D 5.4. Identified enablers and barriers to foster the replicability and transfer of business models for Green Energy Systems

WP5 – Green economy models and Management Systems

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List of abbreviations

ACER	Agency for the Cooperation of Energy Regulators
BMs	Business Models
CECs	Citizen Energy Communities
CNR	Consiglio Nazionale delle Ricerche
DES	Decentralized Energy System
D5.4.	Deliverable 5.4.
ECs	Energy Communities
EED	Energy Efficiency Directive
EES	Electrical Energy System
EPBD	Energy Performance of Buildings
ESR	Early-Stage Researcher
ESS	Energy Storage Systems
ETN	European Training Network
EU	European Union
ECPE	European Center for Power Electronics
EVCSs	Electric Vehicle Charging Stations
FiT	Feed-in Tariffs
GW	Giga Watts
IRP	Individual Research Project
ITN	Innovative Training Network
MSCA	Marie Sklodowska-Curie Actions
NIMBY	Not In My Back Yard
OSS	One-Stop-Shop
PC	Project Coordinator
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
REC	Renewable Energy Community
RES	Renewable Energy Sources
SIEM	Siemens
SLR	Systematic Literature Review
SMEs	Small-Medium Enterprises
ST	Search Term
UB	Bocconi University
UNL	Universidade Nova de Lisboa
WP5	Work Package 5

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1. Executive summary

Work Package 5 (WP5) "Green Economy Models and Management Systems" aims to coordinate interdisciplinary research and provide guidance for the development, implementation, and replication of innovative Business Models (BMs) that support collaborative renewable energy systems (RES), including Energy Communities (ECs), microgrids, and advanced energy management solutions. This deliverable contributes to WP5 by presenting the outcomes of research carried out by Early Stage Researcher 14 (ESR14) and Early Stage Researcher 15 (ESR15), focusing on the enabling and constraining factors affecting the replicability and scalability of green energy BMs across the European Union (EU). In line with WP5 objectives, the work of ESR14 and ESR15 concentrates on ECs as a key instrument to advance decentralised energy production and energy democratisation under the EU Clean Energy Package. Although ECs have strong transformative potential, they continue to face significant operational, regulatory, financial, and institutional barriers. The research developed within this deliverable provides empirical and analytical evidence to identify, assess, and validate the main barriers and enablers affecting EC development. In this way, it supports WP5's broader ambition of advancing sustainable energy solutions through replicable and adaptable BMs, while also reinforcing WP2, WP3, and WP4 by highlighting cross-cutting factors that can influence the deployment of the technologies addressed in those WPs. The research was articulated in successive phases. ESR15 initiated the work with a cross-country survey on EC ownership models and funding mechanisms, covering seven European countries and showing how governance structures influence access to finance. This analysis also revealed the need to extend the focus beyond financial aspects to capture a broader set of barriers. To address this, ESR14 and ESR15 conducted a comprehensive categorization and validation of barriers using a combination of semi-structured literature reviews and primary data collection. ESR15 applied the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology to analyse over 200 academic and grey literature sources, quantifying the frequency and nature of cited barriers. ESR14 developed and administered a survey involving 122 ECs across the EU, gathering direct stakeholder input on the perceived relevance and severity of identified barriers. Building on this barrier assessment, the research then shifted toward identifying and structuring enabling factors. Through a keyword-based literature review, four key categories of enablers were identified: technical, institutional, social, and economic. These enablers are synthesized and discussed in the context of EC development, offering a structured understanding of what supports EC implementation under varying regulatory and market conditions. The research also includes an applied component that connects BM design to technological innovation. A set of techno-economic feasibility studies was conducted to assess the integration of renewable energy sources (RES) into electric vehicle charging stations (EVCSs). These studies demonstrate that RES-powered EVCSs can enhance energy autonomy, provide storage and flexibility services (including V2G capabilities), and enable economic viability for local actors. These findings underline the enabling role of technology-driven BMs in achieving the goals of ECs and decentralised energy systems and reinforce the replicability goals of WP5. The findings of this deliverable contribute to WP5 by offering a validated typology of EC barriers and enablers, applied insights into financial, regulatory, and technological dimensions of BM replication, a better understanding of how innovative solutions within electrical energy system (EES) can promote resilient, inclusive, and low-carbon energy systems, and evidence-based policy guidance at both country and EU level.

