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ENERGY COMMUNITIES:

INSTITUTIONS, FINANCING, ECONOMICS

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ENERGY COMMUNITIES: INSTITUTIONS, FINANCING, ECONOMICS

University of Trieste

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Keywords: energy communities, community energy, management, energy economics, financing, institutions.

Abstract

This Ph.D. thesis investigates the institutional roots and policy aspects of the Europe's evolving energy community organizational form in Chapter I and Chapter II in the period before 2022. Chapter III concentrates mostly on the new Italian energy communities which appear in the period of 2022-2024.

Chapter I presents a bibliometric analysis of academic literature on energy communities (ECs) from 2012 to 2022. Results of the bibliometric analysis were used to conduct the systematic literature review that examines the evolution of research topics, methodologies, and geographical focus. The analysis reveals a shift from the initial focus on grassroots EC initiatives in Northern Europe to a growing interest in the role of policy, technology, and economic viability.

Chapter II maps and classifies ECs in the European Union before the transposition of the Renewable Energy Directive II (RED II) and the Internal Electricity Market (IEM) Directive. The chapter highlights the diversity of EC models across different member states and analyzes factors influencing their deployment, with particular attention to the institutional and policy contexts of France and Italy.

Chapter III begins with examination of the potential impact of various EC business models on key energy market agents and the overall electricity system. It then analyzes the efficiency of Italian policies and regulations governing ECs, focusing on the structure of premium tariff for shared energy and the valorization of avoided grid usage. The second part of Chapter III investigates the financing of EC capital expenditures in Italy. Employing semi-structured interviews with 19 financing and ECs building actors, the chapter explores the roles of different financing actors, the instruments used, and the recipients of financing. The subsequent thematic analysis reveals the diversity of the expertise needed to establish ECs, categories of building partnerships, and the role of main EC promoters. The chapter continues by outlining the economic and ESG expectations of financing and building actors, as well as their pre-investment assessment practices and intentions for evaluating the impact of ECs. Finally, interactions between financiers and ECs are analyzed through the management theories. The concept of 'shared energy' is framed using common pool resources theory, which provides insights into potential obstacles and solutions that ECs may encounter in the future.

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Introduction

To my beloved grandma who passed to another world during this PhD journey

Elinor Ostrom, having got her Nobel Prize jointly with Oliver Williamson, used to gently mock him for focusing only on "*Market and Hierarchies*". pointing out that humans had invented communities centuries ago, to deal with many common issues that markets and hierarchies are not well equipped to address (Glachant, 2022). Indeed, the whole history of energy before the industrial revolution was surrounded around the community lives and particularly around agriculture and ways to advance it (Smil, 2017). Agriculture was always community-based, with only at a later stage starting with the discovery of the Americas, did it become more tradeable and international. The industrial revolution enabled people to improve farming techniques, consequently shifting agriculture to be less community-based and attain features of the enterprise nature. Higher efficiency in agriculture moved exempted labor to the manufacturing sector where energy needed even to a greater extent than in agriculture. Centralized power plants based, primarily, on coal and later oil, supplied this increased manufacturing with energy, although caused unprecedented levels of CO2 emissions. Starting from the twentieth century, the CO2 rise induced such a rapid temperature growth that had not ever been occurring in the last 11500 years of the Holocene period (Marcott et al., 2013).

Decreasing the importance of fossil fuel power plants and their substitution with renewables-based facilities should play a pivotal role in tackling the emissions (supply-side) cause of climate change. However, not only the supply side is responsible for the crisis. Drastically increased demand for energy is a reverse side of the same coin. Will we reduce current demand thus economic growth preventing for future threats? Undoubtfully. Consumers tend to opt for the current wellbeing over the future threats, to what behavioral economists commonly refer as 'hyperbolic discounting'. Nevertheless, we could decrease energy consumption although not by reducing production or drastically changing behavioral habits but by increasing the energy efficiency. A good evidence is a building stock, which is solely responsible for approximately 36 % of all CO2 emissions in the EU (EU, 2018), and if becomes energy efficient can greatly contribute to fighting climate change. Improvements in the energy efficiency should be guided not only by governments but also by other agents including enterprises and private citizens to massively scale up.

Another avenue to reduce fossil fuel demand is fostering active citizen participation in renewable energy generation, as non-institutionalized private citizens currently contribute minimally. However, addressing only the demand for fossil fuels provides an incomplete solution. a comprehensive approach is necessary. A primary barrier to developing efficient electricity markets is their incompleteness, particularly in the form of inelastic demand. Without well-functioning markets, state interventions aimed at CO_2 reduction may inadvertently harm general welfare and various stakeholders' interests. Limited demand elasticity is arguably due to the mentality prevailing until very recently in the electricity industry: continuity of supply was regarded to be a nearly sacred duty, to be fulfilled at any price (Laloux & Rivier, 2013). Consumers, traditionally viewed as subscribers rather than active customers, were largely passive recipients of service rather than active participants in the market.

A shift in consumer mindset is anticipated. Should this occur, it would enable consumers not only to improve energy efficiency and awareness affordably but also to contribute to demand-side flexibility. Engaging private citizens in the energy transition could lead to a fairer distribution of economic benefits, helping to reduce inequality. Fortunately for the EU, attitudes toward energy are evolving. The recent energy crisis has prompted many citizens to reconsider the notion of "energy as a sacred duty."

The transition pathway can be realized not only through large, centralized renewables but also by involving consumers who can co-generate and co-manage energy. Decentralized, community-based energy could be a crucial tool to combat global warming (Poupeau, 2020). Through this, consumers could gain greater benefits from the energy transition. Hence, both the supply and demand sides of the issue can be addressed by communities. Energy communities (ECs), as consumer aggregations, can facilitate this process. In this way, consumer demand and supply activities could become more efficient, capitalizing on economies of scale. Additionally, consumers could contribute to energy efficiency as well as demand flexibility. Finally, ECs make the process fairer.

Structurally, rise of ECs creates new market agents while pushing existing agents to innovate obsolete business models, that, in turn, is a logical process of a capitalistic growth through innovation coined by Schumpeter as ‘creative destruction’ (Schumpeter, 1942). Into the future, new way of organizing energy system could be shared outside of Europe and even traded as the intellectual capital. Today, evolutionary processes begin in Italian power sector. The aim of this Ph.D. thesis is to investigate its institutional roots and to contribute to knowledge on its business and economic aspects.

Chapter I of this thesis presents a bibliometric analysis of academic literature on ECs from 2012 to 2022, followed by a systematic literature review. Chapter II describes the status of energy communities prior to the EU Directives. In the first part, it reviews EC classifications from both legal and academic perspectives, along with mapping and descriptive statistics of the EC movement across the EU, concluding with a discussion on EU-wide experiences and pathways for effective EC deployment. The second part of Chapter II compares institutional and policy frameworks for ECs in Italy and France, assessing their potential to enhance member welfare through three case studies. The chapter concludes by examining how appropriate institutional and policy contexts facilitated EC deployment in France and Italy before the EU Directives' transposition.

Biggar & Hesamzadeh (2022) argue that regulatory choice on organizational model of ECs could make this new phenomenon either beneficial or detrimental to economic welfare. In the first part of Chapter III, we examine the potential impact of various EC business models on key energy market agents, including DSOs, generators, retailers, non-member consumers, and aggregators, as well as the overall electricity system. This is followed by a theoretical analysis assessing the efficiency of Italian policies and regulations governing ECs.

With an understanding of Italian EC regulations, we proceed to the second part of Chapter III, which focuses on investigating the financing of EC capital expenditures. The bibliometric study highlighted that financing remains an under-explored topic in EC literature, with no comprehensive studies specifically for Italy. Alongside technical, legal, and social considerations, successful financing of feasibility studies and infrastructure is a crucial factor for the success of emerging ECs. De Vidovich et.al. (2021) found that most of energy communities are initiated and designed by partnerships of actors with heterogeneous expertise where the main actor is commonly a public administration, energy service company, or non-for-profit organization, or rarer a group of private citizens. One of the primary challenges such partnerships face is securing financing: identifying appropriate financiers, determining suitable financing options for each EC, and aligning with financiers’ expectations without compromising the EC's autonomy and long-term stability. Similarly, financiers seek tailored instruments and partnerships that align with both ESG and economic objectives for EC construction. We start the financing sections with a review of academic literature, industry reports, and key theories supporting this study. This is followed by an overview of the data collection process and qualitative methodology. Subsequent sections present and discuss answers to such research questions: what the actors and instruments are to finance ECs in Italy, what EC-building partnerships do and how, what are the ESG and economic expectations of financing and building actors.

In the thesis conclusion, we summarize the status quo of ECs prior to the EU Directives, highlight their economic value to the broader system, explore financing aspects and outline expectations regarding their ESG impact. Finally, we present key insights and underscore the research's significance.

The thesis was developed during a period marked by ongoing changes and regulatory uncertainty surrounding Italian EC policies. While awaiting new regulations, we identified research gaps in the academic literature and delved deeper into the drivers behind the rise of energy communities in Europe. Key outcomes of this research phase are detailed in Chapters I and II. The long-awaited EC regulation, enacted at the start of 2024, provided a solid basis for the empirical investigations in Chapter III.

Chapter I.
Energy communities in social sciences: Bibliometric analysis and systematic literature review

1.1 Introduction

The concept of an energy community is simultaneously an old and a new social phenomenon (Koltunov & Bisello, 2021). Vansintja (2015) argues that the first centralized fossil-fuel electricity plants at the beginning of the XX century were usually established next to the big production centers – urban areas, where investment in a big facility had positive returns. Rural areas and middle-size settlements were left behind. Here local authorities and civic cooperatives had to bring "the light" (Koltunov, 2019). Many of such historical ECs still exist. A new wave of ECs started to appear after the introduction of the EU energy sector unbundling rules in the late 90s and the removal of barriers for alternative energy suppliers. At that time, literature on energy cooperatives emerges in social sciences. Establishing of the Samso energy island in Denmark attracted great media as well as scientific attention, subsequently increasing interest in the energy community phenomenon. Since then, energy communities developed in many countries with the highest number in Germany and the UK (Koltunov, 2019). The next time pillar was the recognition of energy communities in the EU policy in 2018-2019. Directives (IEM, 2019b; RED-II, 2018) gave a legal definition to the energy communities as well as obliged member states to grant certain rights and incentives to energy communities. They also significantly stimulated the research on ECs, which developments and trajectories we aim to analyse in this chapter.

Hart (2018) outlines two main types of literature review. The first is a 'review of the research', which is intended to provide a summative review based on categorizing the literature. The second is a 'review for the research', which is done for the generative review that aims at producing something new from the literature. Research described in this section is of a first type and therefore it is a summative or systematic review rather than generative. The need for a systematic review of the sector grows from the relevant novelty of the interest in the energy communities' phenomenon. It yet should be clarified, structured, and positioned within the social science discourse. Up to date, some attempts have already been done for this purpose. With our analysis, we discovered 16 articles in which the main research method is a literature review: nine are purely generative, 'review for the research' (Berka & Creamer, 2018; Brummer, 2018a; Gjorgievski et al., 2021; Gui & MacGill, 2018; Hewitt et al., 2019; Holstenkamp, 2019; Klein & Coffey, 2016; Koirala et al., 2016; Sousa et al., 2019) while 7 articles are classified as systematic reviews, thus a 'review of the research' (Bauwens et al., 2022; Busch et al., 2021; Fouladvand et al., 2022; Lode et al., 2022; Soeiro & Dias, 2019; van der Schoor & Scholtens, 2019; Wuebben et al., 2020). However, among 7 systematic reviews, only Schoor & Scholtens (2019) aim at encompassing the whole ECs' research field. Bauwens et al. (2022) narrow the scope for energy community definitions categorization. Fouladvand et al. (2022) concentrate on the heat and cooling ECs to establish a research agenda for this type of ECs. Lode et.al (2022) narrow their review to articles investigating the factors influencing emerging of ECs. Busch et.al. (2021) include only the articles that can provide insights into the policy challenges and only in the European countries. Wuebben et.al. (2020) concentrates on the possible pathways to how citizen scientists could engage in the research on ECs, therefore narrowing the scope to the articles discussing citizen participation in the ECs. Soeiro & Dias (2019) narrow the scope to the energy cooperatives in the Southern European countries. Furthermore, the authors conducted a bibliometric analysis using the computer applications only in 4 articles:

- Lode et.al. (2022) – VosViewer
- Fouladvand et al. (2022), - VosViewer
- Schoor & Scholtens (2019) - Atlas.ti
- Bauwens et.al. (2022) – Not indicated

In the 7 systematic reviews, databases included different periods as depicted in Table 1.

Table 1. Database timeframes of the systematic literature reviews on the ECs

Paper	Database timeframe
Schoor & Scholtens (2019)	1997 – February 2018
Bauwens et.al. (2022)	no limit - 2019
Fouladvand et al. (2022)	no limit - 2020
Lode et.al. (2022)	no limit – May 2021
Busch et.al. (2021)	2007 - 2018
Wuebben et.al. (2020)	2000 - 2020
Soeiro & Dias (2019)	no information available

Our research differs from the previous systematic literature reviews since it provides an updated review, from 2002 until March 2022. Recent EU Directives (IEM, 2019b; RED-II, 2018) spurred dramatically research on the topic as we see in Fig. 1, thus updated results are important. Second, our work does not narrow the database scope for investigating a specific research objective, but rather provides a broad view of the sector's general development. Third, we utilize a Bibliomterix package in R as a tool for the bibliometric analysis. Bibliometrix package in R offers more instruments for the analysis than the VosViewer and far more than Atlas.ti. For instance, Bibliometrix package is particularly strong in providing dynamic visualizations that show change across time whereas the other applications do not provide such instruments (Moral-muñoz et al., 2020; Tay, 2022).

As the main outcome of the bibliometric analysis and a consequent systematic literature review, we consider the discovery of main research topics related to the energy communities, because clarification and structuring of the research background clarify its agenda. It will help scholars to better understand the direction in which the field is going and where the gaps are to provide a guideline for positioning their future research focus (Marzi et al., 2017). Henceforth, the first research question is the following:

- What are the main topics of research on energy communities?

Despite the topics, methodologies applied to the energy communities' research are important to investigate. It will enable a better understanding of the nature of the revealed topics. In addition, authors from different countries might concentrate their research on specific topics. The geographical location of the studies can influence the research results, as different regions have their background, biophysical conditions, policies, and institutions (Fouladvand et al., 2022). This could provide comparative insights, especially if adjusting to the discussion on the state of the sector's development international-wide. We include these two additional objectives - methodologies, and countries - into the first research question.
Also, it is important to trace academic literature chronologically to understand if, why, when, and how the topics discovered had evolved. Accordingly, the second research question entails the timing aspect with reference to a specific timeframe:

- How did the energy community research evolve from 2002 to 2022?

To respond, the Section is organized as follows. Section 1.1.1 starts with defining the concept of energy community, which is utilized for our research, particularly, for the exclusion criteria. The section continues with the methodological framework applied. In Section 1.1.2 the main results of the bibliometric analysis and systematic literature review are illustrated. Ultimately, Section 1.1.3 summarizes the results and delineates the agenda for the further research on ECs.

1.2 Data Collection and Methodology

In the EU legislation energy communities are defined by two distinct albeit non-exclusive definitions, citizen energy communities (CECs) and renewable energy communities (RECs). According to the definition of REC such an entity should "be effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity", however, this statement is absent in a definition of the CEC. Moreover, CEC "may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles", which opens a window of opportunities to much more business models and guarantees stated in Article 16 of Electricity Market Directive (2019a). ECs which primary business activity is the generation of renewable energy considered as "renewable energy communities", whereas ECs which purely operate the grid or sell energy at the retail level, considered as "citizen energy communities". However, the former can be considered as a subset of the latter. Obviously, research on the topic did not start with the introduction of EU Directives (IEM, 2019a; RED-II, 2018), but much priorly dating back to the end of 90s when first niche case studies began to appear in the EU. In many countries phenomenon was widely known by its organizational and legal form, energy cooperatives. Pioneering country in the research on ECs was the United Kingdom with the seminal work of Walker and Devine-Wright (Walker & Devine-Wright, 2008), where from stems a first extensive definition, which was labeled as 'community energy'. It put a clear focus on its social cohesion objective. As indicated by Bauwens et.al. (2022), with time other similar concepts emerged: 'energy community', 'community solar', 'community wind', 'integrated community energy system' (ICES), etc. Creamer et.al. (2019) stated that "what community means should remain open, and there is not any one aspect that community, or [community renewable energy], should mean." Therefore, a broad search criterion was applied to our sample selection in Scopus database. It also corresponds to the objective of a systematic review.

The search query in Scopus was done on April 14th, 2022. The initial search did not exclude publications from non-social science fields such as engineering and computational science. Therefore, it resulted in 2883 findings. We decided to limit the search criterion to only the social science sector. In addition, we included a time frame to the query, from 2002 to March 2022, which showed the most recent publications available at the time of retrieval. It resulted in 1082 findings.

We uploaded the database to R 4.1.2 Statistical Software. Even though papers from the engineering sector were excluded from query, results still contained a great number of those. We decided to keep only those engineering publications where social science perspective was complementary discussed. For example, when calculating feasibility of EC projects economic indicators (e.g., NPV, IRR) were considered, or environmental impact calculated. Strictly engineering works were excluded. Also, papers from biology were still present in the database. In biology, energy community term is used in a totally different context. Papers referring to the energy community as the European institution with the specific reference to the nuclear energy was found too. At last, energy community as the EU policy mechanism towards neighbor states was misleadingly present in the database. We cleaned the corpus from papers contained such terms: *fourier, turbulence, conductor, electron, wind turbine, air conditioning, radio, safety, atomic energy community, nuclear, Euratom, energy union, international cooperation, oil, coal, negotiation, WTO, middle east, belt and road, geopolitics, EU neighbourhood, Iran, Russia, Ukraine, Kyoto, ASEAN, European energy community, European integration, covent of mayors, biology, catfish, predat, wildlife, biopolymer, biodiversity, fish, bird, mammals, catalysis, encephalization, timber, algae, soil, chemical.* After this, 955 publications left. We found papers where authors were not indicated, highly gray and non-relevant literature. After their elimination, 923 publications left. The dataset contained number of erratums, data papers, and editorials. Due to the minor scientific contribution such documents were deleted as well, leaving 911 publications. At last, manual review of the papers was performed which resulted in final 813 publications from 273 distinct sources. The corpus contained:

- 602 articles and reviews
- 143 conference papers
- 53 book chapters
- 5 books

−7 short surveys
−3 notes

Sample selection and refining was not fully consequent and contained iterative stages.

Performance analysis

Performance analysis (White & McCain, 1998) and science mapping (Börner et al., 2003) are the two main techniques frequently used in bibliometric investigations. Performance analysis seeks to assess the impact of various actors using bibliographic information (Aria et al., 2020). We analyze it by descriptive approach using core packages in R. From the other side, science mapping aims to draw attention to the domain's structural and cognitive patterns by either depicting the key topics in specific point of time (Callon et al., 1983) or topics' evolution during a timespan (Cobo et al., 2011). For latter we use specific R package named 'Bibliometrix'. It was elaborated by Massimo Aria and Corrado Cucurrulo in 2016.

We produced distribution of publication by years. Also, we examined journals and authors in respect to their influence in the field of energy communities, analyzed impact of countries. To assess journals most notable measures are total number of papers, total number of citations, the average citation per paper (Garfield, 2006; Garfield & Pudovkin, 2015). Authors were assessed based on the citations of their publications with subsequent deriving of such measures as: documents per author, co-authors per document, share of international co-authorship. For the impact of countries, such measures were used: average article citation per country, total number of citations per country. Descriptive statistics and its visualization were produced.

Science mapping

The great advantage of bibliometric methods is its ability to discover the subfields, clusters, with quantitative analysis. Dimensionality reduction techniques are used for this purpose. The most common are factorial analysis, cluster analysis, multidimensional scaling (MDS), and network analysis community finding algorithms (Cobo et al., 2012). In network analysis, units of analysis (such as document, author, journal, reference, country of affiliation, institution of affiliation, keyword, term extracted from title, abstract, etc.) are represented by network nodes revealing certain scientific topic, and network ties are used to show relationships between similar units of research. Nodes with stronger connections are brought together tighter. There are various sorts of maps that can visualize scientific topics, depending on the unit of analysis. Among most widespread are co-author maps and citation maps (Börner et al., 2003). Co-author maps are used to show the structure of scientific networks, while citation maps represent the intellectual structure of a field (Zupic & Čater, 2015). The bibliometric methods, corresponding statistical techniques, and units of analysis utilized for our study can be found in Table in Annex 1.

Co-author analysis

Co-author analysis examines the social networks scientists create by collaborating on scientific articles (Acedo et al., 2006). Apart from the authors themselves, this analysis can examine countries and institutions of authors' affiliation. We used countries as our unit of interest. A country collaboration network can be obtained using the general formula:

$$B_{coll} = Ci \times Cj$$

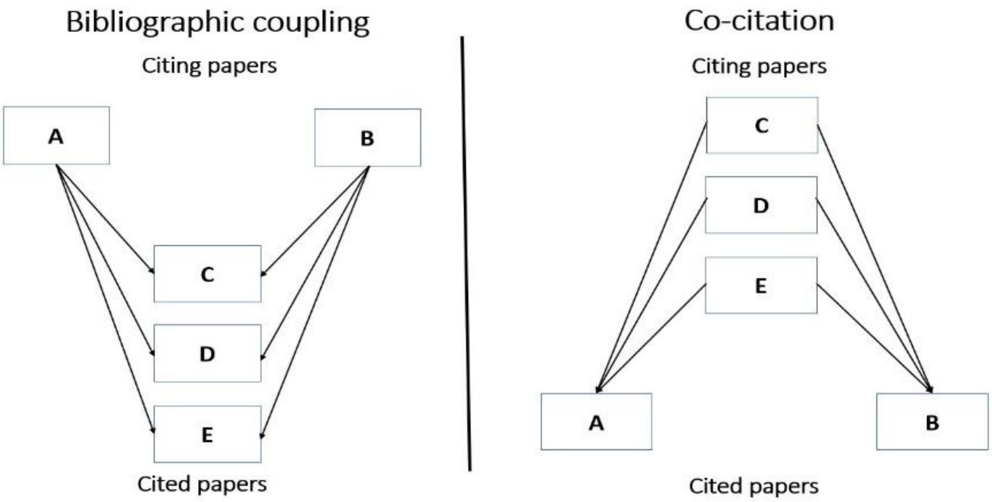
where B_{coll} is a *country* × *country* adjacency matrix. Element b_{ij} in a matrix B_{coll} indicates how many collaborations exist between countries i and j. The diagonal element b_{ii} is the number of documents authored or co-authored by authors from country i.

Bibliometrix functions *metaTagExtraction()*, *bibionetwork()*, and *networkPlot()* function were performed over the database with arguments corresponding to the bibliometric method, unit of analysis, and a statistical technique utilized for the cluster detection. The network map was created where nodes are countries, distance between nodes show strength of the scientific collaboration, node color attributes to the cluster.

Bibliographic coupling

Bibliographic coupling and co-citation analysis are considered methods of the citation analysis. Two articles are said to be bibliographically coupled if at least one cited source appears in the bibliographies or reference lists of both articles (Kessler, 1963). The more the bibliographies of two articles overlap, the stronger their connection (Zupic & Čater, 2015). Examining the research front of a topic or research field is a task particularly suitable for bibliographical coupling since this method uses reference lists for coupling and does not require the documents to be cited in order to connect them (Zupic & Čater, 2015). This method, unlike co-citation, is suitable to use to discover emerging fields with new publications which are not cited yet. However, the method does not inherently identify the most important works by citation counts as co-citation (Zupic & Čater, 2015). Figure 1 shows the difference between bibliographic coupling and co-citation analysis.

Figure 1. Bibliographic coupling and co-citation analysis



A bibliographic coupling network can be obtained using the general formula:

$$B_{coup} = Ai \times Aj$$

where B_{coup} is a *author* × *author* matrix. Element b_{ij} indicates how many bibliographic couplings exist between authors *i* and *j*. B_{coup} is a non-negative and symmetrical matrix. The strength of the bibliographic coupling of two authors, *i* and *j* is defined simply by the number of references that the authors have in common, as given by the element b_{ij} of matrix B_{coup}. Authors with only a small number of references, therefore, would tend to be more weakly bibliographically coupled when bibliographic coupling strength is simply measured according to the number of references that authors have in common (Aria & Cuccurullo, 2017).

Bibliometrix functions *bibionetwork()* and *networkPlot()* were performed over the database with arguments corresponding to the bibliometric method, unit of analysis, and a statistical technique utilized for the cluster detection. For the purpose to explore the main topics, which are implicit in the clusters, we do not need to analyze works of all the authors ever published on ECs. In addition, greater number of nodes are harder to visualize. After we validated that the number of clusters and main authors do not depend on the number of authors included in analysis, we decided to restrict the number of authors in analysis to only those working in the field non-sporadically. At the end, 118 authors published 3 or more papers on ECs appeared in the network plot, Figure 8. Consequently, clusters of authors were analyzed using mixed approach to systematic literature review. Section 2.4 describes the process in detail.

Co-citation

Two articles are co-cited when they are both cited in a third article, therefore it is the opposite method to the bibliographic coupling. Co-citation carries more information for highly cited documents but is much less reliable for clustering smaller niche specialties which are formed by less cited documents (Zupic & Čater, 2015). The co-citation network depicts the field's past condition rather than what it might be today or tomorrow since new publications have not usually been cited enough by the other works. Therefore, results can evolve over time. Co-citations are helpful in detecting a shift in paradigms and schools of thought changing with time (Pasadeos et al., 1998). The general formula for co-citation network is:

$$B_{cocit} = Di \times Dj$$

where B_{cocit} is a *document* × *document* reference matrix. Similar to matrix B_{coup}, matrix B_{cocit} is also symmetric. Element b_{ij} indicates how many co-citations exist between documents i and j. The main diagonal of B_{cocit} contains the number of documents where a reference is cited in our data frame. That is, the diagonal element b_{ii} is the number of local citations of the reference i (Aria & Cuccurullo, 2017).

Bibliometrix functions *bibionetwork()* and *networkPlot()* were performed over the database with arguments corresponding to the bibliometric method, unit of analysis, and a statistical technique utilized for the clusters detection. When the core document set has been selected, authors often exclusively use documents or journals that exceed some minimum citation threshold for the purpose of selecting only influential publications and limiting the core document set to a manageable size (Zupic & Čater, 2015). Thus, analysis was performed only for the 148 documents, which was cited 30 or more times. Based on the results of co-citation analysis the systematic literature review was performed. Section 2.4 describes the process in detail.

Co-word analysis

Co-word analysis (Callon et al., 1983) is a content analysis technique that uses the words in documents to establish relationships and build a conceptual structure of the domain. It uses the actual content of documents for analysis, whereas previous methods only use bibliographic meta-data (Zupic & Čater, 2015). The method's underlying assumption is that when words appear together frequently in documents, it indicates that the concepts they represent are tightly related. The output of co-word analysis is a network of themes and their relations which represent the conceptual space of a field. The unit of analysis is a concept, not a document, author or journal (Zupic & Čater, 2015). A co-word network can be obtained using the general formula:

$$B_{cow} = Wi \times Wj$$

where B_{cow} is a *word* × *word* matrix, where *word* is, alternatively, authors' keywords, keywords plus, or terms extracted from titles or abstracts. Element b_{ij} indicates how many co-occurrences exist between words i and j. The diagonal element b_{ii} is the number of documents containing the word i.

One of the statistical techniques used for dimensionality reduction in co-word analysis is Multiple Correspondence Analysis. It is considered as a subset of the factorial analysis of qualitative data (Hoffman & De Leeuw, 1992). MCA is applied to a *word x word* matrix. The words are plotted on a two-dimensional map. MCA performs a homogeneity analysis of an indicator matrix to obtain a low-dimensional Euclidean representation of the original data (Handl, 1992). The bibliometrix R-package has the *conceptualStructure()* function to perform MCA. It draws a conceptual structure of the field and K-means clustering to identify clusters of documents that express common concepts (Aria & Cuccurullo, 2017). The results are interpreted based on the relative positions of the points and their distribution along the dimensions. as words are more similar in distribution, the closer they are represented on the map (Cuccurullo et al., 2016).

There are number of statistical techniques used for discovering temporal patterns in a co-word bibliometric analysis. 'Trend topics' is one of such techniques. The idea is to build a graphic representation where each topic (by topic means a word) is assigned a year representing, synthetically, the time distribution of the occurrences of the topic itself. The reference year for each theme is identified using the median of the distribution of events in the considered period (Belfiore et al., 2022). To our knowledge 'Bibliometrix' package does not contain a separate automate function for performing this technique. However, such option is available in the user-friendly extension of the 'Bibliometrix' called 'Biblioshiny'. To start with the tool, we performed function *biblioshiny()* in the main R console. It opened the interface in the internet browser. Trend topic technique produced a scatter plot where time is indicated on the horizontal axis while the most frequent terms are indicated on the vertical axis. Each bubble on the graph represents the frequency of the topic in the median year. Bubble size is proportional to the term occurrence (Belfiore et al., 2022). Another graph that indicated the growth of most used keywords with time was also created. Cumulative occurrences depicted on the vertical axis, while years on the horizontal. Lines of different lengths corresponded to the most used keywords. This graph allowed to discover a possible paradigm shift.

Additional powerful statistical technique is the thematic evolution which aims to indicate the conceptual social evolution of the research field by discovering trends, patterns, and outliers. We divided the bibliographic data into 3 multi-year periods and took snapshots of the structure of the field for each interval. Interpretation strategy was to explain how the structure changed and why did this happen. It determined which elements are new in certain period and which are under the decline (Zupic & Čater, 2015). We started from a co-occurrence matrix where each cell outside the principal diagonal contains the similarity of two terms expressed as equivalence (Callon et al., 1991):

$$\mathrm{eqv_{ij}} = \frac{\mathrm{n_{ij}^2}}{\mathrm{n_i \times n_j}}$$

with n_{ij} as number of publications in which two terms i and j co-occur, n_i and n_j number of publications in which each one appears. This measure assumes values in the interval [0.1] and evaluates how much two terms are associated. On each subperiod co-occurrence matrix, we performed a community detection based on the simple center algorithm (Coulter et al., 1998). This analysis allows finding subgroups of strongly linked terms, where each subgroup corresponds to a center of interest or to a given research theme/topic of the analyzed collection (Aria et al., 2020). Once the analysis is carried on, it is possible to plot results in a so called strategic or thematic diagram (Cobo et al., 2011), according to the Callon centrality c_t and Callon density d_t of each cluster/theme t:

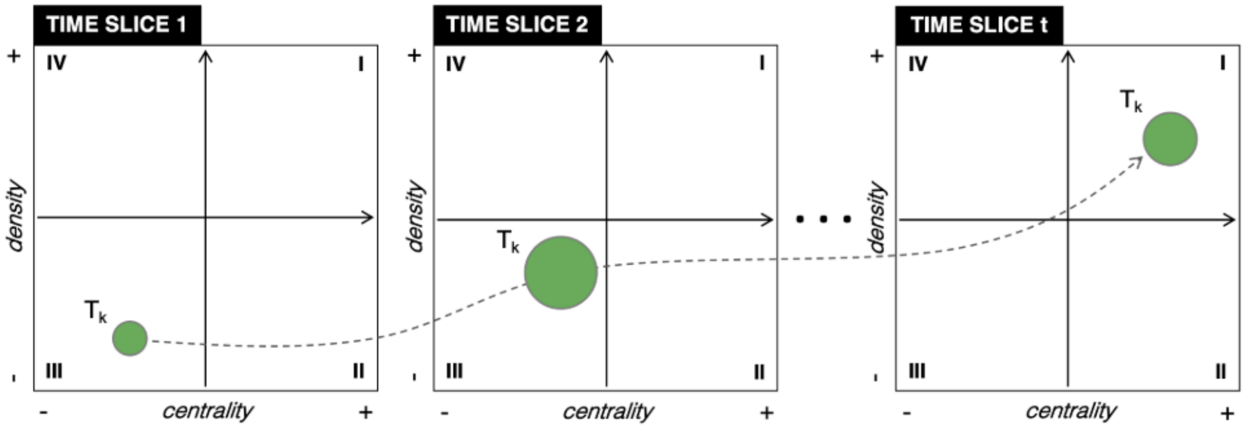
$$c_t = 10 \times \sum eqv_{i_t h_{t'}} \qquad\qquad d_t = 100 \times \sum \frac{eqv_{i_t j_t}}{k_t}$$

with terms i_t and $h_{t'}$ belonging to different topics, terms i_t and j_t belonging to the same topic, k_t total number of terms of a topic. Callon centrality can be read as the importance of the topic in the whole collection, while Callon density can be read as a measure of the topic's development. By dividing the time interval into time slices, it is possible to study the topics' trajectory along time, as visualized in Figure 2, as well as highlight the tendencies of some topics to merge, or of a topic to split into several (Belfiore et al., 2022). As a result, we have obtained three thematic maps: 2002–2012, 2013–2018, 2019-2022. Four quadrants in each map, according to (Cahlik, 2000) represent such typologies:

- Motor themes (upper right quadrant) that are highly relevant and very well developed.

• Basic themes (lower right quadrant) that are highly relevant but not well developed, meaning that they are important for a domain but concern general topics transversal to the different research areas of the field
• Emerging or declining themes (lower left quadrant) that are low relevant and low developed, marginal.
• Niche themes (upper left quadrant) that are low relevant but very well developed. Even though well developed, they are of limited importance to the field.

Figure 2. Topical evolution across different sub-period time slices



Source: Aria et.al. (2022)

Systematic literature review

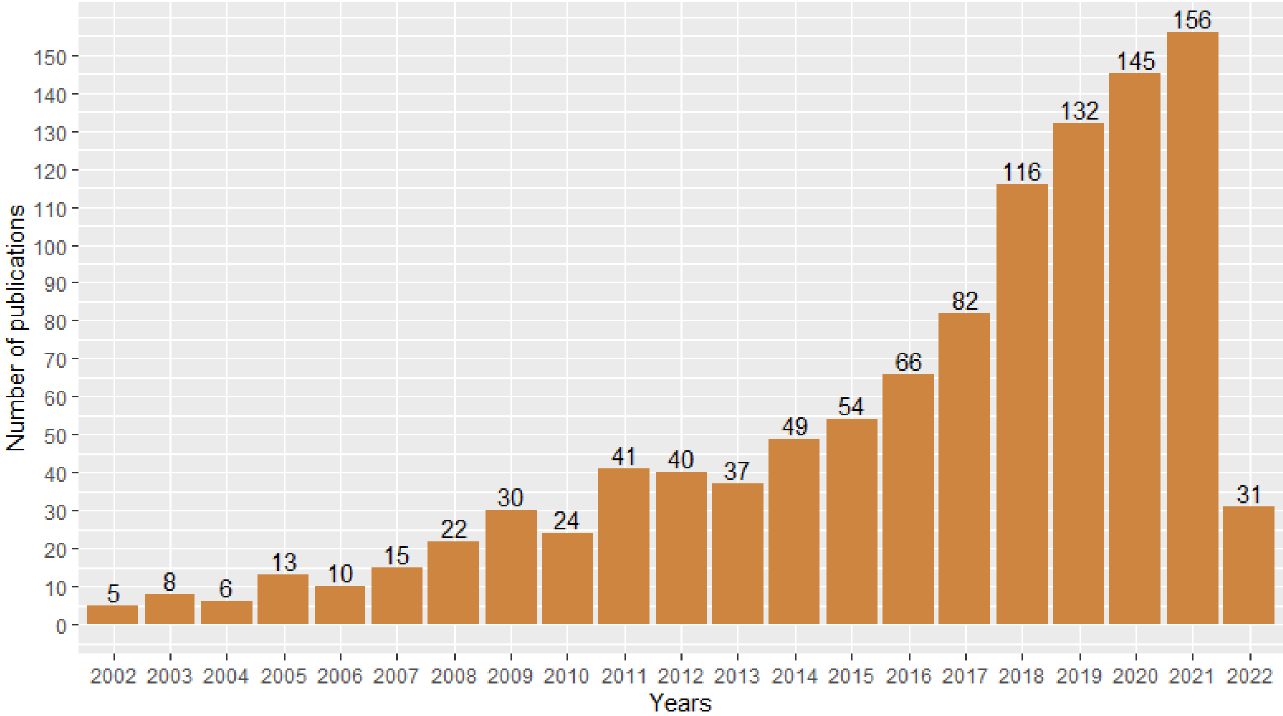
After clusters of authors had been produced by the bibliographic coupling, documents were extracted to the Excel Spreadsheets cluster-wise. In total, 209 documents authored by 118 authors. For each of 8 identified clusters we calculated the ‘Cluster research specialization in ECs’ parameter. We measure it as a ratio between cluster’s number of documents and its number of authors. The parameter was designed by us to obtain a basic intuition behind the concentration of different research groups on the field of energy communities. Coding procedure was performed in four stages. In the first stage, we created wordclouds from the titles cluster-wise, using packages ‘tm’ and ‘wordcloud2’ for the R software. Frequency of the terms’ appearance was labelled by the different color and the font type in a final visualization. It enabled to simplify the coding according to the level of terms’ conceptual importance. Terms explaining similar concepts revealed the initial insight about topics, schools of thought, direction in research. Second stage was filtering documents’ keywords by frequency. This stage of analysis did not entail any meaningful insights. Identified key terms from both first and second stages were used as codes in the third stage, manual revision of titles. Accordingly, one or several codes were assigned to each title. In the fourth stage, manual revision of abstracts followed, which allowed for the in-depth checking of the previously assigned codes. They were validated, partially validated, or changed when did not correctly explain the topic of a document. Separately, methodology used in each document was discovered and coded. Codes were derived from Fouladvand et.al. (2022): D – desk research, F – field research, C – computer simulation. Based on the results of the four-stage procedure as well as authors’ priorly knowledge in the field, description of clusters was outlined. In addition, we decided to check if certain groups of authors have worked on ECs in different times. For this purpose, we used a year when a document was published. T-test on sample differences was performed.

After co-citation analysis, documents that appeared on the plot were extracted to another Excel Spreadsheet cluster-wise too. Out of 148 plotted references only 135 documents were extracted. Due to the nature of co-citation analysis our database did not contain all papers but only referenced more than 30 times. Four-stage coding procedure, same as for clusters from bibliographic coupling, was applied to the co-citation clusters. Additionally, authors' affiliation was explored in search of a possible scientific insight. T-test on sample differences was performed.

1.3 Results

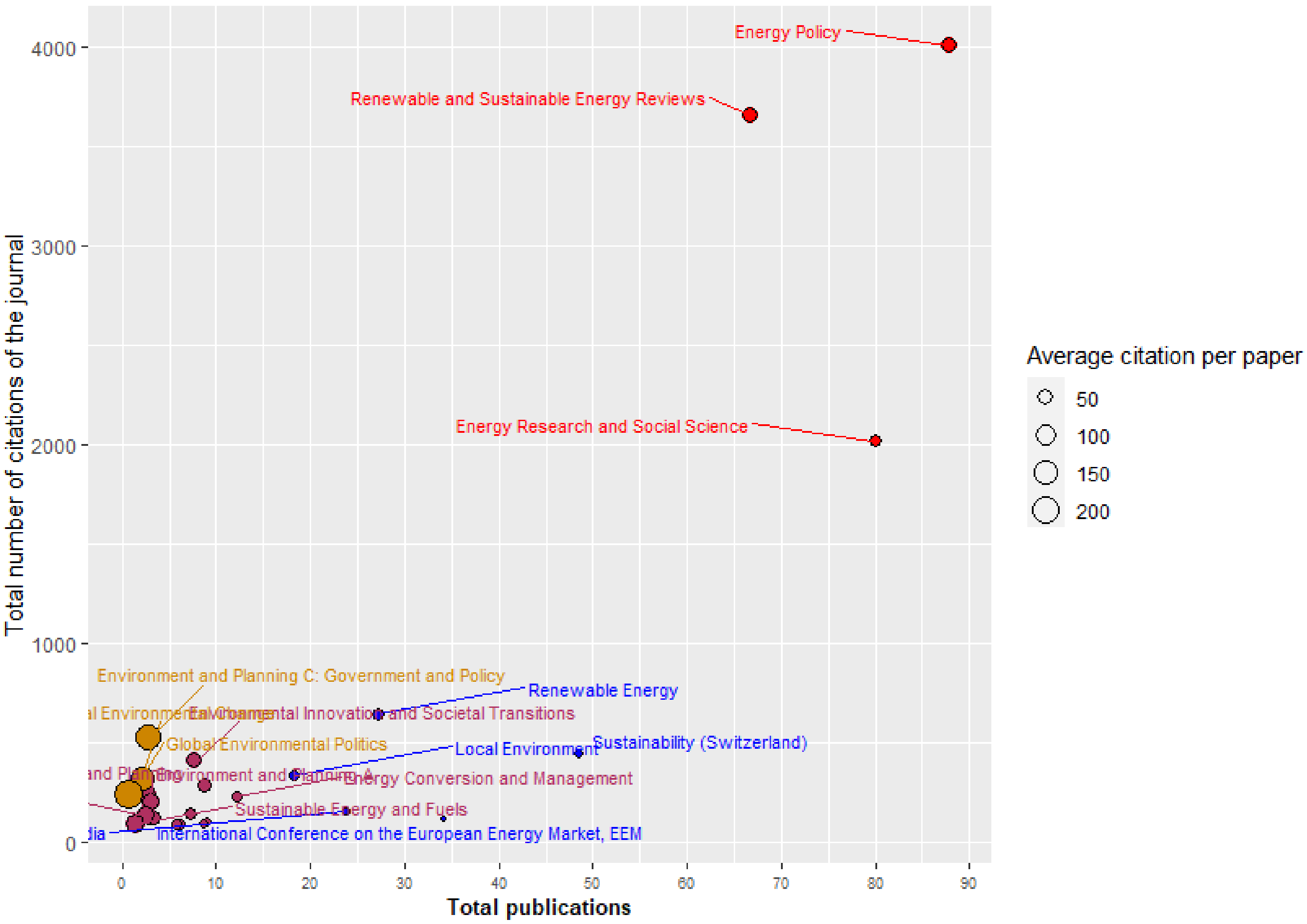
Performance analysis

Figure 3. Annual distribution of the publications in the field of ECs



In Figure 3, we can see that research on ECs in the beginning of the century was a very residual field. Indeed, the seminal article on the topic by Walker & Dewign-Right appeared only in 2008. From 2008 until 2013 the number of publications was stable. Starting from 2014 we observe the gradual growth of the interest to the topic that skyrockets in 2018 achieving almost double increase in 2021 compared to 2017. We relate it to the introduction of the 2nd Renewable Energy Directive in 2018 and Internal Energy Market Directive in 2019, which provided legal definition to ECs and granted them rights and obligations. In the following years, EU Member States have been transposing Directives to national legislation. We assume this factor behind the subsequent growth. In 2022, we observe plumetting because data extraction was up to April of that year.

Figure 4. Journal influence in the field of ECs



In Figure 4, we categorized journals in four groups. Journals that contain the highest number of publications on ECs, which are simultaneously highly cited, belong to the first group, colored in red. The leading journals in the field are “Energy Policy” and “Renewable and Sustainable Energy Reviews”. “Energy Research and Social Science” have a lot of publications although they are two times less cited than publications from other journals of the red group. In addition, average citation per one paper is higher in the leading journals to which size of the circle corresponds. Journals with a medium number of publications on ECs whichh are low cited belong to the second group and colored in blue. Sustainability (MDPI), Renewable Energy, Local Environment, and Proceedings of International Conference on the European Energy Market are included into the blue group. Circles colored in burgundy indicate journals that publish articles on ECs occasionally. Furthermore, articles from burgundy journals are not highly cited or impactful. An interesting group was colored in yellow. These journals cover a broad range of topics related to the environment but do not specialize in strictly energy-related issues. However, a few highly influential articles were published in these journals that explains large size of yellow circles. Such journals as “Global Environmental Politics”, “Global Environmental Change”, “Environment and Planning C” belong to this group. For instance, one of the pivotal works of Walker et.al. (2007) was published in “Global Environmental Politics” while highly recognized work of Seyfang & Haxeltine (2012) was published in “Environment and Planning C”.

Figure 5. Authors with the highest number of citations in the field of ECs

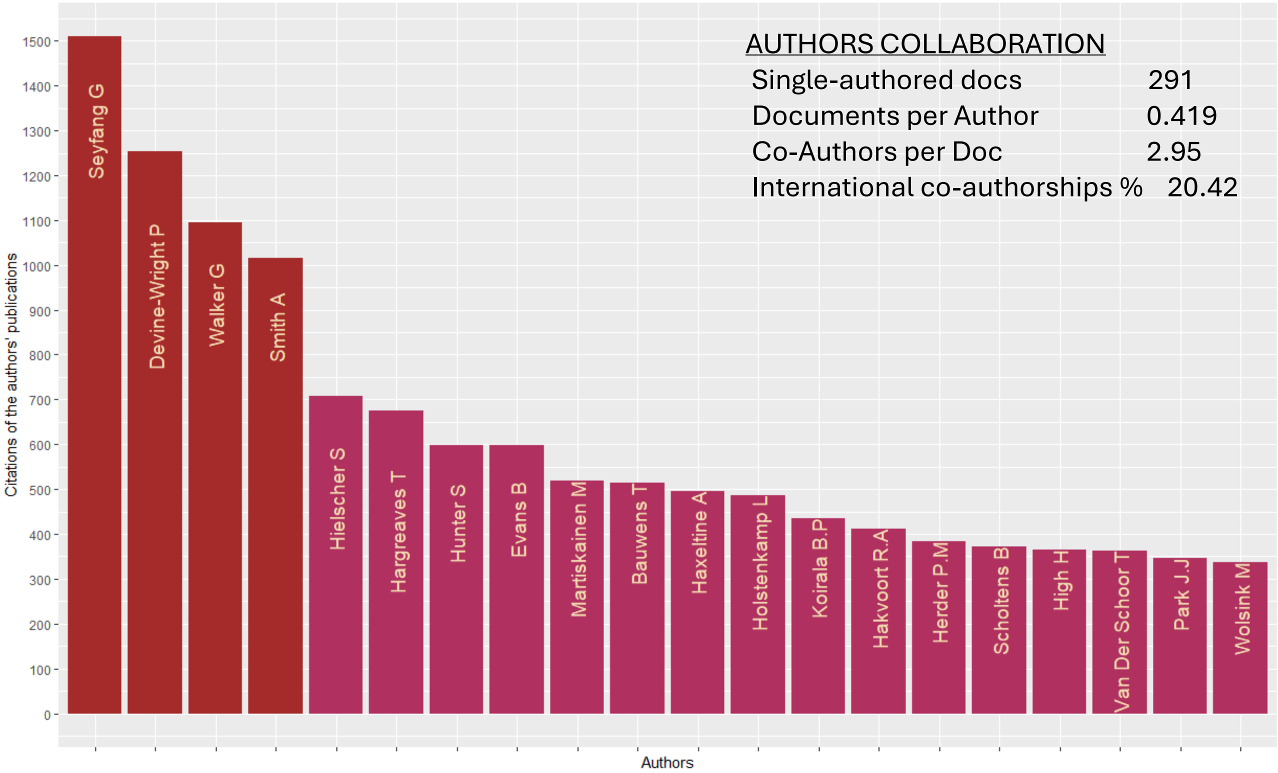
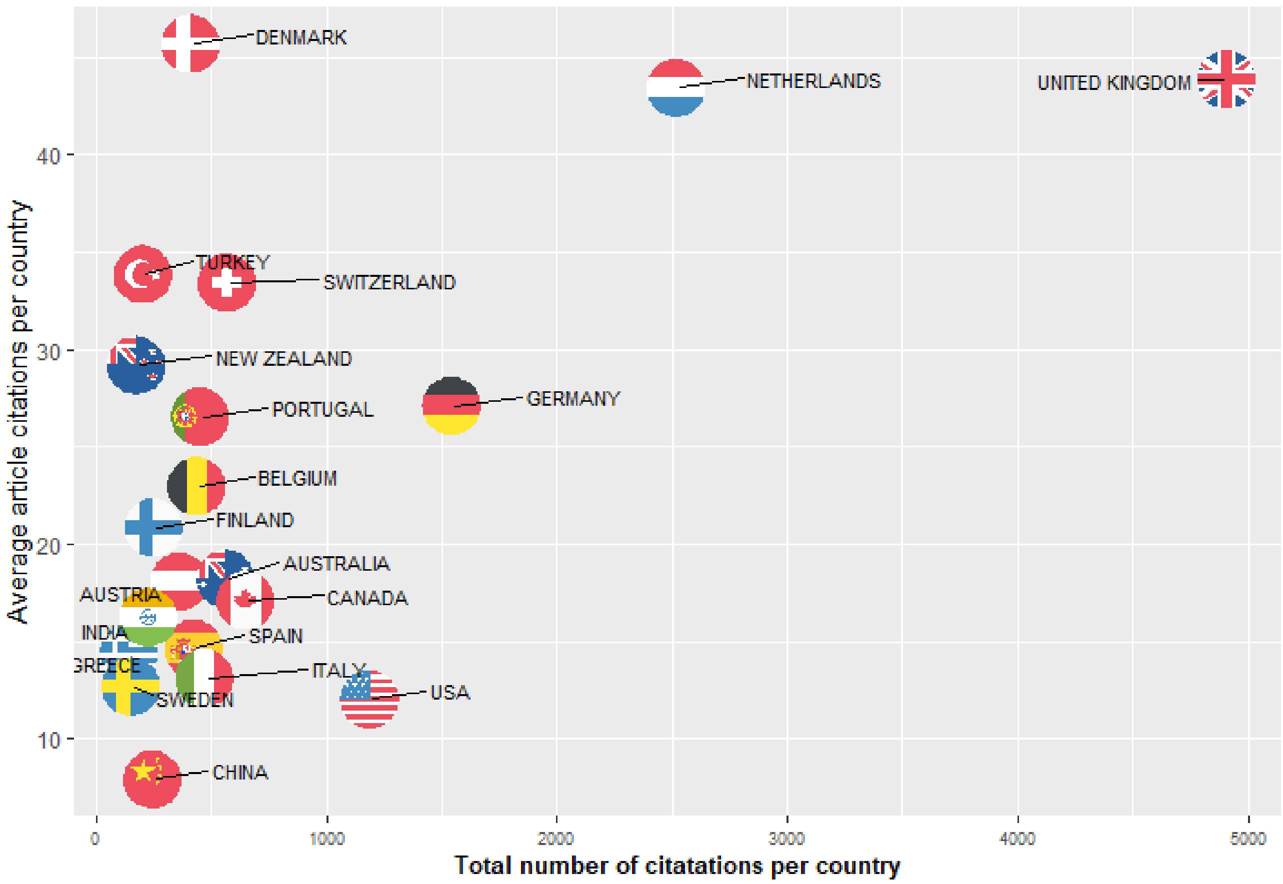


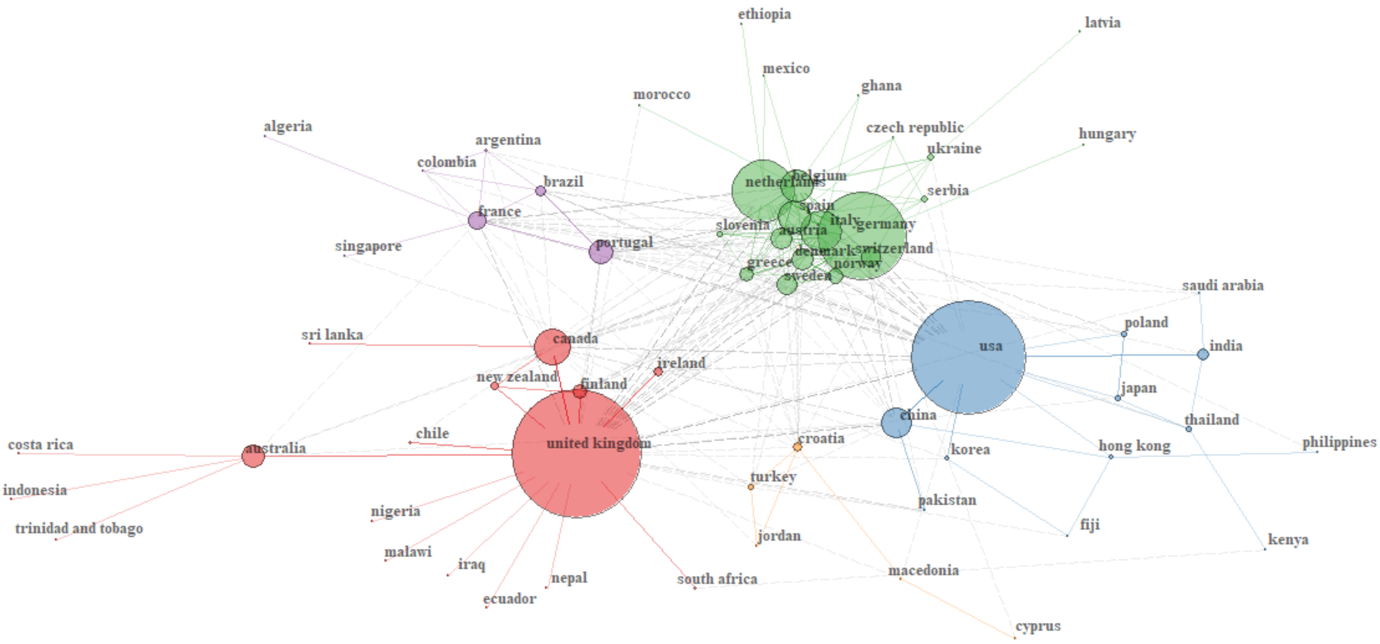
Figure 5 points at most cited authors in the field. Four leading authors in the social science research on ECs are Seyfang G., Devine-Wright P., Walker G., and Smith A. All of them come from the British Isles. Second group of highly cited authors mainly include authors from Netherlands and Germany. In the upper corner we can see descriptive statistics of the authors collaboration. Interestingly, average number of co-authors per article is 3 while many resarchers do not specialize in ECs but occasionally publish. It proves 'Documents per Author' coefficient which is close to 0,5 articles per 1 author. Authors collaborate predominantly with the colleagues from the same country (20.42% of international co-authorship) from which we assume that the cross-country research on energy communities may still be a rare case.

