community solar energy initiatives in urban energy transitions: a comparative study of Foshan, China and Seoul, South Korea, energy resSoc. Sci. 50 (2019) 129–142, https://doi.org/10.1016/j.erss.2018.11.011.
[205] C. Werthmann, What makes institutional crafting successful? Applying the SES to case studies from India and the greater Mekong region, Environ. Sci. Policy. 53 (2015) 165–174, https://doi.org/10.1016/j.envsci.2015.01.014.
[206] R. Roberts, A. Brent, J. Hinkley, Reviewing the impacts of community energy initiatives in New Zealand, Kōtuitui new zeal, J. Soc. Sci. Online 16 (2021) 45–60, https://doi.org/10.1080/1177083X.2021.1877161.
[207] D. Süsser, A. Kannen, 'Renewables? Yes, please!': perceptions and assessment of community transition induced by renewable-energy projects in north Frisia, Sustain. Sci. 12 (2017) 563–578, https://doi.org/10.1007/s11625-017-0433-5.
[208] G. Cheung, P.J. Davies, A. Bassen, In the transition of energy systems: what lessons can be learnt from the German achievement? Energy Policy 132 (2019) 633–646, https://doi.org/10.1016/j.enpol.2019.05.056.
[209] D. Sloot, L. Jans, L. Steg, In it for the money, the environment, or the community? Motives for being involved in community energy initiatives, Glob. Environ. Chang. 57 (2019), 101936, https://doi.org/10.1016/j.gloenvcha.2019.101936.
[210] Trend:research GmbH, Leuphana Universität Lüneburg, Definition und Marktanalyse von Bürgerenergie in Deutschland, 2013. https://www.buendnis-buergerenergie.de/fileadmin/user_upload/downloads/Studien/Studie_Definition_und_Marktanalyse_von_Buergerenergie_in_Deutschland_BBEn.pdf. (Accessed 2 July 2021).
[211] IRENA, Renewable Power Generation Costs in 2019, 2020. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_2017_Power_Costs_2018.pdf.
[212] E. Heaslip, F. Fahy, Developing transdisciplinary approaches to community energy transitions: an island case study, energy resSoc. Sci. 45 (2018) 153–163, https://doi.org/10.1016/j.erss.2018.07.013.
[213] B.K. Sovacool, M.H. Dworkin, Global energy justice, 2014, https://doi.org/10.4324/9781315762203.
[214] B. Fischer, G. Gutsche, H. Wetzel, Who wants to get involved? Determining citizen willingness to participate in german renewable energy cooperatives, Energy Res. Soc. Sci. 76 (2021), 102013, https://doi.org/10.1016/j.erss.2021.102013.
[215] J. Rommel, J. Radtke, G. von Jorck, F. Mey, Ö. Yildiz, Community renewable energy at a crossroads: a think piece on degrowth, technology, and the democratization of the german energy system, J. Clean. Prod. 197 (2018) 1746–1753, https://doi.org/10.1016/j.jclepro.2016.11.114.

[216] G. Seyfang, A. Smith, Grassroots innovations for sustainable development: towards a new research and policy agenda, Environ. Polit. 16 (2007) 584–603, https://doi.org/10.1080/09644010701419121.
[217] D.N. Mah, D.M. Cheung, Conceptualizing niche-regime dynamics of energy transitions from a political economic perspective: insights from community-led urban solar in Seoul, Sustainability 12 (2020) 4818, https://doi.org/10.3390/su12124818.
[218] M. Jain, V. Siva, T. Hoppe, H. Bressers, Assessing governance of low energy green building innovation in the building sector: insights from Singapore and Delhi, Energy Policy 145 (2020), 111752, https://doi.org/10.1016/j.enpol.2020.111752.
[219] A. Mahzouni, The role of institutional entrepreneurship in emerging energy communities: the town of St. Peter in Germany, renewSustain. Energy Rev. 107 (2019) 297–308, https://doi.org/10.1016/j.rser.2019.03.011.
[220] T. Hoppe, A. Butenko, M. Heldeweg, Innovation in the european energy sector and regulatory responses to it: guest editorial note, Sustainability 10 (2018), https://doi.org/10.3390/su10020416.