1.1. Objectives of the deliverable

The purpose of this deliverable is to present the progress of WP5 activities, and the research outcomes achieved by the ESRs in the context of Deliverable 5.4, titled "Identified Enablers and Barriers to Foster the Replicability and Transfer of Business Models for Green Energy Systems". This report focuses on 2 Individual Research Projects (IRPs), namely IRP14 and IRP15. IRP14 explores value chains and market structures emerging under the paradigm of distributed EES, while IRP15 identifies the conditions that facilitate or hinder the transferability of innovative EES. The results included reflect the research achievements reached within the first 46 months of the project. Specifically, the deliverable addresses enablers and barriers that affect the replicability and scalability of BMs in the field of Green Energy Systems. The ESRs are focusing their research on the topic of ECs. Their aim is to analyse the barriers and enablers of ECs that can support the advancement of Green Energy Systems. The deliverable aims to establish a clear link between the research outcomes and the overarching goals of WP5, contributing to the broader understanding of how innovative BMs can be adopted and replicated across different contexts within the green energy system.

2. General progress of the action

2.1. WP5 Objectives and tasks

This deliverable is part of WP5, "Green Economy Models and Management Systems", which addresses innovative energy management tools and BMs to meet the new challenges posed by the EES. WP5 involves four IRPs, each focusing on distinct topics related to innovative management solutions and BMs. Specifically, IRP12 concentrates to develop sustainable strategies for Net Zero Energy buildings and user energy awareness using smart appliances; IRP13 explores digital twins of prosumers using socioeconomical factors and big data for optimization of customer's bill savings, and the adoption of concepts of self-consumption and presumption; IRP14 focuses on energy value chains and markets developed with the new paradigm of distributed EES; and IRP15 is dedicated on identifying enablers and barriers to foster the replicability and transfer of BMs for Green Energy Systems. The research outputs aim to enhance understanding and promote the adoption of technological and business solutions that support the sustainable energy transition. WP5 included 5 Tasks:

- Task 5.1: Development of sustainable strategies for Net Zero Energy Buildings and Energy Awareness using Smart Appliances (UB, UNL).
- Task 5.2: Generation of digital twins of prosumers using socioeconomical factors and big data for Optimization of Customer's bill savings, (UB-SIEM-UNL).
- Task 5.3: Energy value chains and markets developed with the new paradigm of distributed EES (UB-UNL-CNR).
- Task 5.4: Identifying enablers and barriers to foster the replicability and transfer of business models for Green Energy Systems (UB, UNL, ECPE).
- Task 5.5: Elaboration of partial and final scientific reports (UB).

Tasks 5.1 and 5.2 have been completed and the corresponding deliverables submitted. Tasks 5.3 and 5.4 are ongoing and are scheduled to be finalized by September 2025, remaining on track with the project timeline. This deliverable specifically presents the final insights from Task 5.4, while the main results from Task 5.3 are addressed separately in Deliverable 5.3. Both ESR14 and ESR15 have successfully completed their research activities, fully meeting the objectives outlined in their respective IRPs.

The work carried out in Task 5.4 provides a structured and validated assessment of the barriers and enablers that affect the replicability of green energy BMs in Europe, focusing on EC initiatives. Through mixed-method approaches including systematic literature review (SLR), cross-country surveys, and techno-economic feasibility studies, this research has contributed significant new evidence to inform the design of scalable and context-sensitive BMs. These results directly support WP5's ambitions to inform business strategies, enable effective policy design, and promote sustainable energy innovation across diverse socio-technical contexts.

2.2. WP5 – IRPs and ESRs progress

The following table provides a summary of the start dates of each IRP, corresponding to the recruitment dates of the respective ESRs. A brief explanation of the current status of each ESR and the results achieved, related to this deliverable (D5.4), to date is also included.

Table 1

General evaluation and current statues of ESR14 and ESR15.