Figure 6. Impact of countries in the research on ECs



In Figure 6, we can see that researchers with affiliation from the UK institutions have the highest total number of citations as well as a highest score for the average citations per one article. Indeed, the ECs research started in the UK. Also, United Kingdon was one of the countries that together with Denmark and Netherlands pioneered first community collective generation projects at the end of 90s and beginning of 2000s. This may explain similarly to the UK high placement of Netherlands and Denmark in Figure 6. Nevertheless, leading research country on ECs stay the UK with the highest total number of citations per country. A main factor behind it is that several most cited papers in the field (Devine-Wright & Wiersma, 2013; Rogers et al., 2008; Seyfang et al., 2013, 2014; Seyfang & Haxeltine, 2012; Walker et al., 2010; Walker & Devine-Wright, 2008) were published by the British researchers. Germany and the USA are the third and fourth countries respectively in terms of impact on the field after the UK and Netherlands. Articles written by German and American researchers have rather high total amount of citations although medium and low average citations per one article respectively. The reason behind the US low average citations per one article hides in the high number of articles published by the American researchers. However, these articles are non-impactful. For example, there are 71 articles with the corresponding author from Germany albeit German articles have been cited 1503 times. In contrast, there are 114 articles with the corresponding author from the US though which were cited only 1192 times. We assume that this pattern exists because American institutional and policy context of the electricity sector is fundamentally distinct from the European. Furthermore, the concept of energy communities in the American context differs from the European context. For example, many articles are written on the US community solar programs which are deliberately promoted by the state regulators and facilitated by utility companies rather than being grassroot initiatives as it had been the case in many European states before the transposition of Directives. A large portion of US articles study historical electricity cooperatives, mostly active in rural, which functionally are the same as utilities, that is retailing energy. Whereas in the EU, most ECs simply operate a collective generation facility without a retail activity. Turkey, Switzerland, New Zealand, Portugal, Belgium and Finland publish not a lot of articles on ECs but a few publications with a high citation score. For example, among 6 total Turkish papers article by Kaygusuz (2011) was cited 186 times.

Figure 7. Research collaboration on ECs by countries of authors' affiliations



In Figure 7, we observe five main clusters of research collaboration by the country of authors' affiliation. The length of the edge/line signals occurrence of collaboration between two countries which are depicted by nods/circles. The shorter is the edge between nodes the higher is the number of publications written together by authors from the joint node countries, and vice versa. While the size of the nod represents occurrence of the country in a research network. The larger is the nod the more institutions from that country are involved into the cross-country ECs' research. The most congested is the green cluster. It shows high level of collaboration among countries. Cluster is composed by mostly mainland European states with Germany and Netherlands being most engaged states. The United Kingdom is the forming center of the red cluster where we see its intense collaboration with many commonwealth countries but also Ireland and Finland, a few developed countries in Latin America, and Iraq. Forming center of the blue cluster is the USA that has strongest collaboration with researchers from the large Asian economies like China, Japan, Korea, India, Thailand. Another small cluster is colored in purple. Here several South American countries are located together with Portugal and France, where the latter working also with Singapore and Algeria. The last small cluster is yellow and formed by a few Mediterranean states: Croatia, Turkey, Jordan, Macedonia, Cyprus. Interestingly, many of the research collaboration networks on ECs simulate the strength of trade and political relations.

Figure 8. Bibliographic Coupling by Authors

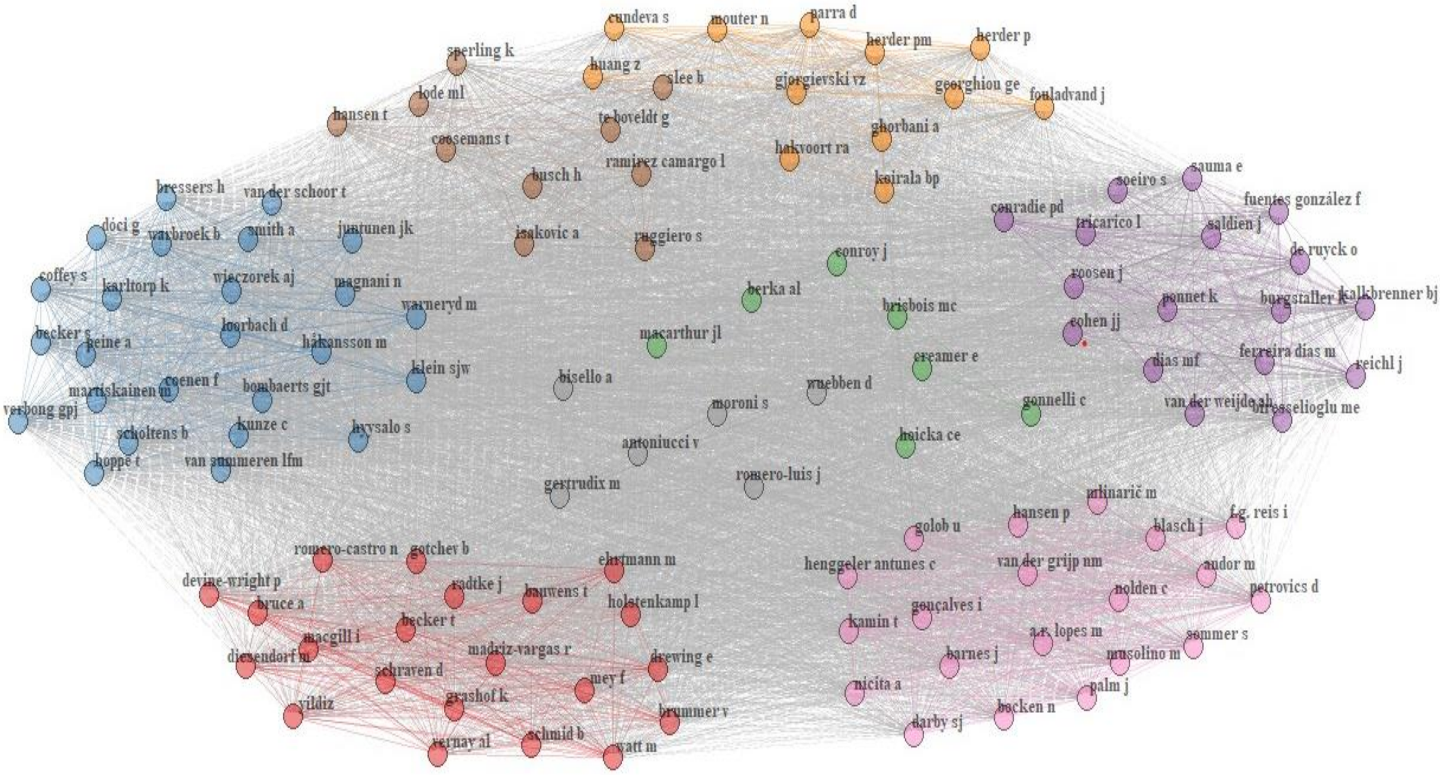


Figure 8 presents the bibliographic coupling net where only first 118 authors plotted for the visualization simplicity. Publications are coupled by similarity of their bibliographies (cited papers) into 8 clusters. We performed manual review of the publications that appeared in the same cluster and found topics studied in each cluster. Topics belong to the management, sociology, and economic geography scientific domain. We extracted main methods used in each cluster, countries where research was conducted and level of concentration of authors on the ECs' research into Table 4. Here is the list of topics for each cluster with description:

- Cluster 1 Red

  Topic: Policy Conditions and Institutional Framework

  This topic deals extensively with how renewable energy policies at the national and local levels support or hinder the development of ECs. It examines regulatory frameworks, subsidies and incentive mechanisms. It also highlights the governance structures that enable or limit the autonomy of community energy projects, including collaborations between municipalities and citizens, and the role of local government in energy decision-making.

- Cluster 2 Blue

  Topic: Trust, Social Acceptance, and Engagement.

  These studies explore factors that drive or hinder the social acceptance of renewable technologies like wind and solar. It includes such factors behind ECs establishment as perceived benefits, risks, and community attitudes toward a RES plant. Trust emerges as a critical factor in whether communities accept renewable energy projects too. The research looks at participatory planning and decision-making, where local citizens have a voice in shaping energy initiatives. These articles focus on psychological and sociocultural motivations behind ECs.

- Cluster 3 Brown

  Topic: Role of Multi-level Governance in ECs deployment.

  This cluster examines how local, regional, and national authorities collaborate to guide the shift to decentralized RES and ECs. Research emphasizes that partnerships between governments, private citizens, and companies facilitate ECs. It also points that coordination between national, regional, and local policies is crucial for the uptake and deployment of ECs.

- Cluster 4 Green

Topic: Energy Cooperatives as Drivers of Social Innovation
These studies examine specifically how energy cooperatives drive social innovation, not just in technology but in governance structures, community empowerment, and new forms of social organization.

- Cluster 5 Orange

Topic: Economic and Social Impact of ECs.
The research shows how ECs can generate significant local economic benefits, such as creating jobs, retaining profits within the community, and reducing energy costs. In addition, a broader economic development, especially in rural or economically disadvantaged regions. Research also addresses social issues such as providing access to clean energy for marginalized groups.

- Cluster 6 Purple

Topic: Policies and Governance behind ECs
The topic examines how policy frameworks can either facilitate or hinder the shift to local energy production. Such policies as FiTs and tax credits are beneficial for local energy generation while bureaucratic hurdles with legal barriers are detrimental to ECs. These studies also explore how local/national/regional organs interact with local actors to enable or restrict ECs.

- Cluster 7 Pink

Topic: ECs as Enablers of Technological Innovation.
This topic highlights the role of cutting-edge technologies (e.g., smart grids, energy storage systems) but also solar, wind, and geothermal generation technologies and their application in ECs. The intersection between a particular technology and its social and economic aspects is a focus here.

- Cluster 8 Grey

Topic: Environmental Impact and Sustainability Goals
These studies assess the environmental benefits and potential risks associated with implementing renewable energy at the community level. Many studies in this cluster are centered on carbon reduction efforts, specifically examining how decentralized, community-driven energy projects contribute to national and international carbon reduction targets. The cluster also investigates how energy communities align with broader sustainability objectives.

Table 2. Methods and Countries Studied

Cluster	ECs Research Concentration (publications/number of authors)	Countries Studied	Methodology
1: Policy Conditions and Institutional Framework	2,3 (48/21)	Germany, UK, Belgium, Denmark, Australia, Netherlands, France, Spain, USA, Italy	survey, semi-structured interview, quantitative (not specified), policy analysis, simulation, statistical analysis, thematic analysis, participant observation
2: Trust, Social Acceptance, and Engagement	2.6 (47/18)	UK, Germany, Netherlands, Italy, Spain, Portugal, Sweden, Canada	semi-structured interview, case study, survey, policy analysis, mixed methods, simulation, content analysis, participant observation
3: Role of Multi-level Governance in ECs deployment.	2 (20/10)	Canada, UK, Netherlands	survey
4: Energy Cooperatives as Drivers of Social Innovation	1.9 (13/7)	Germany, UK, Belgium, Portugal, Spain, Italy	survey, policy analysis, simulation, case study
5: Economic and Social Impact of ECs	2 (24/12)	Netherlands, Canada, Spain, Germany, USA, UK	simulation, semi-structured interview, case study, survey, regression analysis, factor analysis
6: Policies and governance behind ECs	1,3 (22/17)	Denmark, UK, Germany, Spain, Italy, France, Sweden, Australia, Netherlands	semi-structured interview, case study, quantitative (not specified), statistical analysis, thematic analysis
7: ECs as Enablers of Technological Innovation	1 (20/20)	Sweden, UK, Germany, Australia, Netherlands	case study, semi-structured interview, simulation, quantitative (not specified), field trial, descriptive statistics, thematic analysis
8: Environmental Impact and Sustainability Goals	0,6 (8/13)	Netherlands, Ireland, USA, Australia	semi-structured interview, quantitative (not specified), case study, descriptive statistics, thematic analysis

In Table 2, we can see that ECs from the Netherlands have been the most investigated, with only cluster 4 researchers have not written on it. UK and German ECs were researched almost by all groups of authors too, apart from cluster 8 for the UK and cluster 3 and 8 for Germany. Inside the UK, biggest number of articles are devoted to the case of big Scottish ECs that own windmills and hydro power plants. In southern Europe, Italian and Spanish ECs are the most researched. Outside the EU, experiences from the USA, Australia, Canada have been the most investigated. Only ECs from the developed countries have been studied by the groups of researchers in our sample[1]. We can assume that ECs in the developing world remain under-studied since no authors in our sample specialize on them.

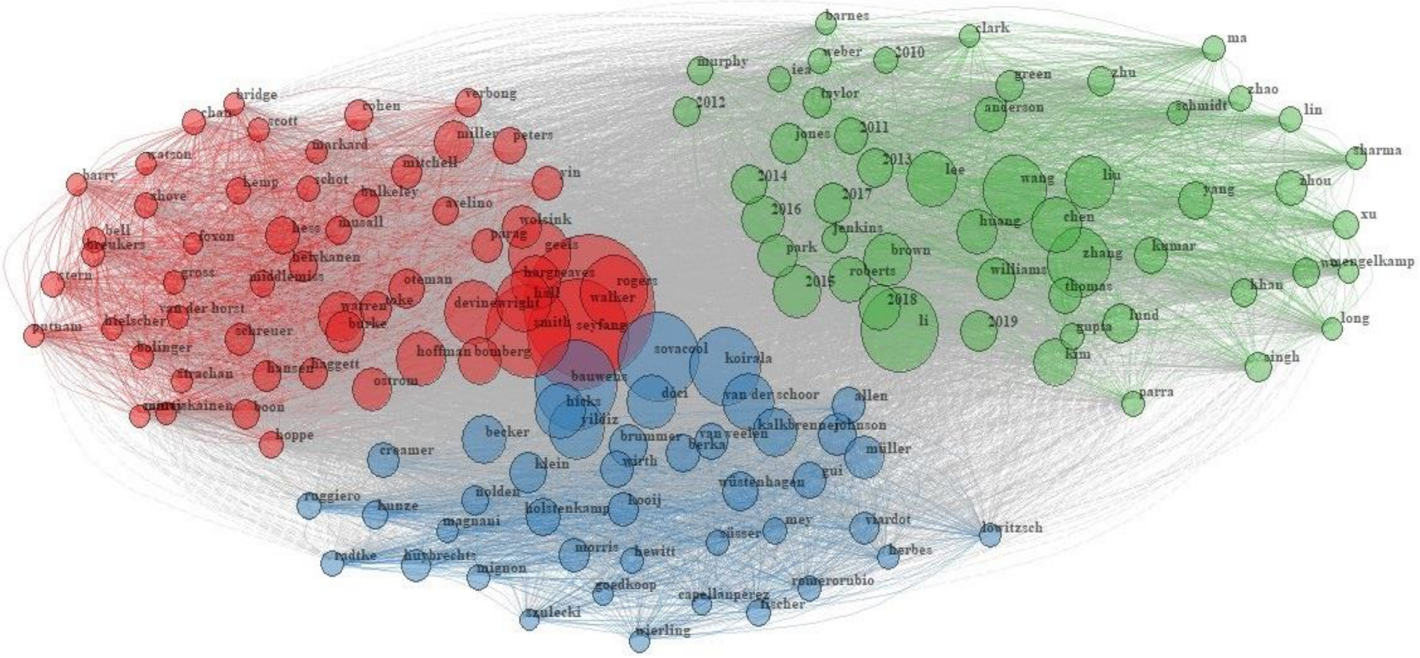
In Table 2, we also observe the prevalence of qualitative methods over the quantitative ones, with semi-structured interview and case study being utilized almost in all clusters[2]. Among quantitative methods, researchers utilized simulation of an engineering nature to study microgrids and wind turbines. Few studies used agent-based modelling. Rigorous quantitative methods based on observational data such as regression and factor analysis were only applied in cluster 5 for the UK and USA. The economic impact of groups of wind turbines owning ECs on the regional economies was quantified see Allan et al., 2011.

[1]Our sample includes only authors that have published 3 or more papers on ECs

[2] Table 4 does not contain all methods from sample articles because methodology was not explicitly specified in all the reviewed abstracts

Entwistle et al., 2014. Kildegaard & Myers-Kuykindall, 2006. Lantz & Tegen, 2009. Okkonen & Lehtonen, 2016. Phimister & Roberts, 2012. Torgerson, 2006. Lantz & Tegen, 2008. Lantz, 2008. DanMar & Associates, 1996. GAO, 2004. We delved deeper into this cluster. The review of all articles can be found in Annex 6.

Figure 9. Co-citation by References



The results of co-citation output are clusters that represent what is called "schools of thought" because depict thematic tracks of already highly cited articles which appeared together in bibliographies. In Figure 9, we see three clusters which compose altogether 148 publications (nods) cited 30 or more times. Only the surname of the first author is visualized. Size of the nod corresponds to the number of citations that a particular publication has while the edges direct to all articles that were citing this publication. Distances between nods correspond to number of times publications appear in the reference list together. After conducting review of the three clusters, we derived 'schools of thought'. The sequence of their emergence we tested with the T-test.

- Cluster 1 Green
  School of thought "Grassroots innovations"
  School emphasizes local ownership, community empowerment, and decentralized energy systems as essential elements of energy transitions. It focuses on social capital, local governance, and community participation. It examines existing ECs mainly in the UK.
  Sequence: 1st that appear in literature.
- Cluster 2 Blue
  School of thought 1: Institutional Dynamics
  School focuses on how institutions and policy frameworks can enable the adoption and scaling of RE technologies through social acceptance and well-designed business models. It emphasizes the importance of overcoming barriers to ECs deployment. Articles are mainly based on German experiences. Many articles compare German ECs with other EU countries experiences.
  Sequence: 3d that appear in literature.
- Cluster 3 Red
  School of thought: Sociological theories
  School sees ECs as niche projects which are the testing grounds for innovative technologies and governance models that can later scale to broader systems. It focuses on multi-level governance, energy democracy, and the role of social movements in challenging existing energy regimes.
  Sequence: 2nd that appear in literature.

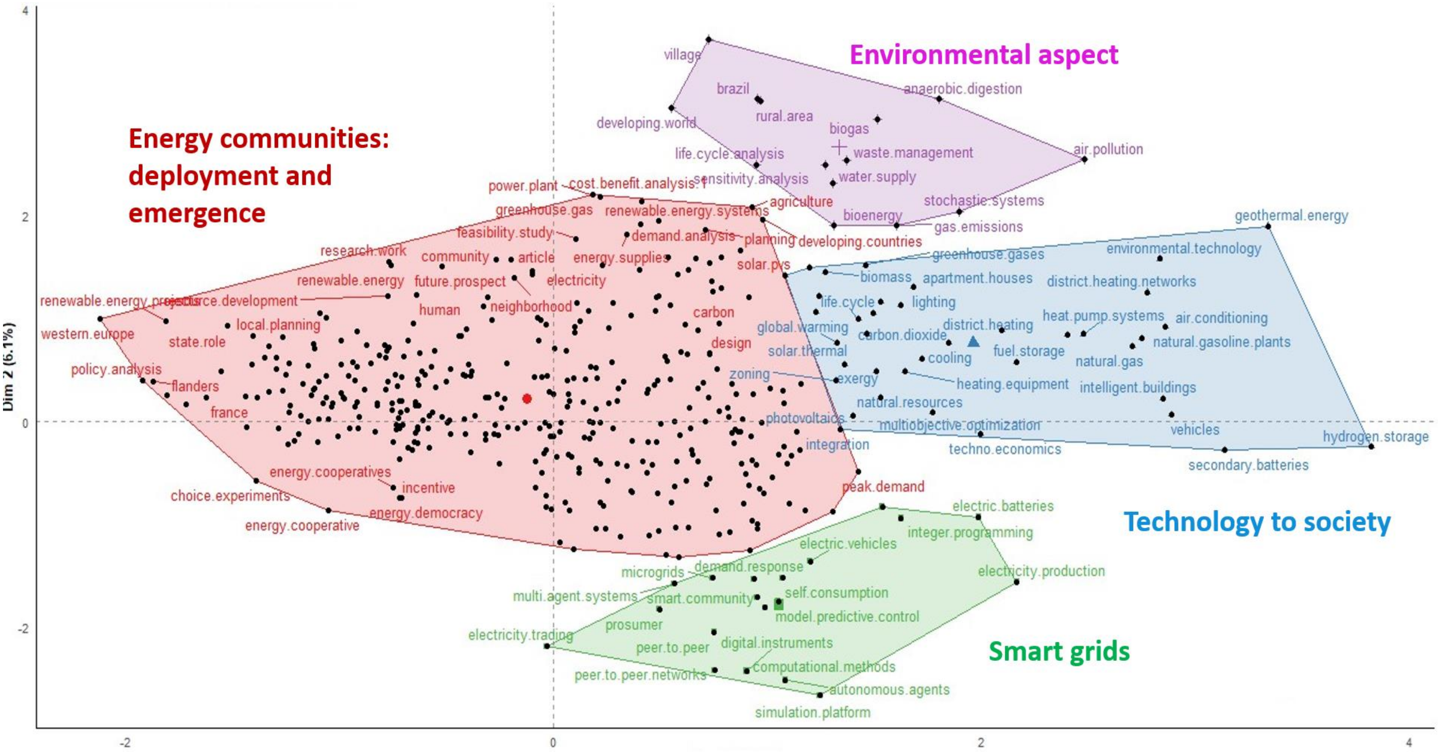
School of thought "Grassroots innovations" appeared first and was descriptive. It explored initiatives that have already been developed mostly in the UK. The emphasis of this school was on how ECs provide social impact to its members and how they emerge from within the society. In addition, challenges that ECs face and how did successful projects overcome it. They investigate deployment strategies that composed by bottom-up tools like social capital and trust, actors and intermediaries, which are necessary to replicate successful initiatives. School of thought that appeared right after attempted to understand the new phenomenon with the theoretical lenses and help of niche theory, energy justice, collective action, energy democracy, and multi-level governance theories. It highlighted the importance of small-scale, experimental projects in driving sustainable energy transition. One of recurring focus is that successful energy transition requires policy alignment across different governance levels with ECs being the bottom level of the multi-level governance. Lastly, German experiences with energy cooperatives and energy communities took attention of the research community. Raise of environmental sentiments, a special Feed-in-Tariff for energy cooperatives, and lowered price for PV at the beginning of 2010s helped German ECs to dramatically deploy (Koltunov, 2019). Researchers from "Institutional Dynamics" school are mostly from Germany and Netherlands and saw ECs as the assistants in the integration of different RES technologies into the specific local institutional and policy contexts. Barriers to RES adoption and solutions at the local level are studied by many authors. Public policies by government and social engagement offered by ECs have been claimed as a key solution to the main goal, successful energy transition. In contrast, "Grassroots innovations" school sees ECs as an independent bottom-up social innovation rather than a tool which simply assist efficient proliferation of RES. A recurring theme of the "Institutional Dynamics" school is a description of business models that allow for financial viability of ECs. Studies from this cluster have been often co-cited together with studies that describe ECs of the other Member States. Usually, they compare institutions and policies to discover the best combination. In Table 3, we summarize main distinctive features of each school of thought. Column sequence indicates time of emergence of each school.

Table 3. Distinctive Features of Schools of Thought

Feature	School "Grassroots Innovations"	School "Sociological Theories"	School "Institutional Dynamics"
Primary Focus	Community-led, local ownership	Niche innovations driving systemic change	Institutional and policy support for tech-society integration
Governance	Local governance with strong community participation	Multi-level governance and policy alignment needed for scaling	Institutional frameworks and multi-level governance
Energy Justice	Strong focus on social justice	Focus on energy democracy, advocating for citizen control	Ensuring public participation and social acceptance
Innovation Approach	Grassroots innovations as local solutions	Niche projects as protected spaces for testing new solutions	Tech-society integration within institutional frameworks
Barriers and Challenges	Focus on local governance challenges and trust-building	Scaling niche innovations while maintaining energy justice	Institutional barriers and policy misalignment
Business Models	Emphasis on community-owned models and local financing	Business models aimed at scaling local niche innovations	Focus on economic feasibility and innovative financing
Scaling and Replication	Moderate focus on scaling ECs	Scaling niche innovations to the mainstream energy regime	Significant focus on scaling ECs through institutional support

MCA algorithm in Figure 10 revealed 4 clusters according to keywords. After manual revision we concluded that the biggest red cluster concerns general topics of ECs emergence and deployment. It associates with topics from the bibliographic coupling: “Policy Conditions and Governance Structures”, “Trust, Social Acceptance, and Engagement”, “Role of Multi-level Governance in ECs deployment”, “Energy Cooperatives as Drivers of Social Innovation” “Economic and Social Impact of ECs”. Keywords that belong to this cluster: policy analysis, energy cooperatives, incentive, energy democracy, neighborhood, cost benefit analysis, energy supply, power plant, choice experiment, etc. MCA revealed us also 3 niche clusters. Blue cluster displays technical aspects of ECs, mostly related to heating & cooling and storage integration into ECs: fuel storage, solar thermal, hydrogen storage, heating equipment, biomass, photovoltaics, vehicles, district heating network, heat pumps. Green cluster which we named “Smart Grids” contain keywords on digitalization of electricity systems: microgrids, electricity trading, peer to peer, digital instruments, demand response, computational methods, simulation platform, smart community, etc. Blue and green clusters correspond to the topic “ECs as Enablers of Technological Innovation”. Keywords in smallest violet cluster belong to articles that discuss environmental aspects of ECs: waste management, biogas, life cycle analysis, air pollution, water supply, anaerobic digestion, etc. Several keywords suggest that ECs environmental aspect is studied primarily in developing states: developing world, developing countries, agriculture, rural area, Brazil. This cluster may correspond to “Environmental Impact and Sustainability” topic.

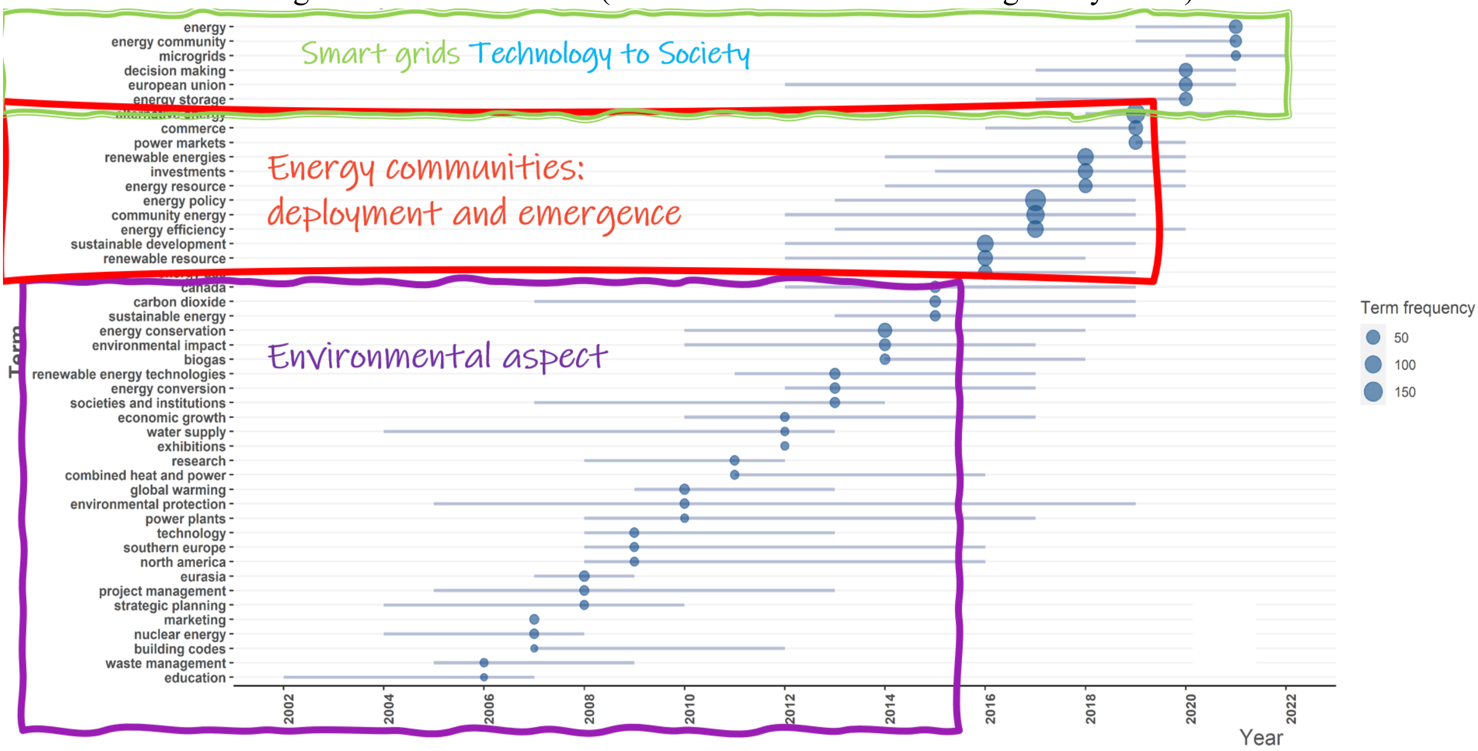
Figure 10. Conceptual Structure Map by Keywords



In Figure 11, we see the duration and frequency of keywords. Duration is displayed by the length of the blue line and frequency by the size of the nod. Trend themes analysis allows us to further argue on the evolution of the field. We found that the keywords associated with the technologies and environmental aspects of ECs emerge first in academic literature. Energy communities were not seen as a separate research domain but as a part of the broader discussion on inclusion of RES into society and environmental discussion. For example, environmental protection keyword began to be used since 2005, carbon dioxide since 2007, strategic planning since 2004, waste management since 2005, water supply since 2004, environmental impact since 2010. However, many of themes lost the attention of the research community after 2015 which we could assume looking at the location of the nods by horizontal axes. Therefore, period of 2002-2015 we associate with topic “Environmental aspect”. Starting from 2012 and even more after 2015, we observe the rise of keywords which specifically point at the EC organizational model: community energy and energy policy. These keywords reach a peak in 2018, year when RED II Directive was published. That is why, 2012-2019 period we relate to “Deployment and Emergence” topic. In 2020-

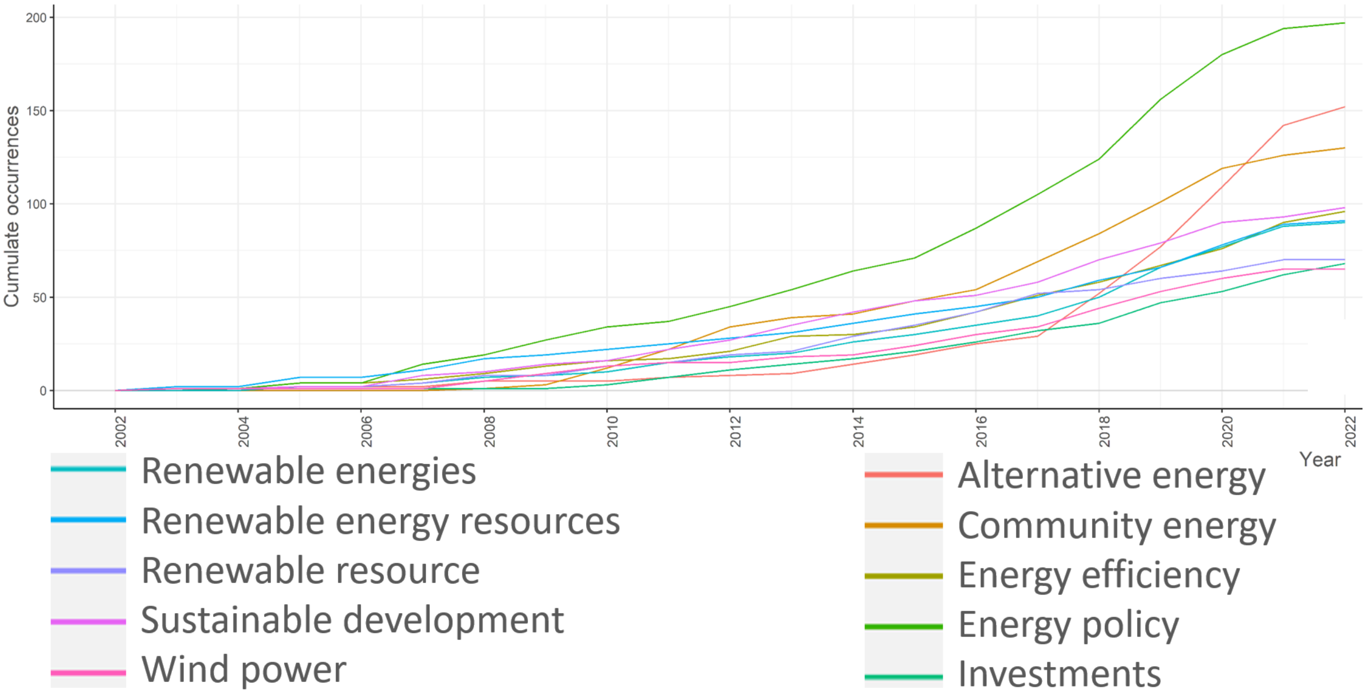
2022 period, keywords such as microgrids and energy storage suggest that "Technology to Society" and "Smart Grids" begin to prevail as a research agenda.

Figure 11. Trend Themes (Evolution of the field according to keywords)



In Figure 12, we see that "energy policy" was always the key interest of the researchers although after adoption of EU Directives its occurrence decreased. Whereas keyword "community energy" start dominating the literature only after 2008 what we associate with the seminal article of Walker & Devine-Wright (2008). Notably, one of the trendy keywords before 2011 was "wind power", it moved to the least used keyword in 2022.

Figure 12. Keyword growth



From Annex 1 "Topical evolution according to titles of the articles" we observe that in the period 2002-2012 motor themes are based on the UK experiences while basic themes relate to energy communities and energy efficiency. Topics related to environmental aspects, such as nuclear energy and greenhouse gases, start to decline. In 2013-2018, new declining topics emerge such as technical aspects of wind energy. This fact is also supported by the previous keywords analysis. Whereas motor theme in 2013-2018 period is energy policy. Basic themes: shared solar, community renewables, collective ownership, energy democracy, business model. In 2019-2022, new declining theme becomes district heating. Motor themes are solar power, energy autonomy, electric trading, peer-to-peer. Energy communities and energy sharing still belong to basic themes. New themes that locate on the border between motor and basic quadrants: electric vehicles, distributed energy.

1.4 Conclusions

In 20 years, we observed the evolution of research on energy communities from being a super niche sociologic topic to one of the hottest fields on intersection among energy, innovation, and society. The term was coined by the UK circles of economic geographers. There, on the British Isles, first collective power plants appeared too. It has been seen as a grassroots social phenomenon. Consequently, it was recognized to be a niche innovation that whether scales up could have a potential to disrupt the existing system. Formal institutions such as enabling policies but mainly informal institutions such as trust and aspiration to the collective ownership were seen as crucial sociocultural factors behind the success of new sociotechnical phenomenon. Since then, UK leads research on the ECs. Slightly later, experiences with first wind and district heating cooperatives in Netherlands, Denmark, and Northern Germany took attention of researchers there. Generous Feed-in-Tariff stimulated growth of distributed photovoltaics in Germany since 2010s. Citizens installed PV in many cases jointly and formed energy cooperatives following the Wilchelm Raiffeisen heritage. Experience with German cooperative movement in 2013-2018 spurred research on ECs adding much policy flavor to it. Subsidies and state incentives were argued as crucial factors behind the emergence and deployment of energy communities while the incentive suspension has been seen as a life threat. It contrasted with the UK-led 'grassroots' school which mostly regarded ECs as an autonomous phenomenon that can emerge without a strong top-down influence. To be fair, UK school of thought also considered subsidies to be important for a long-live of collective initiatives and for their scaling up, but not as a crucial factor behind their emergence. Instead, local financing such as equity crowdfunding was widely discussed by them. Innovation in business modelling that would allow ECs to be economically sustainable with a minimum state support became a hot topic at the end of 2010s mainly within 'institutions' school when many member states suspended net-metering and feed-in-tariffs. Governance and management aspects were widely discussed by all schools and groups of researchers. Due to the distinct organizational form of each energy community, scholars were searching for the tastiest recipe to maximize social, environmental, and economic benefits for local communities.

Field has been studied in social science domain mostly using qualitative methods because of its novelty and absence of the structured databases. This issue we address in Section 1.2 of the thesis and continue in Section 3.3 for Italy. Few studies used econometric approach and slightly more used modelling techniques. Comparison of policies and institutions behind ECs dominated agenda before the transposition of EU Directives. Energy Policy journal became number one target of the social science researchers on ECs. The turning point was 2018-2019 EU Directives[3]. Policies in EU member states were set, and "technology-to-society" and "smart grid" discussions became central. From then, connection of social aspects with technological advancements such as peer-to-peer trading, demand-response, vehicles-to-grid took the major interest.

Work on ECs in USA, Australia, and Canada remains a niche sector. Firstly, ECs are studied having in mind a cooperative electricity utility. Secondly, ECs often considered as a sales offer or new scheme which traditional utilities introduce here or there. In these countries, discussion on ECs belong to a broader domain of decentralized renewable energy. The absence of similar regulation to what exists in the EU makes research agenda for them unclear. In contrast, we expect much more research in the EU on a comparative policy since each Member State transposed Directives in its own unique way. However, we expect largest stream continue to be on the intersection between innovative technologies and its integration into communities.

ECs in the developing countries remain an understudied topic. The most covered country is Brazil where many rural energy cooperatives exist. Several articles are published on African and Indian experiences, mostly considering closed microgrids in areas without pre-existing electricity access. Many Chinese researchers publish highly technical articles that simulate yet non-existent settings whilst rarely investigating their social or economic aspects.

In the European context, legal aspects of ECs remain understudied. How formal relations/contracts inside ECs (among prosumers, consumers, producers, prosumagers) and outside ECs (with local authorities, utilities, aggregators, DSOs, regulators, etc.) should function. We project that this topic gets a huge attention soon with a proliferation of a term "energy commons" among legal scientists. Term suggests that the energy in future may more and more be governed as a common resource: lake, pasture, meadow, forest. Moreover, with the deployment of zero cost RES the new issue elevates of how to share it efficiently while avoiding "tragedy of commons". Since energy communities became a recognized legal concept and slowly but steadily deploy, industry requires answers from academia.

Previously, economic impact of ECs was studied with a limited scope. For example, few studies exist on impact on members or on the regional economies. Latter was assessed for the cases when wind and hydro cooperatives purchase expensive equipment. Impact of the ECs on the other market participants and how ECs could modify the future of electricity market is an under investigated topic too. The reason for that is the prevailed earlier broad definition of the term 'energy community'. Creamer et.al. (2019) even argued that "what community means should remain open". It was needed to allow for the policy experimentation. Therefore, phenomenon was hard "to catch". But without a solid definition how could we quantify or

[3] Remarkably, REScoop.eu, Belgium-based association of the European energy cooperatives was the key lobbyist behind it.

monetize any economic impact? Nevertheless, in 2024 policy on ECs becomes clearer. It opens a perspective direction that we address in Chapter III.

Chapter II. Energy Communities in the EU before transposition of RED II and IEM Directives

2.1 Introduction

Within the energy transition, an innovative aspect of energy communities is the promotion of a new actor on the stage of the energy transition, i.e., the prosumer (Van Sark et al., 2020). Theoretically, every net meter connected to the grid, whether from an industry, a household, or a large building can play the role of a prosumer, by consuming or producing (renewable) energy during the day. However, key figures expected to enter this show are the household or the single citizen. By doing so, citizens may actively participate in the energy system and foster new networks of local relations by sharing their surplus energy. Through ECs, consumers will also find it easier to invest in renewable energy, and then consume, store, or sell the energy that they produce, and even, in the near future, provide flexible services (Fournely et al., 2022). Several studies have already shown that, through these investments, households can save on electricity bills by installing photovoltaic (PV) systems, recovering the full cost of their investment in a short period, and the focus is shifting even more to innovative business models and enabling sharing technologies (Köppl et al., 2022). Energy communities already employ sustainable business models and must play an important role in the just transition. In most cases, returns from ECs remain in the locality, making them a unique opportunity for enhancing community welfare[4]. A French study conducted by Énergie Partagée (2019) showed that for every EUR invested in an EC project, EUR 2.57 in value returns to the territory in 20 years. In addition to local economic benefits, community ownership and decision making in ECs significantly enhance local democracy and the acceptance of new green technologies. Moreover, profits from energy savings in buildings can be redirected to additional actions such as shared e-mobility schemes. Community members are more likely than local/regional/national authorities to support such a local circuit of investment–improvement–investment because it may go against the traditional energy producers' lobby, to which authorities may be susceptible. Additionally, social aspects, such as having higher citizen support for projects promoted by community members themselves rather than by external institutions, mobilize citizen endeavours and local finance for the energy transition (Koltunov & Bisello, 2021).

ECs make it easier for citizens, together with other actors, to team up and jointly invest in energy assets. This helps to contribute to a more decarbonized and flexible energy system since the communities can act as a single entity and access all suitable energy markets on a level playing field with other market actors. More specifically, ECs increase public acceptance of renewable energy projects and facilitate the mobilization of private capital investment in the clean energy transition. At the same time, they have the potential to provide direct benefits to consumers by advancing energy efficiency, encouraging energy savings, and, thus, supporting lower energy bills (European Commission, 2020). Behaviorally informed citizen engagement strategies in ECs can help mobilize citizens to change their energy consumption habits by leveraging individual and social motivations to act pro-environmentally. ECs could, in this way, also tackle structural and behavioral drivers of energy poverty, supporting a just energy transition, including supporting the reduction of greenhouse gas emissions (W. Schram et al., 2019; W. L. Schram et al., 2020). ECs also support lowered energy bills by generating energy and defining energy tariffs for their customers (European Commission & Energy, 2019). They could also incentivize consumers into adjusting their energy demands through demand-side management efforts, which can drastically improve the flexibility of the system. ECs could utilize storage technologies and demand–response strategies to enable both intraday and seasonal flexibility. At the intraday level, demand–response efforts can shift the energy load, for example, from peak load times to off-peak times (Van Sark et al., 2020). This can result in avoided

[4] In the Section 2.2, we investigate in a more detail community welfare enhancing potential of ECs

investments in additional power plants and reduce the overall stress on the power grid (and, as a result, avoid maintenance costs due to stressed grid infrastructure). In addition, demand–response can optimize local resources by matching local distributed generation to local consumption. For example, by matching energy demand with variable renewable energy supply, demand–response strategies can increase the supply of energy from renewable energy assets and further decarbonize the grid.

The objectives of this chapter is to provide a thorough understanding of (i) what are ECs, (ii) their location in the EU and in the UK, (iii) prospects of their deployment, (iv) policy and institutional frameworks which enable their emergence, (v) impact which ECs could bring for their members and local communities[5]. These objectives are attained through two separate studies which share a common feature of investigating ECs according to the broad criteria prescribed by the EU Directives (IEM, 2019a; RED-II, 2018).

- The primary purpose should be the provision of environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits.
- The EC must be organized as a legal entity with an open, voluntary, and participatory basis.
- The EC is controlled by its members, who can be individuals, local authorities, non-profit organizations, or small to medium-sized enterprises.

The transposition of EU Directives into MS legislations resulted in often very distinctive definitions of ECs. REScoop.eu transposition tracker (2022) provides details on what an energy community means in each MS. For instance, Italian EC members should be connected to the same high/medium voltage substation and ECs cannot conduct commercial energy activities, such as those energy cooperatives traditionally conduct. With this limitation, energy cooperatives which operate as retailers for its members, are not considered ECs in Italy. Moreover, consumers can keep their default retailer and involvement in an EC does not induce the retailer's change.

Another situation is observed in Germany, where a minimum threshold is established of 50 natural persons to constitute an EC. Their dwellings must be registered in a postcode that is wholly or partly within a radius of 50 km of the planned installation. Distinct to Italy, where the proximity criterion is electrotechnical (connection to the substation), here criterion is geographical, based on a postcode. Additionally, German ECs can merge with each other and create special purpose vehicles for individual projects, which has not envisioned for Italian ECs. Yet, the main difference is that energy cooperatives in Germany existent prior to EU Directives transposition can be considered ECs while in Italy they cannot. Like Germany, in Denmark legal persons that perform commercial energy activities can be a member of ECs but are forbidden from exercising decisive influence in the EC governance. In France, the minimum threshold to constitute an EC is at least 20 natural persons. In addition, France designed proximity criterion based on geographical principle, residence or location in the department or a bordering department where the project is being implemented. In France, participation in ECs is limited to SMEs that do not have participation in energy communities as a main commercial activity while, in contrast to Italy, they could conduct energy retail as their main commercial activity.

Due to the very distinctive definitions of ECs, EU-wide or cross-country comparative analysis could have substantial obstacles if applying separate MS criteria. Notably, all Italian initiatives which existent before 2021 cannot be considered as ECs while German and Danish initiates can. Such discrepancies complicate a comparison. With the aim to holistically investigate the entire movement we included in Chapter II two research endeavors which applied broad criteria set by the Directives[6]. The very distinct choices of EC

[5] Impact on the electricity market in general and on non-member consumers is discussed in Chapter III Section 2.2.

[6] In turn, Chapter III uses a narrower criteria for defining ECs and concentrates on Italy, although Section 3.2 contains theoretical study generally applicable.

definitions in MSs could have significantly complicated or even make impossible our cross-country comparative analysis.

Section 2.2 presents study of mapping and classification of ECs in the EU plus the UK. The Introduction highlights the objective behind the study and its importance. In the Data Collection subsection, the I outline the methods and data sources used in this research. In Results and Discussion subsection, the I present and analyze the existent classifications of the sector: the typologies, ideal types, taxonomies. Section follows by mapping state of development of the sector up to 2023, in terms of the cross-country distribution of ECs, membership base, main associations for supporting the sector, and energy produced by ECs where data are available. Finally, I discuss the factors behind the diversity of EC movement and the prospects in terms of policy and market dynamics. The Conclusion summarizes the results and outlines a prospective research agenda.

Section 2.3 investigates the welfare enhancing capacity of ECs in France and Italy and is organized as follows. In the Introduction, the motivation for the comparative investigation of the institutional and policy frameworks is explained as well as the rationale behind choosing Italy and France. Section 2.3.2 presents Italian and French policies that stimulated the emergence and growth of ECs as well as respective formal institutions (organizations) that enabled the movements. Section 2.3.3 initially provides argumentation behind the choice of three case studies and then describes the benefits that they bring to the respective communities. Section 2.3.4 discusses the main findings, followed by the Section's conclusions on the difference between French and Italian movements and its welfare-enhancing potential.

2.2 Mapping and classifications of energy communities in the EU

2.2.1 Introduction

There is no consensus in the academic literature and public discourse on the precise definition of ECs despite more than a decade of research on them that started with the seminal paper of Walker and Devine-Wright (2008). Therefore, our motivation is to provide an analysis based on collected data on the number and location of ECs in the EU, the main characteristics such as membership structure, energy technology utilized, and supportive ecosystem, and the main business models. Such an analysis would contribute to the clarity about the sector's current situation, thus highlighting its ongoing and future contribution to the energy transition. Our attempt to map and analyse movements in different countries aims to emphasize the importance of comparative analysis. While ECs have already also existed for a long time in several member states (MSs) in the form of historical cooperatives—e.g., Belgium, Denmark, Germany, Italy (especially in South Tyrol), the Netherlands, Spain (e.g., the historical cooperatives in the community of Valencia), Sweden, etc.—they are a novelty in others. With the Clean Energy Package (CEP) and related directives, the EU has, for the first time, introduced the concept of ECs in European legislation, notably Citizen energy communities (CECs) and renewable energy communities (RECs). In fact, the final CEP contains two definitions of energy community: the citizen energy community (CEC), which is contained in the Electricity Directive (IEM, 2019a), and the renewable energy community (REC), which is contained in the Renewable Energy Directive (RED-II, 2018). They are similar but not completely equal. RECs can generally be seen as a subset of CECs. The defining difference concerns the fact that RECs are rooted in local communities, whereas this geographical scope does not exist for CECs. The Renewable Energy Directive (RED-II, 2018) helps with the administrative procedures and the Electricity Directive (IEM, 2019a) improves the market conditions.

ECs can take any form of legal entity—for instance that of a cooperative, a small–medium enterprise (SME), a partnership, a non-profit organization, etc. However, so far, the majority of ECs are in ranking:

(i) cooperatives, (ii) community interest companies, or (iii) non-profit organizations (NPOs), partnerships, and private and public limited liability companies (Bridge project, 2019).

Against this background, a key element for success in the development of ECs is to support the exchange of best practices. The identification of best practices for citizen engagement in ECs as well as for market response must account for the large variability in contextual factors across member states (MSs), including sociocultural settings, and the supporting regulatory and policy framework. Different contexts will present different barriers to the engagement of citizens and different opportunities or threats to other market players. Hence, the classification of ECs must account for such diversity (Massey et al., 2018).

In this study, the authors firstly provide a review of existing classifications and then find if and how such classifications align with the collected EU-wide data. In Table 1, authors compare their data and the Wierling et al. (2023) database in terms of data collection scope and scale. Previously, energy communities were classified based on a certain characteristic or set of characteristics. Distinct approaches to classification were taken, precisely elaborating typologies, taxonomies, and ideal types. While each classification has a certain degree of detail as well as being scientifically rooted, neither of them provide a comprehensive picture of the overall phenomenon, which is renowned for its multifaceted nature. Furthermore, classifications based on characteristics such as: geographical context, membership size, enabling policy, and legal form were not clearly outlined in the academic literature although they are implicitly mentioned. By providing the lacking classifications, slightly modifying existent ones, and comparing the whole spectrum, the authors aim to summarize the existing scientific debate on the topic. Finally, the authors compare the main groups in terms of existing taxonomies, ideal types, and organizational forms as defined by the EU Directives in Table 2. By doing this, the authors aim to align the classifications to reveal if different studies describe similar organizational forms albeit using distinct wording. The authors leave all interested readers to choose a classification most appropriate to their own needs. Subsequent mapping and descriptive analysis of the aggregated data on energy communities uses terminology from the reviewed classifications.

Estimates suggest that by 2030, ECs could own about 17% of installed wind capacity and 21% of solar. By 2050, almost half of EU households are expected to be producing renewable energy (European Commission & Energy, 2019). At the same time, a lack of aggregated data is hindering a proper understanding of the development of ECs in the EU. A report on ECs by the Joint Research Centre of the European Commission (2019) tells us that sufficient available information on the number and location of ECs is not available, as well as on their impact and potential for growth. Furthermore, the European Federation of Citizen Energy Cooperatives (REScoop.eu) emphasizes that there is a need for more comprehensive data collection on ECs to support their growth and development (Creupelandt & Vansintjan, 2019). REScoop.eu estimates there are 1900 existing ECs (REScoop.eu, n.d.), albeit stating that these estimates are only about half of the ECs active in Europe (Rossetto et al., 2022). The lack of data presents a challenge for the European institutions and national, regional, and local authorities to effectively monitor and support EC initiatives. Thus, collecting and analyzing aggregated data are crucial for identifying and disseminating best practices and know-how for local authorities, citizens, and citizen organizations that wish to set up ECs, particularly but not exclusively in MSs with less developed EC traditions. Most of the previous studies performed analyses based on the data for separate case studies and in specific cases at a country level (Candelise & Ruggieri, 2020; Capellán-Pérez et al., 2018; De Vidovich et al., 2021; Heras-Saizarbitoria et al., 2018; K.Huntala, 2016; Kahla et al., 2017; Magnusson & Palm, 2019; Rivas et al., 2018; Sebi & Vernay, 2020). A number of exceptions providing information and analysis for several countries include Hewitt et al. (2019) for eight countries and Wierling et al. (2018) for four countries. Our research contributes to the analysis of the EU-wide movement rather than a separate country or a group of countries.

2.2.2 Data Collection and Methodology

Methods applied to the current work were the literature review and desk research. The former is applied to the analysis, while the latter is applied to both mapping and the analysis. The research began by elaborating on the EC classification and conducting a literature review of research studies that aimed to classify ECs, where proper classifications had already been designed. Literature review enabled us to analyze patterns after the data collection and properly name different groups of ECs. In addition, it helped with the clarification of reasons behind the sectors' diversity, which are discussed in Section 3. Except for the typologies, the ECs movement was classified in academic literature using taxonomies and "ideal types" (Weber, 2011). Typologies are created to a greater extent by theorizing rather than by observation, whereas taxonomies, in contrast, are grounded in observation of the existing reality. According to Weber, business models, too, might be understood as "ideal types", for they seem to have the characteristics of both typologies and taxonomies: they are based on both theorizing and observation (Baden-fuller & Morgan, 2010). Ideal types can be viewed as a bridge between typology and taxonomy, sharing characteristics of both approaches. As a result, such typologies were outlined according to:

- Renewable energy (RE) technologies (own design mixed with (Herbes et al., 2017)).
- The geographical context (own design).
- Membership size (own design).
- The corporate purpose (Herbes et al., 2017).
- Initiating actor (De Vidovich et al., 2021).
- Economic benefit for members (own design)
- Enabling policy (own design).
- The legal organizational form (own design).
- Level of centralization of organizational structure (Gui & MacGill, 2018).

Taxonomies clustering the existing ECs were organized by:

- Level of maturity of business model, by the main function performed (Rossetto et al., 2022).
- Type of energy activity undertaken, by organizational characteristics, by financing source, by revenue source (Braunholtz-Speight et al., 2020).
- Physical location, by scope of corporate purpose (Moroni, Alberti, et al., 2019).

Furthermore, eight ideal types (also called archetypes) were identified focusing on the value proposition of business models (F.G. Reis et al., 2021). It is important to notice that taxonomies by Rossetto et al. (Rossetto et al., 2022) and Moroni et al. (2019) partially carry features of the "ideal types" since these authors initially theorized on classification and, subsequently, found appropriate cases.

For the mapping exercise authors started with defining the concept of energy community. This outlined the scope for data collection. Each member state transposed the EU Directives into national legislation resulting in diverse perspectives on organizational forms available for ECs. Since authors aimed at a comparative analysis of existent ECs and not their specific legal nature in different countries, they decided to search for organizations that correspond to the broader definitions outlined for the EU-wide level: RECs and CECs. This allowed a greater variety of organizational forms and business models to be mapped and analyzed.

Initially, the search string "energy communities in Country X" was applied to each EU member state in the Scopus database. Relevant publications were reviewed and the most updated information on the number, membership structure, and energy production of ECs was extracted. Authors found limited and obsolete statistics available in the academic literature. When a certain nationwide mapping was performed, its analysis related just to the separate countries or groups of them. Authors did not discover any EU-wide aggregate analysis. Country-scale mapping and subsequent analyses were performed for Spain, for Austria, Denmark, Germany, United Kingdom (Wierling et al., 2018), for Germany (Kahla et al., 2017), for Switzerland, for Sweden (Magnusson & Palm, 2019), for France (Sebi & Vernay, 2020), for Italy, for Belgium, France, Germany, Italy, Poland, Spain, Sweden, and the UK (Hewitt et al., 2019). Moreover, authors found that the country-level data were outdated because most of the academic research had been conducted prior to the EU Directives' transposition, which in turn drove the emergence of many new ECs. Therefore, for the second step, the same search criteria as was priorly applied to Scopus was applied to the Google search engine. Authors collected all available information from the web. It predominantly included grey literature reporting static information for a certain year, in particular:

- Reports from third-party organizations or EC associations.
- Websites of EC associations.
- Public institutions' reports.
- Annual reports of individual ECs.
- Handbooks.
- Working papers.
- Book chapters.
- Websites of individual ECs.