[221] I. Cuesta-Fernandez, S. Belda-Miquel, C. Calabuig Tormo, Challengers in energy transitions beyond renewable energy cooperatives: community-owned electricity distribution cooperatives in Spain, Innov. Eur. J. Soc. Sci. Res. 33 (2020) 140–159, https://doi.org/10.1080/13511610.2020.1732197.
[222] S. Knox, M. Hannon, F. Stewart, R. Ford, The (in)justices of smart local energy systems: a systematic review, integrated framework, and future research agenda, Energy Res. Soc. Sci. 83 (2022), 102333, https://doi.org/10.1016/j.erss.2021.102333.
[223] A. Lawrence, Energy decentralization in South Africa: why past failure points to future success, Renew. Sustain. Energ. Rev. 120 (2020), 109659, https://doi.org/10.1016/j.rser.2019.109659.
[224] M. Lacey-Barnacle, Proximities of energy justice: contesting community energy and austerity in England, Energy Res. Soc. Sci. 69 (2020), 101713, https://doi.org/10.1016/j.erss.2020.101713.
[225] J.M. Wittmayer, I. Campos, F. Avelino, D. Brown, B. Doračić, M. Fraaije, S. Gährs, A. Hinsch, S. Assalini, T. Becker, E. Marín-González, L. Holstenkamp, R. Bedoić, N. Duić, S. Oxenaar, T. Pukšec, Thinking, doing, organising: prefiguring just and sustainable energy systems via collective prosumer ecosystems in Europe, Energy Res. Soc. Sci. 86 (2022), 102425, https://doi.org/10.1016/j.erss.2021.102425.
[226] S. Centgraf, Supporting civic engagement in german energy cooperatives – transdisciplinary research based on the reflection of individual needs, energy resSoc. Sci. 44 (2018) 112–121, https://doi.org/10.1016/j.erss.2018.05.003.
[227] J. Morrissey, E. Schwaller, D. Dickson, S. Axon, Affordability, security, sustainability? Grassroots community energy visions from Liverpool, United Kingdom, Energy Res. Soc. Sci. 70 (2020), 101698, https://doi.org/10.1016/j.erss.2020.101698.
[228] M. Islar, H. Busch, "We are not in this to save the polar bears!" – the link between community renewable energy development and ecological citizenship, innovEur. J Soc. Sci. Res. 29 (2016) 303–319, https://doi.org/10.1080/13511610.2016.1188684.
[229] N. van Aalderen, L.G. Horlings, Accommodative public leadership in wind energy development: enabling citizens initiatives in the Netherlands, Energy Policy 138 (2020), 111249, https://doi.org/10.1016/j.enpol.2020.111249.
[230] T. Roesler, Community resources for energy transition: implementing bioenergy villages in Germany, Area 51 (2019) 268–276, https://doi.org/10.1111/area.12444.
[231] T. Hoppe, E. van Bueren, Guest editorial: governing the challenges of climate change and energy transition in cities, Energy. Sustain. Soc. 5 (2015) 19, https://doi.org/10.1186/s13705-015-0047-7.
[232] E.C. van der Waal, A.M. Das, T. van der Schoor, Participatory experimentation with energy law: digging in a 'Regulatory sandbox' for local energy initiatives in the Netherlands, Energies 13 (2020) 458, https://doi.org/10.3390/en13020458.
[233] H.-H. Höfer, J. Rommel, Internal governance and member investment behavior in energy cooperatives: an experimental approach, Util. Policy 36 (2015) 52–56, https://doi.org/10.1016/j.jup.2015.09.003.
[234] M. Markantoni, Low carbon governance: mobilizing community energy through top-down support? Environ. Policy Gov. 26 (2016) 155–169, https://doi.org/10.1002/eet.1722.
[235] D. Coy, S. Malekpour, A.K. Saeri, From little things, big things grow: facilitating community empowerment in the energy transformation, Energy Res. Soc. Sci. 84 (2022), 102353, https://doi.org/10.1016/j.erss.2021.102353.
[236] IRENA, Renewable Energy Market Analysis: Southeast Asia, 2018. www.irena.org.