ESR#	Starting date	General evaluation	Status
ESR15	01-01-2023	The objective of ESR15 is aligned with IRP15, focusing on identifying the enablers and barriers that promote the replicability of BMs for green energy systems. ESR15 was recruited on January 1st, 2023. So far, three publications have been produced: one journal article and two conference papers. Furthermore, on journal article has been completed and is under submission process. Finally, two more articles are in progress and are planned to be submitted in the coming period. Finally, ESR15 has collaborated with ESR14 on two more papers.	ESR15 will be involved in the SmartGYsum project for a duration of 36 months, concluding on December 30, 2025. Since the project is scheduled for completion by March 2026, ESR15 will

		However, this report focuses solely on the research related to D5.4. Identified enablers and barriers to foster the replicability and transfer of BMs for Green Energy Systems. Therefore, only the research conducted in relation to the objective of D5.4. is presented here. ESR 15 specifically addresses the topic of ECs, which closely aligns with the objectives of WP5, particularly IRP15. Three related research papers are reported here: A survey focuses on examining funding mechanisms and ownership models. Specifically, ESR15 aims to analyse how the ownership model of ECs affects the funding mechanisms they use for their energy generation plants. Additionally, this study seeks to investigate the financial barriers faced by ECs with varying ownership models. This work has been published as conference paper (see Section 3 deliverable description). • A systematic literature review aimed to analyse the barriers that ECs encounter. Specifically, ESR15, in collaboration with ESR14, conducted a literature review to categorize the barriers that ECs face. Later, ESR15 conducted a systematic literature review to validate the barriers by counting the frequency of their appearance in the literature. The findings from this research have been compiled, and ESR15 is in the process of preparing to submit this work as an article to a journal. • A study that examines the policy challenges faced by ECs and offers policy recommendations. ESR15 collaborates with researchers outside the SmartGYsum project to investigate the policy challenges encountered by ECs in various European countries and to provide solutions for overcoming these barriers. ESR15 specifically focuses on policy challenges and recommendations related to Greece. This research has been published as a journal article in Oxford Open Energy (see Section 3, deliverable description). ESR15 is enrolled as a Ph.D. student at the University of Extremadura, with the goal of completing the program no later than June 2026.	continue to engage in activities related to the publication of current work even after the official recruitment period has ended. Overall, the ESR has successfully met the objectives of IRP15 regarding the intended outcomes; therefore, the activities related to the deliverable's objective can be considered good.
ESR14	01/09/2022	ESR14 is progressing well with the declared research objectives, and the research topic aligns with IRP14. Since ESR14's recruitment on September 1st, 2022, he has been actively involved in the project, fulfilling his duties by participating in two secondments in Portugal and Spain, respectively. During these secondments, ESR14 collaborated with researchers from Portugal and Spain, including ESR03, with whom he published one conference. His conference paper has been presented in a flagship conference in Europe as IEEE EUROCON-2025. Another conference paper already published at Springer Nature at DOCEIS-2023. Additionally, he has submitted two journal articles, and one ongoing book chapter, and has planned two more journal articles (in collaboration with ESR15). In terms of awards, ESR14 received the best conference paper award at DOCEIS-2023. Furthermore, this report focuses solely on the research related to D.5.4. Identified enablers and barriers to foster the replicability and transfer of business models for Green Energy Systems.	ESR14 involvement ends on time by August 2025. The ESR will continue his PhD thesis in the upcoming months. Also, he will continue working on ongoing publications with IRP14. Overall, the ESR has successfully achieved the goals of IRP14 regarding the intended outcomes; therefore, the

		ESR14 specifically addresses the topic of ECs barriers and enablers, particularly ESR 14. Two related research papers (one article and one book chapter) are reported for enablers and barriers of ECs: • The first article aims to conduct a survey to assess barriers encountered by ECs in Europe. The survey has already been performed, and ESR-14 will prepare the article and submit it soon to a reputable journal. • A study was conducted by performing a literature review to find enablers; later, enablers were validated with techno-economic feasibility results of D5.3 works in a book chapter entitled "Energy Communities Enablers: Techno-Economic Optimization Analysis of RES for Electric Vehicle charging Station".	activities related to the deliverable's objective can be considered more than satisfactory.