This allowed us to collect very recent advancements in the sector. The sources were intensively screened, and valid data were extracted. As a third step, authors searched the European Federation of Renewable Energy Cooperatives (REScoop.eu) website, where authors investigated one by one all its members through their respective websites and annual reports. A number of members of REScoop.eu are not the ECs themselves according to the EU definitions but rather the consulting firms or tertiary organizations or national/regional organizations promoting ECs. However, for several countries (i.e., Bulgaria, Luxembourg, Slovenia), the REScoop.eu website was the only available source of information. The process of data collection was not linear. Authors used the triangulation approach returning hence and forth to priorly examined resources to find a possible subsequent reference to additional resources. Importantly, the bibliography of the academic articles was investigated if the article itself did not contain the needed data. Our data were collected between 2019 and 2022, with a final screening in November 2022.

In January 2023, a database for the EU-wide ECs was released (Wierling et al., 2023). The database adheres to the rigorous FAIR (findability (F), accessibility (A), interoperability (I), and reusability (R)) guiding principles applied to the scientific databases. It was compiled into the publicly accessible inventory. Table 4 represents differences between the data compiled by authors and the Wierling et al. (2023) database relative to the scope and scale of the data collection.

Table 4. Differences between databases

Scope and Scale of the Data Collection	**Authors' Data**	**Wierling et al.** (2023) **Inventory**
Sources of data collection	• Reports from third-party organizations/EC associations. • websites of EC associations. • public institutions' reports. • annual reports of initiatives. • handbooks. • working papers. • peer-reviewed journal articles. • book chapters. • websites of individual ECs.	• Registries operated by state agencies. • reports from third-party organizations/EC associations. • websites of EC associations. • public institutions' reports. • annual reports of initiatives. • handbooks. • working papers. • peer-reviewed journal articles. • book chapters. • websites of individual ECs. • direct interviews with members of ECs.
Nature of sources	Static	Static, dynamic
Membership	Collected	Collected
Annual energy generation/supply	Collected	Collected only for generation
Operational activities	Collected on the aggregate country-level (not including ECs that solely provide information and awareness services as their	Collected on the initiative level (including ECs that solely provide information and awareness

	core activity, not including shared mobility projects)	services as their core activity, including shared mobility projects)
Number of employees	Not collected	Collected
Legal forms	Not collected	Collected
Financial assets	Not collected	Collected
Production unit capacity	Not collected	Collected

The inventory composed by Wierling et al. (2023) included not only static sources but also dynamic ones in their data collection, particularly registries operated by state agencies. This allowed them to report on initiatives that had terminated their existence as well as those currently existing. In addition, they conducted interviews with experts in the field and members of the ECs. Authors did not conduct the interviews, relying solely on desk research. Another important difference concerns the definition of search criteria for an energy community. While both criteria fall under the EU-recognized definitions of RECs and CECs, the Wierling et al. (2023) inventory adopted a broader definition of ECs, aiming to be over-inclusive rather than under-inclusive. In contrast, our data collection adopted narrower criteria, including only ECs whose core activity is the generation and/or supply of energy, as well as those whose core activity is energy efficiency measures. Therefore, ECs that provide sharing mobility and/or information and awareness services as their core activity did not meet our search criteria. Due to these differences, Wierling et al.'s (2023) inventory reports on over 10,000 ECs in the EU, while our report includes 3931 ECs. Importantly, the inventory of Wierling et al. (2023) includes additional broad information on ECs, such as number of employees, legal forms, financial assets, and production unit capacity, which was not collected for our database. Thus, Wierling et al.'s (Wierling et al., 2023) inventory enables greater possibility for a statistical analysis.

However, the strength of our data collection approach lies in its specialized focus on energy communities that are engaged in energy generation and/or supply, as well as those involved in energy efficiency measures, allowing for more targeted and specific analyses. Furthermore, our database exclusively includes currently active ECs, providing a more up-to-date snapshot of the current state and activities of these communities without the additional complexity of terminated ECs. This feature may be valuable to scholars, policymakers, and practitioners who are specifically interested in the more traditional activities of ECs. Given the great diversity in the EC movement, a narrower analysis can yield more specific research outcomes while keeping track of relevant developments.

After the data collection, authors designed Table in Annex 3, which includes both absolute numbers and descriptive statistics, such as the average number of members per EC and proportions relative to the total country population and total renewable energy generation. The generation and/or supply of energy was transformed into the descriptive indicator "Households consuming the ECs' generated/supplied renewable electricity". The table also indicates the reference year for which the static data were collected and list the national/regional federations of ECs. In Section 3, authors provide a comparative visualization of the descriptive statistics and subsequently examine patterns in the development of the EC sector.

2.2.3 Results and Discussion

Classifications

Several typologies were derived from previous academic studies but were slightly modified to fully correspond to the results of our research. The rest of the typologies were designed by the authors. The taxonomies and ideal types were discovered using the literature review.

Typologies

According to the RE technology:

- Solar: Solar ECs utilize photovoltaic and solar thermal technologies.
- Wind: Wind ECs utilize wind turbine technology.

- Biomass/biogas heat/power. Biomass/biogas ECs utilize technologies allowing the production of heat or electricity from woodchip or from solid or liquid waste and husbandry leftovers such as manure if the biogas power plant is established. Such ECs include combined heat and power (CHP) technology to their generation portfolio (Braunholtz-Speight et al., 2020).
- Hydro: Hydro ECs rely on hydropower technology and are usually represented by micro-hydro plants.
- E-mobility: For ECs, e-mobility means utilizing storage devices as a source of distributed energy. Usually, it is a side activity of the ECs, while the primary activity is the generation of electricity or heat. According to Herbes et al. (Herbes et al., 2017), ECs could offer rental services for their customers with a small fleet of electric vehicles, establishing an infrastructure for electric bicycles, and car-sharing services. However, social enterprises whose sole purpose is shared e-mobility, as well as a source of charge for the batteries is not identified clearly, and the authors do not consider these to be ECs. As a result, the authors do not include them in Table A1.

A growing number of ECs in the EU, especially those established before the RED II and IEM Directives do not utilize one single RE technology but several simultaneously due to the maturity of their business model. During the research, the authors found only very limited empirical information about the renewable energy technologies utilized in the sector. Where country-wide cumulated data are available, they are reported using general terms such as “most”, “many”, “majority”, and “largest”. Precise numbers are not available for the EU as a whole, or for countries separately. However, during the review of the annual reports and websites of many ECs, the authors discovered that such data are available at the level of individual ECs.

According to the geographical context:

- Rural ECs: Cooperatives established in rural areas, of which members are usually rural citizens. Cooperatives are mostly based on the ”community of place” approach rather than the ”community of interest”. The authors also include smart villages in this category.
- Urban ECs: ECs established in urban areas, of which the members are usually urban citizens, frequently organized within the condominium of flats or compound of houses. Urban ECs have a great potential for environmental benefits. Emissions from buildings are the largest portion overall. Xiang et al. (Xiang et al., 2022) pointed out that the end-user activities such as space heating, appliances, and others remained the major contributors to decreasing the energy intensity effect in the last decade. Therefore, ECs organized within a building condominium can be a very promising business model from the environmental perspective because an increase in the energy efficiency of buildings, both from the technical and behavioral aspects, is of clear economic interest for residents. This is a “community of place” approach. Moreover, urban ECs are frequently organized using a virtual business model where members own generation facilities in various regions of the country, and not exclusively in their proximity. Such ECs are based on the “community of interest” approach.

According to membership size:

- Very small EC: fewer than 50 members.
- Small EC: 50–200 members.
- Medium size EC: 200–500 members.
- Large EC: 500–2000 members.
- Very Large EC: more than 2000 members.

According to the corporate purpose, derived from Herbes et al. (2017):

- Generation of energy.
- Operating grid: distribution and/or transmission (rarer). Frequently, such ECs own biogas installations and provide balancing services.
- Retail: Selling renewable energy to customers with certified pro-environmental effects.

- Consumption-related services (consulting services, demand-side management, distributed storage, operating charging points for electric vehicles, energy efficiency models, peer-to-peer trading, microgrids).

According to the initiating actor, derived from De Vidovich et al. (2021):

- Public lead model: These ECs are initiated by municipalities or other public governing bodies, usually local.
- Pluralist model: These are organized by the ecopreneurs, NGOs, local SMEs, and other stakeholders. The main features are the organization "from grassroots" as well as the fact that several local actors join the efforts to establish an EC.
- Community energy builders: Usually organized by a well-established intermediary organization, big cooperative, a research or consultancy agency specifically active in the field, or a national or regional association of ECs. The main feature is that such an entity establishes many ECs of a certain type, duplicating the business model with only slight changes.

The data on geographical context, membership, corporate purpose, and initiating actor are available in the academic and grey literature for France, Spain, Germany, the UK, the Netherlands, Belgium, and Italy. However, it is labelled very differently, which further complicates its extraction and accumulation. Furthermore, most of the data are outdated, at least by several years. Data about the initiating actor are harder to collect. Information to build the classification according to the initiating actor either is not available or reported anecdotally, without quantitative information. Prior research activities should be carried out.

According to the economic benefits for members:

- Lower price for energy: The EC works as a utility selling energy to consumers directly and thus receiving direct payments from them. Usually, the consumers who are simultaneously members have lower bills. A lower cost for energy is therefore a main economic trigger to participate. A difference in price with other retailers forms usually due to the special policy preference or particularly organized business model.
- Dividend pay-out: ECs in which members invest in their own RE generation facilities and receive the revenues as shareholders. It allows for higher incomes, albeit demanding closer management (Brummer, 2018b).
- Participation in energy savings: Consulting services to municipalities and households (HHs) on energy efficiency topics could be an additional revenue stream.
- Contracting: ECs as well as using other revenues in their business model, also use contracting.
- Leasing: When the revenues come from the leasing fee. Herbes et al. (2017) states that revenue would be generated as part of the rental fees for the equipment to the consumer.

According to the enabling policy:

- Feed-in-premia (FIP): ECs relying on the selling of electricity to the grid and the premium tariff provided by the governments to stimulate the deployment of renewable energy.
- Quota obligations: It is an obligation of utility companies/energy suppliers/big energy producers to buy a certain share of the renewable energy (RE) imposed by governments. Quota obligations are created for the dissemination of renewable energy sources (RES). Many ECs in the EU benefit from such a policy.
- RE certificates: RE certificates are the documents that guarantee that a certain amount of RE was produced. Later they are sold to the other energy market players. This is a tool that in most cases is accompanied by the quota obligations. However, the difference is that a separate market is created to trade RE certificates.

- Preferential taxation: For ECs there exist various forms of preferential taxation. It can be in a form of a tax deduction or complete exemption from certain taxes, which otherwise are imposed on market players.
- Investment support: Usually occurs in the form of public grants or preferential loans to cover the capital costs, which make this tool different in nature from the grants or preferential loans subsidizing operational activities.

Data on economic benefit for members are available on the websites of ECs and in annual reports. However, neither national nor regional associations or federations have yet accumulated it. Data on enabling policy are available in the academic literature for all EU countries where the phenomenon exists, except for Finland, Poland, Slovenia, or Romania.

According to the legal form data apply to:

- Cooperatives.
- Community interest companies.
- Non-profit organizations (NPOs).
- Partnerships.
- Limited liability companies.

Data for the legal form can be found in public online databases as well as being collected from the ECs' open sources such as websites and annual reports.

Taxonomies

The taxonomy proposed by Rossetto et al. (2022) is similar to the typology of the corporate purpose (Herbes et al., 2017) but encompasses more organizational forms. The authors offer a taxonomy structured by the main functions performed on one side, and by the level of maturity of the business model on the other side. Taxonomy contains such groups of ECs: joint purchasing groups, assistance providers, community energy producers, community energy retailers, utility cooperatives, energy sharing communities, shared electric mobility providers, community aggregators, and community microgrids. Joint-purchasing groups are citizens who by unifying within an EC can better bargain with technology vendors or energy retailers. Assistance providers assist members of the community in energy efficiency measures by providing technical support, and facilitating access to finance and awareness campaigns. Groups with a primary purpose to tackle energy poverty belong to this category. The "Community energy producers" collectively purchase generation facilities benefiting from selling energy to the grid. The ”Community energy retailers” exclusively sell renewable energy to its members, frequently offering lower prices. In specific cases, ECs under this category own the generation facility too. The category of "Utility cooperatives" mostly includes historical cooperatives in mountainous or remote rural areas that invested in the distribution system infrastructure to connect individual consumers with its own generation facilities or transmission network. Within the "Energy sharing" category, the authors distinguish collective self-consumption and peer-to-peer trading. According to both types, prosumers purchase PV plants and storage devices to cover their energy consumption. However, a difference is that according to collective self-consumption schemes, the renewable asset is owned collectively, while individual members continue to have their own energy providers that take care of their residual demand when the community asset does not cover the energy demand. In contrast, members of peer-to-peer (P2P) trading schemes individually own the generating and storing assets that are connected to a digital platform. Individually generated electricity is traded within the community in a way that reflects peers' personal preferences (e.g., price, origin, destination of the energy). Thus, a key task for the P2P scheme is the provision of a digital infrastructure for trading. "Shared e-mobility providers" purchase a fleet of electric vehicles and make them available to their members. The last two categories "Community aggregators" and "Community microgrids" are described by the authors as the most innovative. Both manage and combine the load of their members. While community aggregators virtually connect consumers, prosumers, and collective generation assets, the main feature of microgrids is a physically connected infrastructure.

The taxonomy offered by Braunholtz-Speight et al. (2020) is empirically grounded. The researchers used a collected dataset on the ECs in the UK. The research itself contains two parts: the construction and analysis of the taxonomy, and the performance and financial analysis. Taxonomy was constructed using cluster analysis, which was run in two sets. In the first run, only "energy activity" variables were used. This produced three clusters: standalone renewables, on-site customer renewables, and demand-side activities. "Standalone renewables" include ground-mounted wind, hydro, solar, and biomass projects. The "On-site customer renewables" cluster almost entirely consists of rooftop solar photovoltaic projects, while the "demand-side activities" cluster consists of a mixture of energy efficiency advice projects with renewable energy generation for their own use. In the second run of the cluster analysis, the researchers also utilized variables on organizational characteristics, financing sources, revenue sources, and location. Three broad clusters were subdivided into 12 smaller ones. "Standalone renewables" had two subclusters: multi-financed hydro and wind, and large wind selling to the grid. "On-site customer renewables" had seven subclusters: medium-scale generation with mixed financing, small–medium solar rooftop, multi-site solar on public sector roofs, professionalized solar rooftop co-ops, small multi-project generation for third sector groups, small solar rooftop, and smaller-scale multi-project co-ops. The "Demand-side activities" cluster had two subclusters: demand-side services and energy as a side line. An additional subcluster was produced after the second run that did not belong to any of three main clusters, multi-tech generation including partnerships. The authors discuss, in detail, the features of each cluster and subcluster.

The taxonomy of Moroni et al. (2019) categorizes ECs by physical location and by the scope of the corporate purpose. The first category consists of two groups: place-based and non-place-based communities. This explains the correspondence between the community and a specific area (Moroni, Alberti, et al., 2019). The second category also reveals two groups: single-purpose and multi-purpose. ECs that are organized solely for energy purposes are labelled as single-purpose, whereas those with a range of objectives including goals encompassing the shared management of energy systems are labelled as multi-purpose.

Ideal Types (Archetypes)

The research by Reis et al. (2021) identified eight community business model archetypes. For this purpose, data were collected by the review of case studies from the academic literature, and the Business Model Canvas and Lean Canvas frameworks were used as the main methods. The following archetypes were identified: energy cooperatives, community prosumerism, local energy markets, community collective generation, third-party-sponsored communities, community flexibility aggregation, community ESCO (energy service company), and e-mobility cooperatives.

Organizational Forms Defined by EU Directives

The main differences between RECs and CECs relate to the activities and eligibility criteria:

- Activities: CECs participate across the electricity sector, while RECs focus only on renewable energy. Most importantly, RECs have a narrower geographical scope of activities.
- Eligibility to participate: as well as citizens and small end-users, entities of any size can participate in a CEC, while RECs limit participation to micro-, small-, and medium-sized enterprises (SMEs).
- Effective control: CECs need to be effectively controlled by natural persons, local authorities, or micro and small enterprises, while RECs must be effectively controlled by members that are located in proximity to the community's projects, without any size reference.
- Autonomy: RECs have to be autonomous (and hence more democratic) in their internal decision making, while this is not mentioned for CECs.

In Table 5, the authors align the ideal types as defined by Reis et al. (F.G. Reis et al., 2021) with groups/clusters represented by taxonomies, and organizational forms defined by the RED-II and IEM Directives (IEM, 2019a; RED-II, 2018).

Table 5. Alignment of classifications of energy communities: ideal types, taxonomies, organizational forms defined by the EU

Ideal Types from Reis et al. (F.G. Reis et al., 2021)	**Groups/Clusters from Rossetto et al.** (Rossetto et al., 2022)	**Groups/Clusters from Braunholtz-Speight et al.** (Braunholtz-Speight et al., 2020)	**Groups/Clusters from Moroni et al.** (Moroni, Alberti, et al., 2019)	**Organizational Forms from the EU Directives**
Energy cooperatives	Utility cooperatives. Community energy producers. Community energy retailers.	Standalone renewables.	Place-based. Non-place-based.	RECs (Community energy producers, place-based) CECs (Utility cooperatives, community energy retailers, non-place based)
Community prosumerism	Energy sharing communities. Joint-purchase groups.	On-site customer renewables.	Place-based. Multi-purpose.	RECs CECs (joint-purchased groups)
Local energy markets	Energy sharing communities.	On-site customer renewables.	Place-based. Multi-purpose.	RECs
Community collective generation	Energy sharing communities. Community microgrids.	On-site customer renewables.	Place-based. Multi-purpose.	RECs
Third-party-sponsored communities	Assistance providers.	Demand-side activities.	Place-based. Single-purpose. Multi-purpose.	CECs
Community flexibility aggregation	Community aggregators.	Not found.	Non-place-based. Single-purpose.	CECs
Community ESCO	Assistance providers.	On-site customer renewables. Demand-side activities.	Place-based. Non-place-based. Single-purpose. Multi-purpose.	CECs
E-mobility cooperatives	Shared e-mobility providers.	Not found.	Non-place-based. Single-purpose.	CECs

Reflection on Results

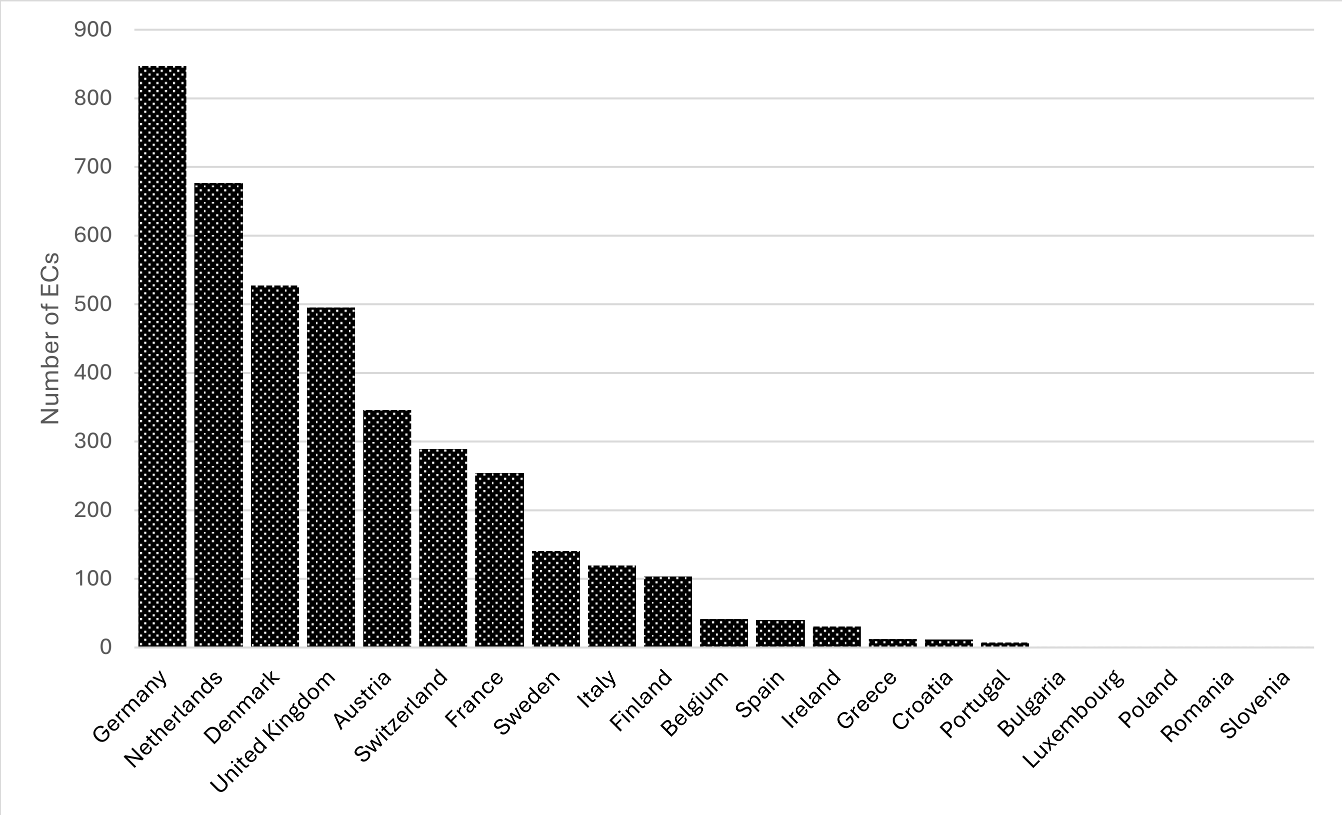
Classification and analysis of the organizational and legal forms are also essential because they enable a subsequent analysis of management issues and a comparison between countries. The transaction cost theory provides a good argument as to why this is worth investigating further. As Bonus (Bonus, 1986) pointed out for cooperatives, "within the typology of transaction costs and governance structures, cooperatives are classified as hybrids within the spectrum of coordination mechanisms, ranging from market to hierarchical organization. The cooperative association possesses features that provide benefits in terms of integrating transactions into a collective organization, while allowing independence of other operational aspects." If cooperatives are not fully market-based organizations and possess features of hierarchical organizations, since they can pool their qualifications and resources (e.g., for joint-purchase bargaining and technical qualification) and the use of the market is more limited, then what might be the relationship of other organizational and legal forms with energy markets? Here, a particular interest concerns emerging business models such as community aggregators and peer-to-peer trading. The trading digital platform represents a fundamental "matching loop" as it reduces the otherwise exorbitant transaction costs for the peers (Glachant & Rossetto, 2021). Which organizational form would adjust better to the existing energy markets and be deployed faster without harming other players? Research studies that allow us to answer such complex questions have only recently been performed due to the publishing of country-based databases (e.g., (Braunholtz-Speight et al., 2020)) and the EU-wide database

(Wierling et al., 2023). Hence, the authors anticipate an agenda for energy community research that will expand our understanding of the role of ECs in the greener energy markets.

Mapping

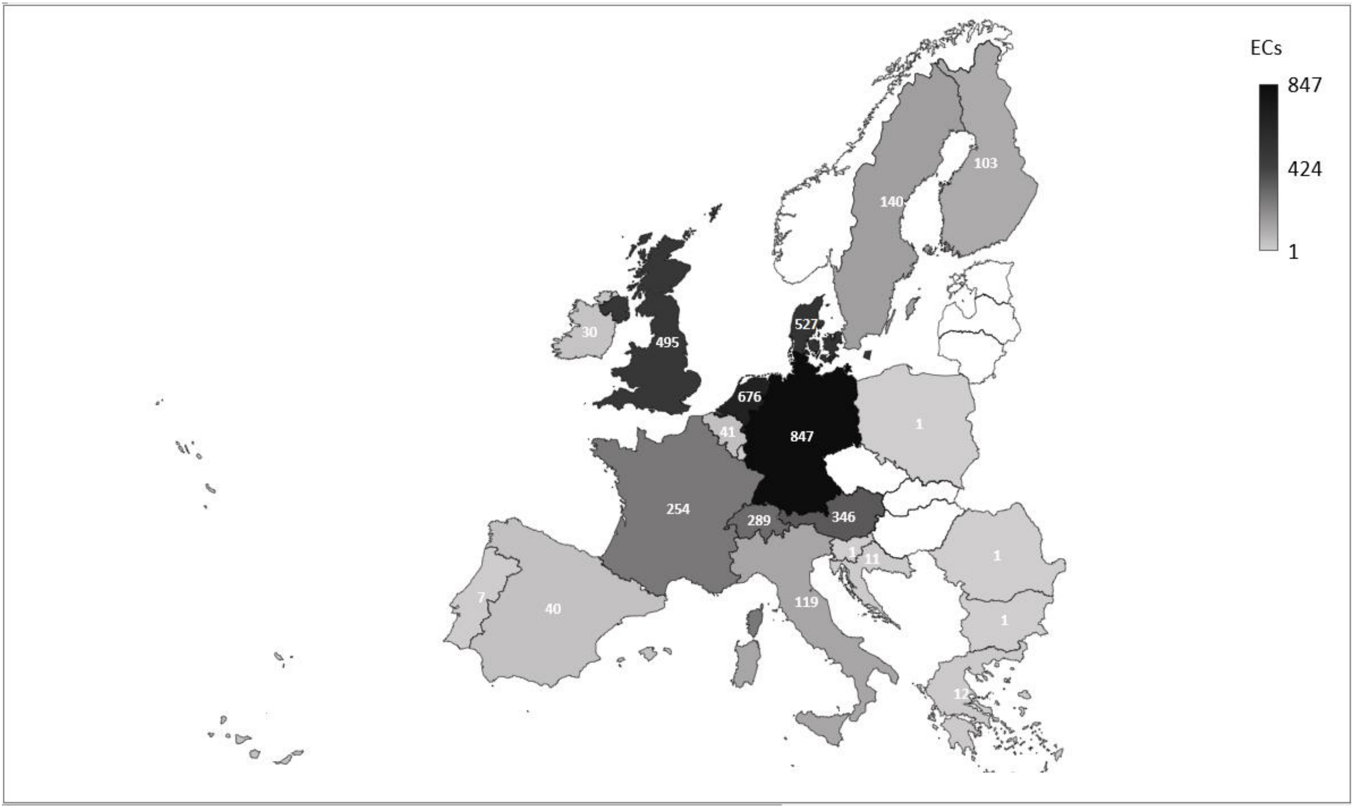
The movement of ECs in the EU is not homogenous. Countries such as Germany, the Netherlands, Denmark, and the United Kingdom are leading the process, whereas in countries such as Italy or Spain the processes involved in the emergence of new ECs has started. however, their number is still small. The majority of ECs in Italy and Spain are represented by the historical cooperatives, which date back to the 20th century and supply rural mountainous valleys with electricity and heat. In other countries, such as Poland, Slovenia, and Bulgaria, the authors found ECs in only exceptional cases. These developments are depicted in Figures 13 and 14.

Figure 13. Deployment of energy communities in the European Union



Source: Table in Annex 3

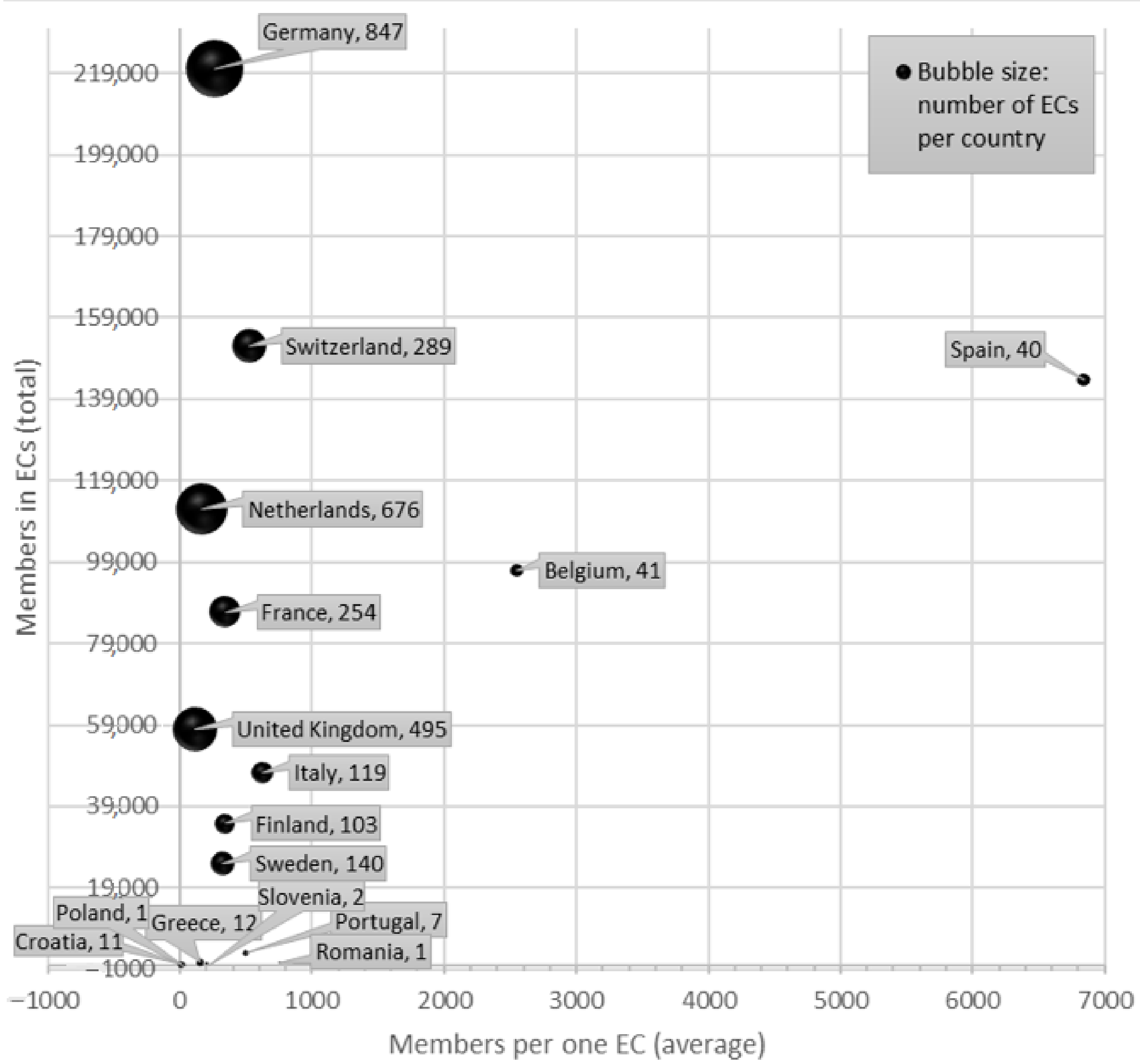
Figure 14. Map of energy communities in the European Union



Source: Table in Annex 3

As can be seen in Figures 13 and 14, Germany has the highest number of ECs relative to other countries, followed by the Netherlands and Denmark. In Germany, most of the ECs utilize solar energy, while in the Netherlands and Denmark, ECs generate electricity from wind and heat from biomass. The factor behind the Danish leadership is the particularly large number of ECs that utilize biomass, i.e., 341 of 527 total ECs. This is a direct result of the prohibition by law of district heating systems from making profit (Gorroño-Albizu et al., 2019). In the UK, ECs that generate solar, hydro, and wind energy dominate. The British EC sector is not only one of the most developed in terms of quantity but also in terms of the ecosystem, with diverse business models and many stakeholders engaged in the sector, including industry, local governments, and NGOs. In Switzerland, most of the ECs are district heating biomass cooperatives, which usually involve a greater number of citizens than solar or wind cooperatives. In Figure 15, the bubble size represents the number of ECs, and we observe that France has a similar number of ECs to Switzerland. However, the latter have twice as many members in their ECs compared to the former. The same situation occurs when comparing Switzerland to the Netherlands, which is one of the leaders in the number of EC initiatives. The average members per one EC is higher for Switzerland than for France and the Netherlands, which can be observed on the horizontal axes. Similarly, the majority of 349 ECs in Austria are district heating biomass cooperatives. Although data on membership are not available for Austria, the authors suppose that it follows the same pattern as Switzerland.

Figure 15. Membership and the average size with respect to the number of energy communities in the European Union countries



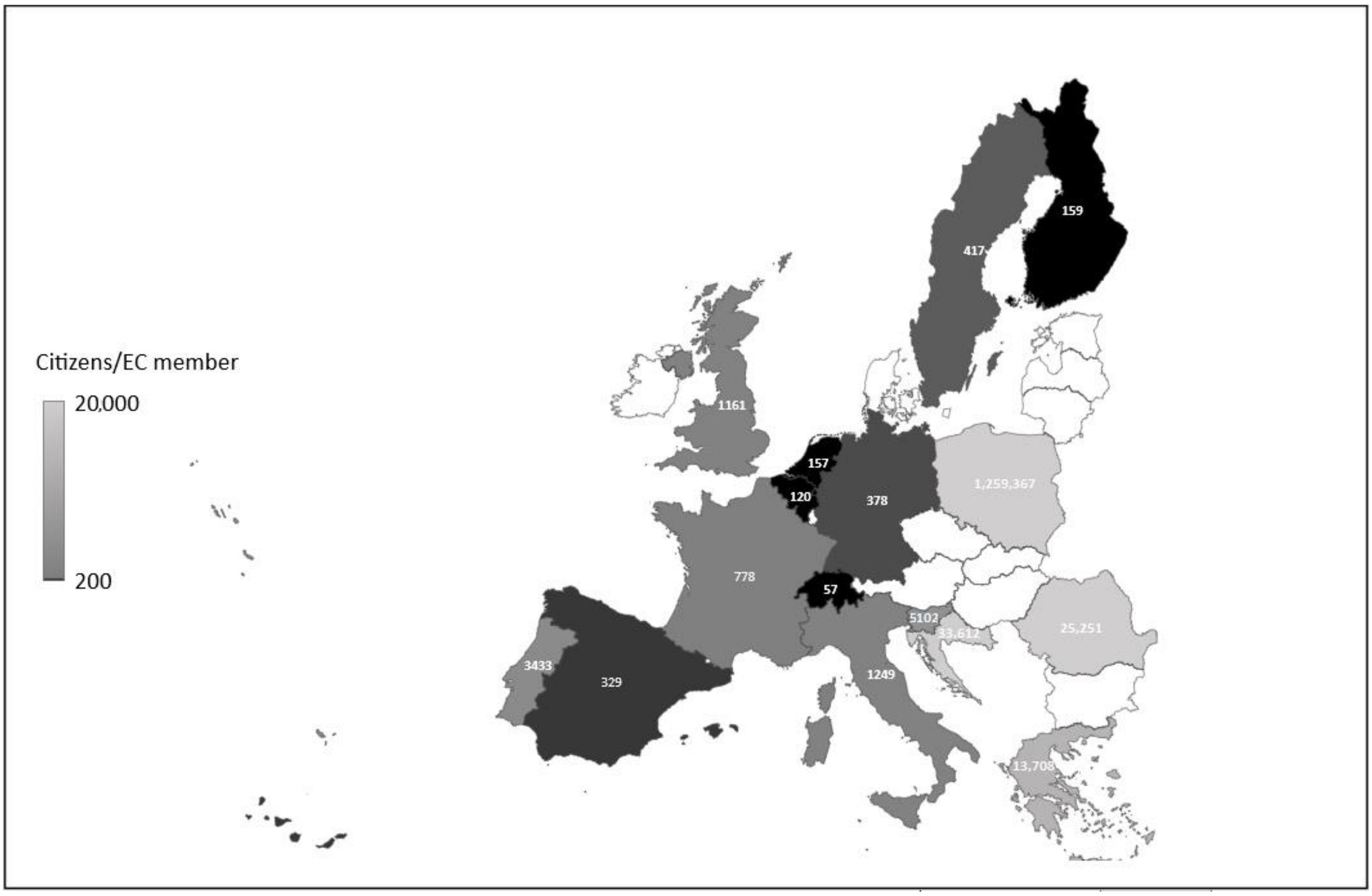
Source: Table in Annex 3

Figure 15 shows the average number of members per EC in EU countries. Spain and Belgium are outliers with average membership numbers of 6841 and 2552, respectively. This difference from other countries is due to the presence of powerful retail ECs. In Spain, for instance, 20 out of 40 ECs sell electricity to consumers as their main business activity, with Som Energia being the most prominent with 83,039 members. In Belgium, the Ecopower energy cooperative consists of 64,114 members. Retail cooperatives' members are simultaneously their customers, although retail ECs can supply energy to non-member consumers. These types of ECs contract renewable energy producers predominantly to supply customers with clean energy. Such enterprises usually aim for social good, leading to decreased energy prices and sustainable energy provision. Another cluster of countries with an average number of members lower than Spain and Belgium, but higher than the rest of the countries, includes Italy, Portugal, Switzerland, and Finland, with average numbers of 622, 500, 526, and 338, respectively. In Italy, a retail EC called E'Nostra comprises 10,702 members. In Portugal, a big retail EC called Coopernico exists with 2531 members. In contrast, Switzerland and Finland have a high average number of members due to district heating biomass/biogas cooperatives.

Figure 16 illustrates that, although Germany is a leading country in terms of the number of ECs in the EU, less densely populated countries, such as Switzerland, Belgium, the Netherlands, and Finland, exhibit higher densities of citizens per energy cooperative member. The density ranges from 57 in Switzerland to

159 in Finland, while Germany has a comparatively modest density of 378. Among these countries, the Netherlands and Belgium have the highest number of wind cooperatives, while Switzerland and Finland have a significant number of district heating biomass/biogas cooperatives.

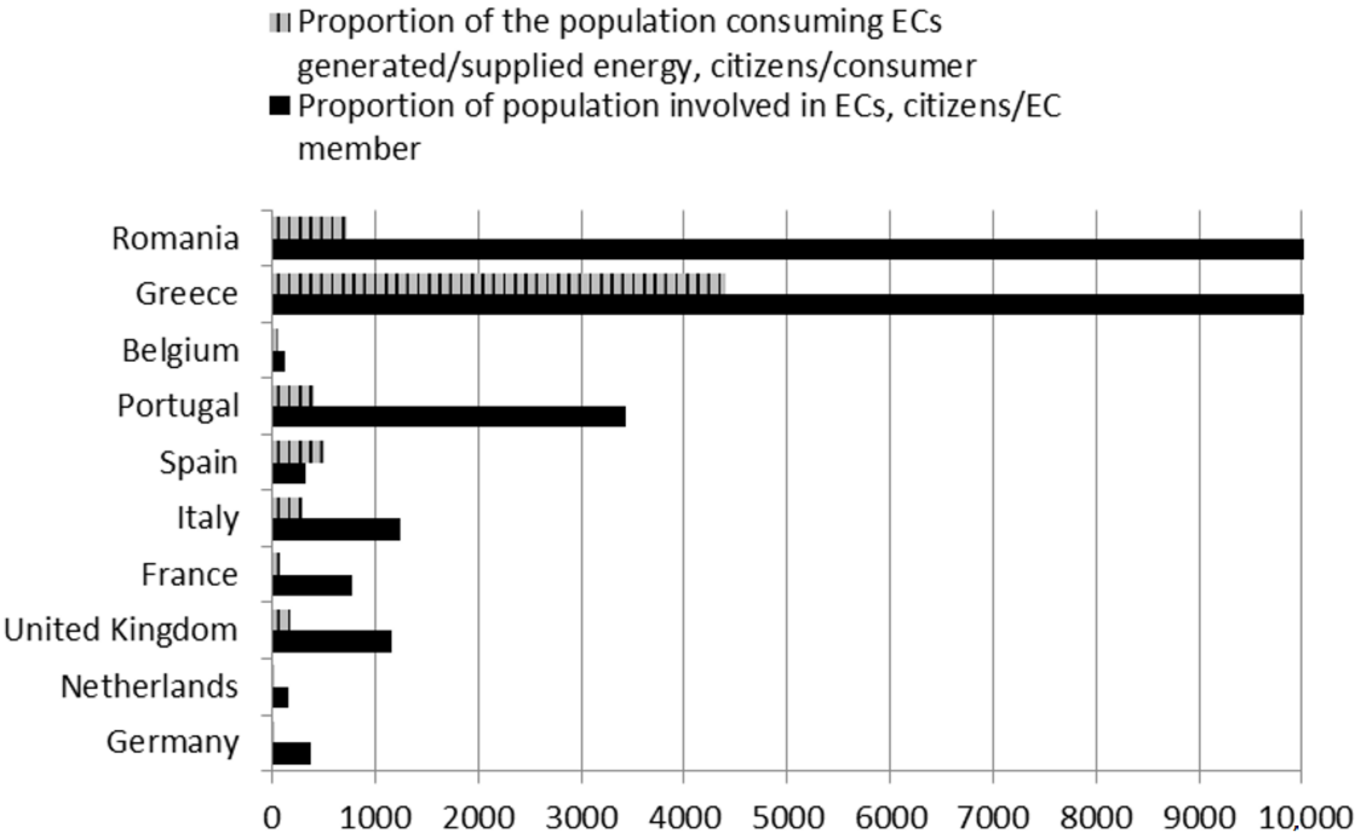
Figure 16. Population involved in energy communities, citizens per one member



Source: Table in Annex 3

Figure 17 depicts the membership and consumption proportions only for EU states where energy generation data are available. Countries with higher proportions have lower bars, and vice versa. Belgium, Germany, and the Netherlands have the highest membership and consumption proportions among the sample countries, indicating their leadership and that their ECs generate and supply renewable energy equivalent to their members' consumption. Slight variations in proportions are observed for the UK, France, Italy, and Portugal, suggesting that a single EC member in these countries provides (either through participation in clean energy generation or by selling) considerably more energy to citizens than it needs for his own consumption. This can be visualized by the difference between bars of the respective country. In Greece and Romania, a significant deviation between membership and consumption proportions exists because only a few ECs have been established, despite managing large renewable power projects.

Figure 17. Comparison of citizens participating in energy communities and consuming its energy



Source: Table in Annex 3

The European Federation of Energy Cooperatives (REScoop.eu) is the umbrella organization that represents ECs throughout Europe. It comprises individual ECs, national/regional federations, and even associate members that are not ECs themselves. However, our data collection revealed that many ECs, such as historical hydro cooperatives and district heating cooperatives in Alpine countries and new ECs that emerged after 2019, are not members of REScoop.eu.

In several countries, intermediary organizations assist ECs in their operation and lobbying activities. These organizations are mostly represented by national/regional federations, such as REScoop Flanders and Wallonia in Belgium, Energie Samen in the Netherlands, Community Energy England/Scotland/Wales in the UK, and DGRV in Germany. In addition, sector builders, such as Énergie Partagée and Enercoop in France, E'Nostra and WeForGreen Sharing in Italy, and Energy4All in the UK, established new ECs as their spin-offs. These sector builders have an organizational nature of the "cooperative of cooperatives". Another type of sector builder consists of research and consultancy organizations, such as the University of Ljubljana's Energy Policy Laboratory in Slovenia and the Energy Center Lab of the Polytechnic University of Turin in Italy, which has started to be particularly active since the enforcement of the EU Directives in 2020–2022. Another type of sector builder was launched in Austria. It is a public institution for the deployment of ECs at a national scale, the Austrian Coordination Office for Energy Communities. The last two types of sector builders concentrate on the development of new ECs rather than supporting the well-established ones. They bridge between different actors within a variety of contexts to establish innovative business models. The most prominent intermediaries are listed in Annex 3.

Impact of EU Directives

New ECs started to appear after the transposition of the EU Directives to national legislations, which happened between 2020 and 2022. Their rapid emergence was observed in Italy and Spain because the national legislations in these countries allowed new actors, who were not previously involved, to step into the energy market. As a result, the organization of these new ECs is different from traditional energy cooperatives. For instance, municipalities and housing associations could not only become members of ECs but even initiate an EC themselves. In Italy, 26 such new ECs have emerged since 2020. On the opposite side of the EC movement, the authors found historical ECs that usually appeared in remote villages in mountains, typically including all local citizens as members. A number of them (i.e., ECs represented by the SEV association in Italy) date back more than a century. They started to generate renewable hydropower and provide it to locals (Koltunov, 2019). At the beginning of the 21st century, their business models were expanded to the provision of district heating from biomass/biogas. Such cooperatives are found in Alpine countries such as Italy, Austria, and Switzerland, but not exclusively. For example, historical cooperatives that supply a village or valley with electricity operate in Spain, and they are united under the umbrella of the Federation of Electric Cooperatives of the Community of Valencia. To fully realize their potential, ECs must develop in terms of their diversity of organizational forms that was enabled by the EU Directives in 2018 and 2019. Classification according to legal organizational form and initiating actor would not only systematize the sector but also provide insights. For example, the authors found that Italy transposed EU Directives that allowed many new players in the market, such as municipalities, small–medium enterprises (SMEs), non-governmental organizations (NGOs), research bodies, social housing associations, and religious organizations, to be organized in an EC under any legal form. Before this, only 77 ECs existed in Italy, most of which were energy cooperatives in Alpine rural areas (Koltunov, 2019). In 2022, 119 ECs existed, a 35% growth due to newly established ECs of different legal forms from the cooperative. Germany, on the other hand, had 862 ECs (Deutscher Genossenschafts- und Raiffeisenverband e.V. (DGRV), 2018) before the EU Directives and 847 ECs in 2022, so the number has almost not changed. Directives were transposed into German law, implying that cooperatives are the main legal form intended for ECs. Other legal entities in the German legislation were not specified (REScoop.EU, 2022). Moreover, in Germany, fewer new actors could be involved in ECs such as SMEs, municipalities, and NGOs. Monetary incentives, however, were promised in both countries. Thus, the difference in recent dynamics for Italy and Germany occurs due to the distinct number of actors as well as legal entities. While Italian legislation has enabled new actors to step into the sector, it has not recognized utility cooperatives (historical cooperatives) as a form of ECs. In contrast, our inclusion criteria were based on the definition provided by the EU Directives. That is why authors mapped historical cooperatives to the ECs.

Deployment

According to Elinor Ostrom (Ostrom, 2010), there are three economic factors that enable communities to address modern challenges more effectively. Firstly, they can address local externalities more efficiently. Secondly, they can respond to preferences for locally differentiated goods. Thirdly, they can group together to reach an efficient scale of operation in production or trade (Glachant, 2022). We should not forget about the vast social benefits of decreasing energy poverty and increasing energy democracy, which could consequently contribute to economic outcomes too. Therefore, there exists a "non-efficient quantity" of small and distributed capacity installed by ECs. If so, governments need to subsidize it until the sector reaches maturity. Studies have shown that without governmental support, today's ECs could barely survive. When such support is provided, the ECs' number and sizes will grow. When this sector attains maturity and an efficient market-justified number of ECs is reached, the growth will cease and thus support can be gradually eliminated. ECs that succeed and stay in the market due to the evolution of their business models and higher productivity will be able to compete with larger players from then on. New efficient prices, which consider the environmental and social aspects of energy, will enable such a scenario to happen. It will be less costly to build and operate small generation facilities. Finally, the unproductive ECs will vanish. Nonetheless, until the market fully embraces ECs, supportive policy tools are crucial.

It is not only policy tools but also the role of investors who are sensitive to ethical finance that can contribute to the deployment of ECs, given the general increase in interest in environmental, social, and governance (ESG) ratings of the portfolios and investment options (Agrawal & Hockerts, 2021). Socially responsible investing has not only demonstrated high social and environmental cruciality, but it has also become more profitable than investing with the sole purpose of maximizing profits. The recent Corporate

Sustainability Reporting Directive (European Commission, 2022) obliges small and medium-sized enterprises (SMEs) to report on their ESG performance from 2026. As the authors have discussed, ECs are organized in various legal forms in different member states. Those that choose to be an entity corresponding to the SME type will be obliged to report on their ESG. Whether this will increase transaction costs for newly established ECs or, conversely, bring positive outcomes such as additional funding, we do not know yet. However, the possibility of being registered under different legal umbrellas should add to the survival chances and development of the sector. ECs that find it burdensome to report on ESG could simply be registered as entities that are not required to disclose those numbers. ECs should be allowed to evolve by testing various business models (Koltunov et al., 2022). This experimentation will permit ecosystem heterogeneity (with multiple key actors) that, in turn, will speed up the evolution of ECs' business models and consequently the deployment of renewable energy. ECs should utilize their uniqueness, which lies in their strong direction towards stakeholders such as the local community in general or the environment, rather than only shareholders. Business model adaptation by other market players, as suggested in the studies of business model archetypes and taxonomies (F.G. Reis et al., 2021; Rossetto et al., 2022), can accelerate the process. For instance, DSOs see the potential in ECs to be aligned with their own business models, which was described in Del Pizzo et al. (Del Pizzo et al., 2022). In the majority of member states, a separate small–medium company can also be one of the members of an EC, although aligning with the cooperative principles. Participation in the EC and a possible installation of generation facilities within the commercial building of a company, although owned by an EC, can add more sustainability value to the portfolio of such an SME member and help to showcase innovative ways to decarbonize commercial building stock. As Minda Ma et al. (2022) argue, stimulating policies and new market financial mechanisms are important to accelerate decarbonization of the commercial buildings. As we can see, urban ECs can evolve in multiple directions, which could engage not only residential but also commercial buildings. For instance, community microgrids, community aggregators, assistance providers, demand-side activities, and peer-to-peer schemes could become suitable models for businesses willing to take a stake in an emerging sector. The authors do not yet know the future dynamics of the energy market and its interrelation with ECs, but we are convinced of the importance of ECs developing in various organizational forms that allow for ecosystem heterogeneity and fluidity. Koltunov et al. (2022) argue that, when comparing the French and Italian EC movements before the implementation of the EU Directives, the French movement was more advanced than the Italian one because it was supported by a more developed ecosystem for ECs. Therefore, when SMEs in the EU are finally required to report on ESG, ECs that choose this legal form should only benefit. Markets may be more important than policies in driving the sector if the profitability assessments of new projects align closely with the sustainable and circular economy paradigms, thereby fostering an impact-investing approach (Koltunov et al., 2022).

2.2.4 Conclusions

This part of the chapter described the process and results of analyzing today's activities revolving around energy communities. We follow with key findings.

First, there are nearly 4000 (3931) energy communities in the European Union and the United Kingdom today. The emergence of energy communities started well before EU Directives were put in place, with Germany, Netherlands, Denmark, and the United Kingdom being leaders in the movement.

Second, the concept of community energy originated in the British academic circles to emphasize the diverse nature of the phenomenon. However, in countries with stronger cooperative traditions, they were referred to as energy cooperatives. For example, in 2022, the authors found that there are 847 energy cooperatives operating in Germany and over 500 (527) in Denmark.

Third, different primary renewable energy sources are utilized by energy communities in different countries. In Alpine range countries such as Austria, Switzerland, and Italy, hydropower plants and biomass district heating plants are built extensively by energy communities in rural areas. Biomass district heating energy cooperatives dominate in Sweden and Finland. Conversely, the majority of energy communities in Germany, Spain, and France generate solar energy. In the Netherlands and Denmark, a great number of wind energy communities are operative.

Fourth, an important insight from our work is that the membership structure of energy communities in different countries is related to the energy source used and the corporate purpose of the energy community. More members participate in biomass/biogas district heating communities and wind communities, which require bigger investments. Retail energy communities that mostly sell energy produced by others also tend to have many more members than purely energy generation communities. The largest retail energy community in the European Union, Som Energia, includes about 83,000 members who are simultaneously consumers and have preferential prices and a guarantee of the renewable origin of the supplied electricity.

Fifth, another insight from our analysis is that regional and national associations exist in each country where a significant number of energy communities are present. In addition, intermediary actors, research, and consultancy agencies show growing interest in the deployment of the movement. In France, Belgium, the Netherlands, and the United Kingdom, an ecosystem for energy communities can be a benchmark for other member states. The interrelation of energy communities with markets and how to properly support them without harming other players, as well as final consumers, poses a crucial issue for further research on the topic. This issue is posed by Jean-Michel Glachant (Glachant, 2022) in the preface of the book on energy communities: "How can energy communities become promising models for different actors along the value chain?"

Sixth, our work demonstrated that more clarity in the field of energy communities in Europe concerning their location, utilized technology, size, corporate purpose, legal form, organizational form, benefits for members, initiating actor, enabling policy tools, and more are needed. This will allow for the benchmarking of best practices across different member states, not only for the type of business models but also for sector builders, intermediary practices, and supportive policy mechanisms. However, achieving conformity of business models Europe-wide would probably be impossible and pointless. Distinct geographical, institutional, and policy context-specific conditions stimulate diversity rather than conformity.

Seventh, with the advent of EU Directives, the number of ECs is expected to grow in the following years. It is important to constantly monitor how EC policies are designed in each country. Without a classification and systematization of the sector a lot of potential reseach would be impeded if not impossible.

Finally, with the publishing of an EU-wide inventory (Wierling et al., 2023), the scope of energy community research is expected to grow. An interesting direction of research is the interrelation of new business models with other market players. In academia, energy communities were previously investigated mostly by sociologists, economic geographers, urban planners, and management scholars. The authors expect growing interest in the topic from energy economists.

2.3 Institutional and policy context of energy communities in France and Italy

2.3.1 Introduction

Climate change and economic inequalities induce policymakers to take action and look for new models of interaction that could be more efficient for the utilization of already available technological advancements in the energy sector. In this context intercountry analysis enables a deeper understanding of the models behind energy communities (ECs). Understanding the background of existing ECs, in turn, supplies fertile ground for innovation.

A comparative cross-country analysis of energy community movements in Italy and France was not undertaken previously. Both countries enjoy significant solar irradiance, providing a strong potential for EC deployment. Neighboring countries such as Austria and Switzerland, situated in the Alps, possess natural resources like forests and mountains, favoring biomass and hydro cooperatives instead of solar-focused ECs. Other regional neighbors, including Slovenia, Greece, Malta, and Croatia, currently lack a sufficient number of ECs to allow for a robust comparative study (see previous section). While Spain and Portugal share sociocultural traits with Italy, a comparison with these countries may yield limited new insights. Conversely, countries like Germany, the Netherlands, Denmark, and the UK feature markedly different societal, climatic, and economic conditions compared to Italy. France, however, stands as a favorable comparison point, with similar levels of solar potential and a comparable number of ECs, albeit slightly higher. By positioning France as a middle ground, this analysis provides meaningful insights into the EC movements in these two similar but distinct contexts.