3. Deliverable description

This deliverable presents the results of a comprehensive study on the enablers and barriers affecting the replicability and transferability of BMs for Green Energy Systems, with a particular focus on ECs. The aim of the current research work is to analyse the enabling and constraining factors that influence the establishment, development, and scaling of ECs. This study is closely related to the Deliverable 5.3 on market solutions and BMs supporting the development and sustainability of distributed EES. In particular, both deliverables focus on ECs as a strategic pillar of decentralized energy transitions. Moreover, part of the research and analysis included in D5.3 provided background knowledge that informed the formulation of research questions and the design of methodological approaches in the present deliverable (D5.4). The scientific work developed here aligns with the overarching goals of WP5, which promotes green economy models and sustainable management systems. ECs represent a key innovation in this context, enabling citizen-led renewable energy production while delivering environmental, social, and economic benefits. By encouraging collective ownership, energy efficiency, and carbon emissions reduction, ECs embody the core principles of the green economy and energy justice. The results presented in this deliverable have been obtained primarily during the research periods undertaken by ESR14 and ESR15 at Università Bocconi, under the supervision of the Bocconi academic team. However, specific outputs-such as the techno-economic feasibility studies-benefited from the research activities carried out during the secondments completed by ESR14 at NOVA University Lisbon and the University of Extremadura. Similarly, the secondments conducted by ESR15 at the University of Extremadura and Siemens were instrumental in collecting data and deepening the understanding of EC implementation and governance practices. These international research exchanges provided essential empirical and theoretical inputs that strengthened the scientific foundation of this work.

3.1. Scientific Background and summary of the main research outcomes

In 2023, the global renewable power capacity reached 3,870 giga watts (GW), contributing 13% of the world's energy consumption [1]. The EU has advanced the transition from fossil fuels to renewable energy, transforming the energy system from a centralized, vertically integrated model to a liberalized and decentralized one. This shift enables citizens, municipalities, and small-medium enterprises (SMEs) to generate and utilize their own energy, transforming them from passive consumers into prosumers [2]. Studies have placed special emphasis on how ECs can impact and propel the transition to a sustainable energy system. ECs empower citizens and local stakeholders, such as SMEs and local authorities, to collectively produce, consume, and manage energy. The Renewable Energy Community Directive (RED II-EU Directive 2018/2001) and the Internal Energy Market Directive (IEMD- EU Directive 2019/944) have significantly enhanced citizen participation in the energy sector. ECs have the potential to substantially alter the energy market by fostering a more democratic and decentralized energy system (DES) [3]. Approximately 10,000 ECs exist in Europe and have initiated around 22,000 projects, resulting in a total installed capacity of approximately 10 GW [4]. However, this number represents only 1.2% of total renewable power capacity in Europe in 2023 [1]. Numerous barriers affect the setup, development, and expansion of ECs, such as the limited adoption of smart meters, hindering the advancement of EC initiatives in the EU, or the lack of funding that can support the establishment and development of ECs [5].

While numerous studies have explored the barriers faced by EC, there is a notable lack of systematic investigation into the various categories of these barriers. Consequently, the research undertaken by ESR14 and ESR15 aims to identify, categorize, and analyse the barriers that ECs encounter. Additionally, the research focuses on identifying enablers and formulating policy recommendations that can help overcome these barriers. Achieving the research objectives outlined above was not accomplished through a single research project or methodology. Instead, ESR14 and ESR15 developed distinct methodologies, which were implemented during different time periods and in various settings. Nonetheless, all of these efforts contributed to fulfilling the objectives of this deliverable, as outlined earlier (see section 1.1. Objectives of the deliverable).

Specifically, ESR15 carried out a survey, with support from a research team at Bocconi University, focusing on the ownership models and funding mechanisms of ECs. This study, which took place from April to September 2023, aims to analyse how the ownership model of ECs impacts the funding mechanisms utilized and the financial barriers they encounter. This work has been completed and presented as a conference paper at the 16th International Conference on Energy and Climate Change, which occurred in Athens, Greece, in October 2023.

Later, ESR14 and ESR15 aimed to deepen the analysis of the barriers encountered by ECs and to develop a research methodology for identifying, categorizing, validating, and evaluating these barriers. First, a semi-structured literature review was conducted to identify and categorize the barriers faced by ECs into different groups. This initial work serves as a foundational stage that supports subsequent research phases. Next, a SLR was performed to validate the

barriers identified in the previous stage by examining their frequency in the literature. Finally, a research survey was conducted to collect primary data, through a questionnaire, from ECs to assess the relevance of the barriers identified in the first stage of this research.

This research, which commenced in June 2024, is ongoing, with results obtained but not yet published. Furthermore, the outcomes of the current research are intended to lead to two distinct research papers that will be published as journal articles. Specifically, ESR15, in collaboration with ESR14 and the Bocconi research team, initiates a SLR regarding the barriers ECs faced in September 2024. The objective of this work was to quantify the occurrence of different types of barriers reported in the literature. This work is still in progress; however, preliminary results have been obtained and are presented here (see Section 3.3.2). The final research paper is aimed to be published as a journal article in October 2025. Moreover, ESR14, in collaboration with ESR15 and the Bocconi University team, initiated a survey in October 2024 to collect primary data and assess the relevance of the barriers that EC encounters; this survey is still in progress. In total 122 responses have been collected and analysed, and the results aim to be published as a journal article in October 2025.

The ESR15, in collaboration with other researchers (not related to the SmartGYSum project), conducted a study aimed at assessing the current state of deployment of EC in ten European countries. The study also explored the barriers ECs face in these countries and proposed policies to overcome them. Specifically, ESR15 concentrated the research on Greece, highlighting the main barriers encountered by ECs in that country and suggesting policies to overcome them. This project commenced in December 2024, was completed in April 2025, and was published as a vignette article in the Oxford Open Energy journal in March 2025.

Subsequently, the ESR14, another part of his research, aimed to identify the enablers of ECs, present in the literature, in order to overcome the barriers identified both in the literature and the survey. A semi-SLR was conducted to identify and categorize the enablers of EC. A book chapter is prepared for this work and will soon be submitted for peer review. While this section constitutes the initial phase of categorizing factors that facilitate EC operation and management, this work can be expanded in the future by conducting a survey similar to the one on barriers.

The following sections present in more detail the research methodology as well as the research outcomes of the aforementioned studies. In addition, the subsequent section illustrates how current research contributes to current deliverables and WP5 goals.

3.2. Energy Communities Ownership Model and funding mechanisms

As previously noted, ECs encounter numerous barriers in their establishment and growth [5]. Various scholars have identified financial barriers as a significant challenge that ECs must overcome. These barriers include a lack of long-term funding, initial funding challenges, high institutional costs, and uncertain levels of Feed-in Tariffs (FiT) [5], [6]. One substantial barrier that almost all ECs need to overcome is finding the capital to finance their activities [7]. As Braunholtz-Speight T. et al. [8] stress, EC funding is not about the cost structure or the revenue structure of the business; on the contrary, it refers to "unearned flows of money into community energy groups". [8]. Thus, the funding mechanism can be described as the "ways by which a supplier makes financial resources available to the organizations that require them. These methods can have a variety of implications for capital recovery, expected returns, ownership rights, and other factors" [9].

EC funding mechanisms can take various forms, which can be categorized into four main types: (i) equity finance, consisting of shares that a community offers in exchange for ownership rights to the community or a project [7]; (ii) debt finance, which refers to the money that an EC borrows from another entity in the form of a loan, requiring repayment over a specified period at an interest rate. While loans allows ECs to operate independently from external influences, it is generally a more costly method of funding a project [10]; (iii) grants, which are funds that an EC can receive without the obligation to repay and can be awarded by the EU, as well as at national, regional, or municipal levels; and (iv) alternative finance, which encompasses crowdfunding and crowd-investment platforms [10].

A key factor affecting how ECs can obtain funding is their ownership model, as the people involved and how the EC is governed greatly impact how they can raise money and support their activities [7]. Furthermore, funding mechanisms, capacity building within ECs, and collaboration with other stakeholders heavily depend on the actors who initiate them. However, there is a lack of academic literature exploring how the ownership model and the initiators of an EC influence the funding mechanisms. In addition, the existing literature lacks an examination of the financial barriers faced by ECs with varying ownership models and actors initiating them. To address this research gap, ESR15 aims to first categorize ECs based on their ownership models and initiators. Second, it seeks to examine the types of funding mechanisms utilized by these ECs. Finally, it intends to investigate the financial barriers encountered by the different ECs. To define the various ownership models of ECs, ESR15 utilizes four dimensions identified by the

International Renewable Energy Agency, namely, (i) membership, which refers to the different types of actors who participate as members, such as citizens, public actors, or private actors; (ii) the level of democratic governance, which refers to the way decisions are made and who has voting rights in the ECs; (iii) the main purpose of the community, which can be economic, environmental, or social; and (iv) the local distribution of benefits, which refers to the extent to which the social, environmental, and economic benefits generated by the EC are distributed locally or not (see Fig. 1). In addition, this study defines the initiators of the EC as any public or private actor, including SMEs, local authorities, or citizens involved in the establishment and setup of the EC.