Institutional relationships are usually anchored in history, and they cannot be ignored in the analysis of the energy transition (Poupeau, 2020). The institutional context of the markets where ECs operate influences either ECs' deployment or their absence, as well as the choice of the business model. Today, ECs have many organizational forms (Moroni, Antoniucci, et al., 2019) whose main purpose is providing people with energy-related services (Koltunov & Bisello, 2021). Beyond institutional forces, policy support determined by political will is another factor explaining the recent development of ECs. A survey from 2014 (Klagge et al., 2016) showed that nearly 80% of all regional ECs in Germany and more than 80% of supra-regional ECs relied on the Feed-in-Tariffs policy for their revenue stream. For France and Italy, such incentive schemes have also been a decisive factor. Nevertheless, in many cases, the institutions interested in renewables and more precisely distributed energy lobbied for support schemes. Such institutions were already involved with or saw the potential of ECs. An interplay of market forces and state support has determined the past of, and will continue to determine, the future of ECs.

ECs represent a unique opportunity for enhancing community welfare because in most cases returns stay in the locality. A French study conducted by Énergie Partagée (2019) showed a ratio of 1€ : 2,57€ for equity invested in a project and the value returning to the territory in 20 years. In addition to local economic benefits, community ownership and decision-making in ECs significantly enhance local democracy and acceptance of new green technologies (see Brummer, 2018. Devine-Wright, 2005. Rosanvallon, 2011. Süsser et al., 2017. Yildiz et al., 2015) Moreover, profits from energy savings in buildings can be redirected to additional actions (e.g., shared e-mobility schemes).

Community members are more likely than the regional/national authorities to support such a local circuit of investment–improvement–investment because it goes against the traditional energy producers' lobby. Also, social aspects, such as having higher citizen support for projects promoted by community members themselves rather than by external institutions, mobilize citizen endeavors and local finance for the energy transition (Koltunov & Bisello, 2021). This study concentrates primarily on the welfare gains of shareholders trying to answer the following questions:

- What influences more the welfare-enhancing capacity of ECs?

• What are the main benefits ECs bring?
• How should the institutional and policy context evolve to foster its deployment?

2.3.2 The energy communities' movements in France and Italy

This section analyzes French and Italian experiences. In the beginning, descriptive statistics about the ECs deployment and typology are presented, followed by the description of the specific factors (state and market institutions, policies, civil society, and research centers) that influence the welfare-enhancing capacity of ECs.

France

France is well known for its highly centralized energy sector, with nuclear energy playing a major role. However, since the 2000s decentralization of the energy system has started to emerge, mostly in response to environmental concerns and the anti- nuclear movement raised after the Fukushima disaster. Consequently, France plans to reduce the share of nuclear energy in its electricity mix from 70% to 50% by 2035 and to close its last coal plants by 2022 (IEA, 2021). Recent EDF bankruptcy suggests that the nuclear generators may not be a reliable and long-term solution today as was considered before. Instead in the country begin to deploy distributed renewable energy, specifically ECs. There are 215 ECs: 118 already operating, 73 under development, and 24 emerging. As Fig 18. shows, most of them have appeared after 2016. However, already starting from 2019 we observe the drop in new ECs because of termination of the feed-in-tariff. Fig. 19 compares the share of ECs by utilized technology or installed capacity. Sebi and Vernay (2020) classified French ECs into four types:

• The first type, "citizen PV clusters", are small individual solar rooftop projects that have been grouped into clusters.
• The second includes wind farms, microscale wood plants, and big PV projects with installed capacities from 2 to 18 MW.
• The third consists of mini-hydro projects and small biogas plants. and
• The fourth consists of big projects, such as large wind and solar PV farms or wood-chip district heating with a high generation capacity.

Figure 18. Annual deployment of ECs in France

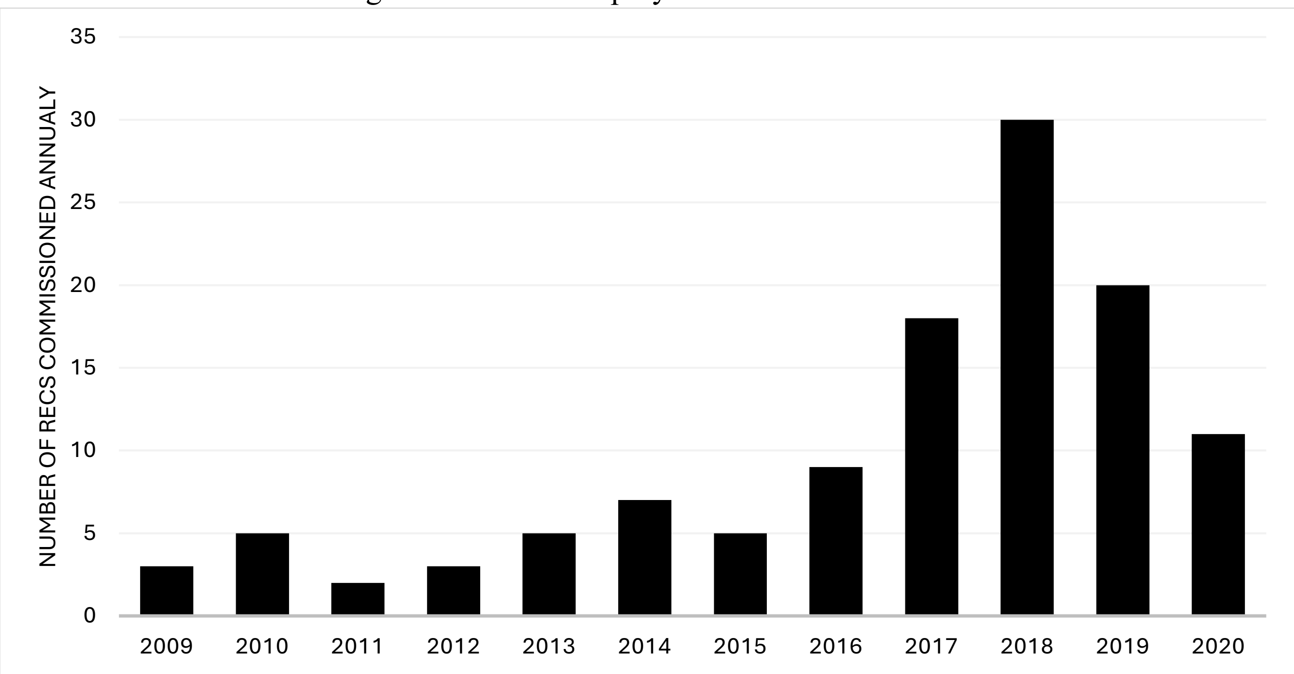
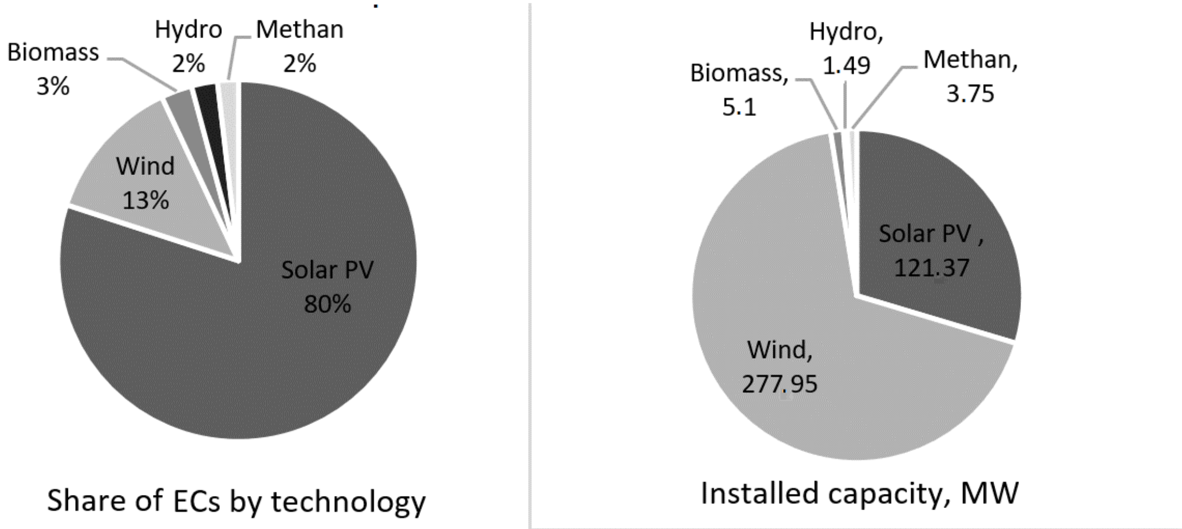


Figure 19. ECs by technology and installed capacity in France



Public and tertiary sectors have a pivotal role for ECs in France. The main public players are EDF[7,] RTE8, ENEDIS[9], DGEC10, CRE[11,] and ADEME[12.] EDF manages all nuclear power plants and most fossil fuel and hydropower plants, together with some large renewable facilities. ECs are obliged to sell their energy to EDF or, more recently, and following highly constrained criteria, Enercoop (Sebi & Vernay, 2020). Although the distribution systems belong to local authorities, 95% are subject to concessions managed by ENEDIS, with the remainder managed by local distribution companies. DGEC is responsible for implementing the government policy on energy according to the framework defined by EU directives, in particular, for liberalization of the energy market, energy efficiency, development of renewable energy, and climate change issues. For instance, DGEC is responsible for transposing EU legislation on "energy communities" into French law and defining the incentive schemes for renewables. Among the public actors, ADEME, which covers a broad spectrum of environmental policies, is the one that supports ECs the most and has done so from the very beginning. For instance, it helped create EPA, which is a national association of ECs. ADEME provides funding for regional ECs' associations and awareness-raising campaigns. indeed, it supported the establishment of the majority of regional citizen energy associations. In 2018, together with an investment company, a cooperative bank, and a pension fund sensitive to environmental issues and solidarity economy, ADEME was also a founding partner of EnRcit, which provides loans under very preferential conditions exclusively to ECs (EnRciT, 2021). Pivotal tertiary actors in the citizen energy sector are Enercoop, EPA[13] with its subsidiaries, and Centrales Villageoises.

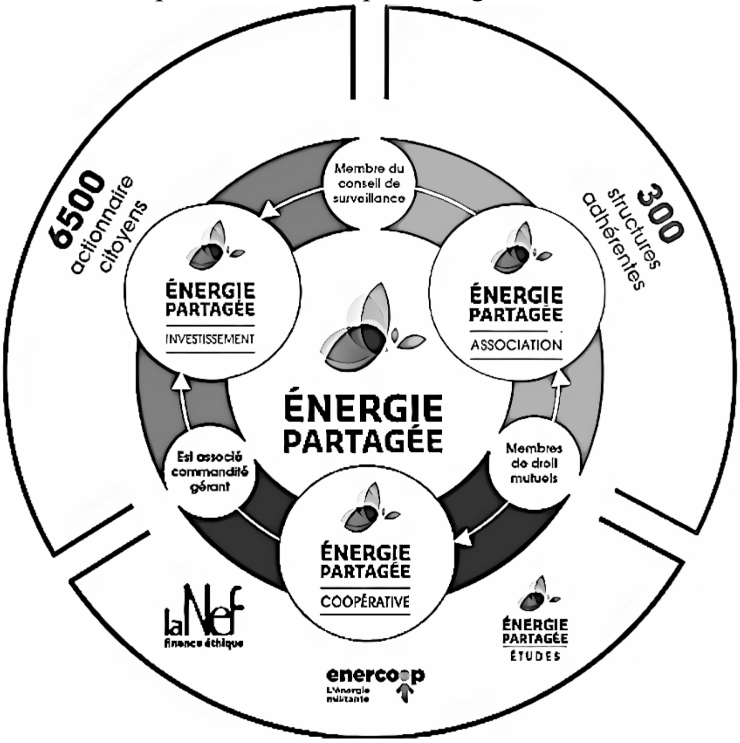
Enercoop was founded in 2005 by environmental and solidarity economy NGOs (Enercoop, 2021). it is a supplier of renewable energy and a cooperative of cooperatives that includes 11 regional sub-cooperatives. It has 100,000 customers, 50,000 of which are members, namely, individuals, communities, and businesses, of the cooperative. Overall, Enercoop purchases electricity from 300 renewable energy producers (Enercoop, 2022), but half of Enercoop's electricity comes from just 48 ECs (Energie Partagée, 2021). Enercoop works very closely with the ECs and, besides purchasing their electricity, supports ECs at all stages of development. Since its inception, the cooperative created several energy-transition actors by itself, including EPA, which is a central actor in ECs' movement in France. EPA unites all ECs and

[7] Électricité de France—dominant energy generator and utility and the former state monopoly
[8] Réseau de Transport d'Électricité—Transmission System Operator
[9]EDF's subsidiary, Distribution System Operator
[10] Direction Générale de l'Énergie et du Climat—The Directorate General for Energy and Climate, Ministry for the Ecological Transition
[11] Commission de régulation de l'énergie—the national regulatory authority that deliver market regulation, tariffs, and promotes competition
[12] Agence de la transition écologique—Environment and Energy Management Agency

[13] Energie Partagée—National RECs Association

has even spun off three regional ECs' associations out of ten in total. Organizationally, it was established as the cooperative structure having as members its founding NGOs and all citizens participating in related ECs. The cooperative spun off EPI[14] and several other subsidiaries, such as EPS[15], a research company in the field of citizen energy and EPO[16] , which delivers management services to ECs. They provide ECs with such services as legal structuring of projects, economic planning, crowdfunding tools, consultation, mobilization campaigns, territorial animation services, and partnership tools. Figure 20 shows the conceptual relationships between EPA and its subsidiaries.

Figure 20. Conceptual relationships among EPA and its subsidiaries



Source: EPA website https://energie-partagee.org/

Simply said, it is on one hand a French one-stop-shop for activists willing to set up an EC, but on the other hand, also an investment company. It has already intervened in 74 EC projects becoming their shareholder and simultaneously providing services to them.[17] It delivers a crowdfunding campaign, on average, promising 4% annual gross profit for future shareholders (Energie Partagée, 2019). EPI's operating income comes from new members' subscription fees, dividends from shares in ECs, and income from the organizations where EPI is a shareholder. Subscription fees cover management expenses of EPI/EPA, whereas dividends are largely reinvested into further EC projects (Energie Partagée, 2019). Such a scheme enables a virtuous cycle of ECs deployment.

Other important players in France are the "Centrales Villageoises" (Village Centers in English), which are local companies with citizen governance that carry out projects to support the energy transition. The organization was established in 2010 by several regional natural parks in the Rhône-Alpes. Their ECs are distributed mostly in eastern and south-eastern France, and fall under the type "citizen PV clusters", according to Sebi and Vernay (2020). All three key tertiary actors, Enercoop, EPA, and Village Centers, as well as ADEME from the public sector, are actively lobbying state authorities for the interests of ECs.

Looking at the financial side, the main policy incentive schemes in France applicable to ECs are Feed-in-Tariffs (FiT) and "participatory bonuses". FiT in France is fixed for 20 years, although for new

[14] Énergie Partagée Investissement
[15] Énergie Partagée Études
[16] Énergie Partagée Exploitation
[17] Data from EPA website: https://energie-partagee.org/, accessed on 02.05.2021

installations its granting has been highly restricted since 2016[18]. For instance, only solar PV on roofs with an installed capacity of less than 100 kW or biogas and hydropower installations with less than 100 kW capacity are eligible for FiT[19]. Participatory bonus is a tool similar to Feed-in-Premium that characterizes citizen energy projects. It was offered by DGEC in 2015, awarding between 1€ and 5€ per MWh to a project participating in auctions[20]. The potential project must meet a given threshold of participatory investments for a minimum period of three years: 40% of equity or 40% of total financing must be raised jointly or separately from 20 investors, who could be individuals or local authorities or groups of communities. Individual investors must reside near the project or adjacent department, and the bonus was promised for 20 years. In 2020, the Directorate-General for Competition of the European Commission advised that the support system of participatory bonus could no longer be maintained as it had been so, therefore, a revised form of modified incentive is still a topic of discussion[21].

Preferential taxes for renewable energy producers and Feed-in-Premium for high-capacity installations are also available in France, and local incentives coming from the regions supplement the national schemes, e.g., Region Occitanie offers an economic multiplier of 1€ per 1€ of citizen-invested funds (Peullemeulle & Duval, 2017), while the Auvergne Rhône Alps Region supports selected renewable energy projects up to 30% of the total investment fund. The summary of policy schemes benefiting ECs in France is reported in Table 6.

Table 6. Summary of policy schemes benefiting ECs in France

Incentive scheme	Period of use	Type of EC benefiting (incl. according to Vernay and Sebi)	Level of actual benefiting
FiT (Tarif d´achat)	2005-2016-ongoing	Type 1, Type 3 (small installations)	High
Participatory Bonus (Bonus participatif)	2015-2021	All ECs (differently according to the installation type and share of participatory capital)	High
Simplification of legal obstacles for ECs´ setting up (Code de l'Énergie)	2015-ongoing	All ECs	High
Feed-in-Premium (Complément de rémunération par guichet ouvert)	2017-ongoing	Type 2, Type 4 (plants that generate power beyond the threshold eligibility of FIT capacities)	Low
Reduced VAT tax	2000-ongoing	All ECs	Low
Income tax deduction (CITE) Since 2019 it was highly modified	2005-ongoing	All ECs	Low
Enabling of energy sales to utilities different from EDF (Code de l'Énergie)	2015-ongoing	supplier ECs (only Enercoop got the accreditation so far)	Low
Loan (Fonds Chaleur)	2009-ongoing	Type 4 (only biomass installations)	Low

[18] The FiT for solar rooftop fluctuates, but stands at 18 c€/kw, approximately,
[19] More details about the complete description of limitations and criteria , including wind installations restrictions, can be found in Vidalic (2019).

[20] Law No 2015-992 of 17 August 2015 on "energy transition for green growth" amended the Energy Code with the new Article L.314-18,
[21] Data from EPA website: https://energie-partagee.org/, accessed on 10.05.2021

Overall, 215 French ECs had 24,627[22] citizen members in 2020 and produced electricity and thermal energy equivalent to the electricity consumption of almost 700,000 people and heat for almost 13,000 people[23]. In Fig. 18, the rapid growth of ECs since 2015 and the decline of new commissioned ECs starting from 2019 are depicted, with further details in Sebi et al. (2020)

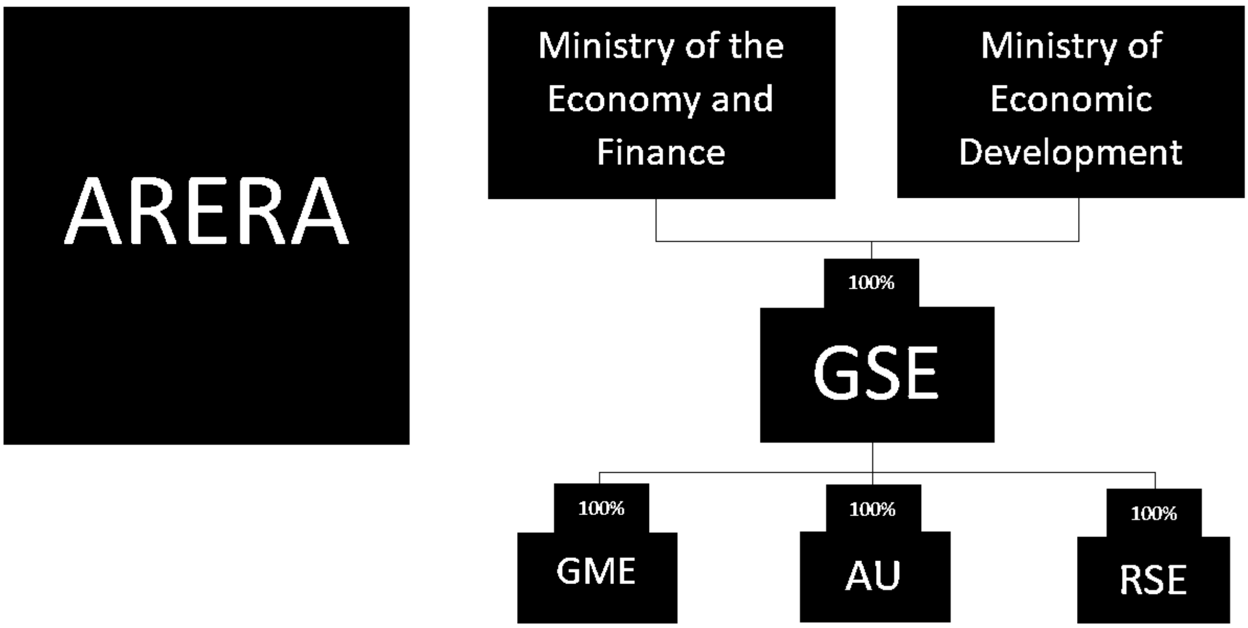
Italy

Energy cooperatives in Italy started to appear as early as the beginning of the 20th century in the Alpine regions of Trentino–South Tyrol and Lombardy. These historical ECs usually appeared in remote valley towns and villages, typically including all local citizens as members. Due to historical reasons and geographical constraints, they are still not obliged to be unbundled as the current national law generally requires, and they usually own generation facilities and distribution systems simultaneously, supplying locally generated energy, mainly from renewables, to their members.

New ECs in the non-Alpine part of Italy have emerged mostly since 2010, as a result of raising environmental awareness of citizens and development of business models as opposed to commercial energy providers, sustained by incentive schemes like FiT. There are currently 76 ECs in Italy with 47,309 members[24], 65 of the ECs considered as historical ECs. Historical ECs are mostly organized as cooperatives with members living in the same municipality or nearby valley. They mostly utilize hydropower and biomass for their installations. On the contrary, members of new ECs do not always live in the same municipality, meaning that they are united on the premise of common interest rather than geographical proximity. New ECs utilize mostly PV solar energy and are organized as innovative business models (Moroni, Alberti, et al., 2019). There are some new ECs that, in addition to generation, also supply energy-efficiency consultancy or provide consumption-related services (Koltunov, 2019), mostly operating on a national scale (Candelise & Ruggieri, 2020).

Key state authorities influencing ECs' institutional context in Italy are shown in Fig. 21 and further described below:

Figure 21. Key state authorities responsible for the energy sector in Italy



[22] Of which 5,000 citizens are members of the Centrales Villageoises network.
[23] Approximate number based respectively on 1,172 kWh of electricity consumption and 4.5 MWh of heat consumption per person per year. Data from the EPA Centrales Villageoises annual reports.
[24] Key figures about Italian RECs from Koltunov (2019) adapted for 2021.

- ARERA is an independent regulatory authority that is responsible for the energy sector and also for water supply and waste management.
- Another important institutional player is the Ministry of Economy and Finance. It established GSE[25] that, in turn, works following guidelines given by the Ministry of Economic Development.
- GSE is a publicly owned company that plays a central role in the promotion and development of renewable energy sources in Italy, including through the provision of economic incentives. GSE implements policy-incentive mechanisms, qualification of plants powered by renewable energy, plant inspections, and forecasting and monitoring of the power fed into the grid. and
- GSE established three other public companies that supplement its activities (GME[26,] AU[27,] RSE[28]), all having responsibilities of public interest in the energy sector.

Finally, there is TERNA, a joint-stock company owning the Italian national transmission grid for high and extra-high voltage power. TERNA, with a few exceptions, has the monopoly granted by governmental concession as transmission system operator (TSO).

The most visible private players are retail suppliers that usually also own distribution companies (DSOs). Among 410 active retailers in Italy, the market is dominated by ENEL, Edison, HERA, and ENI[29]. The top three cover about 50% of overall sales (Koltunov, 2019), and the biggest, namely ENEL, has been a public body since 1992[30.] Several new ECs signed agreements with retailers for energy delivery to the ECs' members on beneficial terms, allowing rebates for energy bills and a certified supply of 100% renewable energy (Koltunov, 2019). For instance, EC Energia Positiva (see section 1.3.2) signed an agreement with Dolomiti Energia. Del Pizzo et al. (2022) addresses in detail the Italian perspectives of DSOs' integration with energy communities. Another remarkable private player for many Italian new ECs is the cooperative bank "Banca Popolare Etica" that, in accordance with its ethical-finance principles, funded the installation of several generation plants.

A unique regional player with whom South Tyrolean alpine ECs tightly cooperates is SEV[31,] a "cooperative of cooperatives" having more than 300 members encompassing energy cooperatives, grid operators, municipalities, producers, etc. SEV acts as a service provider for all members belonging to a specific geopolitical context, including historical ECs but also some new ones (Koltunov, 2019), by taking care of activities such as lobbying, billing, provision of technical systems for grid operation, and trading (SEV, 2019).

For new ECs, private companies providing technical and managerial solutions for shared energy, smart grids, and energy efficiency are important market factors influencing their development opportunities. An example is the Italian company Regalgrid Srl, which created a platform for energy monitoring and sharing that enables the inclusion of consumers and prosumers into a smart grid of interconnected (Moroni, Antoniucci, et al., 2019), turning them into prosumagers (Sioshansi, 2020). Such companies are expected to flourish with the transposition of EU Directives (IEM, 2019a; RED-II, 2018) to Italian law, which

[25] Gestore dei Servizi Energetici
[26] Gestore dei Mercati Energetici
[27] Acquirente Unico
[28] Ricerca sul sistema energetico—Public research institution on the energy systems
[29] Data source: Annual report of ARERA 2018

[30] Today, 23% of the company's shares are owned by government
[31] South Tyrolean Energy Association

partially started in 2020 with the “Milleproroghe” and “Relaunch” decrees[32], as they technically enable what the new legislation allows. In fact, the Ministry of Economic Development currently promotes ECs organized around a block of flats or buildings connected to the same substation, pursuing a collective self-consumption scheme. New laws also increase the role of local authorities in joining citizen-led initiatives or acting as initiators, thus opening the energy market to new actors. An example of such an innovative approach is provided by the small municipality of Magliano Alpi, in the alpine area belonging to the Province of Cuneo in the Piedmont Region, which is an EC founder and simultaneously a member. After the successful launch of this local pioneering initiative, the mayor announced the intention to expand the model also to neighboring municipalities (Matalucci, 2021). Several other municipalities in the Piedmont region declared their interest in establishing ECs, and actors from the municipality of Pinerolo in the Province of Turin and Valle Maira in the Province of Cuneo are currently carrying their two EC projects forward. Such fertile ground was prepared by the local regulatory framework: Piedmont was the first Italian region to transpose the EU Directive RED-II into the regional law 12/2018.

The main civil society actors that urged the Italian government to implement the EU Directive RED-II were NGOs ITALIASOLARE and Legambiente (Magnani & Cittati, 2021). Moreover, environmental NGO “Legambiente” even established the “Renewable Municipalities Association”. Looking at the academic or national research centers engaged in such ambitions, the most prominent example is the RSE endeavors, active since 2018 (Zulianello et al., 2020). Also, the Energy Center Lab of the Polytechnic University of Turin recently started to realize projects in this field, not only from a theoretical perspective but also by becoming involved as the technical coordinator of the EC in Magliano Alpi (Energia Positiva, 2018).

As shown in Table 7, and explained in the following paragraphs, several policy schemes are benefiting ECs. a few of them are explicitly designed to sustain new ECs (e.g., the latest FiT dedicated to ECs), while others are anchored to specific renewable energy systems or investments, thus applicable to old or new ECs according to specific and detailed criteria.

[32] Milleproroghe decree (Law 8/2020) and Relaunch decree (16 September 2020)

Table 7. Summary of policy schemes benefiting ECs in Italy[33]

Incentive scheme	Year of use	Type of EC benefiting	Level of actual benefiting
FiT (ECs' incentive tariff)	2020-ongoing	New ECs	Expected High
IRPEF (income tax) rebate for installed rooftop PV during renovation (Eco-Bonus - Superbonus)	2007-2020-ongoing	New ECs	Expected High
System costs exemption	2008-ongoing	Historical ECs	High
Exemption from unbundling	2016-ongoing	Historical ECs	High
Simplified energy sale and purchase regime (ritiro dedicato)	2007-ongoing	Historical and new ECs	High
IRPEF (income tax) rebate for innovative start-ups	2017-ongoing	New ECs	High
FiT (Conto Energia)	2005-2013	Historical and new ECs	High
FiT (Tariffa onnicomprensiva*)	2007-2016	Historical and new ECs	High
Green certificates	2002-2016	Historical and new ECs	High
Environmental regulations on manure	2001-ongoing	New ECs in South Tyrol	Low
FiP (GRIN)	2016-ongoing	Historical and new ECs	Low
Exemption of non-household users from the state tax on electricity	No data-ongoing	Historical and new ECs	Low
Exemption from the carbon tax on heat energy	2000-ongoing	Historical and new ECs	Low
* The difference with the Conto Energia is that this incentive applies only to the small plants with capacity less than 1 MW (200 kW for wind farms) and for 15 years whereas Conto Energia for 20 years			

Recent Italian regulation[34] allows energy sharing under two configurations of "jointly acting self-consumers" and "renewable energy communities", simplifying the joint management of plants up to 200 kWp. The first configuration requires all the participants (at least two) to be in the same building, while the second requires connection to the same low-voltage transformer substation. This paves the way for the emergence of what Moroni et al. (2019) call "place-based" ECs, which are communities composed by members belonging to a specific place, similar to the French type 1 "citizen PV clusters".

In addition, this regulation awards the ECs with a 20-year incentive of 11c€/kWh for self-produced and immediately used or stored energy and grants 5 cent€/kWh to the self-produced energy sent to the grid[35].

[33] Koltunov (2019), updated to the year 2021

[34] The already mentioned "Milleproroghe" and "Rilancio" decrees.

[35] The "Rilancio" decree increases the previous "eco-bonus" income tax rebate from 50% to a "super bonus" of 110%, allowing homeowners to compensate expenses related to PV and storage systems installation through a tax credit of 110% within five years (up to 48,000€ of investment). This credit may be also transferred to a financial institution in exchange for cash or to the construction company doing the installation, by receiving a discount of 100% of the full cost (Bisello, 2020).

With the average cost for domestic end-users in Italy, which in 2020 stands around 21.5 c€/kWh, new incentive tariffs for ECs allow a considerable rebate, «cash-back», in the electricity bills of its members. Development perspectives of such place-based ECs in the Italian context are also described in Lo Schiavo et al. (2021) and Del Pizzo et al (2022).

The "green certificates mechanism" is based on the mandatory rule introduced in 2002 by the Italian Government under which all producers and importers of electricity must annually ensure an increasing minimum share of electricity in the grid produced by RES. Although this mechanism was terminated in 2016, some energy producers still benefit from their sale on the market or to the GSE because green certificates can be traded and used for 20 years from the date of issue. A similar situation applies to power plants built before 2013 (termination of FiT called "Conto Energia") but still receiving the FiT incentive. For example, Energia Positiva, WeForGreen, and Ènostra ECs benefit from such incentives because most of their plants were acquired on the secondary market (Candelise & Ruggieri, 2020. Koltunov, 2019).

Regarding the historical ECs, the state government granted them an exemption from the system costs component in the members' final bills in 2008, as well as an exemption from the state tax on electricity component but only for non-household members. Also, in 2016–2017, a policy granted an exemption from the unbundling requirement for the companies supplying less than 25,000 points of delivery. Historical ECs meet that condition. Both the exemption from the system costs component and the exemption from the unbundling make historical ECs activities feasible and advantageous for their members (Koltunov, 2019). On the contrary, members of those new ECs recognized by law as innovative start-ups can benefit from an income tax rebate equal to 50% of their investment in shares.

Assuming the same calculation metrics used in subsection on France, the result was that 76 Italian ECs, having more than 47,000 citizens in 2020 as members, produced electricity and thermal energy equivalent to the electricity consumption of more than 420,000[36] people and heat for 64,000 people. This means that members number roughly twice as many in Italy as in France, while the electricity generation is just over half and the thermal energy production is almost fivefold which is therefore a quite different development with a more fragmented ownership structure and a preference for thermal energy.

Termination of previous FiTs has suspended EC deployment in Italy in recent years (Candelise & Ruggieri, 2020). With the transitional provision of EU Directive RED-II in June 2021, Italy hopes to revitalize the sector and engage new players, especially in electricity generation and sharing.

2.3.3 Benefits of energy communities: case studies from France and Italy

Three representative ECs are highlighted below focusing on the business model of each followed by an examination of the factors that influence the benefits. These case studies, one French and two Italian, offer heterogeneous business models, and were chosen to see if different business models, shaped by unique institutional and policy settings, lead to similar or different benefits for EC members. Examining these varied setups allows us to directly explore how differences in context and policy impact the benefits members receive. This approach also enables us to clearly distinguish and contrast the roles of different institutions and policies in shaping the outcomes.

VercorSoleiL (France)

VercorSoleiL is a simplified joint-stock company founded in 2015 by 17 inhabitants from the "Communauté de commune Royans-Vercors"[37] in France, belonging to the Centrales Villageoises network. The original motivation of its members was to manage private funds, contracts, incentives, and

[36] Three historical ECs are excluded due to the unavailability of data

[37] Community of Municipalities of Vercors – Regional public institution that is responsible for the regional planning and cross-municipal economic development

bank loans for a viable energy plan. From 2015 to 2020, the company installed 25 PV plants on public and private housing, reaching energy production of around 300MWh / year and investing more than 800,000€ . In 2020, it also implemented an electric car-sharing service[38].

Today, the company has 124 shareholders and follows the "one person–one vote" rule without any limitation on the number of shares that each member decides to acquire. In addition, the "Communauté de commune Royans-Vercors" became the company's principal shareholder, whose role has been fundamental in boosting the activity in an early stage.

VercorSoleiL benefits from the FiT (Tarif d´achat) selling its energy to EDF and Enercoop. It also benefits from regional government support. Since 2017 Auvergne Rhône Alpes Region has awarded VercorSoleiL 52,700€, which corresponds to 6.6% of total investment in PV plants.

The main motivation for shareholders to join VercorSoleiL is to participate in the community energy transition rather than financial profit. The business model does not grant dividends or rebates in final bills (see also (Archyde, 2019)). However, for the individuals, joining VercorSoleiL means benefiting from being morally engaged in the energy transition. During the meetings, members frequently discuss new ideas on mobility, wind, and micro-hydro energy projects for their communities. In addition, the company boasts a good reputation among the local community and is promoted by local and national newspapers, which are often interested in presenting VercorSoleiL's projects. In turn, a sense of belonging to the community and doing the right thing are the main rewards for members.

Currently, VercorSoleiL intends to secure the energy autonomy of its remote territory by strengthening its renewable energy production. For this reason, its principal goals for the next 20 years are to preserve the existing installations, while investing in further renewable plants, and to encourage a sustainable lifestyle among citizens.

E-Werk Prad (Italy)

E-Werk Prad (EWP) is a historical cooperative in the Italian Alps founded in 1926, a member in turn of the previously mentioned SEV. EWP owns four hydropower plants with a total capacity of 4 MW. two biomass district heating plants with 9 MW of thermal and electric power. a 100 kW PV plant. electricity, heat, and broadband Internet distribution systems. two e-mobility charging stations. and one shared e-car in the small municipality of Prato allo Stelvio (around 3,500 inhabitants). EWP´s 1,442 members constitute the majority of local families, and the cooperative fully covers the energy needs of its members from April to November, also exporting any excess outside of the municipality[39]. From December to March, EWP purchases energy on the market to cover the community's consumption because hydropower stations produce less energy during winter months (Koltunov & Bisello, 2021). However, a recent research agreement between EWP and RSE has enabled experimenting to determine whether EC could be self-sufficient, supplying its members with all their needs throughout the year with its own energy, and, for this goal, digital control systems and efficient energy storage systems are being tested.

Financially speaking, EWP benefits from various policy schemes, including an exemption from unbundling for historical cooperatives in Alpine regions, system costs exemption, simplified energy sales, and a purchase regime. Because of these advantages, EWP can offer its members electricity and heat at lower prices than external suppliers' offers. Tables 10, 11, and 12 illustrate the economic benefits that EC brings to the community.

[38] The section summarizes the interview conducted by the authors with Francis Tasset (co-founder and shareholder of VercorSoleiL) in May 2021, to which we express our gratitude for the collaboration.

[39] Some community citizens are not members of the EWP because they are big consumers or engage in industrial activities. They cannot join the EC because their inclusion will increase the energy bills for the rest of the members and due to the resulting lower self-sufficiency.

Table 8. Electricity cost reduction to the members comparing to non-members[40]

Variable	Members	Non-members	Savings for members
Households			
Price, c€/kWh	17.39	21.35	3.96
Annual expenditure per one HH, €	422	519	97.3
Annual expenditure per community, €	608,329	750,742	142,413
Non-Households (industrial and commercial consumers, farmers)			
Price, c€/kWh	13.86	20.75	6.89
Annual expenditure per community, €	1,688,897	2,528,471	899,574
Public lightening			
Price, c€/kWh	12.52	19.01	6.49
Annual expenditure per community, €	26,058	39,566	13,507
Total, €	2,322,284	3,318,729	995,494

Table 9. Heating cost reduction to the members compared to the equivalent for oil-based generation[41]

Variable	Members	Equivalent for oil-based generation	Savings for members
Households			
Price, c€/kWh	9.53	16.1	6.57
Non-Households (industrial and commercial consumers, farmers)			
Price, c€/kWh	8.66	11.7	3.04
Total, €	-	-	589,145

Table 10. The cumulative economic benefit to the community in 2018[42]

Variable	Economic benefit, €
Electricity bill reduction	995,494
Heat bill reduction	589,145
Broadband Internet bill reduction	27,853
Employees' salaries & social security contribution (10 employees)	501,672
Payments to local contractors	517,425
Own profit reinvested in future energy projects	355,038
Total	2,986,627

Moreover, EWP assisted the local biogas cooperative in the construction of its plant, adding more social and environmental long-term benefits to the community (Koltunov, 2019). Other important benefits not yet translated into a monetary value for the community are the e-car sharing services and the bicycle-route network that EWP developed alongside the pipelines, both contributing to sustainable local mobility. In the future, besides experimenting to become self-sufficient by innovative solutions, EWP plans also to build a new 3 MW power plant in cooperation with a neighboring community. In 2020, EWP green energy provided an environmental benefit by avoiding 13,409 tons of CO_2, emissions in the electricity and heat sectors, in comparison to oil-based equivalents.

[40] Based on data from EWP (2018)
[41] Data from EWP (2018).
[42] Based on data from EWP (2018)

Energia Positiva (Italy)

Energia Positiva was founded in 2015 in Torino, Italy, and since then has achieved rapid growth in its business model. In 2018, 231 members owned 16 plants, whereas, in 2021, 580 members owned 25 plants. Most of the plants utilize solar energy with small hydro and wind plants added to EC's generation. six energy-saving projects are also managed by the EC. According to the conceptual framework of Moroni et al. (2019), it can be classified as a "non-place based community of interest" because members and plants are distributed all over Italy, and online crowdfunding campaigns to raise capital or acquiring existing plants are open to anyone looking for a financial return. Energia Positiva offers each member a rebate on the energy bill, up to its zeroing. This happens by discounting the economic return generated by a virtual renewable energy plant. The size and production of each virtual plant are directly related to the investment of the single member, who subscribes shares of real plants located in various places (Koltunov & Bisello, 2021). This type of bill rebate is possible due to the agreement signed with energy supplier Dolomiti Energia, which sells 100% green electricity to Energia Positiva's members.

The cooperative profits from three policy tools: IRPEF tax credit as an innovative start-up. a simplified energy sale/purchase regime. and the feed-in tariff related to plants acquired on the secondary market (therefore, still included in the "Conto Energia" although no longer available for new plants installed after 2013) (Koltunov & Bisello, 2021).

As illustrated in Table 11, the greatest economic benefit for members comes from the IPREF tax credit scheme.

Table 11. Economic benefit for members of Energia Positiva[43]

Variable	Economic benefit			
The **estimated** annual benefit for 1 member				
Number of shares	1	6	13	21
Cost of shares, €	500	3,000	6,500	10,500
Bill reduction annual	5%	30%	60%	100%
Average electricity expenditures per HH, €	525	525	525	525
Savings due to the bill reduction, €	26.25	150	325	525
Savings due to the 30% IRPEF tax annual credit, €	150	900	1,950	3,150
Total benefit for 1 member, €	176.25	1,050	2,275	3,675
Benefit for all members in 2019				
Number of shares in 2019	9,839			
Cost of shares, €	4,919,500			
Number of members	413			
The average number of shares acquired	23.8			
Production of electricity by EC, kWh	1,554,500			
EC revenue, €	322,453			
Members' consumption of electricity, kWh	614,000			
Members' consumption of heat, m^3	113,000			
Members' electricity bill expenditures, €	188,488			
Savings due to the bill reduction, €	149,003.5			
Actual bill reduction	79.1%			
Savings from IRPEF tax annual credit (30% in 2019), €	1,475,850			
Total benefit, €	1,624,853			

[43] Based on data from Energia Positiva (Gastaldo, 2019)

Actually, the cooperative "EPCO", the acronym for an "energy prosumer company", a spinoff from Energia Positiva, extends the opening of this business model to small companies, shops, or free-lance professionals that intend to reduce their bill, becoming a clean energy producer and profiting from a green status (Koltunov, 2019). In addition, direct supply from owned plans to members becomes possible due to the recent Italian policy updates, making the business model even more sustainable and profitable (Gastaldo, 2020).

The three cases just investigated are evidence of ECs' welfare enhancement for its members and communities. Place-based ECs, like VercorSoleiL and E-Werk Prad, enhance considerably the social and environmental welfare of local communities, and are built on a sense of common belonging to a specific area, whereas ECs with the geographically distributed membership and ubiquity generation facilities, like Energia Positiva, aim to contribute to economic welfare, while leveraging digitalization and innovation.

2.3.4 Insights from French and Italian energy communities

This section synthesizes the main findings related to the analysis of the French and Italian case studies, looking at the interconnections among policy context, market context, civil society, and academia and their roles in ECs' deployment process. Through the analysis of these elements, the authors draw the conclusion about what influences more the welfare-enhancing capacity of ECs. Analogies and difference are discussed in view of the main benefits brought by the ECs. Finally, some insights are provided to the reader, addressing possible paths for the institutional and policy contexts, to contribute to the further development of ECs.

According to Vernay and Sebi (2020), a good ecosystem for the energy transition develops where a single key actor is not favored. In France, a single prioritized institution, EDF, exists, but at the same time, a decisive factor under the French sector's rapid growth is the flourishing of regional associations, ranging from EPA to the Centrales Villageoises network. As for Italy, the policy does not prioritize a specific keystone actor, and there is still a lack of an intermediate level, providing both practical knowledge and technical or managerial services to small size EC, neither sustaining initiative taking the first steps. There are only a few regional capacity builders today in Italy—SEV is unique—while in France, they exist in each region, acting as one-stop shops. In the case of regime-based public organizations acting as intermediaries, a higher levels of trust from citizens could be achieved (Boyle et al., 2021). Beyond the specialized entities, DSOs could also become regional capacity builders of Italian ECs, in the future, as suggested by Del Pizzo et al. (2022).

On the other hand, the French energy sector is still homogenous with a pivotal role played by the monopolist EDF. The Italian energy sector is more heterogeneous, having plenty of market players, and most Italian ECs are historical cooperatives in the Alps.

But, the current experience show that even traditional cooperatives could be potential initiator of new ECs according to the evolution of the legal framework and available technologies. Even though the ECs' movement in Italy is less developed than in France, the number of single citizen members is remarkably high. This may create better general prospects for ECs' deployment, letting people choose not only among business oriented players, but including in the choice options totally different value propositions (Casalicchio et al., 2021). The role of investors sensible to ethical finance is also expected to grow, given the general increase of interest in environmental, social and governance (ESG) ratings of the portfolios and investment options (Agrawal & Hockerts, 2021).

The authors want also to underline the crucial role of the state in unlocking and sustaining the initial investments for the energy transition. Designing supportive policies, especially financial, is of the utmost importance until such a phenomenon as ECs reaches its maturity. After this happens, the sector will follow the usual product life cycle and should be able to sustain itself without subsidies from the government, finding a clear and favorable legislative framework. The recent growth of the number of ECs in France happened due to the "participatory bonus" scheme, which in turn allowed diversification of business models of prominent civil society actors such as EPA and the Central Villages. On the contrary, due to the termination of many supportive policies in Italy, only 11 new ECs exist today, and the recent decline shown by France can be similarly related to the continued uncertainty of the previously mentioned bonus, which is dreaded by the Directorate-General for Competition of the European Commission. It is hoped that this could be outweighed by the removal of some legal obstacles for setting up ECs (D'energie Partagee Cooperative, 2019) done by the energy transition law, making future sector growth less reliant on the availability of financial policy incentives.

Actually, the initial transposition of EU Directives into Italian law is creating new opportunities thanks to allowing energy sharing and collective self-consumption, and it is still facing the uncertainties of the transitional phase. In France, the transposition of EU Directives will probably benefit diverse business models because it is strongly lobbied by the French ECs' associations.

As argued in the research of Heldeweg and Saintier (2020), a just energy transition, to which ECs can contribute, will be more efficiently achieved through a new united sociolegal environment, where various elements cooperate rather than through separate state, market, and the civil society's legal environments. Such a cooperation should induce more educated behaviors by public players, academia, and private and tertiary actors, as suggested by the helix model developed by Carayannis and Campbell (2009; 2010), where the know-how developed by each helix adds to the knowledge circulation, thus enhancing innovation and welfare-enhancing capacity.

2.3.5 Conclusions

Differences in the historical and contemporary framework conditions in France and in Italy have generated different developmental paths, leading to specific forms of ECs. Thus, more than the clear predominance of the sate on market forces (or vice versa), it is a good combination of both, which positively influences the welfare-enhancing capacity of ECs. A well-designed policy system and the plurality of market players are the keys. Further advancement in ECs deployment will again relate to the evolution of the system, which is expected, consisting of: the termination of financial incentives because of technological maturity. alignment of the national legal framework to the requirements of the ECs, according to the EU directives. and hybridization between ECs and energy utilities to intercept a new market sector paying more attention to social and environmental impacts.

In the three case studies, despite very different operational structures, the energy communities deliver considerable welfare gains for the members, although not equally distributed across the various sectors (economic, social, and environmental). Direct economic benefits are more evident in the Italian case studies, while, in the French example, it is the sense of belonging and the proactive contribution to local sustainable economic development that are the main levers to action. To what extent ECs bring gains to non-members and other local stakeholders is still a question to be investigated. Their business models will probably evolve over time, reflecting the interplay between market and policy, with the deployment of decentralized energy playing an important part due to political impetus from the EU.

Concerning the question on how the institutional and policy context should evolve, it is expected that enriching knowledge circulation and the development across states, markets, civil societies and even academia will benefit ECs' deployment and welfare-enhancing capacity—thus, coordination and collaboration are of paramount importance.

Based on the main insights for the sector deployment drawn from the country profiles and case studies presented in the section, the suggested direction for future action is following. First, ensuring and adequate state support for the EC's development. EU Member States need elaborate policy tools suitable for the sustainable evolution of the sector according to their different legal and institutional environments. The level of state support through financial instruments should be ensured until the sector reaches its maturity. Second, develop measures to create and support regional capacity-builders, also acting as local one-stop shops. They may be of various types: from regime-based public organizations to institutions that are dedicated to promoting ECs, such as EPA and SEV. Third, allow ECs evolution by testing various business models, tailored to ensure a fair distribution of benefits for every member, and to local communities. This experimentation will permit ecosystem heterogeneity (with multiple key actors) that in turn will speed up the evolution of ECs' business models and consequently the deployment of renewable energy. Fourth, enhance knowledge of multiple potential benefits of ECs, their positive contribution to SDGs' achievement and overall alignment to ESG criteria. Markets may be more important than policies in driving the sector if the profitability assessments of new projects align closely with the sustainable and circular economy paradigms, thereby fostering an impact investing approach.

Chapter III. Economic and Financing Aspects of Energy Communities in Italy

3.1 Introduction

As of December 2024, there are 325 ECs in Italy, of which 93[44] are ECs that do not align with Legislative Decree (*Decree Law 199*, 2021) and 232 are those new entities that align with it. Out of 93 non-aligning ECs 65 are historical energy cooperatives in Alpine Arc of Italy and 28 are energy communities that emerged after liberalization of the energy market in the EU. Latter mostly grew into established business models, many of which became what De Vidovich et.al. (2023) call "sector-builders" or "EC-builder", ECs that spin-off other ECs themselves and often provide retail sales thus transforming into a small energy utility themselves albeit of a cooperative origin. Prominent examples are ForGreen, E'Nostra, Energia Positiva, etc. Out of 232 new ECs there are 61[45] JARSCs and 171[46] RECs in operational or design phases. New ECs are promoted by municipalities in 44% of all cases (Cuomo et al., 2023). This is unsurprisingly due to huge PNRR funds provided to public bodies and a social purpose of ECs. In 72% of new ECs photovoltaic technology of less than 100 kWp is used (2023, p. 41). However, not only municipalities are active in promoting a sector. Italian regulatory framework allows all possible stakeholders to join in an EC[47]. Many SMEs, NPOs, and even large companies are willing to step in the sector and occupy innovative niche. Indeed, ECs can be composed by individual households and even companies that opens window to creation of industrial ECs as well as enable a variety of different configurations of actors to group together, that have never been witnessed before in history of public utilities. A variety of consultancy and intermediary entities are going to emerge that will lead to a possibly more heterogenous ecosystem than it was witnessed before (Koltunov et al., 2022). Organizational abilities and entrepreneurial talent of Italian society can turn its momentum once again.

After Renewable Energy Directive (2018) and Electricity Market Directive (IEM, 2019a) were published by the EU, Italy started experimental phase of its transposition. Mileproroghe Decree (Law 8/2020) and ARERA (2022) guidelines provided 7 separate types of self-consumption configurations:

- Individual "remote" self-consumer of renewable energy who uses the distribution network
- Active "remote" consumer using the distribution network
- Individual "remote" self-consumer of renewable energy with a direct line
- Jointly acting renewable self-consumers (condominium)
- Jointly acting active consumers (condominium)
- Renewable energy community
- Citizen energy community

The definitions of "active consumers" and "citizen energy community" do not explicitly mandate the use of renewable energy sources (RES). Consequently, out of seven defined categories, only four are required to utilize RES: individual "remote" self-consumers of renewable energy who rely on the distribution network, individual "remote" self-consumers with a direct line, jointly acting renewable self-consumers, and renewable energy communities. Broadly, these categories can be grouped into remote individual consumers, condominiums, and energy communities. Six of the configuration types are allowed to benefit from the valorization of avoided grid usage, with the exception of individual "remote" self-consumers with a direct line. The introduction of a premium tariff for these configurations garnered significant

[44] Data source: Chapter II

[45] Data source: Cuomo et.al. (2023)

[46] Own database updated on 19.12.2024

[47] Only exception are private companies which participation in ECs "should not be a main commercial or industrial activity". This norm barricades purely business and financially minded entities from the sector.

attention from various societal stakeholders, ranging from traditional utilities to institutions such as the Catholic Church. Notably, only two configurations were granted a premium tariff for shared energy, and this tariff was limited to the duration of an experimental phase. As a result, the other five configuration types were neither planned for widespread deployment nor prominently discussed by industry actors at the time of writing this thesis. In light of this, only renewable energy communities and jointly acting renewable self-consumers are analyzed in the sections focusing on Italian experiences. For simplicity, both configurations are referred to as energy communities (ECs). where needed, we specify renewable energy communities as RECs and jointly acting renewable self-consumers as JARSCs.

JARSCs are referred to separate condominiums and RECs to groups of buildings connected to the same voltage substation. After a long authorization process by the EU, Legislative Decree (*Decree Law 199*, 2021) and CER Decreto (2023) were approved on 1 December 2023. With previous regulative instructions from ARERA (2022) and Technical Rules from GSE (2024) it ended up the process of establishing regulatory framework for ECs in Italy. These regulations changed the maximum allowed capacity of installations in one configuration from 200 KW in experimental phase to 1 MW in a final phase. Also, electrotechnical criterion was modified from medium/low voltage substation in experimental phase to high/medium voltage substation in the final phase. New electrotechnical criterion enables to have approximately up to 10 000 members in one EC according to Del Pizzo et.al (2022). In addition, a greater geographical scope of buildings and standalone systems can now be connected to the separate configuration in the energy community. This was impossible during the experimental phase. Besides, GSE (2024) clarified that an energy community can now be established as a legal form within boundaries of an electricity trading market zone[48], that opened a possibility to exploit economies of scale from the management perspective. It should be emphasized that even an EC could theoretically include all subjects within a single electricity zone, a configuration is restricted to the same high/medium voltage substation.

The economic sections of this chapter address organizational models and incentives of Italian energy communities and how they may influence welfare of the market. To explore this, Section 3.2.2 examines academic literature on the effects of different business models of energy communities on the market agents: DSOs, retailers, generators, non-members consumers, aggregators. Section ends with description of the impact of ECs on the elements of the whole system, and limitations of the analysis. The theoretical analysis is conducted to position new Italian ECs within the framework later in Section 3.2.2. Clarifying the economic aspects of this emerging market phenomenon allows us to approach the following financing section with the clearer perspective.

In previous chapter, we revealed that state incentives such as green tariffs, premium tariffs, and quota obligations are acknowledged as key drivers behind ECs successful deployment covering operational expenditures. In the previous decade, these were the primary sources of cashable financial flow for ECs and continue to hold that position today. In line with the broader goal of enhancing public policy efficiency, subsidies to large-scale renewable energy installations in the EU are being phased out. Consequently, the distributed renewable energy sector, including its subset - ECs, are anticipated to receive subsidies only until they reach maturity. However, studies indicate that without government support, the current RECs could barely survive (Braunholtz-Speight et al., 2020; Brummer, 2018a; Klagge et al., 2016). Over the medium to long term, policy subsidies are expected to disappear, leaving ECs to compete solely with market forces. Regrettably, their deployment and sustainability could be jeopardized due to the often limited "economy of scale". Therefore, private investors with an interest in green and ethical finance could help facilitate the smooth scaling up of ECs in the medium to long term. In the financing section of this chapter, we examine only the initial financing needs, which include consultancy and feasibility studies, establishing the legal entity, and purchasing physical infrastructure such as PV panels. For simplicity, we refer to these initial financing requirements as CAPEX financing. In Section 3.2, we seek to answer research questions such as:

[48] There are 7 market zones in Italy starting from 2021

- What are the financing actors, instruments, recipients?
- What do EC-builders and promoters do and how?
- What are the economic and ESG expectations of financing and building actors about ECs?