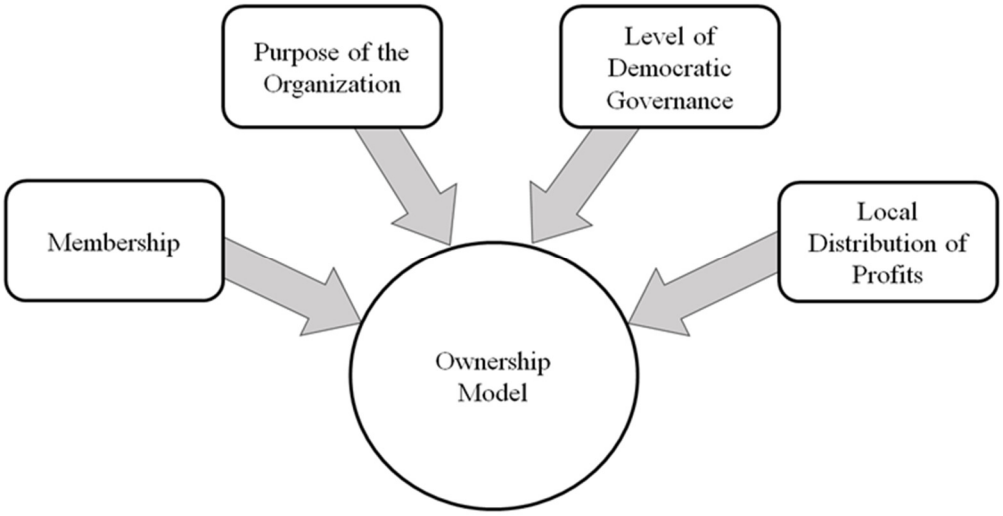

Figure 1: Ownership model dimensions based on International Energy Agency.

To achieve the research aim of the current study, ESR15 conducted a survey using a self-completion questionnaire to gather primary data from ECs. Specifically, the questionnaire is divided into three sections aimed at obtaining data on the characteristics of the ECs in order to analyse their ownership models, funding mechanisms, and financial barriers encountered. It should be noted that the survey considered only ECs that have developed energy generation plants and did not consider other types of activities. The focus only on ECs active in energy production was chosen because the vast majority of ECs are mainly engaged in this activity [11]. Consequently, other activities that could introduce inconsistencies and hinder comparability between the different ECs were deliberately excluded from the analysis.

3.2.1. EC characteristics, ownership model and funding mechanisms

The findings indicated that the predominant characteristics of the ECs are their small size, in terms of number of members, and the primary use of photovoltaic panels for energy generation. Only three communities are categorized as large (500-2000 members) or very large (over 2000 members), while the rest of the ECs have fewer than 500 members. Regarding the year of foundation, the majority of ECs, namely 20 out of 25, were founded from 2017 onwards. Moreover, the predominant number of ECs in the sample are non-profit (16 ECs), with only 6 classified as for-profit ECs, while 3 ECs stated that their primary objectives were non-financial. Regarding the ownership model of the ECs, the analysis revealed that the only variation among the ECs in the sample pertained to their membership. No substantial changes occurred in governance, local profit distribution, or the purpose of the EC. Furthermore, the sample revealed that different actors initiated the ECs. Therefore, this study categorizes the ECs based on two dimensions: the membership and the initiators. Eight separate categories of ECs were delineated (see Tab. 2).

Table 2

Eight Categories of ECs Based on Membership and Initiator Dimensions.