Throughout Section 3.2.2 and 3.3.2 we analyze energy community according to a broader definition given by the EU Directives (IEM, 2019a; RED-II, 2018), because it is more suitable for the purpose of investigating European-wide academic and gray literature. To our best knowledge, Italian literature on financing and economic aspects exist only for old ECs and of a very limited scope, and for the new ECs have not yet been developed. Therefore, we use definition of ECs provided by Italian legislation (*Decree Law 199*, 2021) exclusively in Sections 3.2.2, 3.3.3, and 3.3.4.

3.2 Theoretical analysis of impact of energy communities on the system welfare

3.2.2 Impact of ECs deployment on the other market agents

Analyzing the benefits and drawbacks of various business models (BMs) is valuable for integrating energy communities into the policies of different states. In this section, we build on the findings from Chapter II, Section 2.2, where existing literature on EC classifications was examined. We begin by proposing eight business models for energy communities and outlining their main features. This is followed by a description of how each business model may influence market participants. Finally, we provide insights into the overall impact of ECs on the electricity system, highlighting that certain business models may be beneficial, while others could be detrimental. The results of this analysis are summarized in Table 12. In the final subsection, we discuss the limitations of this analysis.

The criteria used to outline business models (BMs) are based on Osterwalder & Pigneur (2010), as their approach aligns with the analytical objectives of this section. Osterwalder and Pigneur position product attributes and targeted customer segments at the core of business modeling. Accordingly, we developed EC business models using these criteria alongside existing empirical evidence. The first four BMs are widely implemented across Europe (see Chapter II) and beyond, while the latter four are still in early stages, with several pilot cases being tested in various countries.

- BM 1 "Traditional Cooperatives"

This BM includes two subsets: historical cooperatives and citizen cooperatives. Historical cooperatives are located in remote rural areas and own the distribution infrastructure that connects members to cooperative generation facilities. Sometimes, they are referred to as municipal utilities, although a municipal utility is a different setting since it is owned by a public administration and not by people. In turn, citizen cooperatives own a collective generation facility without owning a local grid.
Product attributes: RE electricity generated, non-RE electricity generated, own distribution grid, operation of distribution grid, own heat and broadband internet grid, consumption-related services, services related to the management of the cooperative, ability to reduce bills of the members, ability to direct earnings toward social common needs.
Customer segment: members, local non-member customers, retailers or industry which purchase energy through PPA, a state-owned company responsible for purchase from small-scale generators[49].

- BM 2 “Virtual Cooperatives”

They are cooperatives described in Chapter II as a community-of-interest, who crowdsource citizen funds and invest them into generation facilities throughout the country without attachment to the geographical location of its members. The example of such BM is Energia Positiva cooperative (see Section 2.2).
Product attributes: provision of a crowdsourcing service/platform to its members, RE generated by dispersed facilities which are usually purchased at a secondary market, distribution of dividends derived from electricity generated.
Customer segment: members of the cooperative, retailers or industry which purchase energy through PPA, a state-owned company responsible for purchase from small-scale generators.

- BM 3 "Community Collective Generation"

In this BM consumers can purchase PV and sometimes storage. The generated energy is self-consumed. The assets should be connected to the same substation therefore all members should live also in the proximity. Alternatively, PV can be placed on a roof of a condominium. The assets in most cases is a collective property, while individual members (citizens and/or private/public entities) continue to have

[49] In Italy, it is GSE

own retailers that take care of the residual demand. This business model is close to the one opted in Italy (see next section).
Product attributes: electricity self-consumed from a collective asset, electricity injected into the grid, virtual electricity sharing by members (if rewarded by regulator), management of a cooperative (if organized as cooperative), ability to direct earnings toward common social needs.
Customer segment: members of the community, a state-owned company responsible for purchase from small-scale generators, independent and utility aggregators (potentially).

- BM 4 "Third Party Sponsored Communities"

This BM is promoted by a retailer/ESCO which invests into the generation (storage) assets of the neighborhood and lease its power plant to members of the EC. Members self-consume energy from rented plant benefitting from a lower tariff that is set by retailer while assets remain in the property of a retailer/ESCO.
Product attributes: electricity self-consumed from a retailer owned asset, virtual electricity sharing by members (if rewarded by a regulator).
Customer segment: members of the community

- BM 5 "P2P trading"

Members of a peer-to-peer (P2P) trading scheme individually own the generating and storing assets that are connected to a digital platform. Individually produced electricity is traded within the community in a way that reflects peers' personal preferences (e.g., price, origin, destination of the energy). In this way, members of P2P schemes could gain economic advantage over the status quo without energy trading peer-to-peer. For instance, study by Castellini et.al. (2021) revealed that the highest economic benefit have the P2P schemes where the prosumers are characterized by excess supply and asymmetric and complementary load curves.
Product attributes: provision of digital infrastructure for trading.
Customer segment: members of the community that own generating and storing assets.

- BM 6 "Community ESCO"

"Main purpose is to assist members of the community in energy efficiency (EE) measures by providing technical support and facilitating access to finance and awareness campaigns. Groups with a primary purpose to tackle energy poverty belong to this BM.
Product attributes: provision of EE measures, technical and financial assistance, ability to provide awareness/educational services.
Customer segment: members that are vulnerable households.

- BM 7 "Community Aggregators"

Community aggregator virtually connects active consumers and prosumers selling their flexibility to the DSO. A key element in such energy community is a specific contract with a DSO for provision of flexibility services (e.g., dispatch or consumption). Alternatively, community aggregator could participate in the flexibility market where it exists. Flexibility markets are usually facilitated by the intermediary digital platforms such as Piclo in the UK.
Product attributes: provision of a contractual services, provision of a digital infrastructure for aggregation (possible).
Customer segment: members of the community that own automated appliances, DSOs.

- BM 8 "Eco-villages"

Eco-villages are the neighborhoods/districts where a distribution infrastructure have not existed priorly thus built from scratch in a form of a microgrid. Usually they are innovative neighborhoods/districts promoted by real estate firms or even separate settlements such as Red Sea Project in Saudi Arabia.
Product attributes: own microgrid, operation of microgrid, own internet system, RE electricity generated, consumption-related services.
Customer segment: citizens of the neighborhood.

Table 12. Map[50] of impact of ECs deployment on the other market agents

EC business model	Non-member consumers	DSOs	Retailers	Generators	Aggregators
Traditional cooperatives	red	red	yellow	red	green
Virtual cooperatives	red	red	yellow	red	yellow
Community collective generation	red/green	green	red	red	green
Third-party sponsored communities	red/green	green	green	red	green
P2P trading	red/green	green	red	red	green
Community ESCO	yellow	yellow	red	yellow	green
Community Aggregators	yellow	green	red	yellow	red
Eco-villages	yellow	yellow	red	red	yellow

Impact on DSOs

It is important to first clarify the role of DSOs within the electricity system and then explore the potential impact of ECs on their operations. Electricity possesses characteristics of a network good. The primary similarity is the interconnectedness of generators and end consumers through a common grid. Another similarity lies in value creation: a key attribute of a network good is that its value increases proportionally with the number of users. For instance, the value of a social media platform rises with an expanding subscriber base, making it difficult for newcomers with fewer users to succeed. This phenomenon is typical of a natural monopoly. Similarly, an investment in a highway will not pay off if it only connects to a small village with few residents. As discussed in Chapter II, the lack of external investors was a primary factor behind the emergence of historical energy cooperatives in Northern Italy.

When we're on a congested highway early in the morning, time becomes a costly resource. Similarly, congested electric lines increase costs for everyone—a type of network externality. Microeconomic theory suggests that the solution to such externalities is "internalization." In the EU, DSOs are private or sometimes municipal companies, so congestion externalities have already been partially internalized by the private sector. However, as regulated monopolies, DSOs do not always bear full entrepreneurial responsibility for their actions. They are allowed only a fixed revenue from which they derive a return on investment and a prudent margin. The real issue arises with the complexity of forecasting demand growth, where DSOs cannot precisely signal to regulators the costs they will incur in the next regulatory period. Yet, managing congestion and maintaining balance in the grid are among DSOs' core responsibilities. This creates a risk of insufficient return on grid reinforcements, potentially preventing DSOs from delivering quality service. The problem is likely to intensify with the anticipated rise in electrification and data center expansion. Stranded assets could lead to either low quality grid reinforcement or financial losses.

New business models, such as collective generation, third-party-sponsored communities, P2P, and community aggregators, still depend on grid connections to operate. Glachant (2021) emphasizes the necessity of these actors in the inevitable "delivery loop," which can limit their creativity in value proposition. The network demands of newly connected actors are prompting DSOs to evolve in ways that go beyond merely expanding their infrastructure. One potential solution is large-scale investment in network digitalization, but this raises additional questions: Who should bear the cost—the injection side or the withdrawal side? And to what extent? There is a risk that grid reinforcement costs could escalate and be distributed in an inefficient or inequitable manner.

[50] Legend: red – rather detrimental impact, green – rather positive impact, yellow – rather neutral impact, red/green – mixed positive and negative impacts

Responsible agents can address imbalance issues more cost-effectively at the local level, such as within a neighborhood or district. These responsible agents are, in fact, the final consumers themselves. Citizens equipped to handle these issues are known as prosumagers (prosumers with storage capabilities, such as batteries). Today, an energy community consists not of individual prosumagers but of a group of prosumers and consumers acting collectively. Collectively, such a group functions similarly to a prosumager, and over time, these groups could evolve into communities of prosumagers. Prosumagers can adjust their consumption profiles to align with grid requirements, reducing congestion management costs and mitigating frequency imbalances that gradually wear down equipment. In doing so, DSOs can lower future reinforcement costs. Additionally, if EC members continue to have a DS component on their bills, DSOs could benefit from lower costs while maintaining steady revenue.

The challenging aspects of integrating ECs were explored by Mendicino et.al. (2021) and Backe et al. (2022), who found that coordinating with multiple ECs and managing bidirectional energy flows can pose significant challenges for DSOs, necessitating new operational and planning strategies. However, we believe that the emergence of energy communities represents an opportunity for DSOs to innovate and improve cost efficiency. Grids have demonstrated adaptability to changing environments when regulation is well-designed, as illustrated by the successful integration of offshore generators in the UK (Glachant, 2021). MIT's Utility of the Future (2016) envisions a model where DSOs refrain from differentiating among "behind-the-meter" users based on individual characteristics, instead treating all injections and withdrawals equally, provided they are equivalent from a grid perspective. This approach would facilitate finer spatial and temporal granularity, enabling an efficient "distribution nodal price system" where grid revenues could be shared with agents that add value to the network. Such an evolution in DSOs' business models would allow energy communities and similar actors to flourish, creating mutual benefits.

Del Pizzo et al. (2022) highlight another important factor influencing DSO operations with the emergence of ECs: the geographical aspect tied to the proximity criterion set forth by the RED II Directive (2018). Del Pizzo et al. (2022) use Italy as an example. When ECs are organized based on an "electrotechnical criterion," meaning connection to the same substation, they can either complicate or facilitate DSO operations. For instance, ECs connected to the same MV/LV substation can pose challenges, while those linked to the same HV/MV substation can be beneficial. The authors note that Italy has approximately 480,000 MV/LV substations, each serving an average of 70 clients, making ECs relatively small—typically around 70 households per EC. This creates a high number of small ECs, potentially lacking sufficient management capacity, which complicates interactions with DSOs. In contrast, ECs connected to the same HV/MV substation can encompass about 10,000 members, offering a more manageable number and size of ECs for DSOs. When organized by "geographical criterion," such as around a municipality, EC membership can range dramatically, from 10 to as many as 850,000 members per EC, adding complexity to DSO interactions. Alternatively, organization by zip code yields ECs with roughly 1,000 members each, resulting in a reasonable number and size of ECs. A third approach to meet the proximity criterion is to use a geographical radius from a "center" (e.g., a generation plant or consumption point). In urban areas, a 1 km radius would typically include around 1,000 members.

Traditional and virtual energy cooperatives operate solely on the supply side, injecting energy into the grid and thereby contributing to congestion management and imbalance costs. Consequently, their deployment rather harms DSOs than benefits.

Impact on retailers

In Table 12, only the impacts of third-party-sponsored ECs on retailers are highlighted in green, as retailers typically serve as sponsors for this model, making it their preferred approach. Other business models that incorporate self-consumption or energy efficiency measures naturally reduce the volume a retailer can supply to EC members and are therefore seen as a potential threat. In contrast, traditional and virtual cooperatives simply inject energy into the grid, resulting in a neutral impact on retailers.

Forward-looking retailers can satisfy active consumers through innovative offerings. ECs consist of such active consumers, who act flexibly for both individual and community benefit. From this perspective, progressive utilities can enhance customer-centricity by providing technical expertise and financial support to ECs, thereby fostering demand elasticity and improving overall welfare. As discussed in the Introduction, retailers that prioritize common well-being over short-term profit may find themselves rewarded by the dynamics of "creative destruction."

Impact on conventional generators

The deployment of all business models, except for community aggregators and community ESCOs, poses a barrier to the expansion of conventional generators. The impact of ECs on conventional generators mirrors the broader impact of RES in general. Thus, ECs may also be seen by conventional generators as direct competitors. First, the deployment of ECs, particularly traditional and virtual cooperatives, reduces the volume of large-scale electricity supply needed in the wholesale market. Second, additional ECs contribute to the "cannibalization effect," similar to the impact of general RES deployment. This effect lowers wholesale prices due to the zero marginal cost of RES, which in turn extends the return on investment period for conventional generators. As a result, the business models of conventional generators are perturbed and can be fully destroyed (Joskow, 2019).

Impact on aggregators

Traditional cooperatives, community collective generation, third-party-sponsored ECs, P2P, and community ESCOs are advantageous for aggregators because they inherently perform a significant portion of the work that aggregators would otherwise need to handle independently. Once EC members are organized, aggregators can engage with their administrative bodies to offer additional aggregation services. However, depending on the specific context, coordination and data management between ECs and aggregators could present challenges (Backe et al., 2022).

In contrast, virtual cooperatives operate solely on the supply side, offering neither opportunities nor risks for aggregators. Eco-villages are typically fully self-sufficient and disconnected from the grid, making them generally irrelevant to aggregators. However, in cases where a microgrid is connected to the external grid (e.g., for emergency purposes), eco-villages could hold significant potential for aggregators. Lastly, the "Community ESCO" model naturally competes with both utility-owned and independent aggregators. The interaction between ECs and aggregators will depend heavily on future market dynamics, as both actors are relatively new players.

Impact on non-member consumers

Entrepreneurs in the electricity sector are unlikely to take risks without confidence in their investment returns. Ultimately, both the poor and successful decisions of all market participants will be reflected in the final consumer bill. We identify several specific features of ECs that impact non-member consumers.

Robinson & Guayo (2022) highlight the locational aspect of EC impact. Regions with existing over-supply do not benefit from additional generation, and the flawed placement of ECs that only inject energy—such as traditional and virtual cooperatives—into over-supplied areas can affect retail prices. These ECs are generally not charged for network usage when injecting energy, similar to distributed energy resources (DERs), where bi-directional flows at the distribution level can increase congestion management costs. However, DERs typically avoid grid usage fees, with network costs commonly socialized among end consumers. This structure enables EC members to benefit from revenue on injected energy without network fees, leaving non-members to bear an unfair surcharge. Only non-member consumers, priced by non-uniform tariffs, experience these changes, as their costs reflect direct dependencies on grid and market conditions.

An opposite scenario occurs with business models focused on self-consumption, such as community collective generation, third-party-sponsored communities, and P2P models. These models maximize self-consumption and avoid adding to over-supply in specific locations, thereby reducing network costs. They also limit additional consumption in areas with under-supply, avoiding the costs of transmission and distribution for transported energy. Furthermore, these ECs may provide flexibility services to the grid, reducing network costs for non-member consumers as well. Thus, the impact of these business models is marked as partially positive.

Another network-related impact, independent of location, arises in systems where network charges are fully volumetric rather than fixed. EC members (in community collective generation, third-party-sponsored, P2P, and community ESCO models) reduce their network fees by consuming less from the grid. Although fair in principle, as these members use the grid less, DSOs base their investments on anticipated grid usage, intending to recoup CAPEX through future network charges. EC deployment risks leaving DSOs unable to fully recover these investments, potentially resulting in stranded assets. More likely, these uncovered costs would be socialized among non-members. Consequently, EC members would pay less in volumetric network charges, while non-members would face increased fees, hence the partially negative impact.

Another factor that could negatively impact non-member consumers is the non-simultaneity effect, examined with respect to historical cooperatives and community aggregators. Historical cooperatives often own local distribution grids, purchasing only residual energy from external retailers and acting as intermediaries between members and retailers. A similar effect occurs in community aggregators, where members act as though they control a closed-loop grid. Non-simultaneity refers to the mismatch in timing between individual peak demands and simultaneous electricity transport needs. Robinson & Guayo (2022) illustrate this with an example: if 10 consumers each contract a 10 kW capacity-based network charge, the total contracted capacity would be 100 kW. However, due to non-simultaneity, regulation requires that the system only meet a combined demand of 75 kW, effectively overcharging consumers by 25 kW, which covers network costs. When consumers form an EC, they contract only for 75 kW, benefiting from the non-simultaneity effect and avoiding the 25 kW surcharge. The resulting reduced network cost for EC members shifts the financial burden onto non-members.

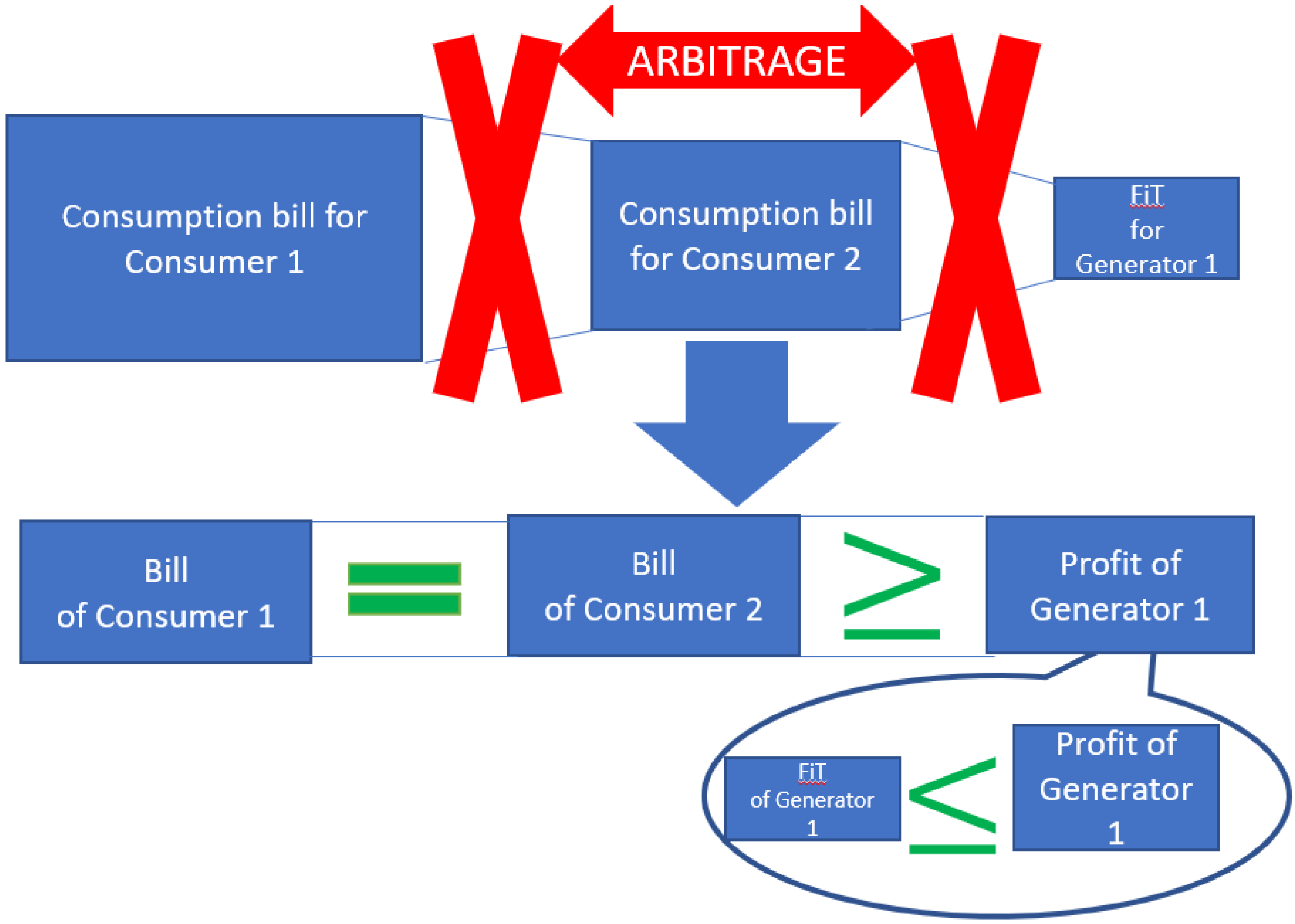
The community ESCO and eco-village models have a neutral impact on non-member consumers, as these models either lack collective generation facilities or, in the case of eco-villages, are not connected to the distribution grid.

Impact on overall system welfare

Another potential impact of EC deployment on the electricity market is the distortion of price signaling mechanisms, particularly through the elimination of non-uniform tariffs and prices—a concept explored by Biggar & Hesamsadeh (2022) and related to price arbitrage. This logic, illustrated in Figure 22, can be explained with the following example:

Suppose we initially have two separate Consumers and one Producer. The Consumers face very high monthly bills, while the Producer earns minimal revenue due to low market prices or a low feed-in tariff (FiT). After forming an EC, the Consumers gain the ability to purchase energy directly from the Producer at a negotiated rate, likely lower than their standard tariff. Meanwhile, the Producer can sell directly to Consumers at a price higher than the usual market rate or FiT. In this scenario, all EC members benefit: Consumers pay less, and the Producer earns more. Naturally, agents are inclined to form an EC if regulations allow. However, what is the system-wide effect of such price arbitrage? In systems where retail tariffs and FiTs were previously uniform or constant, the impact of new ECs would be minimal, as there were no market signals before the EC's formation. The opposite occurs in systems with non-uniform tariffs or variable pricing for small generators. In these cases, non-uniform locational tariffs, time-of-use tariffs, and wholesale variable pricing lose their effectiveness. EC members no longer respond to these signals as they would have before joining, distorting market mechanisms designed to optimize asset location and encourage demand response for peak shaving. As a result, the deployment of business models in which generators supply consumers behind the meter (either physically or virtually within the same distribution grid) could potentially harm the system. Such models include traditional cooperatives, third-party-sponsored communities, and community collective generation.

Figure 22. Arbitrage effect of energy communities



Limitations

Previously, we discussed how increased energy injection from ECs could negatively impact non-member consumers. However, this is a theoretical assumption that requires further empirical investigation. In light of this, we need to acknowledge the potential limitations of our analysis.

One limitation is the empirical phenomenon known as the "German Paradox." In Germany, the share of RES has increased dramatically over the past two decades. Contrary to expectations, balancing costs have not risen. instead, they have decreased by 30%. Hirth & Ziegenhagen (2015) attribute this to market design improvements, including enhanced imbalance settlement, joint reserve dimensioning, an improved intraday market design, cross-border imbalance netting, and refined balancing market pricing. This example demonstrates that increased renewable penetration does not necessarily lead to higher balancing costs.

Another limitation of our analysis is the assumption that local energy over-supply and under-supply are reflected at the wholesale level. This assumption holds only in systems with nodal pricing (such as in the U.S.) or at least zonal pricing (as seen in many EU Member States). Only in these systems could EC locations, when deployed at scale, directly influence market prices. In systems lacking this market granularity, the impact of ECs on prices would primarily affect balancing costs, which would not be directly reflected in energy prices. However, as illustrated by the "German Paradox," the effects of EC deployment on balancing costs remain challenging to predict.

A final assumption in our analysis is that system balancing through demand response is possible. This issue, however, is not yet fully regulated in the EU. The forthcoming Network Code on Demand Response (DR NC) is expected to address this and may open opportunities for ECs to offer flexibility services in the future.

3.2.2 Italian regulation: sharing, self-consumption, sales, subsidies.

MASE (2023) establishes incentive premium for the shared energy and a capital cost contribution that will be offered to ECs. Premium tariff of approximately 100-120 €/MWh of shared energy will be applied depending on a size of installation and a region. The tariff is promised for 20 years and will be granted only to installations that are commissioned before the end of 2027. Italy plans to spend 3,5 € billion for the premium tariff which will be financed by the revenues from the levy on electricity consumption (EC, 2023). Levies will be distributed equally among all electricity consumers. The tariff is accessible to all ECs, provided they do not collectively exceed a national cap of 5 GW of new renewable capacity. Capital costs can be covered up to 40% but only for small municipalities with populations of 5,000 or fewer. The capital cost contribution depends on installation size, with smaller installations eligible for reimbursement of up to €1,500/kW and larger ones up to €1,050/kW. Subsidies are available for both new installations and upgrades to existing assets joining an EC. In addition, CER Decree (MASE, 2023) outlines specific regional adjustments in PNRR funding with additional €4/MWh for ECs in central Italian regions. An extra €10/MWh are allocated for the northern regions, highlighting a higher funding rate aimed at incentivizing RE projects in these areas. The main regulatory motive behind this adjustment is to use market signals to encourage new installations in regions where energy demand is high and supply is insufficient. Italy will draw €2.2 billion from the National Recovery and Resilience Fund (PNRR) for this purpose. Reimbursement can be claimed only for plants commissioned before the end of June 2026, in accordance with internal PNRR guidelines.[51].

It is essential to clarify the concept of shared energy and the premium tariff designed to stimulate the sector. In Italian regulation, shared energy refers to the minimum amount between the total energy injected into the public grid by all EC members within a given hour and the total energy withdrawn (consumed) by all EC members within the same hour. This means that if consumption is higher in a particular hour, the amount of injected energy will be considered as shared energy. Conversely, if the injected energy is higher in a given hour, the amount of consumed energy will be counted as shared. The generalized formula (Lo Schiavo et al., 2022) for calculating shared energy is as follows:

$$E_{sh} = min_h \begin{cases} \sum_{i=1}^{n} Eout_{i,h} \\ \sum_{i=1}^{n} Ein_{i,h} \end{cases}$$

where
- E_{sh} is the shared energy
- $Eout_{i,h}$ is the energy withdrawn from the grid in a given hour h by the i-th member
- $Ein_{i,h}$ is the energy fed into the grid in a given hour h by the i-th member

Members of ECs will retain their existing electricity retailers, who will continue to supply electricity as before. Accordingly, EC members will pay their conventional bills to these retailers, unchanged by the installation of new assets. At the end of each month or year, a cashback is calculated by GSE based on several factors: the market payment for energy injected into the grid, the premium for shared energy, and the valuation of avoided grid usage through self-consumption. Administrative costs incurred by GSE are then deducted from this cashback. In this setup, the regulator keeps the conventional bill and cashback separate, in contrast to net-metering programs, where the amount of purchased energy is offset by the amount injected into the grid, regardless of the time of day. The cashback logics is given by ARERA (2022) and Technical Rules from GSE (2024). It is possible describe it with formula:

[51] PNRR is an Italian national fund that utilizes funds from EU Next Generation Fund Program, therefore guidelines of a former depend on those of a latter

$$Cashback = E_{inj}(P_{sell}) + E_{sh}(P_r) + V_{agus} - GSE_{costs}$$

where

- P_{sell} - price for which GSE is purchasing renewable energy from eligible subjects. Regulated by ARERA 280/07 and it is equivalent to "Prezzo Minimo Garantito" (PMG).
- P_r – premium tariff for shared energy
- V_{agus} - valorization of avoided grid usage due to self-consumption
- GSE_{costs} - administrative costs incurred by GSE relative to the management procedure related to cashback calculation and remuneration

It is critical to consider how distinct components of the cashback are calculated too. In fact, premium tariff itself is not a single value. Final premium tariff for an EC can be calculated via formula:

$$P_r = Fix + Var$$

Where

- Fix is fixed component of a premium tariff that according to CER Decreto stands at 60 – 80 €/MWh depending on the asset capacity. PV systems in central and northern Italy get an extra premium of 4 and 10 €/MWh respectively.
- Var is a variable component that can be expressed like $\max(0.180 - P_z)$ with P_z being the hourly zonal price of electricity

The valorization of avoided grid usage due to self-consumption includes two components: the reduction in grid costs due to self-consumption and the reduction in costs related to decreased grid losses from self-consumption. JARSCs are compensated for both components, whereas RECs receive compensation only for the first. This distinction arises because RECs still rely on the distribution grid for energy sharing, thereby incurring grid losses. In contrast, JARSCs operate within a single building where a common load (e.g., lighting, elevators, EV charging stations) directly consumes energy from rooftop installations, bypassing the distribution grid. The valorization of avoided grid usage for JARSCs and RECs can be calculated using the following formula:

$$V_{agus} = T + L$$

$$V_{agus} = T$$

Where

- T is reduction of grid costs due to self-consumption
- L is reduction of costs related to decreased grid losses due to self-consumption

Reduction of grid costs due to self-consumption (T) is calculated by formula (Lo Schiavo et al., 2022):

$$T = E_{sh} * (TRAS_E + \max(BTAU_m))$$

Where

- $TRAS_E$ is a sum of transmission tariff for LV household consumers,
- $BTAU_m$ is a distribution tariff for LV commercial and industrial consumers

Reduction of costs related to decreased grid losses due to self-consumption (L) is calculated by formula (Lo Schiavo et al., 2022):

$$L = \sum_{i,h}(E_{sh,i} * c_{agl} * P_z)$$

Where

- c_{agl} is a coefficient for avoided grid losses of the voltage level to which generator/s are connected (2.6% for generators in LV grid. 1.2% for generators in MV grid).

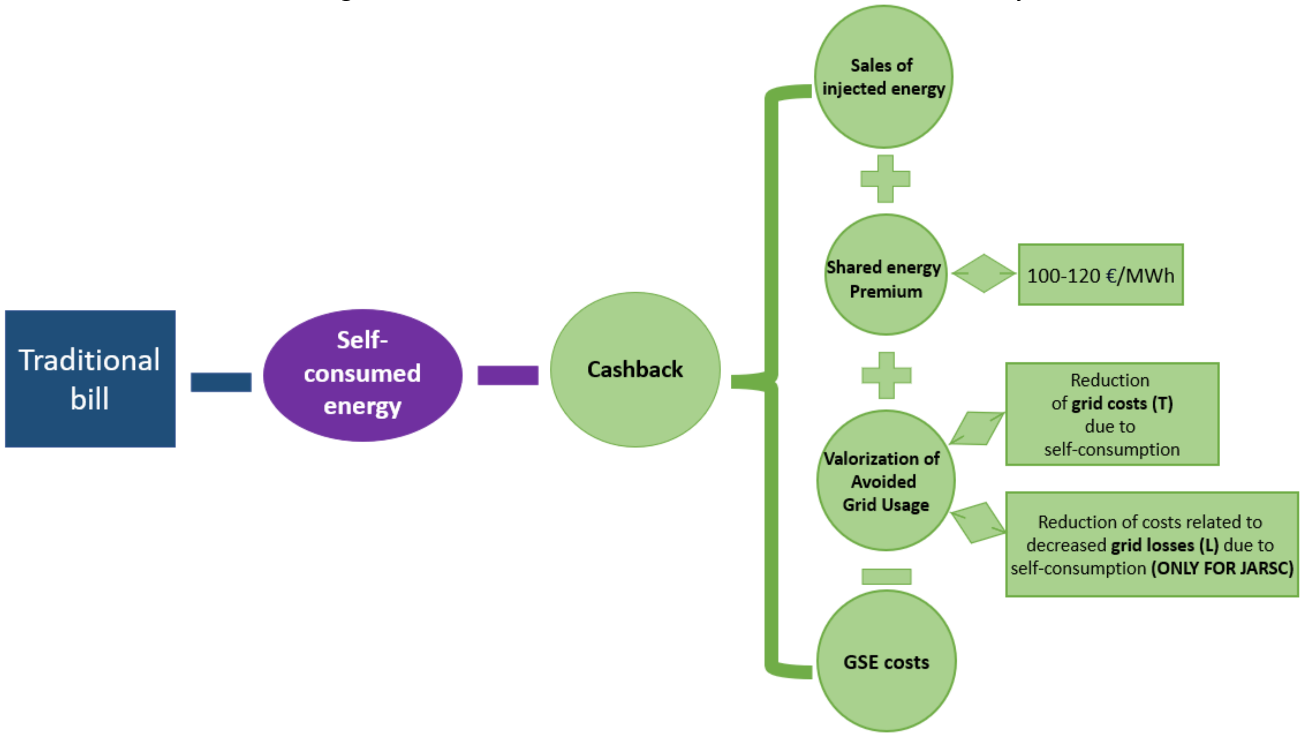
- P_z is the hourly zonal energy price of the day-ahead market

By identifying all components of the cashback, we can calculate the actual economic benefit for EC members, which includes savings derived from self-consumed energy. For JARSCs, these savings apply only to a common load when using a PV-battery system. In contrast, for RECs, prosumer members can directly self-consume energy from the PV-battery system, thereby reducing the amount of energy purchased from a retailer. The economic benefit is visually represented in Figure 23 and can be calculated using the following formula:

$$B = E_{sc}\left(P_{buy}\right) + [E_{inj}(P_{sell}) + E_{sh}(P_r) + V_{agus} - GSE_{costs}] \quad (8)$$

Where
- E_{sc} is an amount of self-consumed energy by common loads for JARSCs and by prosumers for EC
- P_{buy} is a retail price that a member of EC pays to it's retailer.

Figure 23. Economic benefit to members of ECs in Italy



The greatest economic benefit for EC members is anticipated to stem from savings through self-consumption. For instance, in November 2023, the average market price for a "typical consumer" in Italy was €443/MWh (Sostariffe.it, 2023). These high prices incentivize self-consumption and encourage individual battery storage installations. The larger the storage capacity, the more self-produced solar energy can be stored for later use. Similarly, the premium for shared energy implicitly aims to increase battery storage capacity. As the amounts of energy injected into the grid, $Ein_{i,h}$ and withdrawn from the grid $Eout_{i,h}$ converge, the shared energy—defined as the minimum of the two—naturally increases. PMG price P_{sell} for which GSE purchases renewable electricity injected into the grid was 44 €/MWh in 2023 (sorgenia.it, 2023), which is obviously lesser than a retail price for consumers, P_{buy}. Additionally, the valorization of avoided grid usage, V_{agus}, which also depends on shared energy, is not expected to yield substantial remuneration. For example, Assolombarda & RSE (2023) estimated it at €11.5/MWh, while Coletta & Pellegrino (2021) reported €8/MWh. Hence, V_{agus} will likely represent a smaller portion of the total economic benefit compared to other components:

- PMG price P_{sell} of 44 €/MWh
- Premium tariff P_r of 100-120 €/MWh

- Market price P_{buy} of 443 €/MWh.

We have examined the benefits to EC members, but what about the overall welfare impacts on the system? In the previous section we described theoretical factors associated with the deployment of energy communities that could benefit or potentially harm other agents and the system as a whole. The Italian incentive structure is designed to reduce costs for the existing system by encouraging ECs to self-consume, thus placing less demand on the public grid and reducing congestion. ECs are remunerated by premium tariff P_r, and valorization of avoided grid usage V_{agus}. These remuneration components, as outlined in formulas 1, 6, and 7, were carefully crafted by the Italian regulator to minimize market distortion. Nevertheless, it is stated in ARERA Resolution (2022, p. 18) that premium tariff P_r costs will be evenly distributed inside the renewable energy component of a final retail bill of consumers, implying that non-EC members will experience higher costs, which creates a cross-subsidization issue.

Differentiating JARSCs and RECs for V_{agus} calculations also prevent implicit incentives for RECs, which, unlike JARSCs, inject all their energy into the grid, incurring grid losses. This means fewer grid costs will be not recovered by DSOs and TSO thus they will not end up on retail bills of non-members. Another positive aspect of Italian regulation is that incentive structure indirectly encourages the installation of storage capacity, which in turn reduces future grid costs. Batteries enable smart devices to respond to price signals, promoting demand response and reducing grid stress, thereby decreasing the need for reinforcement.

While DERs may not achieve the same economies of scale as large RES, which could result in higher future system capital and management costs, an advantage of the Italian tariff arises when an EC invests in storage. This flexibility allows ECs to store renewable energy (RE) when demand is low and use or sell it when the marginal energy in the system is from fossil fuels, thereby contributing to system-wide emissions reduction (Robinson & del Guayo, 2022).

Italian tariff is region-variable with additional premium granted to Center and North, that is positive for the system too. When the new generation is injected into areas with already existent over-supply, such as in the South Italy, it causes a congestion with all subsequent implications. Whereas when it is injected into the areas with under-generation it reduces transportation costs needed to supply such areas.

A big difference exists between retail price for consumption P_{buy} and GSE selling price P_{sell}, 443 and 44 €/MWh respectively. It creates a temptation for consumers and prosumers to group in an EC to arbitrate (see previous section). Consumer in an EC will pay less due to the premium on shared energy and valorization of avoided grid usage V_{agus}. Prosumer in an EC will try to maximize self-consumption (because P_{buy} is high and P_{sell} is low) and sell less of 'cheap energy' to the public grid and instead use it for own needs and for the common load purposes like community e-vehicles charging. As a result, consumer consumes less of energy accounted for market price signals while prosumer sells less of energy accounted for market signals. Yet, Italy eliminates the wholesale price averaging system called 'PUN' in the beginning of 2025. Instead, regulator introduces zonal pricing for the retailers[52] which will be passed on to consumers. Locational (zonal) and time-of-use tariffs exist for regulating network congestion by the means of market mechanisms (Biggar & Hesamzadeh, 2022). If their effect is eliminated (like in the case of ECs arbitrating on a price difference), retail tariffs would not anymore affect wholesale prices and thus locational and time-of-use choices will be biased. Consequently, increased intervention by DSOs and TSOs will be necessary, potentially raising network costs.

Another potential issue is the "contracted capacity" discussed earlier. Fortunately, new Italian ECs do not face this challenge, as each EC member is required to maintain a separate contract with their retailer, preventing ECs from acting as independent entities that could focus solely on internal gains. Ultimately,

[52] Previously, zonal prices (established at a day-ahead market) concerned only generators, whereas retailers obtained an averaged country price called PUN.

whether Italian ECs will enhance market efficiency through demand-side flexibility or hinder it due to arbitrage stimulus will depend on numerous factors. Overall, however, we believe that Italian EC regulation has important positive features and is likely more efficient than net-metering schemes, although it is not entirely free from cross-subsidization concerns.

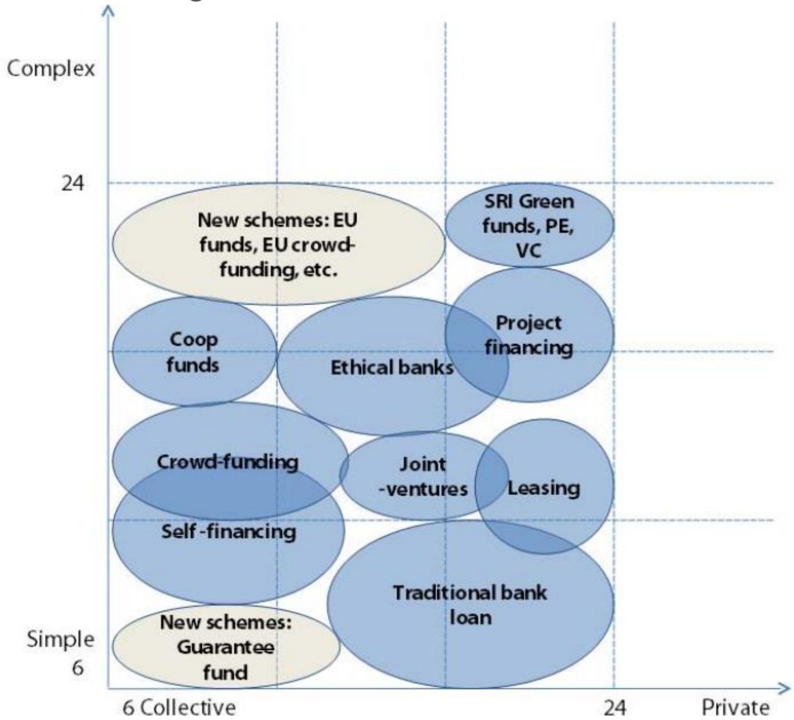
3.3. Financing energy communities in Italy

3.3.1 Literature Review

One of the first comprehensive works on financing the ECs was published in 2014 in a handbook on investment schemes for ECs by REScoop.eu (EFREC, 2014). This report identified nine primary sources of cashable financial flows in the European Union and positioned them within an investment matrix (Fig.24): ranging from collective to private, and simple to complex. A more recent work was published in 2023 by REScoop.eu and Ecopower (2023). In this guide, financing options for energy communities are explored based on case studies and include equity participation, loans from ethical and traditional banks, equity crowdfunding, bonds, and grants from public support schemes, donations, and awards. The guide emphasizes the importance of selecting financing models that align with the values of ECs, particularly their commitment to community ownership and democratic control.

Barriers and opportunities for financing ECs have been the focus of a number of other famous studies (Bauwens et al., 2016; Braunholtz-Speight et al., 2020; Herbes et al., 2017; REScoop.eu, 2020). Comprehensive studies on the topic for Italy are scarce, with several works briefly mentioning financial mechanisms for enabling separate cases (Arcudi et al., 2023; Candelise & Ruggieri, 2017; Cuomo et al., 2023; De Vidovich et al., 2021; Eroe & Polci, 2022; Koltunov et al., 2022; Magnani et al., 2017; Wirth, 2014). Study by Lupi et.al. (2021) reports on a survey conducted in six European countries, among which is Italy. Article explores how ECs are created, organized, financed, and what activities they perform. The study found that citizen members were the main investors in Belgium, Italy, the Netherlands, and Spain. Given the limited availability of public grants, Italian ECs frequently rely on loans to complement member contributions and support their projects. During the last 10 years, the Italian supporting schemes changed almost every year, creating a particularly unstable and uncertain environment for private investors and funders (REScoop.eu, 2020).

Figure 24. Investment matrix for ECs



Source: (EFREC, 2014)

Financial schemes such as green tariffs, premium tariffs, and quota obligations are acknowledged as key drivers behind energy communities. In the previous decade, these were the primary sources of cashable financial flow for ECs and continue to hold that position. In line with the broader goal of enhancing public policy efficiency, subsidies to large-scale renewable energy installations in the EU are being phased out. Consequently, the distributed renewable energy sector, including its subset - ECs, are anticipated to receive subsidies only until they reach maturity. However, studies indicate that without government support, the ECs could barely survive (Brummer, 2018a; Klagge et al., 2016). Over the medium to long term, policy subsidies are expected to disappear, leaving ECs to compete solely with market forces. Regrettably, their deployment and sustainability could be jeopardized due to the limited "economy of scale". Investors with an interest in ethical finance can help facilitate the smooth scaling up of ECs in the medium to long term. Therefore, it is critical to structurally describe all potential sources of monetizable financial flows for ECs.

- Sales.

According to Herbes et.al. (2017), revenue generation can align with the specific corporate purpose of the individual EC: energy sales, revenues from grid operation, balancing services provision, retail sales of renewable energy to customers, consumption-related services revenues (consulting, demand-side management, distributed storage, electric vehicle charging point operation, energy efficiency services, peer-to-peer trading, microgrids).

- Equity crowdfunding[53] (members financing).

Traditionally, this is the most prevalent financing source for ECs, where citizens become shareholders through share purchases. Beyond social advantages, equity crowdfunding proves more cost-effective than loans. For instance, ECs in the UK are estimated to obtain the annual interest payment for the first year on average lower by 2.016% if financed by community shares instead of loans (Braunholtz-Speight et al., 2020). Bauwens (2019) quantitative study on Belgian ECs found that the return on investment is the most important determinant of equity crowdfunding for members of large ECs where members are distributed around the country, while environmental and social drivers motivate members of smaller ECs where members reside in proximity. The CONSOB, Italy's regulatory agency for financial institutions, has established regulations to enable the collection of private savings through crowdfunding (REScoop.eu, 2020).

- Loans.

Bank loans and funds from large investors play an integral role for mature business models. A study by Braunholtz-Speight et al. (2020) found that larger projects rely more on loans. Implementation of larger projects, such as the construction of windmills, biomass district heating plants, biogas facilities, or renovation of hydro power plants necessitates substantial funds that are difficult to accumulate through the cooperative's share offering. Therefore, mature ECs aiming to expand and/or innovate their businesses require loans from financial institutions or major investors. In Italy, Banca Etica and Raiffeizen Bank of South Tyrol have been traditionally biggest lenders and supporters of energy community movement. ESG reporting can significantly influence the success of borrowing endeavors too. For example, Banca Etica gives loans to SMEs which build energy communities exclusively based on ESG performance. Their approach is called “50/50”, where 50% of pre-investment evaluation depends on financial performance, while another 50% depends on an ESG profile of a company.

- Equity participation.

Depending on a statute and a legal entity chosen by a particular energy community and according to Italian regulatory framework, EC’s shares could be acquired not exceptionally through traditional equity

[53] Some sources call equity crowdfunding ‘members financing’ or ‘self-financing’. Equity crowdfunding represents a specific form of member financing that utilizes online platforms and focuses on issuing ownership shares. However, due to proximity of these two concepts and for the simplicity reasons we further use only the term equity crowdfunding.

crowdfunding, but by a variety of actors. Among them, private funds, impact investing funds, large companies and SMEs are present. We have found no data on institutional financing actors participating in ECs' equity at the date of writing this thesis.

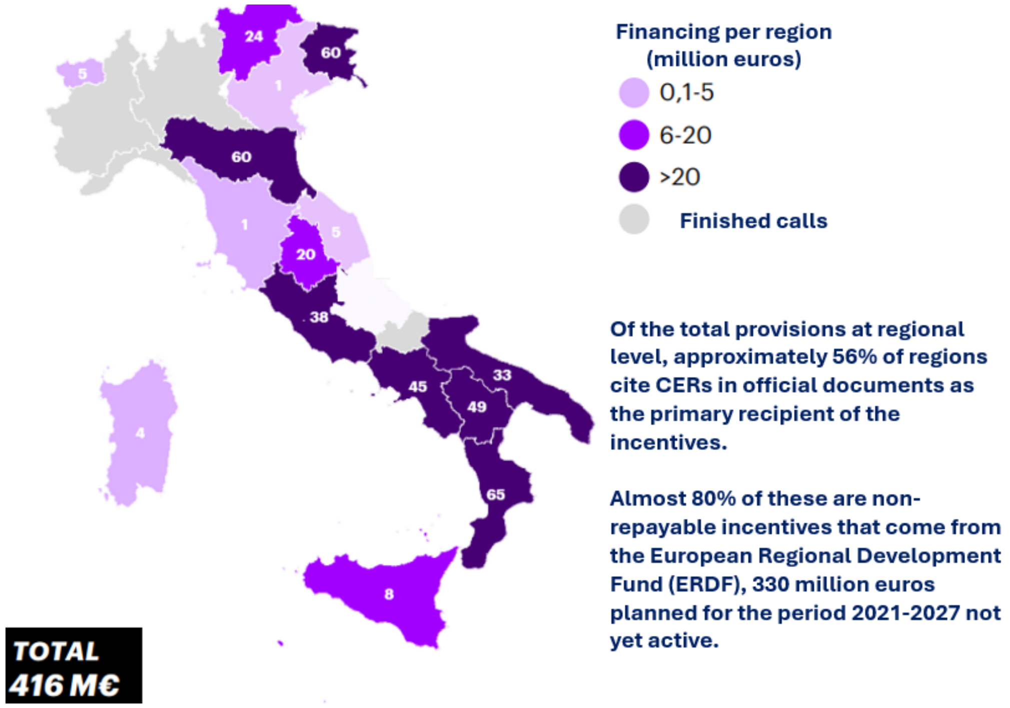
- Public subsidies and grants.

In Italy, several financial incentives facilitating the emergence of ECs existed even prior to the transposition of the EU Directive (RED-II, 2018). Particularly important schemes encompassed: Conto Energia, Tariffa onnicomprensiva, IRPEF (income tax) rebate for innovative start-ups, system costs exemption for historical energy cooperatives in the Alps, among others (see Chapter II Section 2.2). During the experimentation phase of Italian regulation on ECs explicit subsidies in the form of public grants for the establishment of ECs have been declared by many Italian regions. For instance, the Emilia Romagna Region announced a contribution of 4.6 million euros for the establishment of new ECs (QualEnergia.it, 2023). The Lombardy Region declared 22 million euros, which will be allocated for the creation of new ECs until the end of 2024 (Bellini, 2022). Some of these resources are allocated through European Union mechanisms such as the ERDF program54, or Next Generation EU and its Italian managing fund, PNRR. PNRR's 2,2 € billion are expected to create 2GW of distributed renewable energy capacity according to CER Decreto. ERDF grants by regions are mapped in Fig.25. The "Norma Fraccaro" stipulates that a portion of PNRR funds managed by local energy and environment departments should be directed to energy efficiency and renewable energy projects. Many municipalities will therefore utilize these funds for the promotion of ECs. A study by Arcudi et al. (2023) disclosed that for 55 new ECs established since 2021, 80% were financed through public grants, with only about 20% that utilized other types of funding. While a study by Energy & Strategy Group of Politecnico Milano (Cuomo et al., 2023) indicated that for 85 new ECs, 68 % were financed through public grants, 32 % were financed by other types of funding, and only 12 % secured funding from private funds.

A particular attention deserves the study by Braunholtz-Speight et.al. (2020) where authors simulated ECs survival rates after removal of state subsidies in the UK. They also mentioned several factors that may contribute to post-subsidy viability such as choice of a rooftop solar as most cost competitive option, location of PVs on buidings with high energy consumption such as schools or community centers, securing customers willing to pay a premium for community-generated electricity. In the UK, grants form a relatively small part of total capital for all project scales. They may play a significant role in de-risking projects, as they are often used to finance the earliest and riskiest stages of project development (Braunholtz-Speight et al., 2020).

[54] ERDF plans to distribute €416 million for ECs in Italian regions until 2027, out of which €330 million as non-repayable grants.

Figure 25. Regional distribution of public grants for ECs in Italy



Source: modified from Arcudi et.al.(2023)

- Equity participation of affiliated ECs (Revolving fund)

De Vidovich et.al. (2021) identified that in Italy certain companies or cooperatives create smaller ECs. These are known as "energy community builders" (EC-builders) and usually are represented by a well-established intermediary organization, a large cooperative, research, or a consultancy agency, or a national or regional association of ECs. The main feature is that such an entity establishes many ECs of a certain type, duplicating the business model with only minor adjustments. They participate in the equity of its spin-offs. A representative example is the ForGreen Spa that established 4 EC spin-offs. E'Nostra cooperative that established 2 spin-offs[55]. Some big energy cooperatives in South Tyrol expressed an interest to spin off ECs[56] and have already secured PNRR funds for such a purpose[57]. In France, the biggest energy cooperative Enercoop holds the equity stake in the national EC association, Energee Partagee, which in turn spined off 74 ECs in 2021 becoming their shareholder and simultaneously providing services to them. In the UK, a famous player is Energy4All that spined off 33 ECs.

- Leasing of equipment.

For the first time, this financing method for ECs was categorized in the study of Herbes et.al. (2017). ECs might rent PV panels, storage facilities, and other equipment owned by the third-party companies. Therewith, ECs could benefit from state subsidies, fully or partially, without investing substantial funds in assets acquiring, which in turn would be provided by third-party companies. Such schemes are especially favored by the utility players which prefer to adapt their business models to the changing business environment without losing market share. Studies by Del Pizzo et.al. (2022), Arcudi et.al. (2023) provide more details on how utilities see business opportunities in emerging ECs and how such collaboration could serve for the common good. Due to the profit-oriented nature of big utilities, it is important that social impact of ECs is guaranteed when choosing this form of financing.

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[55] ECs of new type promoted by Italian legislation

[56] ECs of new type promoted by Italian legislation

[57] Personal communication, 20 July 2023

- Cost reduction.

ECs are predominantly small-scale organizations and may suffer from the high transaction costs. These costs often encompass expenses for billing and accounting services, regulatory compliance, research & development, negotiations with contractors, and lobbying efforts. Forming associations that can assist in these tasks can lead to significant reductions in transaction costs and, as a result, increase available financial resources. In Italy, prime examples of such assisting organizations include Legacoop, SEV58, universities and municipalities that assist ECs with feasibility studies and commissioning. Additionally, EC-builders such as the ForGreen Spa and E'Nostra provide similar support as we talked in Chapter II Section 2.2. The existence of the supportive ecosystem plays a crucial role in the overall development of the EC sector. In Chapter II Section 2.2. we argued that, in a comparison of the French and Italian EC movements before the enactment of the EU Directives (IEM, 2019a; RED-II, 2018), the French movement was more advanced because it was supported by a more developed ecosystem for ECs.

- Bonds

There is a big market of green and sustainability bonds. Large corporations could utilize funds attracted through such markets for financing a specific project for ECs. Such investment could be valued very well from the point of view of a big investor. It may be a small project for a large corporation albeit being beneficial for a public image. Therewith, it could bring a positive impact for many people on a territory and promote new model of energy sourcing. In turn, corporations could disclose it in their ESG report and report on additional taxonomy aligned activities. There are examples of ECs' financing through bonds in the UK, which is reported by Braunholtz-Speigh (2020). They found that projects financed by bonds do not have an interest rate that is significantly different from loans (Braunholtz-Speight et al., 2020).

De Vidovich et.al. (2021, 2023) identify three main organizational models for building ECs in Italy: public-led, pluralistic, and energy community builder (EC-builder). Public-led models, often seen in early EC development, feature public administrations as key stakeholders driving the process from a top-down approach. Pluralistic models prioritize bottom-up, grassroots initiatives where informed citizen members, prosumers, NGOs, energy service companies, and third-sector actors collaborate. This approach emphasizes horizontal community involvement, leveraging local knowledge and relationships to establish partnerships and generate collective benefits. EC-builder models bridge the gap between public and private sectors, employing expert intermediaries like energy cooperatives or consultancies specializing in sustainable development. These builders support public administrations, facilitate community engagement, and guide the technical design and implementation of EC projects, blending top-down and bottom-up approaches to achieve alternative energy consumption models and deliver localized benefits. Musolino et.al. (2023) investigates three Italian case studies. Authors highlight the crucial role of municipalities in the development of ECs in Italy. They observe that municipalities often act as catalysts, taking a top-down approach by initiating projects and providing resources such as access to public buildings for installations. The research stresses the importance of incorporating bottom-up elements within this top-down framework. A balance between a top-sown and bottom-up approach to building ECs is vital for maximizing the social and economic benefits. Musolino et.al. (2023) also explore regional differences claiming that Northern Italian initiatives often prioritize local economic development, leveraging the region's existing technological capabilities. In contrast, Southern Italian RECs often prioritize social goals, such as combating energy poverty. Another recent study by Grignani et.al. (2021) explores legal forms of ECs in Italy under the transtionary legislation. Authors say that lack of rigid legal structures allows for adaptability to local contexts, but it also makes it difficult to standardize successful models and scale up the legal form of a cooperative nationally.

[58] Südtiroler Energie Verband Genossenschaft

The primary purpose of ECs should be the provision of environmental, economic or social community benefits for its shareholders or members or for local areas where it operates, rather than financial profits (RED-II, 2018). Thus, measuring ESG benefits is a key issue for effective policy implementation. Utilities, large corporations, and even municipalities that simply wish to utilize "cheap" public money may jeopardize the concept of an energy community. Therefore, ESG expectations should be an integral part while financing ECs..

We have found empirical evidence of a mismatch between certain financial tools and the impact investing approach. Our unpublished study, built upon the study conducted by Braunholtz-Speight (2020), used the public database of British ECs to uncover the bidirectional relations between financial tools (loans, grants, equity crowdfunding) and ECs' expenditure on community benefit projects. We used multiple regression modeling that accounted for possible confounders available in the dataset. All models were checked for the presence of multicollinearity and heteroscedasticity. When needed, models were adjusted to better fit available data. Results can be checked in Annex 4. We discovered a significant negative correlation between loans and ECs' spending on community benefit projects. A significant negative correlation was also revealed between grants and ECs' spending on community benefit projects. Conversely, we did not find any significant evidence of a correlation between equity crowdfunding (value of share offering) and spending on community benefit projects. Theoretically, this might suggest that ECs facing financial difficulties might be more inclined to take loans or seek grant opportunities. ECs in a weak financial situation may prioritize the funds obtained through loans and grants for other purposes, such as installing new generation facilities, rather than redirecting them to community benefit projects and social benefits in general. However, the relationship between corporate borrowing and financial distress is not straightforward and depends on numerous factors (Mariano et al., 2021). In contrast, higher amounts obtained through equity crowdfunding do not provide any information about a EC's financial situation but only suggest the existence of broad community participation in the EC project. Our empirical findings are supported by literature on financial tools and the social impact of ECs (Bauwens, 2016; Braunholtz-Speight et al., 2020; Seyfang et al., 2014) and firms in general (Myers, 1977).

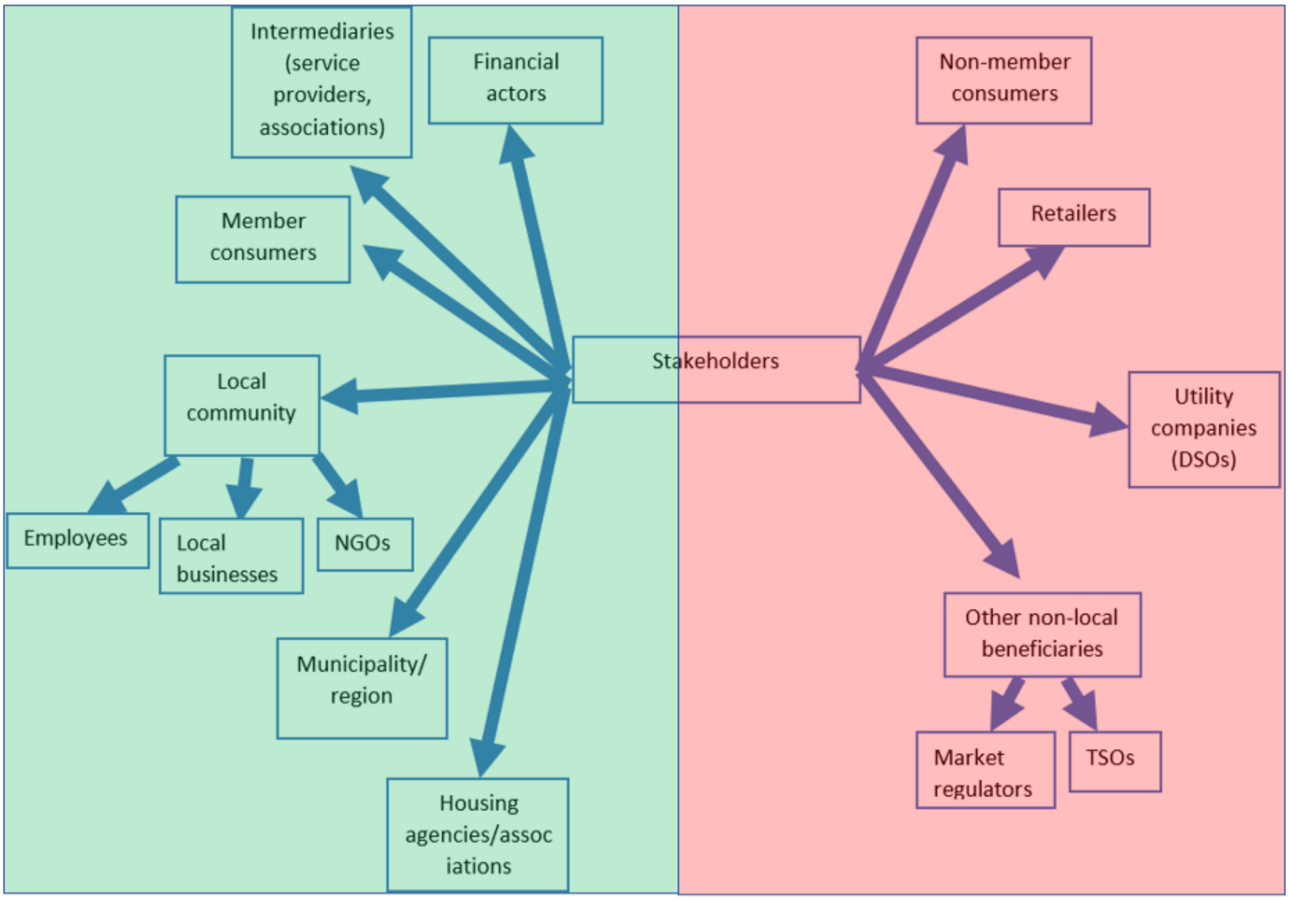
In this context, ESG reporting can be a useful tool assisting financial actors not only in assessment during the pre-investment stage but also in effectively monitoring the investment's performance. We assume that ESG reporting could be used as a leverage by ECs and EC-builders to access financing. We analyse this hypothesis through management theories: legitimacy theory, stakeholder theory, principal-agent theory, and signaling theoryFor example, in last 3 years several communiity energy projects were financed in Italy by Banca Etica and Sefea Impact Fund after evaluaiton of ESG report of the EC-builder, for 1.96 € millions and 0.6 € million respectively (Chiti & Quatraro, 2023). Another example of the ESG-conditioned equity is the Coopfond's recent mixed loan and equity participation in ForGreen's 1,2 MW energy cooperative project "Fattorie del Salento". The project requires approximately 1 € million, half of which should be invested by financial players. Coopfond agreed to secure 0.37 € million as a loan under 1,75 % interest rate and 0.13 € million as an equity investment with expected 2% annual return (Bellotti, 2021). Requested annual return could be reduced proportionally to achievement of targets, based on ESG indicators: CO2 avoided, and adherence to values (kWh consumed by member / kWh generated through shares purchased). They are included in the shareholder agreement and will be monitored annually (Coopfond, 2022).

In this regard, we assume that ESG reporting could be used broadly as a leverage by EC-builders or ECs themselves to access financing after the termination of state subsidies. We argue this hypothesis through legitimacy, stakeholder, principal-agent, and signaling theories.

Legitimacy Theory. The theory suggests that a social contract exists between society and a business. A company is legitimate when following such a contract. Notable example of a 21^{st} century social contract is the EU Green Deal. The majority of ECs are registered under different legal forms than listed SMEs, which means they are not obligated to report on ESG performance as per the CSRD Directive (2022). For instance, most ECs in Italy are either associations (*Associazione ETS*), partnerships (*Fondazione di Partecipazione*), cooperatives (*Soc. Coop*), or private, unlisted SMEs (*S.r.l.*). Only in exceptional cases are ECs registered as listed companies (*S.p.a.*), with those few mostly being mature businesses established well before the EU Directives (IEM, 2019a; RED-II, 2018). As a result, most of ECs might choose to disclose ESG information voluntarily. Hence, their primary motivation would be to gain societal legitimacy rather than meet a legal obligation. This is particularly true for newly established ECs that want to highlight their positive contributions. An enhanced image could emphasize ECs' leading role in sustainability, resulting in stronger legitimacy. Consequently, this could facilitate easier access to finance.

Stakeholder Theory. We identify stakeholders as EC members, local community citizens, financial actors, local authorities, community NGOs, suppliers, outsourcing organizations, intermediaries, and any other parties interacting with an EC. This broad definition allows for a holistic view, which is essential for an impartial assessment. Stakeholder interests can sometimes conflict. However, overlapping interests do exist (Freeman, 1984), and an EC could act as a mechanism that benefits all stakeholders over time. Collaborating with an EC may help stakeholders discover common interests, resulting in mutual benefits and improved overall efficiency, instead of conflict. Notably, the validation of ESG standards and metrics by stakeholders is a critical component of many reporting standards (e.g., the official GRI procedure to report on ESG). Figure 26 illustrates all EC stakeholders, with those colored green expected to benefit from ECs, and those colored red still in question.

Figure 26. Impact of ECs on stakeholders



Principal-Agent Theory. The theory suggests that "the Agent almost always has more knowledge than the Principal about the status quo of the activities and how these can be optimized" (Akerlof, 1970). The relationship between a stakeholder and an EC can be viewed as a Principal-Agent problem, where the EC, as the Agent, has a more comprehensive understanding of its activities, while the stakeholder, as the Principal, possesses less information but requires more. Table in Appendix 1 explains the relationships between stakeholders and ECs, showing majority cases where the EC serves as the Agent, and several others where it functions as the Principal. A governance mechanism (performance measure) is supported by a control mechanism to ensure that the Principal's objectives concerning the Agent will be realized. For the majority of relationships outlined in Table 13, ESG reporting serves as a critical control mechanism capable of filling the knowledge gap for the Principal, thereby reducing information asymmetry.

Signaling Theory. The theory suggests that “organizations are motivated to disclose/communicate the information regarding their unique operations, setting them apart from other organizations in the industry” (Spence, 1973). An organization seeks to differentiate itself from its competitors. In the context of ECs, traditional private utility companies may be seen as direct rivals. The competitive advantage of ECs over private utilities lies in their collaborative/cooperative nature, which promotes fairness, as well as their exclusive generation of clean and decentralized energy. ESG reporting could facilitate signaling such competitive advantages to the public. Consequently, ECs could potentially secure a significant niche and even gain market share from private utilities. Moreover, the heterogeneous nature of the energy market and the potential rise of energy communities align with the goal of a fair energy transition, which prioritizes empowering citizens. Private utilities acknowledge these processes and, as previously mentioned, aim to adapt by striving for a "third-party sponsored" business model to become the primary business model for ECs. In this context, the use of ESG reporting for signaling by ECs can be regarded as vital.

In our study, we also aim at exploring if financing actors would suspend or keep investing into ECs when public subsidies terminate. We aim to investigate their considerations which could prevent financing ECs after the termination of public subsidies or vice versa continuate it. In addition, we are interested in the reasones behind such considerations. For this purpsose, we use the common-pool resource theory.

Common-Pool Resource (CPR) Theory. The theory is derived from microeconomic and environmental economic frameworks. CPR theory characterizes resources that are available to all (non-excludable) but finite in nature, which can lead to overuse and scarcity issues (rivalrous). This theory suggests that without effective management, common resources are vulnerable to the "tragedy of the commons”. Roelich & Knoeri (2015) and Wolsnik (2014) discuss energy communities within the framework of CPR theory. Roelich and Knoeri (2015) point out that community energy provision differs significantly from mainstream energy provision, driven not by profit but by social and environmental motivations. This difference presents governance challenges, especially when the energy system is treated as a commodity market. Roelich and Knoeri (2015) propose drawing upon lessons from common pool resource management to develop more plural approaches to energy system governance, allowing for self-governance alongside market mechanisms. Wolsnik (2014) advocates for a shift towards polycentric governance, where decision-making about energy infrastructure is distributed across multiple levels, enabling community participation and control. Roelich and Knoeri (2015) also underscore the need for institutional variety in governing energy provision, moving away from the "pro-market paradigm" that hinders community energy. They discuss Ostrom's design principles for self-governance, suggesting their adaptation to support community energy projects. Roelich and Knoeri (2015) highlight the crucial role of municipalities in facilitating polycentric governance, bridging the gap between national policies and local community needs. They propose using design principles to guide the development of locally relevant institutions rather than imposing standardized best practices that might not suit diverse community contexts.

3.3.2 Data Collection and Methodology

Bhattacherjee (2012) argues that interpretative research is often helpful for theory construction in areas with no or insufficient a priori theory. Unlike a positivist method, where the researcher starts with a theory and tests theoretical postulates using empirical data, in interpretive methods, the researcher starts with data and tries to derive a theory about the phenomenon of interest from the observed data (Bhattacherjee, 2012). It becomes especially relevant in the areas with a limited prior existent knowledge such as new ECs in Italy. Therefore, to answer our research questions we chose a semi-structured interview as a main method.

We identified key Italian stakeholders with an interest or potential interest in financing energy communities. Initially, we categorized them based on their likely strategies toward ECs, as adapted from OECD (2019): public and philanthropic, impact investing, and sustainable financing. Public and philanthropic actors focus on social returns, impact investors balance social and financial market rate returns, and sustainable financiers, such as banks, prioritize financial market rate returns. Next, we conducted exploratory desk research to identify all actors who have financed or may be interested in financing ECs in Italy. We validated each actor's interest through a review of their organizational websites, publicly available reports, and the authors' prior knowledge. This research resulted in a comprehensive database in MS Excel, containing information on the actor type, relevant contact persons, contact details, and a detailed description of each actor’s connection to ECs. The database includes 59 actors across the three OECD (2019) categories, but is not limited to them. We gathered information on EC-builders, major energy equipment manufacturers, financial intermediaries (such as crowdfunding platforms), and various sectoral networks and associations. Among EC-builders, we identified energy service companies (ESCOs) associated with traditional utility groups, as well as energy cooperatives. In this text, we refer to ESCOs affiliated with traditional utilities simply as "traditional utilities." Energy cooperatives that build ECs and also engage in retail activities are categorized in Chapter II as “retail ECs.” However, to enhance clarity throughout this chapter, we refer to them as “cooperative utilities,” highlighting both their cooperative roots and their participation in the energy market.

We created a customized letterhead after which sent 59 email requests to conduct interviews. The requests included details about the project and our personal information. Each letterhead also contained a section explaining the relevance of this research for the sector and for each specific actor. After the first round of requests, we received 12 agreements to participate in the interviews. However, after further communication, it was determined that only 11 of these participants had sufficient experience with ECs to meet the study's objective. In a second round, we sent follow-up emails to those who had not yet responded, this time directed to a new contact person. From this follow-up, we obtained only one additional interview agreement. The remaining seven interviewees were reached through channels such as the authors’ personal connections, interactions at industry events and conferences, and snowball sampling. The latter is a commonly used approach in recruting participants for a qualitative studying in hard-to-reach and specific characteristics populations (Noy, 2008). In total, 19 semi-structured interviews were accomodated, and all interviewees were from the initial database. The financial actors and EC-builders interviewed can be categorized as follows: three sustainable financiers (banks), four philanthropic and public actors (two philanthropic foundations, one banking foundation, one regional energy agency), three impact investors (one venture capital fund, one ethical fund, one mutualistic fund), two traditional utilities, two cooperative utilities, two financial intermediaries (crowdfunding platforms), two sector associations (a regional federation of cooperatives and an advocacy network), one company. Of the 19 interviews, 18 were conducted orally (five in person and 13 online), while one interview was conducted in written format. Table 13 presents a summary of the data and indicates the organizational role of each interviewee.

Table 13. Interviewed actors

Actor	Type	Organizational role of the interviewee
1.Banca Etica	Sustainable financing	Strategic marketing officer
2. Volksbank	Sustainable financing	Area Director

3.Intesa San Paolo	Sustainable financing	Managers/officers
4.Fondazione Con il Sud	Philanthropic & Public	Project manager
5.Fondazione Cariplo	Philanthropic & Public	Project manager
6.Fondazione Banca dell'Energia	Philanthropic & Public	Project manager
7. APE FVG	Philanthropic & Public	Project manager. Researcher.
8. ForGreen Group	Utilities (coop.)	Area director. CSR specialist.
9. E`Nostra	Utilities (coop.)	Project manager
10. Iren Group	Utilities (trad.)	Area Director. Project officer
11. Edison Group	Utilities (trad.)	Area Director
12. Avanzi SICAF	Impact investing	Area director
13. Coopfond	Impact investing	Area director
14. Etica SGR	Impact investing	Senior ESG specialist
15. Ecomill	Financial intermediaries	Founder/CEO
16. Ener2Crowd	Financial intermediaries	Co-founder/CSO
17. Maire Tecnimont	Company	Area director
18. Raiffeisenverband	Sector association	Project manager
19. Forum per la Finanza Sostenibile	Sector association	Senior policy officer

The questionnaire included 13 to 17 open-ended questions. Eleven core questions were consistent across all interviews, while an additional 2–5 questions were customized based on each actor's profile and experience with ECs to collect richer data. These customized questions were developed through a careful review of each actor's publicly available documents, such as ESG reports and calls for proposals for funding ECs. Interviews lasted between 45 minutes and 1 hour and 50 minutes, and each was recorded for transcription purposes. To quantify respondents' level of agreement, Likert-scale statements were presented following each open-ended question. Only the most important insights from these statements are presented in the Results section.

Additionally, we extracted indicators potentially suitable for the ESG assessment of energy communities from prevalent standards, including ESRS, GRI, SASB, and TCFD. The indicators were categorized into environmental, societal, governance, economic, and mixed dimensions. Subsequently, EC groups/archetypes from Section 2.2 Table 5 were adapted to align with the seven business models considered in this study. Interviewees were asked to rank each ESG indicator from 1 to 5 based on its relevance to one of the business models. We received only six completed ESG surveys from interviewees or their sustainability departments. Although this limited response does not allow for conclusive research findings, the survey itself remains a valuable research tool, as presented in Annex 5.

Interview recordings were transcribed using the built-in transcription tool in MS Word, followed by manual review and editing, which allowed the author to gain deeper insights into the nuances and patterns in the collected dataset. After the transcription files were finilized we proceeded with descriptive analysis presented in the first part of the Results section. The analysis was performed by the manual review of the relevant interview responses. It resulted in Figure 27, Table 14, and Table 15, and Annex 7. Therewith, we answered the first research question.

The main method for answering second and third research questions is thematic exploration. Before beginning the analysis, each transcript was carefully anonymized to ensure confidentiality. Data analysis was conducted using a combination of AI tools and MS Office, following the guidelines suggested by Kriukow (2024). In the first stage, initial coding, we utilized AI generative software, Scholar GPT[59]. In addition to anonymization, we ensured to switch off the option of 'improving model to all' in platform settings. For the subsequent stages—focused coding and theme development—we conducted a manual analysis using MS Excel. This approach accelerates the routine aspects that do not require data interpretation, while ensuring transparency and full control over the latter stages, which demand a higher level of knowledge and comprehension.

Our decision to use AI tool was carefully taken after inspecting published studies on the matter to familiarize with dangers and benefits of such approach. There are advantages and disadvantages to using ChatGPT in thematic analysis. The ability of ChatGPT to significantly boost consistency and efficiency when working with large datasets is one of its main advantages. ChatGPT's proficiency in generating human-like text therefore makes it a valuable tool for qualitative researchers, who often grapple with the challenges of interpreting complex data (Turobov et al., 2024). Similarly, Jalali and Akhavan (2024) pointed out that "AI language tools like ChatGPT contribute to improved efficiency and unbiased data processing". The AI tool can quickly organize data into initial codes and clusters, reducing the manual labor associated with early stages of qualitative research (Turobov et al., 2024). Furthermore, recent advancements in qualitative analysis software have integrated OpenAI's technology to enhance their data processing capabilities. Morgan (2023) notes that "Two of the major software packages for qualitative analysis, ATLAS.ti and MAXQDA, have both developed partnerships with OpenAI". However, it is also important to carefully consider ChatGPT's limitations, especially its lack of contextual understanding. As Lee et al. (2024) explained, "ChatGPT may not adequately capture the full context of each participant, but it can serve as an additional member of the analysis team, contributing to researcher triangulation". Furthermore, the AI's struggle with capturing interpretative or subtle themes makes human involvement indispensable in ensuring depth and accuracy (Morgan, 2023).

In this study, ChatGPT was employed solely for the initial coding to maintain neutrality in data interpretation. As Turobov et al. (2024) recommended, "ChatGPT can save time, enhance coding quality, expand the empirical base," but the human researcher remains essential for interpreting the final themes. We cross-verified the initial coding results to ensure that no abstractions or inferences were made, allowing us to leverage the efficiency of AI while maintaining essential human oversight of the AI-generated output. Our prompt to ChatGPT instructed it to be detailed and self-explanatory, avoiding brevity or abstraction. We provided the AI with examples of the desired format for initial codes, as well as examples to avoid. Additionally, we requested that the AI extract precise quotes from the transcript to accompany each code. The specific prompt used is available in Annex 6. After preparing the prompt, we uploaded the transcripts one at a time and executed the coding process. Scholar GPT generated between 30 to 60 codes for each transcript, each accompanied by the corresponding quote. To ensure accuracy, we selectively checked these quotes against the original transcripts in MS Word, using the 'Find' function to verify their exactness. In cases where the quote did not fully match the transcript, we adjusted the prompt to ask GPT for precise matches to the text, which typically resolved any discrepancies.

After verifying the accuracy, we copied the codes and quotes from the 19 transcripts into individual MS Excel spreadsheets. Each spreadsheet was then formatted using different colors and fonts to facilitate

[59] Powered by GPT-4, developed by OpenAI.

distinction. In total, we generated 670 initial codes. While working in Excel, we re-anonymized the data for clearer analysis and ensured each code was specific enough to identify the relevant part of the interview. This step was essential for the next phase, focused coding. Despite our prompt for specificity, some initial codes were still too abstract. In these cases, we transferred the codes with quotes into Excel and manually refined them to better reflect the underlying data. Once finalized, we consolidated only the codes into a single spreadsheet for the focused coding stage.

We began focused coding by cleaning the dataset, merging codes that referred to identical concepts, patterns, or situations. Merged codes were kept in the comments of a new explanatory code, allowing us to locate related quotes in the original spreadsheet as needed. This merging process reduced the codes to 280. We then grouped these initial codes into 27 focused codes. Periodically, we revisited the quotes and original transcripts to clarify context or nuances. Finally, we reviewed each focused code and synthesized them into themes, resulting in seven themes and sub-themes that comprehensively addressed the three research questions.

3.3.3 Results[60]

We begin this section with a descriptive overview of financial actors, instruments, and financing recipients. Following this, we detail how specific financing instruments operate in the context of energy communities (ECs). This concludes the descriptive narrative, after which we introduce the thematic framework as a guide to the results and discussion that follow. First, we describe the themes that address the research question on financing actors, instruments and recipients. Next, we explore themes related to EC-building actors and how they collaborate. We then discuss themes that reveal the economic expectations of financing and building actors regarding ECs. Lastly, we present themes within the ESG spectrum, focusing on the expectations of both financing and building actors for ECs.

3.3.3.1 Description of financing actors, instruments and recipients

Here is the short description of the interviewed financing actors and their activities directed to ECs. Where available we present numbers of financed or supported ECs as for the time of data collection.

<u>Philanthropic & Public</u>:

- Fondazione Cariplo. Philanthropic banking foundation funding initiatives in social welfare, environmental protection, and cultural development, supporting projects that address societal challenges. It supported ECs through its "Alternative" call, providing technical assistance and funding for the development of ECs. Foundation financed 17 ECs so far.
- Banco dell’Energia. A foundation bridging the gap between private sector donations and energy poverty-related projects. Supports renewable energy communities as one of its three project types, providing funding and technical assistance for ECs tackling energy poverty.
- Fondazione con il Sud. Foundation promoting social cohesion and sustainable development in Southern Italy. Launched its first call for ECs projects, focusing on marginalized communities and alleviating energy poverty in Southern Italy. Foundation financed 9 ECs so far.
- APE FVG. Regional energy agency in Friuli Venezia Giulia promoting energy efficiency, renewable energy, and sustainable development through consulting and support to local entities. There are 10–20 ECs that were funded and followed by the agency.

<u>Impact investing:</u>

[60] We remind the reader that in this section we investigate only CAPEX financing sources, while sources that finance OPEX are examined in the previous economics section of this chapter.

- Avanzi. A social impact fund focused on early-stage SMEs, prioritizing ventures with significant social or environmental benefits.
- Etica SGR. An ethical fund that applies ESG criteria to its investments in large corporations and SMEs, supporting sustainable projects.
- Coopfond. Mutualistic Fund of the Legacoop Federation that supports cooperatives by providing equity participation and ESG-linked loans, including ECs which wish to be established in cooperative legal form.

Sustainable financing:

- Banca Etica. A bank that provides loans to socially and environmentally responsible organizations, applying the ESG-based evaluation. Provides loans and financial assistance to ECs
- Intesa San Paolo. One of Italy's largest banking groups with a focus on sustainability and responsible finance, offering products that support the green economy and social impact projects.
- Volksbank. Cooperative bank offering traditional services with a focus on supporting local communities and small businesses, committed to ethical finance and sustainability. Financially supports ECs, providing up to 80% financing for projects.

Financial intermediaries:

- Ecomill. Crowdfunding platform for renewable energy and sustainability projects, including ECs.
- Ener2Crowd. Crowdfunding platform focusing on renewable energy projects, including ECs. Three ECs were financed through the platform at the interview date, 4th in progress.

Sector associations:

- Raiffeisenverband. Cooperative association supporting the development of cooperative banks and businesses in South Tyrol. Assists ECs formation, providing legal and fiscal support, working with local municipalities, cooperatives, and businesses in South Tyrol. They have 6 ECs under development in the region.
- Forum per la Finanza Sostenibile. Organization promoting sustainable finance by fostering dialogue between financial institutions, companies, and policymakers. Advocates for integrating ESG criteria in finance. It was involved into EU funded project that established ECs focused on energy efficiency technologies. According to Chapter II Section 2.2. can be classifed as service-related ECs.

Traditional utilities:

- Edison Next. An ESCO company, part of the major energy utility group focused on electricity and natural gas production with an emphasis on renewable energy and decarbonization. Group developed a commercial offer for RECs and JARSCs, and have plans to activate over 2000 configurations by 2030. Over 9 ECs that were financed and developed currently are operational.
- Iren Smart Solutions. An ESCO company, part of the multi-utility group working on both residential and industrial-scale EC projects. Special feature of this utility is that most of shareholders are municipalities, which make it highly oriented toward their needs. Operates two models of support for RECs and JARSCs, focusing on larger photovoltaic installations, leasing and managing plants while sharing energy benefits with community members.

Cooperative utilities:

- ForGreen. An innovative utility/retailer company that beside energy selling also offer ESCO-type solutions. It also develops shared investments in renewable energy for citizens and companies and created few spin-off energy cooperatives. According to Chapter II Section 2.2. can be classifed as mixed EC. Actively supports the formation of ECs mostly in a cooperative form. Over 6 ECs supported.
- E'Nostra. A utility/retailer of a cooperative legal form and origin producing and supplying clean energy to its members and clients, promoting energy self-sufficiency and sustainability through community initiatives. According to Chapter II Section 2.2. can be classifed as mixed EC. There were 3 ECs so far supported by E'Nostra.

Company:

Maire Tecnimont is a large engineering company that manufacture petrochemicals and green energy plants. Its sustainability department is interested in ECs as an ESG tool for possible mitigation of its environmental impact in areas where company is manufacturing its plants, especially ouside the EU.

Other non-interviewed actors that finance ECs include:

- Enel X. An ESCO company, part of the major energy utility group.
- ACEA Pinerolese. A multi-utility company based in Pinerolo.
- Garda Uno. A multi-utility company that operates in area around Garda Lake, mostly concentrating on waste management and energy services.
- Federcoop Trentino. A cooperative association in the Trentino region that supports the development of cooperatives, providing consulting, financial services, and assistance to cooperative enterprises.
- Compagna di San Paolo. One of Italy's largest banking foundations.
- Cassa di Risparmio di Cuneo. A banking foundation that funds and supports local projects in the areas of social welfare, education, research, and cultural heritage, particularly in the Cuneo region of Italy.

Figure 27. Map of ECs financing instruments in Italy

We identified three main clusters of financing instruments for Italian energy communities: those currently available or planned for near future introduction, instruments intended for co-financing EC projects, and additional potential instruments. Figure 27 illustrates only the financing instruments currently available for ECs in Italy, which generally fall into private and philanthropic/public categories based on the type of actors involved. Private instruments include debt capital, equity capital, and leasing. Debt capital encompasses green loans, ESG-linked loans, project finance, and lending crowdfunding, while equity capital includes equity participation and equity crowdfunding. Philanthropic and public instruments cover donations (in-kind), grants from foundations, regional and state grants, EU grants, tax deductions, and public collateral. Actors across these categories may also provide pro-bono technical or legal advice to ECs, which serves as a cost-reduction or pro-bono financing mechanism. In Section 3.3.1 of the literature review, we explain how various financing mechanisms, such as cost reduction, loans, leasing, equity crowdfunding, equity participation, and different types of grants, function for ECs. Section 3.2.2 provides a detailed explanation of how state grants under the PNRR are awarded. Another available state grant for ECs is Conto Termico 2.0, which supports electrification and requalification projects, specifically for the installation of energy-saving technologies and heat pumps. Additionally, a tax deduction known as the "eco-bonus" is available for citizens purchasing photovoltaic (PV) panels, potentially enabling them to join energy communities. A detailed explanation of the eco-bonus is provided in Chapter II[61]. Below, we focus on 'lending crowdfunding' and 'project finance,' which were not covered in the literature review on EC financing.

- Lending crowdfunding allows individuals to collectively lend small amounts of money directly to projects, bypassing traditional banks. In the context of ECs, it helps fund projects by offering investors a return through interest payments, along with the repayment of the loan principal. Online platforms simplify the process, ensuring transparency and lowering costs. As Mollick (2014) highlights, crowdfunding relies on many small contributions made online, bypassing conventional financial intermediaries. Instead, alternative financial intermediaries organize the process. In our study, we interviewed two of the crowdfunding platforms: Ecomill and Ener2Crowd.

- Project finance is a financial mechanism that allows to secure funding for projects by relying on the future revenue streams rather than the financial health of the sponsors/borrowers. Project finance structures are critical for renewable energy projects, particularly due to the large initial investments required and the lengthy period before returns are realized (Gatti, 2012). The project finance loans are based on the income generated by the project, thus minimizing individual members financial liabilities, although creating a possibility of a higher risk for the lender, which could not request a loan back from the other assets of the borrower. In our sample, one bank offers project finance backed by public collateral/guarantee for environmental projects including purchase of infrastructure for ECs. However, another interviewed actors critically argued about project finance utilization for small scale projects such as ECs: "*There are certainly more difficulties in defining the agreements, given that there is a high number of parties involved, and it has very specific obligations of* ***diligence****, being a slightly* ***more complex contract****…And they require the investment size, usually very high, of* ***10, 20 million****, so it can certainly be used for very high investment projects*".

Table 14. Financing and co-financing instruments of different actor types

Actor Group	Financing instruments (used or planned)	Co-financing instruments (used)	Other mentioned instruments
Philanthropic & Public	Grant (found.), cost reduction, grant (region)	Grant (found.), private funds of promoter, cost reduction (NPO paid volunteers), grant (PNRR)	Equity crowdfunding , loans, tax deduction (IRPEF), grant (municipality), grant (EU), leasing crowdfunding.
Impact investors	Equity participation, grant (mutualistic fund), cost reduction	Equity crowdfunding, green loan	Green bonds, sustainability bonds, public collateral (from CDP), social bonds
Sustainable financing	ESG-linked loan, green loan, cost reduction, project finance, public collateral (from SACE)	Equity crowdfunding, equity participation, grant (PNRR), grant (region)	Leasing, equity participation
Traditional utilities	Leasing, project finance, donation	Grant (PNRR), Green loan	Equity crowdfunding

[61] Section 2.2., Footnote 32

Cooperative utilities	Equity crowdfunding, cost reduction, leasing	Green loan, grant (EU)	Grant (region), grant (PNRR), grant (found.), tax deduction (eco-bonus), loan ESG-linked, equity participation
Financial intermediaries	Equity crowdfunding, lending crowdfunding, cost reduction	Green loan, equity participation, leasing	Public collateral (from CDP)
Sector associations	Grant (EU), grant (mutualistic fund), cost reduction	EPC (combined with P4P), project finance, equity crowdfunding, green loan	Grant (region), grant (PNRR, Conto Termico), tax deduction (eco-bonus)

Table 14 categorizes the financing, co-financing, and other mentioned instruments by types of actors. All interviewed actors participating in our study typically do not fully finance a PV installation. Instead, they require recipients to secure co-financing from other sources. Philanthropic and public actors usually provide grants for consultation and feasibility costs through separate calls. Later, they may or may not offer grants for purchasing PV systems. If they do not provide grants for PV acquisition, they still assist with legal matters and offer free technical advice through their partners. For foundations, it is also common to require co-financing from supported projects. In cases of ECs already receiving support from a foundation, co-financing was obtained from a grant provided by another foundation or from the project promoter’s own funds. It is notable that two foundations include a co-financing requirement in their calls for proposals. However, both interviewees indicated that their foundations generally accept the working hours of a promoting entity’s employees as valid co-financing. There was also one instance of a physical donation of PV panels to two ECs by the Edison Group, as part of their ESG initiative marking the group’s anniversary. This donation was facilitated indirectly through the Banca dell’Energia Foundation. In the "Impact Investors" category, ECs are planned to be financed through grants from cooperative or mutualistic funds. For example, Coopfond may award grants to new ECs that choose to register as cooperatives, aligning with Coopfond’s mission to promote cooperatives nationwide. A similar funding approach is planned by the Raiffeisen Federation[62] albeit at a regional level. Impact investors and Financial intermediaries mentioned a crucial importance of a collateral that could be provided by the state fund, CDP[63]. This can considerably decrease risks of banks and other private players to invest directly into ECs. We discuss it in a greater detail in the next subsection.

Leasing of PV plants for energy sharing is provided by utilities, which take on the role of a 'third-party energy producer' in relation to a REC. Utilities can also serve as an external 'Referee'[64]. Another instrument utilized not only by impact investors but also by traditional utilities is equity participation. While traditional utilities cannot be members of a REC, they can participate as members of a JARSC group, to which they may contribute a power plant, such as by installing it on the roof of a condominium. Because JARSC[65] does not constitute a legal entity, PV plant contribution of a utility to a JARSC cannot be regarded as a formal equity participation. This arrangement is actually a collective agreement registered by the GSE to access incentives for shared energy. Another instrument, though not yet widely used by traditional utilities, is project finance. For example, Iren has developed a project finance solution for municipalities seeking to benefit from PNRR co-financing. The GSE awards the PNRR grant post-investment, often with a significant delay, and many small municipalities lack the budget to initially purchase infrastructure. In this case, a utility can finance the PV installation for the municipality, recovering part of the investment once the municipality receives reimbursement from the GSE. The remainder of the cost is then repaid to the utility over the lifecycle of the project.

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[62] Actually, grants from mutualistic fund are usually given not by the Federation itself but by its Fund.

[63] CDP – Cassa di Risparmi e Prestiti

[64] For the precise definition of a third-party producer and a referee check GSE (2024)

[65] JARSCs belong to condominiums, which in turn are not considered legal entities in Italian law

One co-financing instrument used by sector associations is the Energy Performance Contract (EPC). It is an innovative tool that was tested by the Forum per La Finanza Sostenibile within the NEON EU project, where few ECs[66] were foudned in Sardegna with a purpose of common energy efficeincy interventions. The EPC model enables an ESCO to cover the upfront costs of energy efficiency measures or PV installations, recovering its investment by retaining the savings generated from reduced energy consumption by members of energy communities. This approach is further enhanced by the Pay for Performance (P4P) model, which offers additional incentives to EC members for optimizing their energy usage. For example, members are encouraged to consume more energy during peak production periods, further reducing costs and maximizing self-consumption.

Table 15. Map of financing recipients

Type of Actor	**Main instrument used/available**	**Instrument recipients**							
		EC recipients						Non-EC recipients	
		Private citizen	PA	NPO	SME	EC regis. coop., Srl, SpA	EC regis. Other/ cond.	ESCo	SIV
Impact investors, Philanthropic & Public, Utilities (coop.), Financial intermediaries	Cost reduction (pro-bono)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Banks	Loan (Green)	Yes	Yes	Yes	Yes	Yes		Yes	Yes
	Loan (ESG-linked)					Yes		Yes	
Banks, Utilities (trad.)	Project finance (backed by collateral)		Yes		Yes	Yes		Yes	
Utilities(trad.), Utilities(coop.)	Leasing (combined with management)		Yes	Yes	Yes	Yes	Yes		Yes
Philanthropic & Public	Grant (foundation)			Yes					
	Grant (region)		Yes		Yes				
Impact investors, utilities (trad.)	Equity participation				Yes	Yes		Yes	
Sector associations (funds of coop. federations)	Grant (mutual fund)					Yes			
Utilities (coop.), Financial intermediaries	Equity crowdfunding				Yes	Yes		Yes	Yes
Financial intermediaries	Lending crowdfunding				Yes	Yes		Yes	Yes
Philanthropic & Public	Tax deduction (eco-bonus, IRPEF)	only eco-bonus	only eco-bonus	only eco-bonus	Yes	Yes	only eco-bonus		
	Grant (PNRR, Conto Termico)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Sector association	Grant (EU)		Yes	Maybe	Maybe	Maybe		Maybe	
Utilities (trad.)	Donation	Maybe	Maybe	Maybe	Maybe	Maybe	Yes		

[66] They belong to consumption-related services type of ECs described in Chapter II Section 2.2

Almost all actors indicated that they do not finance an EC directly, due to its typically weak legal form, but rather finance individual members within an EC. Table 15 outlines which financial instruments are accessible to which recipients. Potential recipients include EC members such as private citizens, PAs (public administrations), NPOs (non-profit organizations), and SMEs (small-medium enterprises). Many financial instruments are available to an EC only if it is registered as a cooperative or another corporate legal form (e.g., srl, spa). In the following subsection, we address challenges related to financing specific legal forms.

There are also two types of entities eligible for EC financing without being part of an EC: ESCOs, which may act as third-party producers, and SIVs (special investment vehicles). SIVs are entities created specifically to collect EC financing and guarantee returns to lenders or investors. This topic is explored in greater detail in the following subsection. Table 14 shows that instruments such as ESG-linked loans, project finance, equity participation, and both equity and lending crowdfunding are accessible only to corporate entities. In contrast, utilities have also provided leasing options for PV panels to PAs and non-profit organizations that later establish an EC. In fact, two of the four utilities we interviewed have designed special leasing offers for PAs that wish to incorporate public entities, such as schools or hospitals, as EC consumers. Under this arrangement, the PV plant remains the property of the utility, while the PA benefits from the shared energy produced. PV installations can also be placed on the roofs of public buildings, providing these entities with additional self-consumption and shared energy benefits, while the utility benefits from selling excess energy to the grid and receiving rental payments from the municipality, NPO, or EC. It is worth noting that private citizens generally cannot secure individual financing but can benefit through membership in a financed EC. Exceptions include green loans, eco-bonus, and Conto Termico grants, which private individuals can access directly.

An interesting grant source is the “Nextappenino” program, backed by the Complementary Fund to PNRR. Nextappenino has a specific, temporary objective: supporting reconstruction in the earthquake-affected areas of central Italy. Financing is available exclusively to PAs and can be used to install renewable energy plants integrated with district heating and energy communities. The program has financed multiple ECs in the regions of Abruzzo, Marche, Lazio, and Umbria. However, since the program supported ECs in central Italy as a supplemental, one-time project rather than as its primary goal, we do not include it in Table 15.

Fourteen actors reported providing pro-bono technical, legal, or administrative assistance to clients interested in establishing an EC, regardless of their nature. Consequently, this cost-reduction tool is accessible to all types of recipients. In Chapter II, Section 2.2, we discuss the IRPEF tax deduction in detail, including a case study of the Energia Positiva energy cooperative. This tax benefit could also potentially be available to new ECs if they register as innovative startups. In our study, grants for implementing EU projects (within which ECs could be established) and in-kind donations from companies are isolated cases. Therefore, while a wide range of recipients could potentially access these resources, they are not consistently available, thus labeled ‘Maybe’ in Table 15.

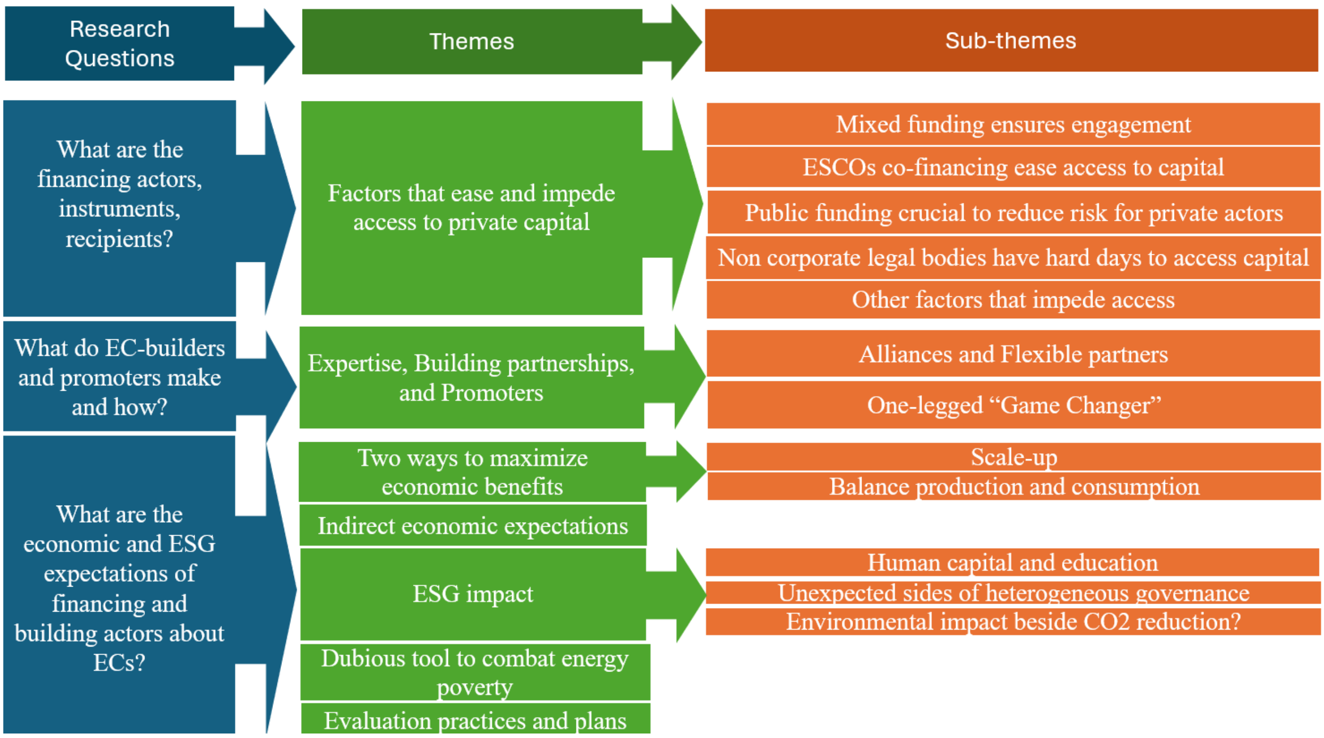
We developed process schemes illustrating the relationships between financiers and recipients across specific financing instruments. Additionally, these schemes clarify whether financiers or recipients benefit from revenues generated through shared energy, self-consumed energy, and energy sold to the grid. These schemes are available in Annex 7.

3.3.3.2 Thematic analysis

Seven themes emerged from the focused coding stage. The largest theme, “Factors that ease and impede access to private capital,” comprises five sub-themes, providing deeper insights into the first research question on actors, instruments, and recipients. The second theme, “Expertise, Building partnerships, and

Promoters", consists of two sub-themes and addresses the second research question regarding EC-builders and their approaches. The themes "Two ways to maximize economic benefits" and "Indirect economic expectations" illuminate the economic expectations of both financing and building actors. Lastly, three themes provide answers to the research question on ESG expectations. The themes "Let's forget about economic impact" and "Dubious tool to combat energy poverty" examine the environmental and societal aspects of ESG, emphasizing that these goals are central to this emerging phenomenon but may be difficult, if not impossible, to achieve. Contrary to the literature review and theoretical analysis in Section 3.3.1—where we developed a framework for how ECs could leverage their strengths through ESG reporting—our findings reveal a lack of clarity and commitment among actors regarding ESG assessments, though they generally recognize the importance of such practices for the future. This topic is largely summarized in the final theme, "Evaluation practices and plans." The thematic framework is illustrated in Figure 28.

Figure 28. Thematic Framework



Factors that ease and impede access to private capital

As environmentally and socially beneficial entities, energy communities have access to loans with reduced interest rates specifically designed for renewable energy projects. Two of the three banks we interviewed reported that they have internally developed dedicated financing solutions for entities borrowing funds to purchase PV systems for energy communities:

"Customers who invest in a relevant energy plant and make it available to a renewable energy community... will automatically benefit from a ***discount on the rate****."*

This is certainly a positive sign. however, the banks we interviewed are, to our knowledge, the only Italian banks that have publicly expressed interest in ECs. Beyond offering dedicated solutions, all three banks also evaluate the ESG performance of entities applying for such loans: *"In 2022 if you consider a total number of more or less 1000 loans procedures, 95% was covered by an ESG analysis."* Applying with an EC project is, in this context, an additional advantage.

Our statement, "CERs do not have difficulties in accessing loans or equity," was rated by eight actors, most of whom disagreed. On average, they ranked it 2.4 out of 5, which signals at the prevailing opinion that barriers do exist. However, several actors suggested distinguishing between loans and equity, noting that they perceive borrowing as more accessible for ECs than accessing equity. Five actors reported that a critical factor in facilitating funding for EC projects would be the availability of a state guarantee on loans. Such a guarantee would allow banks to significantly reduce risks associated with newly established organizations and concerns over potential subsidy suspensions. Actors mentioned MCC[67] and CDP as state funds that can provide collateral. One actor even told that such conversations are already conduced inside these guarantee funds:

"It's not remunerative, you see. And so, there need to be some public subsidy. Not to the level of PNRR today because that's a lot, but something more sophisticated, maybe, and something ***more geared to private finance****, to private banks, like* ***collateral*** *systems. CDP.. tomorrow we have a meeting with them on energy communities because they want to know what we're doing bacause* ***they want to do something****"*

All financing actors indicated that they do not fully fund EC projects independently but prefer a mixed or blended approach, where part of the funding is sourced from another actor. The specific co-financing tool chosen by EC members—whether it be a grant, loan, or equity—is less important than its role in reducing the risk for the primary financing actor. Several interviewed actors have even formed partnerships with other financing providers. A notable example is the RESPIRA project, where, in addition to technical and legal partners, three financial partners collaborate to offer tailored financial products that minimize risk and are suitable for ECs. We provide a more detailed description of the RESPIRA initiative when addressing the second research question. Here, we note that in RESPIRA, Banca Etica provides loans, Coopfond offers equity, and Ecomill acts as an intermediary for equity crowdfunding. This blended funding approach not only mitigates risk but also fosters a higher level of engagement from the recipients, who must demonstrate their reliability by securing co-financing. As one foundation representative put it:

*"because we want also to ask them to be involved in the project, because if you give them 100% and the project fails****,*** *they can say* ***'it's not my money'. You know, if it's not his money…*** *So, its our policy and has always been so [to ask co-financing]".*

Additionally, a matching portion of financing could be sourced from regional grants. For example, Fondazione Cariplo collaborates closely with the Lombardy Region to align its grant policies, allowing entities in the region to combine foundation and regional grants. Similarly, the Friuli Venezia Giulia Region aims to co-finance municipalities that receive a 40% PNRR contribution. Regional EC grants are increasingly targeted toward a broader range of entities, beyond just municipalities.

It is standard practice for crowdfunding platforms to require co-financing in the form of equity participation from entities launching lending campaigns. One platform, in particular, has a strict policy to protect its lenders, requiring a substantial matching contribution:

"more than 50% of the budget that you need in terms of debt to realize the energy communities ***is too much risk on the shoulders of private investors****. OK, you should need at least another component of equity contribution or traditional financial tools so that you will redistribute the risk on a major number of subjects"*

Crowdfunders argue that the only secure way to raise funds for an EC project is to establish a special investment vehicle (SIV), which can guarantee returns to lenders and ensure fair dividend distribution in the case of equity crowdfunding. They emphasize this approach as follows: *"we cannot finance directly*

[67] Mediocredito Centrale is a specialized bank that focuses on supporting SMEs in Italy. It manages the Fondo Centrale di Garanzia, which provides guarantees to facilitate access to credit for SMEs.

the energy community. Because it is an association[68]. ***There's no record, there's no balance sheet****, there's no, no, no. It has no chance to say that we will respect the commitment to give back the money to investors, so we need this vehicle to be co-owned by the developer that will take the responsibility of paying back investors".* Equity crowdfunding is an attractive financial tool as it allows projects to remain independent from debt, thereby promoting better long-term economic sustainability. However, crowdfunding remains more of a niche than a mainstream option in Italy, as it has yet to reach maturity. While some ESCOs have borrowed capital from citizens through these platforms, this has not included equity funding. One interviewee provides a sober assessment of the current situation: *"it's quite possible that more than 90% of the energy communities will be financed through traditional or institutional tools managed directly from the energy service companies or utilities. So, already setting a* ***1%*** *goal of energy communities, financed and developed through an alternative financial model, is something very challenging".*

Issues related to legal structure are less of a concern when a crowdfunding campaign targets citizens or entities that already trust the organization launching it. In these cases, a matching component may not be necessary. This is common practice among cooperative utilities, which have experience financing their energy projects through equity or lending crowdfunding alone. Occasionally, they may take out a bank loan as a temporary measure, particularly to expedite the construction of a new plant, which is later fully funded by equity crowdfunding. More details on such campaigns are provided in the case study of Energia Positiva in Chapter II, Section 2.3. This approach is also used by ForGreen and E'Nostra, both of which have many years of experience with equity and lending crowdfunding. They have successfully raised funds from their members, and at times from non-members as well. Both organizations reported an increase in interest from private citizens to finance collective energy plants and now ECs—a trend they attribute in part to the energy crisis of 2022.On the other hand, if an EC decides to be established as an Srl, Spa, or a cooperative, it has much more fiscal obligations, accounting, and higher transcation costs. However, access to capital improves a lot: *"if an EC is a company it has operating schemes that are somewhat standard or balance sheets that are more easily known and recognizable by an investor, so being company can certainly be a leverage in some way for financing".*

Nevertheless, ECs are not alone if securing financing from the investors specilizing in impact and venture capital. For example, Avanzi not only participate in the equity of startups but also provide pro-bono services to them, help to develop other revenue streams that support social purposes and accelerate returns. In the case of cooperatives, a comprehensive support ecosystem is available in Italy. Initiatives such as the RESPIRA project or regional services provided by Raiffeisen Federation and Federcoop Trentino are notable examples.. Seven actors indicated for our statement that they view the cooperative structure as the most suitable legal form for ECs. However, the cooperative option primarily serves private citizens aiming to establish ECs from the grassroots level, rather than municipalities, SMEs, or NPOs.

Leasing contracts offered by utilities to private citizens, NPOs, and SMEs significantly simplify access to infrastructure and its benefits. Often, this approach allows citizen members to avoid financial risk while also eliminating bureaucratic and management challenges. Utilities typically offer all-inclusive solutions for public and private entities by managing the entire process, from PV system installation to energy sharing and incentive management, taking on the role of "Referee." An interesting example is Edison's additional benefits, such as discounts on energy and gas contracts, offered to private citizens who join an EC and also become Edison clients. SMEs and municipalities also benefit from utility-financed PV systems installed on their premises, with the utility serving as both producer and EC manager. This model enables SMEs to access renewable energy and related incentives without investing in infrastructure, while also reducing costs through self-consumption. In contrast, for municipalities to access PNRR funds, they must own the PV plant. Having the PV ownership municipalities benefit additionally from energy sales. Regrettably, the leasing cannot be opted in this case thus municipalities must secure financig themselves. Utilities often assist municipalities in accessing PNRR funds. In the case of Iren, this assistance is even

[68] We discussed these legal forms in the literature review Section 3.2.2

offered as a pro-bono service: *"We are studying a possible model to approach the funds for our municipalities [meaning those being in the Board of Iren]".*

Another factor that potentially facilitates access to private capital is the diverse range of technologies available to ECs beyond photovoltaics. A variety of technologies can unlock specific financial instruments. We have previously discussed the public grant *Conto Termico* for requalification, as well as green minibonds and EPCs. For example, an ESCO could issue a green minibond with a preferential discount rate, using the funds to purchase a heat pump for the EC in addition to PV. This approach enhances electrification, maximizing self-consumption from PV, which remains the greatest economic benefit to date, as outlined in Section 3.1. However, EPC contracts applied to ECs are not yet a widespread practice.

A significant barrier to private capital access is the lengthy payback period. While this issue was manageable during the transitional regulatory phase, it has worsened under final regulation. Previously, many SMEs considered establishing ECs among themselves, enabling them to retain all benefits from shared energy while contributing to grid balancing and renewable deployment. However, final regulation prohibits SMEs from distributing all profits from shared energy to expedite investment recovery. Now, 55% or more of shared energy revenues must go to a social fund, redistributing resources either to private citizen EC members or to social projects. This rule is intended to prioritize citizen and NPO involvement in ECs, emphasizing social and public welfare over purely commercial interests. This requirement is further reinforced if the EC has benefited from a PNRR grant, in which case the share of revenue available to SMEs decreases to 45%. Additionally, if an SME participating in the EC has received a PNRR grant, its incentive for shared energy is halved. These two regulatory restrictions, designed to preserve the social focus of ECs, have also discouraged SMEs from participating. This limitation not only restricts access to SMEs' own capital for EC investment but also reduces potential leverage that could otherwise be achieved through their involvement. Ironically, one bank noted that industrial roofs represent a significant yet underutilized resource that ECs could benefit from.

Another impeding factor, highlighted by six actors, is the complexity of the energy community model adopted in Italy. This complexity frustrates the general public, particularly private citizens, leading even initially motivated individuals to lose interest in investing in an energy community:

"It was extremely hard to explain to people. You have to think that when you are talking about virtual self-consumption, they ask ***what does it mean****?"*

The issue goes even deeper. Many private citizens still view electricity as a fixed resource, rather than something they can actively influence or benefit from. As one interviewee from a traditional utility group noted:

"The fact is that is not so easy as it sounds to sell this kind of opportunity because ***condominiums are suspicious*** *... even if we are giving them something for free. The only thing that they have to do is to of course renounce to the rooftop for 25 years."*

Another barrier is the lack of benchmarks for successful ECs based on the virtual self-consumption model. Where examples do exist, they are typically rooted in unique local institutional contexts and comprise specific member configurations that are difficult to replicate elsewhere. Both traditional utilities we interviewed noted that they are working to design standardized EC offerings, but this remains a challenging task.

Expertise, Building partnerships, and Promoters

We define a building partnership as a formal or informal association of actors that either assists EC members in establishing the community or takes full responsibility for its setup. Building actors are not members of the ECs. For simplicity, I refer to 'builders' as both financial and building actors in this theme, distinguishing their roles when necessary. However, some, like ESCOs, may act as third-party producers. In contrast, a promoter is an entity that initiates the EC or becomes its driving force at a later stage and is a member of the EC.

Establishing an EC is a complex task that demands a wide range of expertise and skills, as reported by all actors already engaged in the field. Essential areas of expertise include technical, legal, social engagement, financing, administrative, and procurement skills. Key technical tasks involve conducting feasibility studies, installing and commissioning the plant, maintaining the plant, and installing additional equipment as the EC grows. Legal expertise is critical for selecting the legal structure, drafting statutes, and managing the entry and exit of new members. Social engagement functions are focused on recruiting members, whether consumers or prosumers, and managing the social budget. Financing expertise is typically required to secure initial capital for feasibility studies, CAPEX financing, and additional projects during the EC's lifecycle. Administrative tasks are extensive, including documentation support for accessing GSE incentives (both tariffs and PNRR contributions), accounting, and managing the membership base, especially if the EC is structured as a cooperative. This may also involve organizing annual meetings, distributing newsletters, handling correspondence, and overseeing organizational growth and development. The precise scope of these functions depends on the level of complexity chosen by the members, whether they are uniting simply to access the GSE tariff on shared energy or envisioning the EC as a platform for broader sustainability goals.

Currently, actors providing technical support include ESCOs, energy cooperatives, and both public and private research institutions. Within ESCOs, a key role is played by energy service subsidiaries of traditional utilities. Historical and newly established energy cooperatives also typically possess sufficient technical expertise. A significant portion of Chapter II provides an in-depth examination of cooperatives. Another emerging technical partner is software companies, which can supply ECs with Energy Management Systems (EMS) and other tools to optimize self-consumption and coordinate energy sharing among members.

Notably, ESCOs and energy cooperatives can contribute not only technical but also financial and administrative expertise. One financing actor described the ideal technical partner as one who brings a broad spectrum of expertise:

"and the other request was to bring along a technical partner which could provide some technical insights. Both on the plant part that is strictly ***technical part****. And on the management of the community, so how to* ***manage the energy flows*** *and the* ***economic flows*** *that will come from the start of a new organization"*

Legal expertise is sometimes provided by sector associations that may be directly involved in building partnerships. For example, associations like Legacoop, Raiffeisenverband, and Federcoop Trentino have mandates in their statutes to promote the cooperative model within their regions. However, in most cases, legal matters are outsourced to law firms, known in Italy as 'studi legali'. Many of these law firms have been active in educating the public from the early stages of the EC movement.

For effective social engagement, it is crucial to involve either the municipality, a local NPO, or a church. The latter two actors are often well-informed about the needs of private citizens and are typically trusted within their communities, making it easier to encourage citizen participation in ECs. The importance of trust in social engagement was highlighted by 15 interviewees, with one providing an example:

"one of the first energy communities in Italy in Naples in the neighbourhood of San Giovanni. It was created by a non profit organization that has a very strong role in helping children to study, helping family

to have food, and so on. And so this community was created and a lot of families became a member because they ***trusted a lot*** *the nonprofit organization"*

In small towns, the local municipality often holds a high level of trust and can engage not only citizens but also various SMEs in an EC. Further below, we examine the municipality's key role in more detail. One interviewee also mentioned a partnership with a national real estate company that manages condominiums across the country. This collaboration facilitates the involvement of condominium administrators, a crucial role in engaging citizens in a JARSC.

Table 16. Building Partnerships

Alliances	Flexible Partners
"RESPIRA": Banca Etica, Legacoop, Coopfond, Ecomill	Raiffeisenverband, Raiffeisen Energy, Alperia, Regalgrid srl.
Intesa San Paolo, Deloitte, Enel X, Regalgrid srl.	Fondazione Cariplo, Lombardy Region
Volksbank, Regalgrid srl.	Banco dell'Energia, Fondazione con il Sud
Edison Energia, Gabetti Lab	E'Nostra, Banca Etica
Iren Smart Solutions, Legacoop	Fondazione Compagna di San Paolo, Fondazione Cariplo
Banco dell'Energia, Edison Energia	Sinloc Spa, Ener4com coop.
"Energheia": Acea Pinerolese, Tecnozenith	Fondazione Casa Risparmio di Cuneo, Environment Park
Garda Uno, ENEA	-

In Table 16, we have clustered EC-builders. We found that some partners have formed partnerships with officially announced formal agreements targeted for EC building, which we term "Alliances." These partnerships resemble a 'one-stop-shop' solution for ECs. Other partners, which we call "Flexible Partners," rely on external outsourcing support. If a flexible partner is a financial actor, it may either cover the cost of external services on behalf of the EC or simply refer the EC or its members to an external provider, in which case the EC bears the cost. "Flexible Partners" operate more informally, directing ECs to each other without establishing formal agreements. Contrary to our expectations, we did not find any entities with fully in-house expertise.

A prominent example is the large "umbrella" project RESPIRA, where partners offer mixed financial instruments to ECs aiming to register as cooperatives. One such instrument is equity crowdfunding, facilitated by the Ecomill platform, which, if successful, is matched by Coopfond. Another product is a *"**debt product** which has a **high premium** for cooperatives that are invested by Coopfond"* offered by Banca Etica to ECs. Legacoop is a legal and administrative partner, while technical partner is not rigidly determined but rather chosen on a project to project base.

Some partnerships are formed based on similar expertise but with slightly different specializations, territorial scopes, or beneficiary types. For example, the partnership between two technical actors, Acea Pinerolese and Tecnozenith, focuses on developing JARSCs, with Tecnozenith serving as an ESCO specializing in energy efficiency and electrification. Notable examples also include partnerships between foundations or between foundations and regional governments, such as the collaboration between Fondazione Cariplo and the Lombardy Region to co-design support policies:

"We had some meetings together ... we launched our call in May, they launched in June or July. And we wanted to coordinate ... two initiatives that are ***not overlapping,*** *but work in a very* ***synergetic*** *way"*

Interestingly, the expansion of some partnerships has begun to include future PV suppliers as separate partners, potentially signaling ambitious plans or a close territorial relationship: "*Then we have Alperia which can deliver PV plants to interested citizens or interested municipalities"*.

The partnerships primarily support ECs by providing services, either pro-bono or commercially. Many actors reported that they do not intend to continue their involvement with ECs once their services are completed. Therefore, the long-term success of these initiatives largely depends on their core members: municipalities, NPOs, private citizens, SMEs, and religious entities. As one interviewee noted, success will depend, first and foremost, on the promoter, who ideally should be: *"**the most financially capable, stable**, **ambitious** in the territory, who has the most capacity to engage general population".* A recurring theme in our interviews was the importance of municipalities. Although municipalities were not specifically mentioned in the questionnaire, questions about partners or members consistently led interviewees to emphasize the critical role of public administrations, with one interviewee even calling them "game changers." Indeed, evidence suggests that the majority of EC initiatives are driven by municipalities, whose involvement is a primary factor behind the success of an EC:

*"if it is the municipalities that owns, manage and coordinate the process, the people feel more sure to become a member. If it is something 'in which **my mayor** is, that **I voted** for'. My mayor want to **install an energy community**. The municipality is one of the member and it wants to also **share profits with me!**"*

Another factor contributing to the importance of municipalities is their ownership of public buildings, such as schools, fire stations, and police headquarters. These buildings consume significant amounts of energy during the daytime, when the sun is shining, and residents are typically away from home. As a result, public buildings are ideal candidates as primary consumers in any EC configuration. The inclusion of public buildings, along with industrial facilities, enables ECs to maximize profits from shared energy and optimize self-consumption. In this context, municipalities should be seen not only as recipients of services from building partners but as proactive agents in EC development:

"*Municipalities are **in love** with energy communities. It's their social goal, also engagement, also environmental mission".* Municipalities also know where to direct social money better.

Five actors reported that access to capital is a greater challenge for smaller municipalities than for larger ones. Even when PNRR contributions are granted to small municipalities, they only cover 40% of CAPEX, and obtaining the funds is challenging since they are awarded post-investment. In this context, one bank representative noted that his bank specifically targets small municipalities due to their higher need and the bank's strong territorial focus. However, this bank operates in only a few regions. Another challenge for municipalities in ECs is that they cannot participate through a corporate legal form. The most commonly used EC legal structure so far is the "Fondazione di Partecipazione," which, being less binding, poses difficulties for financing. Overcoming these hurdles requires significant perseverance from municipalities, which are often conservative. As one interviewee from a state body emphasized:

*"In a way, it's a **matter of timing**. So of course, the municipalities do have a priority and public entities in general to be sure that what they do **legally is correct**, because the type of negative outcome they can face is in a way worse than what a private entity can go through when they make a mistake, you know? So, they tend to be **quite conservative**"*

Both traditional utilities have developed EC offerings for public administrations, though not comprehensively. Utilities generally expressed frustration with the lengthy and complex bureaucracy required to establish public-private contracts. For example, Edison Next even established a dedicated subsidiary, Edison Next Government, to handle these processes. An added challenge is that PNRR contributions period ends in 2025. To access these funds, small municipalities must purchase PV systems in advance. However, this poses a dilemma: where will they find the necessary funds in advance if they lack sufficient resources of their own? For example, the EC's legal structure must be anything but a "Fondazione di Partecipazione" to qualify for bank loans. Ironically, the most crucial promoter faces the most significant hurdles. Fortunately, private actors like Iren and Edison are willing to "lend a shoulder."

Two ways to maximize economic benefits

First and foremost, the economic benefits of ECs depend on the economic sustainability of these initiatives. When we asked interviewees to assess the statement, "Private financing of CERs will fully replace public subsidies after 2026-2027," opinions were divided. All actors agreed that the economic aspect currently poses a challenge for the sustainability of ECs. However, public and philanthropic entities, impact investors, sector associations, and banks voiced the opinion that, without explicit state subsidies for CAPEX or private grants, ECs will face significant difficulties, potentially jeopardizing their survival. The primary issues are the low price for energy injected into the grid and the modest premium tariff for shared energy, both of which contrast sharply with high CAPEX requirements. These groups of actors emphasized that the availability of grant support is crucial for the survival of ECs:

*"at the moment without grant public or private grant it is very difficult to have the economic impact and the social impact is limited **because if they need to give the loans back, this is a problem**"*

On the other side, respondents from traditional utilities and one financial intermediary believe that private financing will fully replace state CAPEX grants, asserting that finding private funds for ECs will not be an issue. This perspective contributed to an overall rating that averaged around 2.8 out of 5. In contrast, all actors agreed that without a premium tariff, ECs not only would struggle to survive but would ultimately *"doesn't make sense"*. The valorization of avoided grid usage alone is insufficient to unify consumers, prosumers, and producers of diverse backgrounds into a single entity. The importance of implicit subsidies aligns with our literature review findings reported in Section 3.2.2.

There are two primary strategies for maximizing the economic benefit of ECs. Seven actors emphasized that achieving an optimal balance between energy consumed and produced within the EC is essential, aligning with our discussion in Section 3.1.2 of this chapter. To this end, traditional and cooperative utilities aim to involve PAs and SMEs, with notable projects incorporating farms. One interviewee reported that ECs must achieve 70% renewable energy sharing to ensure financial sustainability, which requires a carefully conducted technical feasibility analysis and a precise composition of producing and consuming members. The second strategy for maximizing economic outcomes is scaling up. Given the maximum allowed configuration size of 1 MW, ECs should aim to reach this capacity to enhance financial viability. Small-scale EC PV plants anticipate excessively long payback periods, especially under regulatory social provisions, making it challenging to achieve a return on investment. For instance, Iren designs its ECs to consistently reach 1 MW capacity, requiring the involvement of consumers who can virtually consume the majority of generation during the day. This again underscores the importance of municipalities, which could involve variety of public buildings with high day-time consumption such as schools. Furthermore, many Italian utilities are exploring the creation of expansive ECs comprising multiple 1 MW configurations to reduce transaction and administrative costs. This strategic approach was aptly described as:*"The main plan is to create **one legal body** that will manage many configurations."*. Importantly, the issue of scale is not a concern exclusive to utilities. One sector association advises its ECs to adopt scaling as a core expansion strategy:

*"You need **at least 300 to 400 kilowatt** power plants that you reach a break-even for the energy community…We tell them that it is best if they reach **1 MW in the next two to three years** so that each member can also expect a nice interesting amount of incentive"*

Indirect economic expectations

Financing and building actors do not view ECs as a direct profit generator. However, traditional utilities and banks anticipate nuanced, indirect economic benefits for their businesses. Cooperative utilities, on the other hand, are especially encouraged, as much of their core business is grounded in innovative energy models.

Strategically, ECs represent a new market structure that could challenge the existing status quo, particularly for market players like retail companies and utilities. We explored this topic in Section 3.1 of this chapter. In our financing study, interviewed utilities are actively working to develop appealing offers for various potential EC members, with particular attention to condominiums, public administrations, and SMEs. Engaging these entities provides an additional opportunity to increase utility's presence within the territory, which can serve as an effective marketing strategy with two indirect benefits. First, several interviewees mentioned offering discounts and preferential rates to future EC members willing to switch to them as energy suppliers. Although joining an EC does not legally require a supplier change because EU policies support consumer choice. Second, utilities engage in cross-selling by proposing additional energy services to entities with whom they build an EC, enhancing the EC offer's profitability, which might otherwise be limited. In this respect, they see ECs as a potential leverage point for their core, more profitable business:

"since the instrument of ***public private partnership is expensive to be developed****, we try to put in* ***all the other services*** *we can offer to a public administration. So, we can offer not only the creation of an energy community in this case, but maybe the energy efficiency of the public building, the efficiency of the public lighting, smart services like smart parking, smart traffic lighting services."*

Furthermore, if a photovoltaic panel supplier belongs to the same utility group as the ESCO working with ECs, this could create an indirect economic benefit. Such an arrangement allows the PV supplier to diversify its commercial channels, reaching more municipalities, SMEs, and ultimately more citizens.

In a traditional sense, a market is a place where consumers' willingness to pay intersects with producers' willingness to sell, with equilibrium occurring at that intersection. This logic shifts with cooperative utilities. Since cooperative utilities are managed by private citizens, their interests take precedence, with growth opportunities arising from increased member equity participation and expanding membership. When the primary owner and main customer are one and the same, the economic expectations of each align. Here, your shareholder is also your client: *"A lot of* ***our Members want to promote*** *renewable energy communities in their municipality,* ***in their area****. And so we offer them the possibility to receive training on various energy communities topics".* In fact, these utilities are actively working to integrate ECs into their own models through various approaches. This shift presents significant potential for innovative growth, where cutting-edge organizational models are often central to cooperative utility businesses. For this reason, in Chapter II, we sometimes refer to them as "virtual ECs" due to their innovative nature. Below is an example of one cooperative's adaptation of its business model to incorporate ECs:

"We would like to implement the Gubbio power plant and use [sell] this electricity for our members distributed all over Italy. At the same time, creating a local renewable energy community that is connected to this Gubbio power plant and will benefit from the premium tariff… ***both our Members*** *will have a benefit* ***and the local people*** *who will indeed host the power plant… CER member could in principle* ***also become our member****… In principle we could also design special tariff, as other utilities intend to do"*

Cooperative utilities will undoubtedly leverage EC incentives to create novel commercial offers and enhance economic outcomes for their members. Additionally, this will enable them to diversify their offerings. Business diversification contributes to resilience during crises. Both cooperative utilities interviewed noted that several small retailers in the Italian market went bankrupt during the 2022 energy crisis. In contrast, the cooperatives attributed their stability to the cooperative business model, supported by social capital—namely, member trust—which not only safeguarded them but also provided a testing ground for innovation. A bank closely aligned with the cooperative system confirmed cooperatives' interest in expanding their activities around ECs, stating that: "*this is a strategical aspect for them, not just the economical aspect".*

One bank reported that involvement in ECs creates competitive advantages for their corporate clients and supports their long-term growth. By helping corporate clients gain a competitive edge, ECs can also serve as a strategic leverage point for banks. Another bank highlighted its strong territorial focus, indicating an interest in ECs not only for sustainability but also for strategic regional presence, particularly in municipalities with access to PNRR funding that supports co-financing for PAs and SMEs. However, this does not mean they overlook the economic outcomes of ECs as projects or entities. The bank noted that due diligence on repayment flows is conducted with the same rigor as for other projects. Nonetheless, non-obvious economic impacts for the bank may also arise:

"*However, the sustainable aspect of these projects is rewarding or beneficial because it can allow the Bank to access special funds, such as* ***BEI (European Investment Bank) funds****, which offer cost mitigation or financial support through favorable terms".*

ESG impact

One of cooperative utilities awakened us by emphasized that their policy prohibits overinvestment, as their primary objective is to maximize social value. They noted that energy cooperatives and energy communities are, above all, tools for ESG impact. They also mentioned that companies could use ECs as a welfare solution for their employees—for example, a company might establish an EC where members are its own employees, creating a direct social impact. However, a representative from a large industrial company offered a different perspective. He was interested in the potential of ECs to mitigate the NIMBY effect associated with their industrial activities:

"If you create an energy community together with the realization of your plant, this will increase ***the acceptance*** *maybe* ***of the people*** *towards this project".*

He also viewed ECs as a tool that could help public administrations further justify the presence of industry within their communities: *"Local authorities will be more happy because they see they have also* ***a tangible result*** *that they can* ***explain to the population****".*

A sector association highlighted that their region has many SMEs within the energy supply chain, and if ECs procure infrastructure locally, this generates a positive economic impact that strengthens social cohesion in the area. Another representative from a similar association noted that the deployment of such initiatives could also increase system security during extreme weather events.

One bank and an impact investor shared the view that the primary focus of ECs should be on generating social impact, with profit as a secondary objective. This social impact can be reflected in the ESG reports of SMEs participating in ECs, and for those not issuing such reports, the larger companies in their value chains could highlight this contribution. In this way, SMEs may gain a competitive advantage through their social and environmental contributions.

All three foundations share a clear vision of the importance of appropriately distributing social fund money. Beyond addressing energy poverty, which we discuss below, ECs generate other types of social outcomes: "*one of the communities we are going to finance…use the funds to provide the opportunity for* ***six peoples*** *to attend a specific* ***course*** *on how to effectively* ***maintain the PV****"*. Moreover, the lifestyle changes promoted by environmental education can lead to outcomes of consuming less and consuming more responsibly: *"As people say,* ***the best energy*** *is not renewable energy. It is the* ***energy you don't consume*** *at all".* A participatory approach to energy communities is also crucial, gradually encouraging members to take on more management responsibilities within the EC, thereby transferring administrative duties from the technical partner to the members. This approach allows members to learn how to calculate energy and economic flows, building valuable skills. Dedicating EC social funds to education, rather than solely to reducing energy bills, represents the ideal social outcome that foundations aspire to achieve.

One utility shared that their company strategy includes achieving a specific renewable capacity within their portfolio—a strategic objective aligned with the social contract reflected in the "Green Deal," which asserts that European citizens care about the environment. Currently, in Italy, the premium tariff for ECs is the only type of feed-in-tariff available for new installations. While it may not represent the most profitable business case, it enables the installation of additional capacity and offers a forward-looking perspective:

*"Which is the value for us to be there? We don't know. Which is the Business today of the energy community? It's very small. If we look at the numbers, it's **not** a valuable subject **where to invest**. But it's still a business. It's not a marketing and not a sustainability expense. We believe that more than **10- 15% of residentials** in Italy will be part of ECs in 10 years from now. And that's a lot. So, of course, being there is **strategical**".*

All actors recognized the environmental impact of ECs as the most prominent among ESG components, with carbon emissions reduction seen as the primary benefit. Optimizing land use was also frequently mentioned. For instance, Iren noted their plans to install large-scale PV plants on former landfill sites, producing clean energy while repurposing degraded land—one such PV plant is already operational. Additionally, three other interviewees mentioned that municipalities in ECs which they finance plan to install PV plants on municipally owned wasteland. Three utilities are also developing ECs that involve farmers, where agriculture is combined with solar energy production by co-locating PV panels with crops and possibly even livestock.

A key issue raised during our interviews was the sustainability of governance in ECs given their heterogeneous membership. We asked respondents to evaluate the statement, "The heterogeneity of entities participating in CERs complicates decision-making related to project financing." The opinions of 11 respondents were divided. Public and philanthropic actors, as well as sector associations, generally disagreed, arguing that heterogeneity contributes valuable expertise, which in turn supports the successful implementation of initiatives. One foundation shared that, in their experience, projects led solely by NPOs encountered substantial challenges that were difficult to overcome. A common concern, however, was the long-term stability of EC governance, given that the premium tariff lasts 20 years, which may involve turnover of managing members—a potential governance challenge. From this perspective, heterogeneity can be beneficial, providing a broader pool of members to ensure continuity. Still, several actors acknowledged potential conflicts between the economic interests of municipalities, NPOs, and churches on one hand, and SMEs on the other, though they affirmed that such issues are manageable. An actor closely involved in the cooperative sector expressed a strong conviction:

*"You don't want to have cooperatives that are so **homogeneous** because then **conflict is easier.** I think it's better if you have a **heterogeneous** base where all the interests are fully represented, where you **have to negotiate the interests of all groups**... So, that's a very healthy model. It is also, the most complex. However.. we know how to manage that. We have dealt with governance issue for the past 120 years"*

Actors aligned more with the private sector, including traditional utilities, one financial intermediary, and a bank respondent, held the opposite view—that membership heterogeneity complicates investment decision-making. Their argument centered on the ambiguity regarding responsibility for debt repayment to investors. As a result of this division in opinions, the statement received an average rating of 3.1 out of 5.

Dubious tool to combat energy poverty

The results of the statement assessment and related questions on energy poverty were surprising. The statement "CER is an excellent tool to combat energy poverty" received a somewhat skeptical response, with nine respondents giving it an average rating of 3.5 out of 5.

According to most respondents, the most effective way for energy communities to address energy poverty is not by using social fund money to reduce members' bills but by aggregating these funds and directing them to vulnerable non-member families. One interviewee suggested this approach, noting that vulnerable families are unlikely to comprise the majority of EC members nationwide. Therefore, the altruism of those who actually constitute the EC is crucial. This sentiment was captured straighforward by one interviewee:

"I'm a consumer of a solidarity energy community. I can participate without paying anything. It's free for me. I don't have any effort. I only have to sign my participation. But I know that with my participation, I

can allow the energy community to ***sustain few specific families****. So, I renounce to take €50 per year because* ***€50 are not so much for me****. And then maybe a family can have* ***€500*** *per year [if other members also decide so] and be sustained in a more appreciable way".*

Another actor emphasized that the goal of combating energy poverty should be established from the outset, as a foundational intention for the entire enterprise—not as a vague objective to be considered only after initial revenues are generated.

A recurring theme was the need for a public or social actor's involvement to effectively address energy poverty. Six actors specifically noted that energy poverty is more pronounced in Southern Italy. Furthermore, many respondents highlighted that access to capital in Southern Italy, especially for smaller municipalities, is generally much more challenging than in the North, as discussed earlier. Often, local NPOs or churches are well-positioned to understand the needs of vulnerable households and address the issue effectively. Regional EC funding could provide a viable financing solution, though it faces obstacles. Firstly, there is less regional funding available for ECs in the South. Secondly, such funding typically targets municipalities rather than non-profits. Consequently, the regions that most need energy communities have the least opportunity to establish them. One interviewee envisioned an ideal future where ECs could create significant social impact, proposing that Northern regions, with greater access to capital, could lend or invest in Southern energy communities. In his view, such solidarity would strengthen social cohesion at a national level. However, several interviewees pointed to a lack of expertise necessary to deploy ECs at scale in the South to effectively address energy poverty. Interestingly, one actor noted the South's high solar irradiation potential, which remains largely untapped by distributed generation. In Section 3.1.2, we described the structure of Italy's premium tariff, where Southern Italy receives less support compared to other regions due to its higher solar irradiation and the higher penetration of large renewable energy sources, which congests the grid. This approach may suggest that policymakers primarily view ECs as a tool for reducing future grid reinforcement costs rather than a tool to combat energy poverty.

As one interviewee suggested, given the relatively low margins, it makes more sense to direct profits toward activities with socially transformative potential:

"The cost of the energy will not be impacted as much as you can impact the community by creating new environmental, educational, cultural property support projects… This is how you will also ***leverage/multiplicate the value of the energy in the perception of people****".*

To conclude this theme, we highlight the skeptical perspective of one public and philanthropic actor:

"CERs are ***a gamble****. Really. In Italy, we are walking on a thin line. Because in Europe, maybe, it's something that has been working better than here, but in Italy it is something that, for the moment, we are* ***not that hopeful****. Whether this is going to be a game changer for energy poverty and energy models of auto-consumption, or whether it's going to be* ***an empty box****. Because we're just financing these projects, keeping our fingers crossed that everything will be OK…"*

Evaluation practices and plans

First, it's important to note that none of the interviewed banks expressed a decisive intention to assess the ESG potential of the energy community itself. Instead, they plan to evaluate the general ESG performance of the SMEs or ESCOs requesting a loan. This pre-investment sustainability assessment of SMEs can be complex, particularly for ethical banks. For energy communities specifically, the financial plan of the project remains the primary criterion for financing decisions.

In contrast, two of the three impact investors indicated a selective approach to the ESG data they request, tailoring requirements to each applicant. As a result, it was generally confirmed that when a cooperative or SME seeks investment for an EC project, ESG data would be equally important as financial data.

Additionally, one impact investor mentioned having prior experience with equity participation contingent upon the investee's attainment of ESG targets. if targets are met, the dividend percentage is reduced. Impact investors also expressed interest in monitoring ECs over time to assess their impact, with social indicators being the most relevant ESG metrics for ECs:

"I would value social and governance more than environmental because ***environmental is basically there****... But on social and governance I would go deep".*

Foundations typically conduct thorough evaluations before awarding grants, hiring external technical advisors to assess whether proposed projects aim to install sufficient power capacity to meet members' energy needs. Grants are awarded to ECs or partnerships exclusively when an NPO is involved in ECs. Depending on the funding level, foundations may issue a call for interest if only feasibility studies are financed or a call for proposals if infrastructure is also financed. The criteria for EC projects, as well as the expected impact, are clearly outlined in these calls. Foundations request detailed information from ECs, such as the anticipated energy consumption of future members, potential community membership, and the available space for energy installations. Additionally, they may ask for social data: *"to briefly describe the strategy through which they are going to involve into the energy community fragile people or people in poverty".* Partnerships applying for grants must provide data to substantiate their commitments. When asked about the weaknesses in unsuccessful applications, two of the three foundations noted a lack of technical data and a vague plan of action from those applicants. In response to the statement, "Actors lack expertise on how to build a CER," financial actors generally agreed, giving it an average rating of 4.1 out of 5.

One foundation shared that they have already contracted an external evaluator to assess the impact of EC projects they have sponsored, both one year and five years post-implementation. Two of the three foundations mentioned that, while it is too early to conduct impact evaluations for EC projects, this is something they plan to pursue. Regarding indicators, it was noted that for ECs, qualitative indicators might be more meaningful, as quantifying social impact poses challenges. As one actor noted:

"You will have 100 families paying their bills due to ECs, but after one year, what has really ***qualitatively helped them*** *because it's the long term, it's not the short term".*

Crowdfunding platforms conduct rigorous financial and ESG analyses of projects before launching campaigns. Both the ESG and financial performance of EC promoters and the EC projects themselves are thoroughly evaluated. However, financial intermediaries do not monitor projects once the campaign concludes, and energy communities are no exception. Meanwhile, one utility noted that they have long-term monitoring plans for ECs and intend to include indicators on CO_2 reduction and social impact in their own ESG reports. A sector association remarked that monitoring the financial performance of ECs over time would be valuable. Survival and financial stability are not guaranteed in 20 years. As it is seen now: *"at the moment it's more a* ***temporary opportunity*** *to us to promote the renewable energy installation and to* ***use*** *those* ***subsidies*** *that are provided by the government".*

3.3.4 Discussion

This section is organized into two sub-sections. In the first, we discuss findings related to our research questions and identified themes, comparing these findings with existing literature. In the second sub-section, we examine the alignment of our findings with theories presented in the literature review. While established practices for evaluating the ESG performance of new ECs are not yet in place, indications suggest their eventual development. We explore how motivations among financing and building actors may drive future ESG evaluations of ECs. Finally, we discuss the applicability of CPR theory in the context of Italian ECs.

How do our findings support or contradict existing literature?

Our study found that many ECs are financed through grants, with the type of grant often depending on the requesting actor. Foundations provide grants to NPOs, while most regional authorities direct grants to municipalities. The state authority, GSE, provides PNRR contributions to potential EC members in small municipalities. When a grant serves as the main financing source, co-financing is typically covered by a separate grant from a different funder, as shown in Table 15. This suggests that builders seeking support from public and philanthropic actors often struggle to secure the remaining funds from private sources. Legambiente (2024) suggested that one reason for this difficulty may be a lack of knowledge about financing options, indicating a need to enhance educational efforts. Similarly, the REScoop & Ecopower (2023) report on European EC experiences highlights that public grants and subsidies significantly ease the financial burden on ECs, especially in the early development stages. The relatively new legislative framework for Italian ECs has understandably led builders to seek public support over private capital. One interviewee noted that future economic sustainability would benefit if ECs relied less on debt, as long payback periods could jeopardize their social impact. Interestingly, builders who initially turn to private capital also seek public and philanthropic co-financing to support projects. Grants are a more economical means of financing CAPEX than equity or debt, raising the question of how long these grants will be available and whether they will be sufficient to achieve the 5 GW policy goal.

Most financing actors we interviewed require co-financing and do not provide full funding. Exceptions include traditional utilities that fully cover costs for JARSC projects, although RECs projects often still require co-financing. Traditional utilities finance ECs through leasing contracts as third-party producers or project financing for municipalities with PNRR contribution access. In our sample, both traditional utilities offered such financing to RECs, where direct utility membership is restricted. The Arcudi et.al. (2023) report indicates that only four of Italy's eight utilities offer financing solutions. However, the utilities we interviewed were not listed as financiers in this report. This discrepancy could be due to the Arcudi et al. (2023) study being conducted a year earlier, as the market is rapidly evolving, or possibly because leasing was not considered a financing tool in their analysis.

Both studies underscore that utilities view ECs as medium- to long-term commercial opportunities rather than purely sustainability investments. Arcudi et.al. (2023) suggests that utility companies could serve as promoters, investors, technical partners, administrators (or "referees"), and infrastructure and service providers. Our research confirms that traditional utilities are already fulfilling all these roles across various commercial offers and contexts. We also observed that utilities are more prominent in formally established partnerships ("Formed Alliances") compared to "Flexible Partners." Typically, these "Formed Alliances" include a technical partner, often a utility or its subsidiary ESCO. When financing ECs through leasing, utilities often provide "turnkey" solutions that include administrative services, such as acting as the community's "Referente." Beyond leasing, traditional utilities also offer project financing to ECs, particularly for public administrations with fewer than 5,000 inhabitants. This is due to PNRR contribution requirements, which mandate that beneficiaries own EC infrastructure, making leasing unfeasible in these cases. REScoop and Ecopower (2023) suggest that project financing is generally more appropriate for larger projects due to the stringent requirements and associated costs. Our findings indicate that, for small municipalities, project financing is a necessity rather than a preference, as other financing options are limited. Utilities with municipal shareholder bases, such as Iren, are often obligated to assist public administrations in overcoming financing challenges.

Several of our interviewees emphasized that public collateral would be crucial for the sector's growth. They suggested that large public funds could provide this support, with one interviewee noting that such an option is already under consideration. In the literature, only REScoop & Ecopower (2023) mention this instrument, referring to collateral provided by municipalities rather than on a national scale. We assume that national-level policies for ECs were previously lacking, which likely explains the limited use of public collateral. Nevertheless, we believe this instrument will be important not only in Italy but also in many other Member States.

While many sources identify equity crowdfunding and equity participation as important tools, there is little evidence that institutional investors commonly finance ECs through member participation in other countries. We attribute this to the novelty of Italian regulations, which allow a broader range of actors to participate in ECs and, indirectly, in the energy market. This expansion raises questions about the most suitable legal form, particularly in cases where public administrations (PAs) wish to join as equal members. Unfortunately, legal forms that align with PA interests often do not adequately protect private actors' interests. As illustrated in Table 15, ECs registered as non-corporate entities (such as Associazione ETS, Fondazione di Partecipazione, or Consortia) have limited access to financing. Additionally, if citizens wish to establish an EC without involving a legal entity, their only option is to form a cooperative or company—both of which entail a lengthy and costly process. Factoring in the limited timeframe for public subsidies, a purely grassroots initiative led by citizens becomes nearly impossible. One potential exception is for condominium tenants in small municipalities who choose to establish a JARSC, financed through the PNRR grant and supplemented by personal contributions. In this case, citizens would still need technical expertise to work with GSE effectively, althouth they would not need to specifically ask a legal entity to join a JARSC for the sake of obtaining financing.

The available literature, along with our findings in Chapter II, highlights the extensive experience of cooperatives in the renewable energy sector, particularly in countries like Germany, where ECs have significantly contributed to expanding RE capacity. Our research identified one alliance (RESPIRA) and two flexible partnerships (Raiffeisenverband with partners, E'Nostra with Banca Etica) that focus exclusively on promoting the cooperative model. Cooperative ECs thus have distinct advantages in accessing financing and expertise, as they can more readily secure green loans from ethical banks, attract co-financing through impact investor equity participation, and benefit from a comprehensive range of pro-bono advisory services. Non-academic literature largely supports the cooperative legal form, noting its advantages for financing renewable energy projects. Numerous reports describe successful cases of cooperatives leveraging member investments, bank loans, and even crowdfunding to fund renewable energy initiatives (Coopfond, 2022; EFREC, 2014; REScoop.eu & Ecopower, 2023). However, academic evidence suggests some challenges with the cooperative structure. Studies indicate that energy cooperatives can face management difficulties, and the risk-averse nature of some cooperative members may inhibit the adoption of innovative financing approaches (Herbes et al., 2017). Despite these challenges, participants in our study affirmed that cooperatives are a well-suited model for ECs, with one stating: "***We know how to manage that****. We have dealt with governance issues for the past 120 years."*

Our study consistently highlights the importance of mixed funding for ECs. This approach mitigates risk, particularly for new ventures like ECs. Philanthropic actors may require only the commitment of NPO employees' working hours as reassurance of future engagement, while private actors often recommend potential co-financiers. In more advanced cases, financing actors form partnerships that offer "turnkey" mixed financing through one-stop-shop alliances. While the significance of mixed funding has not been strongly emphasized in existing literature, it has been briefly noted in descriptions of specific cases. The evidence in prior studies largely comes from interviews, surveys, and case studies featuring representatives from energy communities. In contrast, our focus was on the financiers' perspectives. We believe this difference explains the general absence of a detailed mixed-funding narrative in both academic literature and industry reports. One relevant example, however, is the REScoop.eu (2014) account of the Westmill Wind Farm in the UK, where the financing structure comprised 60% equity raised from the community and 40% project finance from the Co-operative Bank, which waived the lien on shares. Similarly, in our study, Banca Etica reports a strategic, long-term relationship with the E'Nostra energy cooperative, including customized ESG-conditioned loans for ECs under the new regime.

Unlike Italy, where new RECs are primarily funded through grants, 64% (Arcudi et al., 2023) or through utilities' equity participation for JARSCs, in many other countries, the primary financing instrument for ECs is equity crowdfunding. A survey by Lupi et al. (2021) notes that 62% of ECs in their EU-wide sample were financed by members, with public grants as the second funding source, though only at 13%. We attribute this difference to the financing phase of ECs in Italy, where the first ECs under the new regulatory regime began to appear only in 2021. This aligns with findings from Lupi et al. (2021) on Poland, where public grants dominated as the main financial support in the early stages.

A significant barrier to EC financing in Italy is the reduced interest among SMEs under the final legislative provisions, compared to the transitional phase. The payback period has become much longer due to a "solidarity rule," which allocates 55% of shared energy proceeds to social projects, further reduced to 45% when accessing the PNRR grant. Braunholtz-Speight et al. (2020) similarly notes that in the UK, long payback periods make EC projects less competitive than other investment opportunities with faster returns. Additionally, if an SME applies for EC PNRR grants, the premium tariff is reduced by 50%. These restrictions diminish SMEs' motivation to join ECs, yet their involvement is critical due to their consumption profiles, which help maximize shared energy and provide easier access to private capital. In general, the literature does not specifically connect financing challenges to SMEs, only noting that policy changes are a primary risk to financing access. A recurring theme in financing barrier studies is uncertainty and unclear regulation. In our study, while many actors acknowledged the regulatory and incentive scheme's complexity—commenting, for instance, on confusion around "*virtual self-consumption, they ask* ***what does it mean****?"*—they did not view this complexity as a primary barrier to financing. Brummer et al. (2018a) and REScoop.eu (2020) identify administrative barriers like high connection costs, complex applications, and lengthy approvals as obstacles. however, our sample did not support this finding. Instead, several actors stated that their technical partners are well-equipped to navigate these issues. Financial actors also pointed to the lack of benchmarks for the "shared energy" concept and institutional frameworks that complicate replication. Interestingly, the body of thought discussed in Chapter I explores the institutional contexts in which ECs emerge and generally views this diversity as a positive feature, one that differentiates ECs from the traditional market and promotes their resilience and growth. In Chapter II, Section 2.2, we advocate for this diversity, predicting that the Italian EC movement may prove more resilient than the French model over time. Here, social science perspectives favoring diversity contrast with industry needs for replicable benchmarks and stable institutional settings.

Our second research question was inspired by De Vidovich et al. (2021), who identified three organizational models of ECs in Italy: pluralistic, public-led, and EC-builders. We expanded on this concept by dividing organizational models into two distinct categories: building partnerships and promoters. This distinction arose from the final EC legislation, which restricted energy and large companies from direct participation in ECs. In our study, a "Promoter" is an EC member, while a "Partnership" refers to a group of actors that assist the promoter in establishing the EC. This differentiation guided the structure of our questionnaires from a new perspective. Another key difference from De Vidovich et al. (2021) lies in our focus: while they explored various cases holistically, our study concentrated on the approaches of financing and building actors without delving into the broader institutional context. Our findings indicate that partnerships rely heavily on a diversity of expertise. In nearly all cases, the primary building actor does not establish the EC alone but leverages the expertise of others. Based on this, we categorized partnerships into formal "Alliances" and informal "Flexible Partners." The "Alliance" extends the "EC-builder" model, while "Flexible Partners" is a variation on the "Pluralistic" model. Additionally, the "Promoter" role in our study differs from the "Public-led" model described by De Vidovich et al. Here, the promoter is typically a single actor, often an NPO or municipality, rather than a larger public-led structure.

Musolino et al. (2023) identified a strong connection between geographical location and organizational structure in Italy, noting that the established energy sector in Northern Italy leads to a more technical focus, with energy companies often playing key roles. In contrast, in regions with less developed energy sectors, local authorities—particularly mayors—tend to take the lead, leveraging strong community trust to engage citizens. Our study did not confirm significant differences in focus between Northern and

Southern Italy in terms of trust's role in community engagement. Instead, we observed that trust is a critical element in community engagement across regions. However, our interviewees did agree that access to technical expertise is more readily available in Northern Italy. They suggested this disparity might pose a greater barrier to financing ECs in the South, as a well-designed technical model is essential for creating a solid business plan and tailoring community engagement strategies effectively.

Municipalities can provide direct funding, grant access to public land for installations, and support permitting and regulatory compliance (REScoop.eu & Ecopower, 2023). Their understanding of local needs enables them to serve as effective intermediaries between EC projects and residents, fostering engagement and addressing community concerns (Musolino et al., 2023). Additionally, municipalities play a critical role in navigating complex energy regulations, advocating for policies that support community energy, and offering compliance guidance—particularly vital during the early stages of EC development (Arcudi et al., 2023). German municipalities benefit from a certain degree of autonomy and accountability in local governance. They also have considerable powers to establish new municipal utilities, which has facilitated the emergence of community energy projects (Arcudi et al., 2023). Our study supports these findings but adds unique barriers in the Italian context: small municipalities face challenges in accessing capital due to limited local financial institutions, they cannot participate in the legal structures preferred by financiers, and the regulatory timeframe for accessing PNRR funds is very short. These barriers are often interconnected, earning the sub-theme title "One-legged Game Changer" in our analysis. Arcudi et al. (2023) further criticizes PNRR funding, noting that many target municipalities are in regions with lower solar irradiation, potentially reducing the efficiency of electricity production and the effectiveness of public subsidies. We assume this critique is related to the PNRR distribution rule favoring higher capital contributions for Central and Northern Italy, as outlined in Section 3.1.2. While we partially agree, it is essential to note that this regulation is intended to signal the market toward new installations in areas with high energy demand and lower supply.

Economic benefits are not the primary priority for the actors we interviewed. All of them—whether public, philanthropic, or private—emphasize the social purpose of ECs. However, economic sustainability is essential for the longevity of these projects and, consequently, their social impact. Achieving the appropriate balance of consumers, prosumers, and producers is crucial to maximizing shared energy and ensuring project viability. Cuomo et al. (2023) specifically examines this by modeling different business compositions, concluding that ECs with high consumption and limited local production may rely more on external energy sources, whereas ECs with abundant renewable resources can aim for greater local production.

The importance of scaling for optimal economic outcomes was consistently reported in our sample. Larger ECs can spread administrative and operational costs across a broader membership base, reducing per-unit costs (Arcudi et al., 2023; Bauwens, 2016). Klagge et.al (2016) notes that larger ECs in Germany also have greater negotiating power with energy suppliers, technology providers, and financial institutions, often securing more favorable terms. However, this advantage was not evident in our study, likely due to the Italian context, where larger ECs often require the involvement of formal Alliances or dedicated ESCOs, whereas in Germany, private individuals may have more financial capacity to invest independently in ECs. Smaller communities often lack access to specialized expertise needed for effective project planning, implementation, and operation (Roelich & Knoeri, 2015). An interesting insight from Arcudi et al. (2023) suggests that utilities in Italy plan to use digital platforms to connect producers and consumers, manage energy flows, and streamline membership processes, which could enhance scalability and accessibility for both larger and smaller ECs.

Most studies examining the economic benefits of ECs beyond their immediate members highlight positive impacts on the local economy and job creation, particularly in the construction and maintenance of renewable energy installations. For example, historical ECs in Italian Alps or wind cooperatives in

Scotland employ numerous local workers. In a systematic review, Brummer et al. (2018a) cataloged the range of economic benefits from existing literature, especially noting the role of wind ECs in bolstering local supply chains. In Koltunov & Bisello (2021), we similarly reviewed literature on ECs' economic benefits, with many studies indicating that ECs can stimulate tourism, attract new residents, and more. In our current study, however, financing and building actors shared distinct, indirect economic expectations from ECs. These positive expectations include strengthening their territorial presence and networks, cross-selling their products alongside EC offerings, increasing market share through new marketing channels, and supporting client growth, which indirectly improves their own outcomes. To our knowledge, previous academic literature has not explicitly explored these advantages. While prior studies have largely investigated ECs as integral parts of local communities—such as towns or villages—our study offers the perspective of those who finance or construct ECs and their own benefits. Magnani et al. (2017) suggest that Italian ECs can serve as catalysts for innovation and entrepreneurship, fostering new business models and services in renewable energy and energy efficiency. This aligns with our narrative regarding ECs' strategic importance, especially for cooperative utility models focused on innovation and traditional utilities pursuing customer-centric strategies. Non-academic literature also lists similar expectations, including access to new customer segments, cross-selling, and strategic entry into new markets (Arcudi et al., 2023).

The funds available in the solidarity fund for combating energy poverty are limited, largely due to the relatively modest premium on shared energy. Meanwhile, EC members primarily benefit from self-consumption rather than shared energy. Many EC builders plan to maximize consumption volumes to achieve economies of scale, which tends to exclude families with low energy consumption—especially given the challenges in reaching vulnerable households. Exceptions exist when an EC is specifically established to support low-income families. However, the CEES[69] survey reveals that relatively few ECs are implementing substantial measures to address energy poverty, even though they acknowledge it as an issue (De Vidovich, 2024). Given the socioeconomic needs of energy-poor households, it may be necessary to emphasize direct economic benefits, such as lower energy costs, rather than focusing solely on social or environmental aspects (De Vidovich, 2024). Reflecting this perspective, several actors in our study suggested that future EC members might consider redirecting part of their potential savings to help vulnerable families: "*So, I renounce to take €50 per year…then maybe a [vulnerable] family can have €500 per year.*"

Can EC financing be explained through management and economic theories?

Our findings suggest that ESG reporting may not be a priority for EC members or ECs as legal entities in the near term. This could reflect the relative newness of ECs and the perception among some actors that they are primarily temporary vehicles for state subsidies. Financing and building actors also appear to have given little thought to the potential benefits of ESG reporting for ECs. Nonetheless, we observe that theoretical elements from our literature review find some support in practice.

Stakeholder theory, for instance, emphasizes overlapping stakeholder interests, which, rather than leading to competition or conflict, can foster shared goals through active engagement with the organization. Indeed, one intermediary actor noted that public and private interests may sometimes diverge. However, none of our interviewees, including those from private organizations, opposed the introduction of the solidarity fund into legislation. In our economic analysis, we speculated that retailers might view ECs as competitors, marking retail stakeholders in red in Figure 25. When questioned directly, however, both traditional utilities viewed ECs more as strategic opportunities than threats, underscoring the potential beyond immediate economic gains. They emphasized that municipalities are crucial for citizen

[69] CEES (Community Energy for Energy Solidarity) survey can be found at**:** **https://www.energysolidarity.eu**

engagement and trust, also serving as valuable marketing channels. Initially, we expected utilities might see municipalities as new entrants or passive consumers whose increased self-consumption could threaten utilities' revenues. However, interviews revealed a different reality. From a shareholder theory perspective, anything that detracts from profit maximization might face resistance. Yet, in practice, our findings suggest a more collaborative view aligned with stakeholder theory.

Principal-Agent theory suggests that reducing information asymmetry is essential to maintaining stable relationships between the principal and the agent. In Table 12, we proposed that multiple actors might have an interest in assessing the ESG performance of ECs. Our findings indicate that while some actors are indeed interested, many are not. For instance, most sustainable finance actors prioritize examining the ESG performance and financial stability of organizations that constitute ECs rather than assessing the projected ESG benefits of the EC project. Conversely, two impact investors expressed an interest in monitoring projects and evaluating their ESG impact over time. An exception was Etica SGR, which does not include small projects in its portfolio and lacks the capacity to conduct close project monitoring.

Foundations, although not initially included in Table 12, emerged as key actors with a strong interest in assessing the ESG performance of EC projects both pre-selection and over time. We also found that some of the envisioned "Performance Measures" from Table 12 are already significant for these "principals." These include metrics such as hours of voluntary support, level of self-consumption, mitigation of the NIMBY effect and media image, member retention levels, and the number of projects undertaken in collaboration with energy cooperatives affiliated with associations. Each of these performance measures was highlighted by different interviewees.

Signaling theory suggests that ECs might aim to communicate their competitive advantages to gain market share. However, our findings indicate that none of the actors view ECs as independent entities actively seeking market share. Signaling theory may be more relevant for established ECs—often referred to today as "energy cooperatives." Over time, some of these cooperatives, such as E'Nostra and Energia Positiva[70], have evolved from grassroots, citizen-led initiatives into significant market players.

Legitimacy theory also finds support, with private actors expressing strong adherence to the social contract set forth by the EU Green Deal. Actors see ECs as vehicles intended not only to generate environmental benefits but also to enable fair profit distribution. Nevertheless, many actors are skeptical about ECs as effective tools for sharing the benefits of the energy transition with regular citizens, especially as a means to combat energy poverty. Importantly, none questioned the concept of ECs themselves but rather the Italian model or the scale of subsidies involved. As one interviewee remarked, *"In Europe, maybe, it's something that has been working better than here."*

CPR theory applies not only to renewable energy or the concept of common energy, as suggested by Roelich & Knoeri (2015) and Wolsnik (2014), but also to the Italian-specific concept of "shared energy." Contrary to initial impressions that may label "shared energy" as merely a technical term, it represents a distinct market product with the potential to deliver additional value. The Italian model of shared energy combines aspects of both common and private goods. It features low excludability due to regulatory structures that allow open entry for all consumers, prohibiting restrictions on participation.

Shared energy is not owned or governed by a single entity but relies heavily on collective governance. At the same time, shared energy involves high rivalry. Members of an EC cannot use it without limitations. Regulators provide both the premium tariff and valorization of avoided grid usage only for a specific amount of energy, which is then redistributed among members based on their contribution to shared energy (as specified by the EC's statute). As detailed in Section 3.2.2, shared energy is calculated each hour as the minimum between energy consumed and produced by all EC members. Consequently, one

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[70] See Section 2.2 for more details about Energia Positiva

member's actions can directly impact the benefits others receive. To illustrate this rivalry, consider a thought experiment: if Consumer A turns off her appliances while at work (a reasonable choice if outside an energy community), it reduces the midday shared energy available to other members. Since shared energy is defined as the minimum between generation and consumption, a reduction in midday consumption from Consumer A's actions lowers potential shared energy profits for everyone else. However, if Consumer A programs her appliances or battery pack to operate around midday, this benefits the collective, increasing the shared energy and potentially the returns for all members. The redistribution of these gains depends on the EC's statute. Gains could be directed to a social fund, supporting local causes like combating energy poverty or financing a kindergarten, or they could be allocated based on individual contributions to shared energy. For example, if Consumer A dispatches her appliances at midday, she significantly contributes to shared energy, earning the highest profit if the gain is redistributed individually. However, this also introduces competition, as other consumers may miss the opportunity to maximize their benefits by not dispatching at the optimal time. With low excludability and high rivalry, shared energy closely resembles a common good.

While assuming the shared energy is highly rival we could look at its excludability from the other angle. We can assume it being not only low, but also high. Even though regulation prescribes open participation, in practice the access to ECs could be granted based on the technical model and not open entrance. To clarify, EC managers could limit the number of consumers to match it with the installed capacity. The reason for such restriction is that the excesive consumption will not increase profits but rather cause less profit per one member. We can see that 'shared energy' in some contexts can also be interpreted as highly excludable.

We consider the economic nature of "shared energy" to be ambiguous, as it exhibits characteristics of both a common good (low excludability and high rivalry) and a private good (high excludability and high rivalry). If common-good features were to dominate, ECs could face a "tragedy of the commons," where no entity takes responsibility for governance and financing beyond initial public subsidies.

Our findings partially align with Roelich & Knoeri (2015) and Wolsnik (2014). Roelich & Knoeri, following Elinor Ostrom's principles, highlight the importance of heterogeneous, polycentric governance for managing common goods effectively. Similarly, our findings suggest that heterogeneous governance empowers rather than hinders ECs. A supportive evidence is that winning projects of the interviewed foundations were heterogeneous posessing full set of the expertise. Moreover, municipalities play a crucial role within polycentric governance, aligning national policies with local needs. Regional governments dedicate additional funds and also provide a scope of other supportive services to municipalities and even to other territorial entities. Therefore, they are also important element in the polycentric governance. Roelich & Knoeri (2015) also argue that applying standardized best practices to energy commons is challenging, as these initiatives tend to thrive in diverse institutional settings. Traditional utilities in our study echoed this sentiment, explaining that they struggle to design standardized commercial offers due to the variability of local contexts. Conversely, one financial intermediary noted that this diversity poses a challenge, saying, *"From an investor point of view, it's difficult to find* ***structured examples*** *of successful energy community investments."* We deem that relavant local institutions can be facilitated by alliances and flexible partners. Their territorial ties embody these diverse institutional settings, creating conditions in which energy commons can truly flourish.

Roelich & Knoeri (2015) advocated moving away from the "pro-market paradigm," arguing that it inhibits community energy in the UK. However, we found no supporting evidence for this suggestion in Italy. Roelich & Knoeri also emphasized a key design principle from Ostrom for common goods survival: *"the boundary of resources is crucial…finite stock has to be preserved."* They argue that this is a problem to implement this principle for energy commons due to typically open citizen participation. However, if shared energy functions as a hybrid good, common and private, this problem could be avoided. Who, then, should oversee the preservation of this "finite stock"? Our answer: a technical partner who designs 1MW configuration. This partner would decide who will enter and who will not, based on a finite 1 MW stock. This will benefit both distribution system with all its connectors and a commons.

3.4 Conclusions

Italian EC model's reliance on a premium tariff for shared energy, while beneficial in the short term, raises concerns about long-term sustainability. As government subsidies are eventually phased out, ECs should develop alternative revenue streams and business models to remain viable. This may involve exploring new market opportunities, such as providing grid services, participating in demand response programs, or offering energy management services to their members.

ECs demand a diverse skill set encompassing technical, legal, social engagement, financial, and administrative expertise. Building strong partnerships between public, private, and philanthropic actors is crucial for successful EC development. These partnerships allow ECs to pool resources, share expertise, and navigate complex regulatory and financial landscapes. Municipalities emerge as key promoters of ECs, often leveraging their public trust and ownership of public buildings to facilitate ECs establishment. However, smaller municipalities face difficulties accessing capital and navigating bureaucratic procedures.

While not seen as a direct source of major profit, ECs offer indirect economic benefits for different actors. Traditional utilities and banks view ECs as a strategic opportunity to expand their market reach, cross-sell products and services, and enhance customer engagement. Cooperative utilities see ECs as a natural fit for their business model, aligning with their commitment to innovation, social impact, and member empowerment.

The ECs economic viability depends on multiple factors. A critical element is achieving an optimal balance between energy production and consumption. This requires detailed planning and a well-defined composition of producing and consuming members, often involving partnerships with municipalities, SMEs, and agricultural companies. Scaling up is another key strategy. Larger ECs, potentially encompassing multiple 1 MW configurations, can leverage economies of scale to reduce administrative costs and enhance financial sustainability.

Effectively addressing energy poverty through ECs is a complex endeavor. The relatively modest premium tariff for shared energy limits the funds available for social programs. A more impactful strategy might be to pool social fund money and directing it toward vulnerable non-member families, rather than solely focusing on reducing members' energy bills.

Although formal ESG evaluation practices for new ECs are not yet standardized, there is growing interest from foundations and impact investors in monitoring performance of ECs.

We also examine EC financing through various theoretical lenses, including stakeholder theory, principal-agent theory, legitimacy theory, signaling theory, and common-pool resources theory. The findings support the importance of stakeholder engagement and information transparency. Shared energy concept presents a fruitful leverage for the deployment of the EC model in the grid friendly and welfare-enhancing manner.

Recommendations:

- Developing clearer investor-friendly regulations
- Creating standardized EC offerings to help attract more private investment
- Exploring alternative revenue streams beyond the premium tariff for shared energy, such as providing grid services or energy management services
- Developing ECs ESG reporting frameworks to increase appeal to both investors and community members.

Due to the relevant novelty of Italian regulation on ECs we concentrate just on initial financing phases, specifically feasibility and CAPEX financing, neglecting the possible challenges associated with financing operational expenses. Another limitation is using of the AI tool for initial coding in data analysis. While efficient it still needs a careful human oversight and cross-verification, which we tried to exhibit.

Conclusions

The growing interest in energy communities (ECs) aligns with the EU's energy transition goals. In Chapter 1, we mapped the academic landscape on ECs, highlighting influential authors, journals, and key research teams. Through bibliometric clustering, we conducted a systematic literature review, identifying major themes over the past two decades. Initial studies focused on the emergence of grassroots ECs in Northern Europe, which developed without incentives during high wind and photovoltaic costs. These early ECs were treated as unique cases, as researchers explored the informal institutions that enabled their creation and identified elements that could be replicated elsewhere. The arrival of renewable energy subsidies shifted the landscape, making small-scale generation profitable and driving EC growth, particularly through "energy cooperatives" in Northern Europe. Many cooperatives established collectively owned generation plants. As these initiatives expanded, concerns arose about the visual impact of wind turbines (NIMBY) and the use of agricultural land for photovoltaics, prompting further study on EC impacts and benefits. Researchers explored how different governance models shaped the specific social, environmental, and economic advantages that ECs could deliver, underscoring governance as a critical factor in achieving community-led energy transitions.

I was inspired to study energy communities (ECs) by meeting the first Ukrainians who brought American and European best practices to Ukraine. One of them became a popularizer of ECs and later established the first energy cooperative in the country. These influences sparked the research projects in Chapter II. Specifically, Section 2.2 aimed to classify ECs to understand the future direction of this growing phenomenon. At the time, systematic data on ECs were scarce, as they still are to some extent. Mapping European-wide experiences seemed like a valuable task for the research community. Even in 2021 and 2022, specialized sectoral associations had limited data on the status of ECs across Europe. The movement's diversity was the main reason behind this gap, as each EC was highly unique. Recognizing this, we took on the task of organizing the available knowledge. We identified nearly 4,000 ECs, with about a quarter in Germany alone. Their business models and types were primarily shaped by local renewable resources, community financial capacity, and available incentives. Hydropower and biomass ECs were prominent in the Alpine countries, solar energy in Germany, Spain, and France, wind in the Netherlands and Denmark, and various renewables in the United Kingdom. In Section 2.2, we also mapped supportive organizations, including regional associations, intermediary actors, research entities, and consultancy agencies, revealing a striking North-South divide. Local generation-focused EC models were common in Northern Europe, while innovative models like retail ECs (cooperative utilities) or virtual ECs were more prevalent in Southern Europe. As a result. I was inspired to do a cross-country comparison of policies favoring development of ECs as well as a comparison of institutional contexts[71] where ECs emerge.

For our cross-country analysis of ECs, we chose Italy and France, both of which have high solar potential and similar levels of EC development, providing a balanced comparison with deeper insights than neighboring countries. Notably, while comparative studies exist between Italy and other nations, Italy and France had not been directly compared. Our main question was to determine whether differences in EC growth were primarily influenced by institutional context or by state-driven policies. We found that subsidies played an equally crucial role in both countries, eliminating it as a distinguishing factor. However, our findings pointed to the plurality of market actors as a factor slowing Italy's EC growth, whereas in France, the presence of a national capacity builder, Energee Partagee, catalyzed EC development. This discovery led us to focus on institutional context through a narrower lens, specifically examining partnerships in the financing section of Chapter III. Additional insights came from case studies, revealing that all three EC cases provided member benefits, with economic benefits generally outweighing social and environmental ones. Recognizing an extensive body of literature focusing on the factors leading to benefits for EC members, we decided to shift focus to a lesser-explored area: the impact of EC

[71] In that study, institutional contexts meant public and private organizations that supported ECs development.

deployment on broader energy markets, particularly on how non-member consumers might gain or lose as EC members benefit.

In Chapter III, we initially aimed to investigate the impact of ECs on the energy market. However, the diversity of EC experiences and classifications required a degree of standardization for this study. To address this, we developed a framework of four established EC business models and three innovative models based on our classification and mapping findings. We observed that Italy's "collective generation model", selected by policymakers, has the potential to yield system-wide benefits, particularly by reducing pressure on the distribution grid. Indeed, this economic value of ECs is ascertained by the policymaker through the 'avoided grid usage' component in the cashback. This ensures a rationale behind a vision when one day energy communities become economically sustainable market-driven actor without state subsidies.

Italian policy mitigates market inefficiency from the emergence of the new incentivized actor. It is done by allowing EC members to retain their existing retailers, thereby lowering transaction costs and minimizing impact on other market players. Initially, we hypothesized that EC-driven reductions in member energy purchases could result in revenue losses for utilities and retailers. However, our financing study contradicted this view, showing that retailers perceive ECs as a strategic opportunity rather than a threat. Furthermore, utilities see potential for expanding their service offerings to EC members. Thus, ECs emerge as a competitive market tool, not by disadvantaging established players but by fostering innovation among any actor ready to enhance their corporate value proposition

ECs that only generate electricity without engaging in self-consumption or energy sharing can benefit the system primarily when located in high-demand, low-supply areas, such as densely populated regions distant from major generation sources. Conversely, if situated in areas already rich in renewable resources, these ECs may be advantageous for their members but could strain the overall system. Italian EC regulation provides an effective model, particularly when compared to net-metering schemes, as it distinctly separates the premium from the economic value of ECs—a signal of a well-designed regulation. Discriminatory attitude toward parts of the country (South-Center-North) with different grid congestion patterns is necessary for a regulation to be cost-reflective. Nevertheless, subsidies always cause a certain level of inefficiency. In the case of the Italian tariff, premium for shared energy while benefitting the grid would still be today socialized among the general population even indirectly causing their future network charges to be smaller.

We anticipate that EC business models—community aggregators, P2P, community ESCOs, and eco-villages—may emerge as consumers increasingly become active participants. These models are likely to find fertile ground with newly accessible resources, such as unutilized public and industrial rooftops, distribution grid capacity, and e-vehicles, along with novel value propositions like shared energy and flexibility services, as well as rediscovered social community benefits. We hope the adoption of ESG principles will permeate the energy market, enabling ECs easier access to private capital. Additionally, the 55% solidarity fund is crucial for future EC deployment. though it may extend payback periods today, it strategically legitimizes ECs as an actor of a fair energy transition. It will signal to banks and private companies their attractiveness, potentially leading to a full integration of ECs into the private sector. Evidence from Italian cooperative utilities, for instance, shows that value proposition grounded in social benefits can make a business model economically viable.

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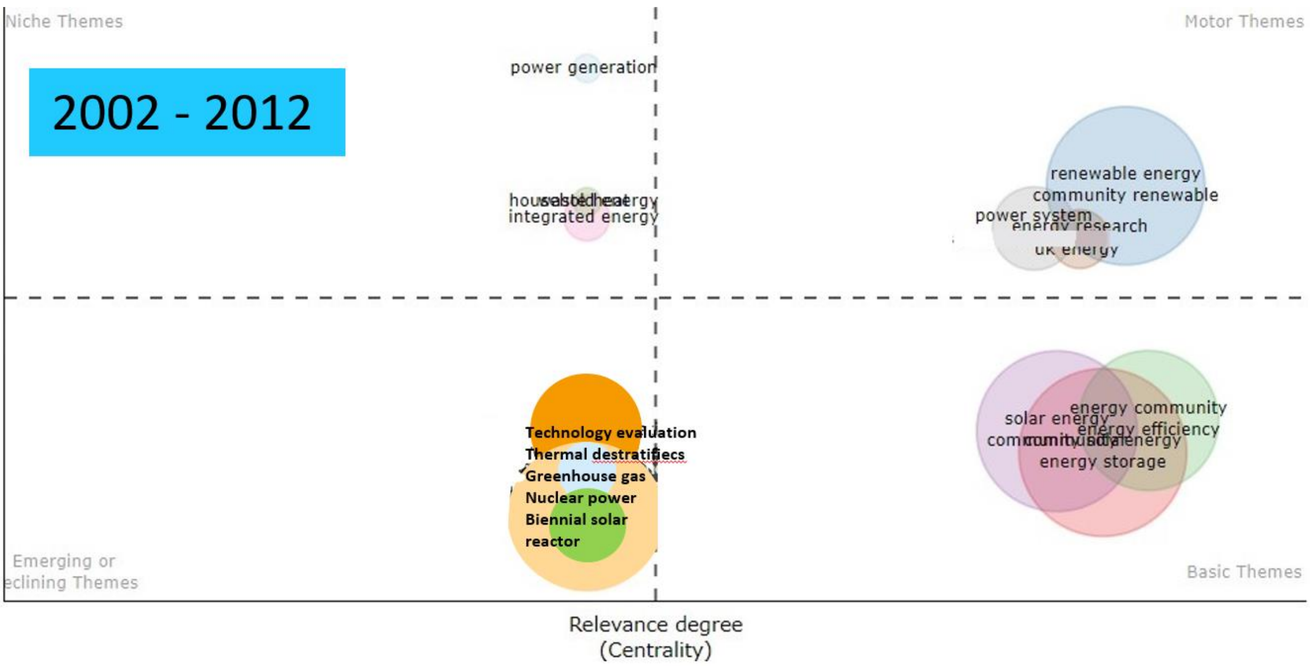
Annex 1. Bibliometric study

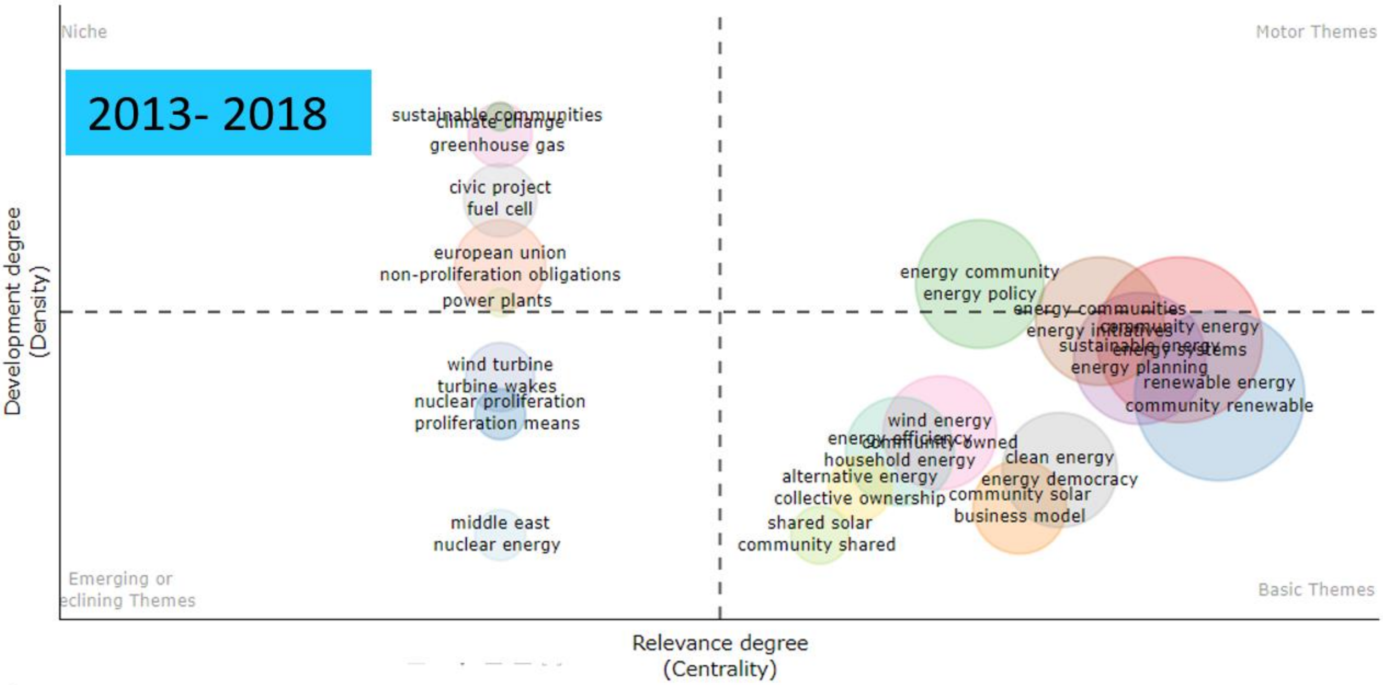
Table “Bibliometric methods, statistical techniques and units of analysis utilized for science mapping”

Research question	Bibliometric method	Statistical technique	Unit of analysis	Description
What are the main topics of research on energy communities?	Co-author	Cluster analysis, Network analysis (Louvain algorithm)	Country	Connects countries by co-authors’ affiliation
	Bibliographic coupling	Cluster analysis	Author	Connects authors based on the number of shared references
	Co-citation	Network analysis (Louvain algorithm)	Reference	Connects documents based on joint appearances in reference lists
	Co-word	Factorial analysis (Multiple Correspondence Analysis)	Keyword	Connects words when they appear in the same keyword list
How did the energy community research evolved from 2002 to 2022?	Co-word	Word growth	Keyword	Connects words when they appear in the same keyword list or title
		Trend topics	Keyword	
		Thematic evolution	Title	

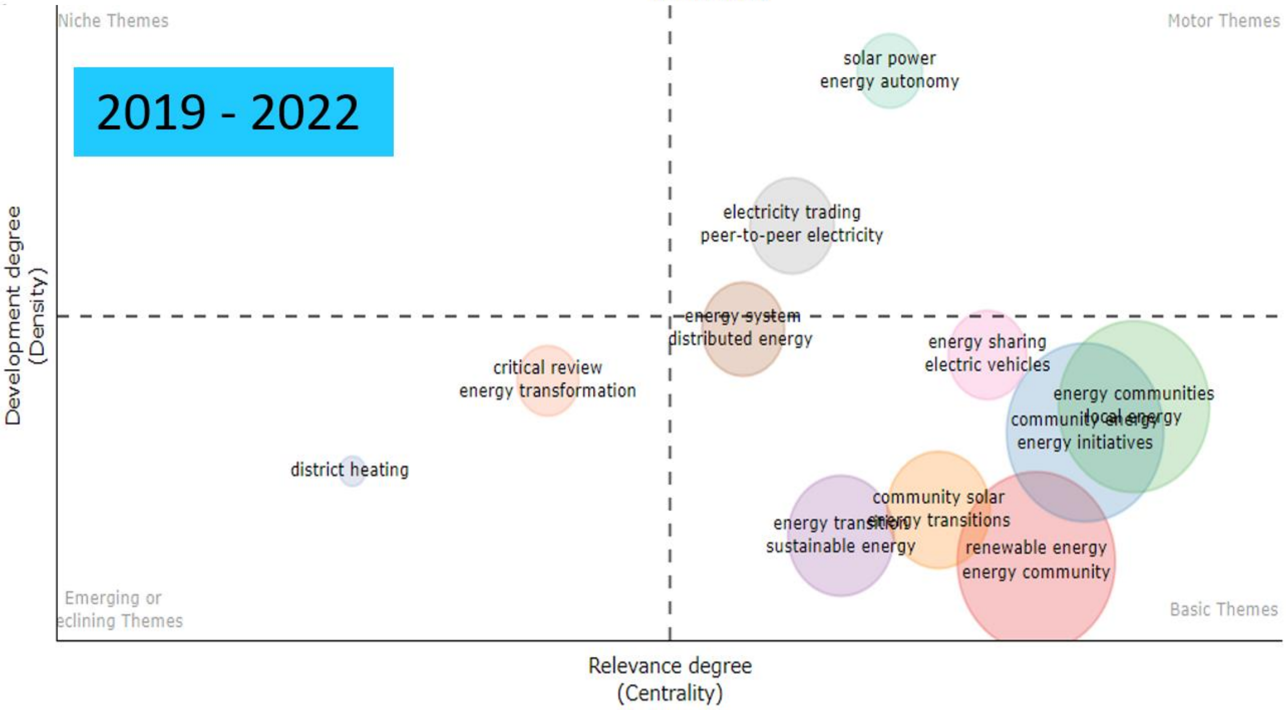
Source: author, adapted from Cobo et.al., Aria et.al., Zupic & Čater (2017; 2011; 2015)

Figure. Topical evolution according to titles of the articles





Niche
Motor Themes
2013- 2018
sustainable communities
climate change
greenhouse gas
civic project
fuel cell
european union
non-proliferation obligations
power plants
energy community
energy policy
energy communities
energy initiatives
community energy
sustainable energy
energy systems
energy planning
renewable energy
community renewable
wind turbine
turbine wakes
nuclear proliferation
proliferation means
wind energy
energy efficiency
community owned
household energy
clean energy
alternative energy
energy democracy
collective ownership
community solar
business model
shared solar
community shared
middle east
nuclear energy
Emerging or
eclining Themes
Basic Themes
Development degree
(Density)
Relevance degree
(Centrality)



Niche Themes
Motor Themes
2019 - 2022
solar power
energy autonomy
electricity trading
peer-to-peer electricity
energy system
distributed energy
energy sharing
electric vehicles
critical review
energy transformation
energy communities
local energy
community energy
energy initiatives
district heating
community solar
energy transitions
energy transition
sustainable energy
renewable energy
energy community
Emerging or
eclining Themes
Basic Themes
Development degree
(Density)
Relevance degree
(Centrality)

Annex 2. Literature on economic impact evaluation of ECs

Authors and Year	Title	Country	Renewable technology utilized	Methodology and data sources	Research objectives	Analysis perspective	Scope of evaluation
Okkonen & Lehtonen (2016)	Socio-Economic Impacts of Community Wind Power Projects in Northern Scotland	UK	Wind	CGE, Input-Output tables, primary data	Economic impact assessment	Actual	Sector (group of 11 actual ECs) on a regional economy
Torgerson et.al. (2006)	Umatilla County's Economic Structure and the Economic Impacts of Wind Energy Development	US	Wind	CGE, Input-Output tables, primary data	Economic impact assessment. Comparison of regional impacts VS local impacts, comparison of impacts of EC ownership VS privately-owned	Projection	"typical" EC and "typical" privately-owned firm on a regional economy, local economy (county)
Lantz & Tegen (2009)	Economic Development Impacts of Community Wind Projects: a review and empirical evaluation	US	Wind	CGE, Input-Output tables, primary data	Economic impact assessment. Comparison of impacts of different ECs, comparison of EC ownership VS privately-owned, literature review	Actual	actual (3 ECs) on a regional economy
Kildegaard & Myers-Kuykindall (2006)	Community Versus Corporate Wind: Does it Matter Who Develops the Wind in Big Stone County, MN?	US	Wind	CGE, Input-Output tables	Economic impact assessment. Comparison of EC ownership VS privately-owned	Projection	"typical" (2 ECs) and "typical" privately-owned (1 firm) on a local economy (county)
Phimister & Roberts (2012)	The Role of Ownership in Determining the Rural Economic Benefits of Onshore Wind Farms	UK	Wind	CGE, Social Accounting Matrix (SAM)	Economic impact assessment. Comparison of impacts of EC ownership VS farmers VS external privately-owned.	Projection	Sector (300 MW capacity) on a regional economy
Allan et.al. (2008)	The Importance of Revenue Sharing for the Local Economic Impact of a Renewable Energy Project: A Social Accounting Matrix Approach	UK	Wind	CGE, Social Accounting Matrix (SAM)	Economic impact assessment, Comparison of EC ownership VS privately-owned	projection	"typical" EC on a regional economy
Bere et.al. (2015)	The Economic and Social Impact of Small and Community Hydro in Wales	UK	Hydro	CGE, Input-Output tables	Economic and social impact assessment	actual	"typical" EC (composed from the profiles of 16 ECs) on a regional economy
Entwistle et.al. (2014)	Measuring the Local Economic Impact of Community-Owned Energy Projects	UK	Wind	LM3, primary and secondary sources	Economic impact assessment	mixed: actual, projection	actual (1 EC) on a local economy
DanMar & Associates (1996)	Economic Impact Analysis of Windpower Development in Southwest Minnesota	US	Wind	CGE, Input-Output tables	Economic impact assessment. Comparison of impacts of EC ownership VS privately-owned	Projection	"typical" (1 EC) and "privately-owned" (2 firms) on a regional economy
GAO (2004)	Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities	US	Wind	CGE, Input-Output tables, primary data	Economic impact assessment. Comparison of impacts of EC ownership VS privately-owned	projection	"typical" (1 EC) and "typical" privately-owned (2 firms) on a local community (11 distinct communities tested)
Lantz & Tegen (2008)	Variables Affecting Economic Development of Wind Energy.	US	Wind	CGE, Input-Output tables	Economic impact assessment. Comparison of impacts of EC ownership VS privately-owned	projection	"typical" (2 ECs) and "privately-owned" (1 firm) on a regional economy
Lantz (2008)	Economic Development Benefits from Wind Power in Nebraska: A Report for the Nebraska Energy Office.	US	Wind	CGE, Input-Output tables	Economic impact assessment. Comparison of impacts of EC ownership VS privately-owned	projection	"typical" (2 ECs) and "privately-owned" (2 firms) on a regional economy

Annex 3. Deployment of energy communities in the European Union.

Country	Number	Members of ECs	Members Per One EC (Mean)	Approximate HHs Number [1] Consuming Electricity Generated/Supplied [2] by ECs	Country Total Population	Proportion of Population Per One EC	Proportion of Population Involved in ECs, Citizens/EC Member	Proportion of the Population Consuming ECs Produced Energy [3], Citizens/Consumer	National/Regional Federation of ECs or Sector-Builders	Status Year	Source
Austria	346 [4]	-	-	-	8,956,290	25,885	-	-	Österreichischen Koordinationsstelle für Energiegemeinschaften	2018	(Österreichische Koordinationsstelle für Energiegemeinschaften., 2022; Wierling et al., 2018)
Belgium	41	96,966 [5]	2552 [6]	96,102	11,587,880	282,631	120	52	REScoop. Vlaanderen, REScoop. Wallonie	2021	(REScoop Wallonia, 2022), websites and annual reports of individual ECs
Bulgaria	1	-	-	-	6,899,130	6,899,130	-	-	-	2022	(REScoop.eu, n.d.), websites of individual ECs
Croatia	11	116	11	-	3,899,000	354,455	33,612	-	-	2021	(REScoop.eu, n.d.)
Denmark	527 [7]	-	-	-	5,856,730	11,113		-	-	2018	(Wierling et al., 2018)
Finland	103	34,775	338	-	5,541,700	53,803	159	-	-	2015	(Carmen Quintana with Cooperative Europe's team, 2015)
France	254 [8]	86,720	341	404,746 [9]	67,499,340	265,745	778	73	Énergie Partagée, Enercoop, Centrales Villageoises	2022	(Energie Partagee, n.d.)
Germany	847	220,000	260	2,378,378	83,129,290	98,146	378	15	DGRV	2020	(DGRV, 2021), energy consumption—own calculation based on (DGRV, 2021)
Greece	12	778 [10]	156	1052	10,664,570	888,714	13,708	4409	ElectraEn	2022	(REScoop.eu, n.d.), websites of individual ECs
Ireland	30	-	-	-	5,028,230	167,608	-	-	Nationwide Community Energy Ireland CLG, Energy Cooperatives Ireland, Sustainable Energy Authority of Ireland	2021	(NCEI, 2022)
Italy	119 [11]	47,309 [12]	622	88,272 [13]	59,066,220	496,355	1249	291	SEV (only for South Tyrol region), WeForGreen Sharing, Energy Center of Politecnico Torino, Energy4.com, Fratello Sole	2021	(De Vidovich et al., 2021; Federazione Cooperative Raiffeisen Società, 2021; Koltunov et al., 2022) websites and annual reports of individual ECs
Luxembourg	1	-	-	259	639,070	639,070	-	1074	-	2022	(REScoop.eu, n.d.), websites of individual ECs
Netherlands	676	112,000	166	380,000	17,533,400	25,937	157	20	Energie Samen	2021	(Energie Samen, 2022; Sataloff et al., 2021)
Poland	1	30	30	-	37,781,020	37,781,020	1,259,367	-	-	2022	(Orhan, 2022)
Portugal	7	3000	500	11,174	10,299,420	1,471,346	3433	401	-	2018	(REScoop.eu, n.d.), websites of individual ECs
Romania	1	757	757	11,351	19,115,150	19,115,150	25,251	732	-	2021	Websites of individual ECs

Slovenia	2	413	207	-	2,107,010	1,053,505	5102	-	University of Ljubljana Energy Policy laboratory	2022	(REScoop.eu, n.d.), websites of individual ECs
Spain	40	143,668	6841	40,239	47,329,690	1,183,242	329	511	Red de Comunidades Energeticas S.coop, Union Renovables, Federation of Electric Cooperatives of Community of Valencia, Sapiens Energia	2021	(Capellán-Pérez et al., 2018), websites and annual reports of individual ECs
Sweden	140 [14]	25,000 [15]	321	-	10,415,810	74,399	417	-	-	2018	(Magnusson & Palm, 2019)
Switzerland	289	152,036 [16]	526	-	8,697,720	30,096	57	-	VESE (solar coops), ASEC (Swiss Association for Citizen Energy)	2016	(Rivas et al., 2018; Schmid & Seidl, 2017)
United Kingdom	495	58,000	117	174,000	67,326,570	136,013	1161	168	Community Energy England, Community Energy Wales, Community Energy Scotland, Energy4All, Sharenergy, and Communities for Renewables	2021	(Community Energy Scotland; Community Energy Wales; Community Energy England, 2022; Energy4All Limited, 2022)
TOTAL/AVERAGE	**3931**	**899,811**	**844**	**3,585,573**	**489,373,240**	**124,112**	**532**	**59**	-	-	-

[1] Calculations based on the average EU household consisting of 2.3 members (residing in a single dwelling) consuming 3.7 MWT of electricity per year in 2019 (ODYSSEE-MURE, 2020). [2] For ECs with the main business activity being the generation of energy, we used energy generated by their plants. For ECs with the main business activity being retail although owning shares in generation plants, we used the energy generated. For ECs purely providing retail service, we used energy supplied to the clients. ECs with the main business activity being the provision of services were not included. [3] Calculated by dividing "Country total population" on the outcome of multiplication of "Estimated HHs number consuming electricity generated/supplied by ECs" and 2.3 (which is an average number of household members in the EU in 2019). [4] A total of 286 energy cooperatives reported by Wierling et al. (2018) [37] predominantly district heating + 60 energy communities created since Austria transposed EU Directives and established a new legal organizational form mapped by Austria Coordination Office for Energy Communities. [5] Info just for 38 ECs (19 Wallonia and 19 Flanders, 3 Flanders is not available). [6] Info corresponding to 38 co-ops for which generation numbers are available. [7] Included only district heating and wind cooperatives. [8] Including functioning as well as development stage, without emergence stage. [9] Reported by the Énergie Partagée, 930,915 people divided by 2.3 (average number of ppl per HH). [10] Available data for only 5 ECs included. [11] Total of 65 historical in Alpine arc, 28 new ECs not corresponding to Italian regulation, 26 new ECs emerged after 2020–2021 corresponding to Italian regulation. [12] Only members of 65 historical and 11 new ECs included, for ECs emerged after 2020–2021 data are not available. [13] Only data for 65 historical and 11 new ECs included. [14] Total of 78 wind cooperatives, 32 eco-villages, the rest are solar, hydropower, and district heating. [15] Only wind. [16] Approximated calculation based on numbers reported by 129 ECs participated in survey by Rivas et al. (2018) [27]. Membership of 129 ECs is 68,416. number for 289 ECs was approximated using data from 129 ECs.

Annex 4. Results of the multiple regression analysis

Model 1.
Dependent variable: Loans – total value.
Independent variable of interest: Annual spending on community benefit projects
Adjusted R squared: 0.707

Independent Variables	Coefficients	Std. Error	t-value	p-value	[0.025	0.975]
Constant	828340.03	549536.41	1.51	0.15	-336625.12	1993305.18
Organisation FTEs employed	212749.67	82547.97	2.58	0.02	37755.79	387743.59
Revenue annual bills saving	1505.05	3239.26	0.46	0.65	-5361.87	8371.97
Revenue annual other	-5.33	6.69	-0.80	0.44	-19.52	8.85
Total members of organisations in this record	-1648.68	650.94	-2.53	0.02	-3028.60	-268.75
Capex	0.65	0.04	14.82	<0.001	0.55	0.74
Community benefit funds total annual spend	-13.25	3.00	-4.41	<0.001	-19.61	-6.88

Model 2.
Dependent variable: Annual spending on community benefit projects
Independent variable of interest: Loans – total value
Adjusted R squared: 0.738

Independent Variables	Coefficients	Std. Error	t-value	p-value	[0.025	0.975]
Constant	57424.35	29546.62	1.94	0.07	-5211.68	120060.38
Organisation FTEs employed	8764.82	5037.01	1.74	0.10	-1913.16	19442.80
Revenue annual bills saving	45.13	182.06	0.25	0.81	-340.82	431.09
Revenue annual other	-0.15	0.38	-0.40	0.69	-0.96	0.65
Total members of organisations in this record	-86.66	37.26	-2.33	0.03	-165.64	-7.68
Capex	0.03	0.00	6.65	<0.001	0.02	0.04
Loans - total value	-0.04	0.01	-4.41	<0.001	-0.06	-0.02

Model 3.
Dependent variable: Grants – total value
Independent variable of interest: Annual spending on community benefit projects
Adjusted R squared: 0.715

Independent Variables	Coefficients	Std. Error	t-value	p-value	[0.025	0.975]
Constant	106184.29	76512.46	1.39	0.18	-56014.89	268383.46
Organisation FTEs employed	-10965.62	11493.23	-0.95	0.35	-35330.18	13398.94
Revenue annual bills saving	-248.20	451.00	-0.55	0.59	-1204.29	707.89
Revenue annual other	1.65	0.93	1.77	0.10	-0.32	3.63
Total members of organisations in this record	-24.87	90.63	-0.27	0.79	-216.99	167.26
Capex	0.04	0.01	7.39	<0.001	0.03	0.06
Community benefit funds total annual spend	-1.98	0.42	-4.74	<0.001	-2.87	-1.10

Model 4.
Dependent variable: Annual spending on community benefit projects
Independent variable of interest: Grants – total value
Adjusted R squared: 0.813

Independent Variables	Coefficients	Std. Error	t-value	p-value	[0.025	0.975]
Constant	52607.08	28344.25	1.86	0.08	-7480.05	112694.20
Organisation FTEs employed	-3282.88	4484.31	-0.73	0.47	-12789.19	6223.43
Revenue annual bills saving	-89.10	174.23	-0.51	0.62	-458.45	280.26
Revenue annual other	0.55	0.37	1.50	0.15	-0.23	1.33
Total members of organisations in this record	-24.23	34.52	-0.70	0.49	-97.42	48.95
Capex	0.02	0.00	9.42	<0.001	0.01	0.02
Grants - total value	-0.29	0.06	-4.74	<0.001	-0.43	-0.16

Model 5.
Dependent variable: Annual spending on community benefit projects

Independent variable of interest: Equity crowdfunding (community shares – total value)
Adjusted R squared: 0.563

Variable	Coefficient	Std. Error	t-value	P > |t|	[0.025	0.975]
const	21902.003177	66749.504261	0.328122	0.747355	-111820.266464	153624.272818
Community shares -total value	-0.014272	0.026605	-0.536423	0.599532	-0.067030	0.038485
Organisation FTEs employed	363.762567	7239.620189	0.050246	0.960589	-14005.059375	14732.584509
Revenue annual bills saving	-32.727474	284.308561	-0.115113	0.909883	-602.336543	536.881595
Revenue annual other	-0.078856	0.567872	-0.138862	0.891406	-1.203813	1.046100
Total members of organisations in this record	-6.702825	58.44912	-0.114678	0.910221	-123.992771	110.587121
Capex	0.013300	0.003002	4.430351	0.000486	0.007354	0.019246
Number of projects in this aggregated record	-633.324529	7714.236551	-0.082098	0.935654	-16224.963443	14958.314385
Adj. R-squared	0.562605					

Model 6.
Dependent variable: Equity crowdfunding (community shares – total value)
Independent variable of interest: Annual spending on community benefit projects
Adjusted R squared: 0.388

Variable	Coefficient	Std. Error	t-value	P > |t|	[0.025	0.975]
const	-432801.638350	634192.265964	-0.682445	0.505361	-1700132.145768	843528.869067
Community benefit funds total annual spend	-1.318849	2.458599	-0.536423	0.599532	-6.194886	3.557188
Organisation FTEs employed	42525.073148	68728.875442	0.618737	0.545372	-94915.578394	179965.724690
Revenue annual bills saving	-1866.078705	2691.481741	-0.693328	0.4987	-7248.139163	3515.981753
Revenue annual other	0.007997	5.462472	0.001464	0.998851	-10.875718	10.891713
Total members of organisations in this record	823.875444	520.313013	1.583423	0.134178	-221.985805	1869.736692
Capex	0.089710	0.037229	2.410	0.029266	0.015833	0.163587
Number of projects in this aggregated record	45041.598088	73256.323062	0.614849	0.547869	-101383.860239	191467.056415
Adj. R-squared	0.387650					

Annex 5. Survey of ESG indicators for ECs

Please rank each indicator from **1 to 5** according to it's relevance for one of the business models (1 is less relevant, 5 is the most relevant)
BM 1 "Energy Cooperatives"
Mostly includes **historical cooperatives** in mountainous or remote rural areas that own the distribution infrastructure connecting consumers to its own generation facilities or transmission network. Also include community-of-interest/**virtual cooperatives** who crowdsource funds from the citizens that might be dispersed country-wide and invest into generation facilities country-wide that solely sell energy to the grid.
BM2 "Community Collective Generation"
Primary business model recognized in **Italian legislation** as an energy community. Consumers purchase PV and storage assets. The generated energy is **self-consumed**. The assets should be connected to the same HV/MV substation. Assets are owned collectively, while individual members (citizens and/or private/public entities) continue to have their own energy providers that take care of their residual demand when the community assets do not cover it.
BM 3 "Third Party Sponsored Communities"
A **retail company invests** into the generation and storage assets of the neighbourhood. Households self-consume its energy benefitting from a lower tariff that is set by retailer while assets remain in the ownership of a retailer.
BM 4 "P2P trading"
Members of peer-to-peer (P2P) trading scheme **individually own** the generating and storing assets that are connected to a digital platform. Individually generated electricity is traded within the community in a way that reflects peers' personal preferences (e.g., price, origin, destination of the energy). Thus, a key task for the P2P scheme is the provision of a **digital infrastructure for trading**.
BM 5 "Community ESCO"
Main purpose is to assist members of the community in **energy efficiency** measures by providing technical support, and facilitating access to finance and awareness campaigns. Groups with a primary purpose to tackle **energy poverty** belong to this category.
BM 6 "Community Aggregators"
Aggregator virtually connects consumers, prosumers, and collective generation assets providing flexibility services that it sells to the DSO.
BM 7 "Intentional Eco-Villages"
Eco-villages are the neighbourhoods/districs where a distribution infrastructure have not existed priorly and is **built from scratch** in a form of a **microgrid** where all units are interconnected. Innovative neighbourhoods/districts promoted by real estate firms.

Standard and Topic	Metrics	Dimension
ESRS E1-1 Transition plan for climate change mitigation	•Explanation of how the undertaking's targets (from ESRS E1-4) are compatible with the limiting of global warming to 1.5°C in line with the Paris Agreement	ENV
	•Explanation of the undertaking's investments and funding for climate change mitigation actions (from ESRS E1-3) supporting the implementation of the transition plan.	ENV
ESRS E1-2 Policies related to climate change mitigation and adaptation	•The undertaking shall indicate whether and how its policies address climate change mitigation, climate change adaptation, energy efficiency, renewable energy deployment.	ENV
ESRS E1-3 Actions and resources in relation to climate change policies	•The undertaking shall disclose its climate change mitigation and adaptation actions and the resources allocated for their implementation	ENV
ESRS E1-4 Targets related to climate change mitigation and adaptation	·Targets to reduce GHG emissions within Scope 1,2,3 from the year 2030 and, if available, each five years until 2050	ENV
	·The undertaking shall describe the expected decarbonisation levers and their overall quantitative contributions to achieve the GHG emission reduction targets	ENV
ESRS E1-5	·Share of non-renewables in total energy consumption	ENV

Energy consumption and mix	·Consumption of renewable sources	ENV
	·Consumption of self-generated RE	ENV
	·Energy intensity per net revenue	ENV
	·Renewable energy production in MWh	ENV
ESRS E1-6 Gross Scopes 1, 2, 3 and Total GHG emissions	·GHG emissions within Scope 1, 2, and 3, and milestones for their reduction	ENV
	·Monetized GHG emissions in the reporting year (Cost rate factor)	ENV
	·GHG intensity per net revenue	ENV
ESRS E1-9	·Ratio of amount of assets vulnerable to material physical or transition risks / net revenue	ENV
	·Climate-related opportunities (metrics of qualitative and quantitative nature)	ENV
	·Amount and percentage of net revenue from its activities at material physical risk over the short-, medium- and long-term horizons.	ENV
	·Breakdown of the carrying value of its real estate assets by energy-efficiency classes	ENV
TCFD	·Absolute emissions of Scope 1,2, and 3	ENV
	·Weighted average carbon intensity.	ENV
	·Revenues from products and services that support transition to a low carbon economy.	ENV
	·Net premiums written related to energy efficiency and low-carbon technology	ENV
SASB Renewable Resources and Alternative Energy, Topic "Energy Management"	·Total energy consumed (can be considered as consumed by members of ECs)	ENV
	·Percentage grid electricity (can be considered as purchased by members of ECs from external utility)	ENV
	·Percentage RE consumed (can be considered as self-consumed self-generated by members)	ENV
SFDR PAIs Climate and other environment-related indicators	·GHG emissions within Scope 1,2, and 3 + actions taken, actions planned, and targets set for the next reference period	ENV
	·Carbon footprint	ENV
	·GHG intensity	ENV
	·Share on non-renewable energy consumption and production	ENV
	·Activities negatively affecting biodiversity-sensitive areas	ENV
	·Emission to water	ENV
	·Hazardous waste and radioactive waste ratio	ENV
SFDR PAIs Indicators for social and employee, respect for human rights, anti-corruption and anti-bribery matters	·Violations of UN Global Compact principles and OECD Guidelines for MNCs	GOV
	·Lack of process and compliance mechanisms to monitor compliance with UN Global Compact principles and OECD Guidelines for MNCs	GOV
	·Unadjusted gender pay gap	SOC
	·Board gender diversity	GOV
GRI 2 General Information	Total number of employees and breakdown by gender	GOV/SOC
	Approach to stakeholder engagement	GOV
GRI 3 Material topics	Process of determination of material topics	GOV
	List of material topics	GOV
	Management of material issues	GOV
GRI 103 Management approach	Explanation of a material topic and its perimeter	GOV
	Management approach and its components	GOV
GRI 201 Economic performance	Economic value directly distributed	SOC

GRI 203 Indirect economic impacts	Significant indirect economic impacts	ECON
GRI 401 Employment	New hires and turnover	SOC
GRI 404 Training and education	Average hours of training per year per employee	SOC
GRI 405 Diversity and equal opportunities	Diversities in governing bodies and among employees	SOC
GRI 413 Local Community	Impact evaluaiton activities involving local communities and programs for development	SOC
Civil Economy paradigm metrics	11. Caring attitude and positive customer relationships	SOC
	15. Investments in green/social bonds and use of ethical finance	ENV
	1. Use of sustainable (and traced) materials in the inputs of the production activity	ENV
	13. Earnings reinvested in R&D	ECON
	22.Technologies for the creation of innovative products for the common good	SOC
	14.Presence of sustainability disclosure numbers	GOV
	20.Presence ofn impact assessment tool or other non-financial reporting	GOV
	6. Investments for the promotion of the psycho-physical health of the worker	SOC
	4. Training of employees and centrality of people	SOC
	8. Presence of horizontal and/or transversal mechanisms in the departments or funcitnos of the company	GOV
	10.Communication of socio-environmental responsibility activities	GOV
	24. Shared definition of work and career paths among workers	SOC
	27. Supplier selection based on Civil Economy criteria	GOV
	32. Investments targeting youngsters	SOC
	34. Gender equality in hiring	SOC
	12. Promotion of transparency towards customers	SOC/GOV
	16. Presence of collaboration network with direct stakeholders	GOV/SOC
	19. Involvement of stakeholders to build territorial network	SOC/GOV
	28. Customer selection based on Civil Economy criteria	GOV/SOC
	31. Investments in philanthropic projects and corporate volunteering	SOC
	2. Presence of the recyclable materials in output of its own production activities	ENV
	3. Reduction of environmental impacts	ENV
	5. System of the risk prevention (with involvement of stakeholders)	GOV
	17. Promotion of legal business practices	GOV
	18. Fighting against administrative violation (malfeasance)	GOV
	37. Homogeneity/consistency of remuneration with the area of work (reference area)	SOC
VSME Basic Module	Total nature-oriented area on-site and off-site	ENV
B5	Area (in hectars) of sites that undertaking owns/leases/manages, that are located in or nearby biodiversity sensitive areas	ENV
B7	A description of waste diverted to recycle or reuse (expressed in metric system)	ENV
B8	Number of employees broken down by gender, country, temporary OR permanent contract	SOC
B10	Ratio of the entry level wage to the official minimum wage	SOC

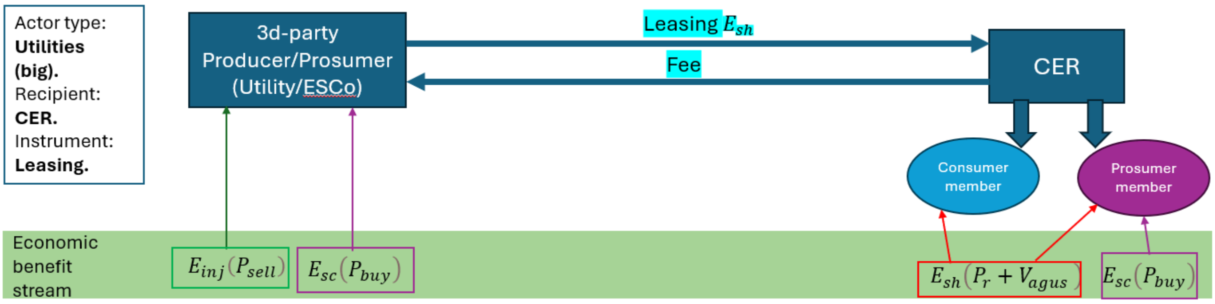
	Number of employees covered by collective bargaining agreements	SOC
VSME Sustainable Finance (Business Partners) SF10	Expected changes to net-revenue from low carbon products and services	ENV
SF14	Percentage of employees, entitled to take family-related leave, with a breakdown by gender	SOC
SF15	Placements for trainees/apprentices in the reporting year	SOC
VSME Narratives PAT N4	A brief description of engagement activities with stakeholders	GOV
	Reference to third-party standards or intiatives the undertaking commits to respect through the implementation of sustainabiltiy policy	GOV
N3	The list of key actions related to sustainablity policy taken in reporting year and planned for the future	GOV
	Targets the undertaking uses to monitor the implementation of the policy & progress achieved	GOV
Academic literature based (not a standard) Source: Koltunov & Bisello (2021), etc.	Cost of additional tourist infrastructure to which energy Energy Community (EC) contributed	SOC
	Avoided cost of by-products disposal (only for biogas ECs)	ENV
	Energy bill savings due to implementation of energy efficiency measures	ENV
	Members' motivation to support community activities due to experience with an EC	SOC
	Members' support to green values over time of participation in an EC	SOC
	Reported friendship ties inside an EC	SOC
	Share of citizens considering an EC project as the value added for the community social capital	SOC
	Number of members who have received specialized trainings for hard skills development related to energy	SOC
	Funds allocated to community development projects	SOC
	Number and quality of newsletters	GOV
	Conflict of stakeholder interest caused by EC activities	GOV
	Number of members who left an EC	GOV
	Share of members voting in an annual assembly	GOV
	Number of lacking votes to achieve a quorum during an annual assembly	GOV

Annex 6. Main prompt for Scholar GPT used in initial coding stage

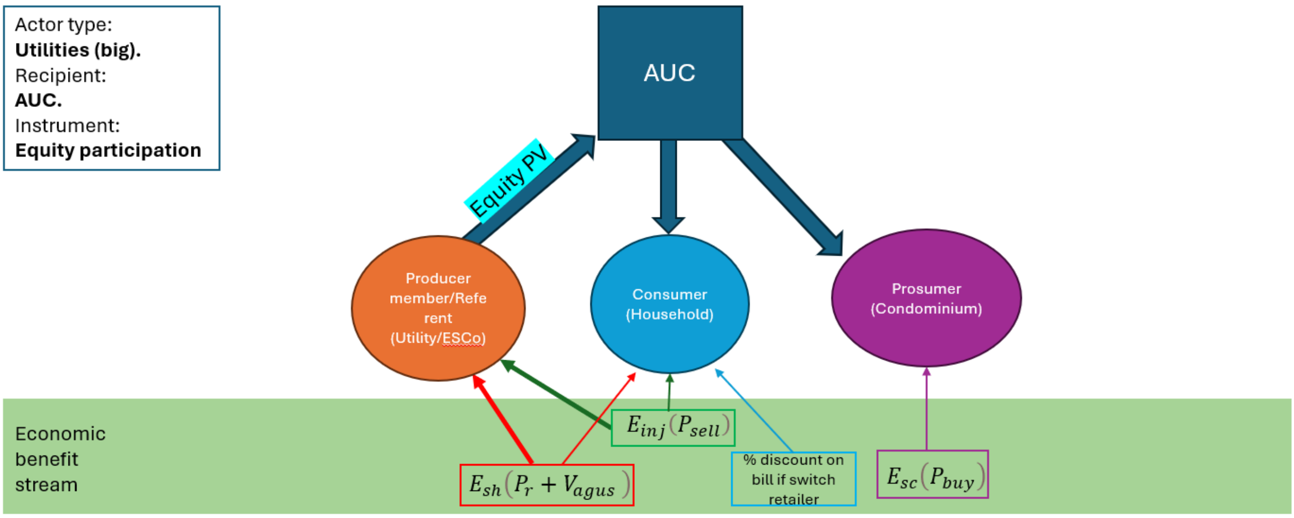
I uploaded a transcript from an interview, where experiences with financing energy communities (ECs) in Italy and SMEs in general discussed. I want you to review this transcript and code it (a code is a unit of analysis in qualitative research) with detailed, descriptive codes. I want codes to be as descriptive, self-explanatory and specific as possible, rather than short or abstract (e.g. I would prefer a code that is called "ECs help bridging public and private territorial entities" rather than "energy communities as a social development tool". e.g, a code "Bank provides discounted interest rate on loan to support ECs" rather than "Incentives for Energy Community Investments"). Very important again, codes should be very detailed, because it is a first stage of analysis, initial coding. I want all accounts, including all reported experiences, all opinions and comments, to be coded. As the output, I want you to provide a list of codes you created, and under each code I want you to provide a full segment of text (e.g. a sentence or part of a sentence) that this code was applied to. Please, provide me all codes at once in one output reply, so I won't need to ask you each time continue with coding. Please, remember to be more specific with codes, so researcher at a later stages can more easily remember what was the initial code about. Do not fear including into codes the specific details from quotes. However, avoid codes to bee too long hence it impedes its comprehension. Do not do any assumptions, but instead capture all details from the text. Ground your analysis only based on textual data from word files provided by me. Please, use for codes words that are carrying same meaning but more simple to comprehend. Provide some specific details in each code, so it is easier to remember which part of text they come from. Do not consider the questions of the interviewer for the codes, but only the answers of the interiviewee. There should be as much codes as possible. Quotes must have exact wording and punctuation, etc, as in the transcript original files.

Annex 7. Financing processes

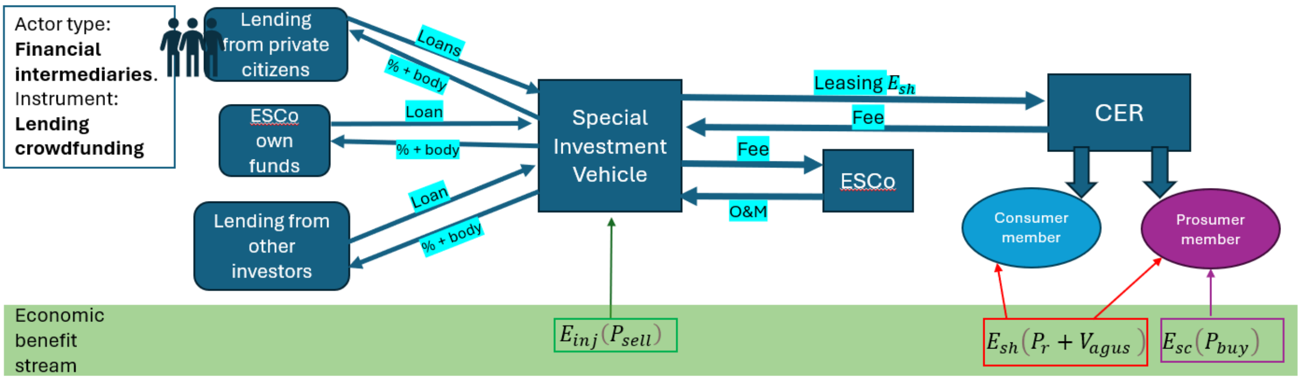
$$Benefit = E_{sc}(P_{buy}) + [E_{inj}(P_{sell}) + E_{sh}(P_r + V_{agus}) - GSE_{costs}]$$



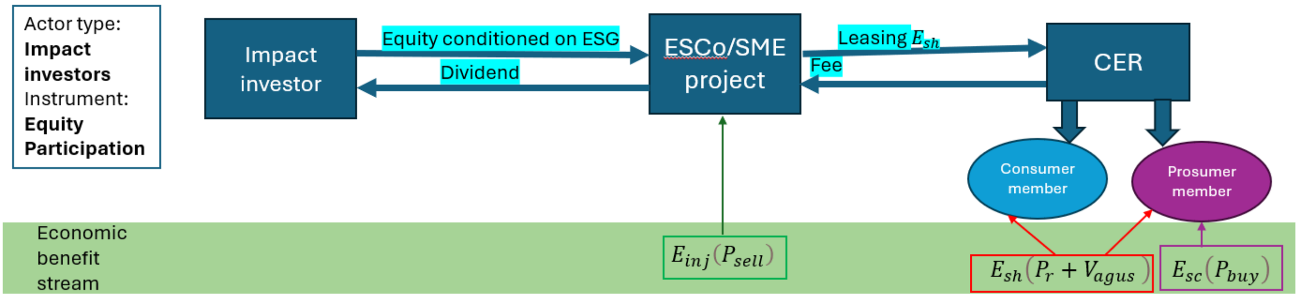
$$Benefit = E_{sc}(P_{buy}) + [E_{inj}(P_{sell}) + E_{sh}(P_r + V_{agus}) - GSE_{costs}]$$



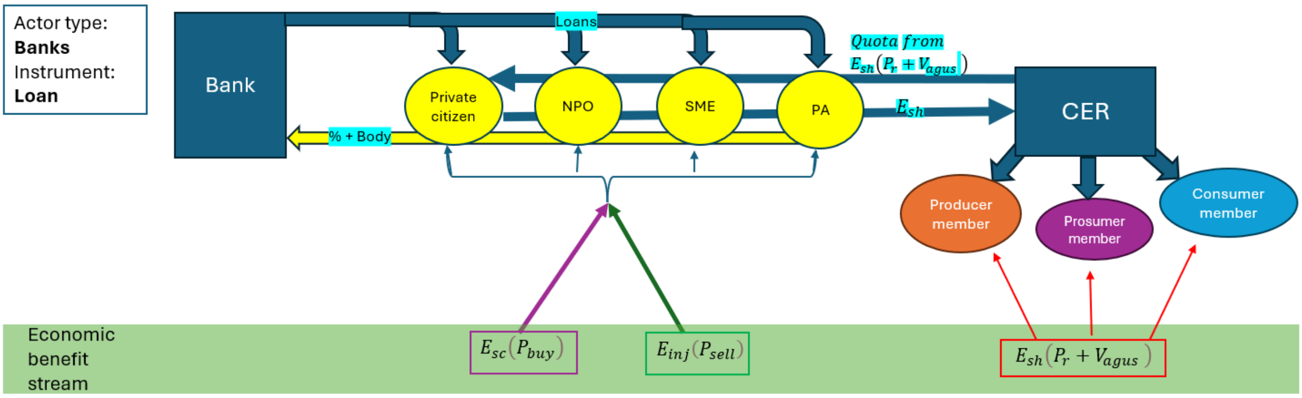
$$Benefit = E_{sc}(P_{buy}) + [E_{inj}(P_{sell}) + E_{sh}(P_r + V_{agus}) - GSE_{costs}]$$



$$Benefit = E_{sc}(P_{buy}) + [E_{inj}(P_{sell}) + E_{sh}(P_r + V_{agus}) - GSE_{costs}]$$



$$Benefit = E_{sc}(P_{buy}) + [E_{inj}(P_{sell}) + E_{sh}(P_r + V_{agus}) - GSE_{costs}]$$



$$Benefit = E_{sc}(P_{buy}) + [E_{inj}(P_{sell}) + E_{sh}(P_r + V_{agus}) - GSE_{costs}]$$