Categories	Initiators	Membership	Number of EC in the sample
1	Citizens	Citizen	4
2	Citizens	Citizens + Private	6
3	Citizens	Citizens + Public	1

4	Citizens	Citizens + Public + Private	7
5	Public	Public	1
6	Public	Public + Citizens	1
7	Private	Citizens	2
8	Citizens + Public + Private	Citizens + Public + Private	3
Total			25

Most ECs used a combination of funding mechanisms. Specifically, almost 70% of ECs in the sample relied on debt capital, while 60% stated they relied on equity capital. Furthermore, approximately 40% of the ECs in the study utilized grants or crowdfunding. Regarding the relationship between the categories identified in this study (see Tab. 2) and the funding mechanisms employed, it is noted that ECs initiated by citizens, which include public and/or private actors as members (Tab. 2, categories 2, 3, and 4), are more successful in raising capital through equity or other internal resources compared to ECs that consist solely of citizen members (Tab. 2, category 1). Additionally, this study, similar to others, indicates that both the number of community members and the total capital needed for project funding may influence the choice of funding mechanisms. Specifically, ECs, with investments of more than 200,000 euros in energy generation plants, tend to use debt capital. However, large ECs (more than 2000 members) can use different funding mechanisms, such as green bonds provided to their members, thus reducing the financial risk by depending on debt capital.

3.2.2.EC financial barriers

ECs in the sample encounter financial barriers, particularly in raising capital from both private and public actors. Table 3 summarizes the main barriers that ECs encounter to raise capital and fund their generation plants. The most frequently reported barriers are the lack of grants or subsidies at the national level (barriers 1-3), followed by barriers related to private funding (Tab. 3, barriers 4-6). In contrast, barriers concerning crowdfunding and citizen participation are reported less often (Tab. 3, barriers 7 and 8).

Table 3
Financial barriers EC face

N.	Barriers	Number of ECs reporting impact
1	No subsidies or grants for EC provided at a national level	14
2	Public grants or prizes are not tailored-made for your EC	14
3	Complex bureaucratic processes make it difficult to access public finance	14
4	Private financial institutions or banks do not fund your generation plant because they consider it non-profitable.	11
5	No access to favorable loans, such as soft loans, green loans, etc.	12
6	Unattractive environment for private investors because of the absence of FiT or other pricing mechanisms	8
7	Absence of a legislative framework for the proper functioning of crowdfunding or crowd-investment platforms	7
8	Low participation of people in funding energy generation plants; thus, it isn't easy to raise capital from equity shares	11

Finally, the current analysis indicates disparities among EC categories regarding the barriers they encounter. Communities created by citizens identify the absence of citizen participation as a barrier (Tab. 2, categories 1, 2, 3, and 4), whereas those initiated by public or private entities do not. Additionally, citizen-initiated ECs that include both public and private members (Tab. 2, categories 2, 3, and 4) can more easily get internal funding through equity than ECs created only for citizens (Tab. 2, category 1). Ultimately, concerning access to public funding sources, it seems that all ECs face obstacles, irrespective of their category. Nonetheless, the restricted sample size of this study needs further investigation to corroborate this pattern.

3.3. Energy Communities barriers analysis

The study mentioned above concentrates exclusively on the financial barriers faced by ECs. However, literature highlights many additional barriers that impact the establishment, growth, and expansion of ECs [12], [13], [14], [15]. Furthermore, the financial barriers discussed above pertain only to ECs that have constructed energy generation plants, omitting other activities such as energy storage, e-mobility, supply, etc. Additionally, the data analysed in this study were limited to just seven EU countries, resulting in a lack of information regarding other national contexts within the EU. Consequently, ESR15 and ESR14 aim to carry out a comprehensive analysis that identifies, categorizes, validates, and assesses all existing barriers, thereby providing a complete picture of all types of barriers. Consequently, a three-step approach was created. The initial stage seeks to identify the primary barriers present in academic papers and policy reports using a semi-structured literature review and desk research. Identified barriers are grouped into categories (economic, institutional, technical and technological, socio-cultural, and behavioural) and then sub-categorized into classes. The second stage seeks to validate the identified barriers and incorporate any additional ones through a SLR utilizing the PRISMA technique. Finally, the third stage aims to evaluate the significance of the barriers identified and validated in the preceding two stages through a survey. To this end, a questionnaire was created and disseminated to ECs throughout the EU.

3.3.1. EC Barriers identification

As already mentioned, the first stage of this research concentrates on the identification and categorization of the different types of barriers. To that end, ESR14 and ESR15 conducted a semi-structured literature review and desk research to identify papers and policy reports addressing EC barriers. The papers and the reports were retrieved from Google Scholar, Scopus, and Web of Science databases using different keywords, based on the diversity of terms used in academic literature concerning the topic of ECs, such as "energy community", "community energy", "renewable energy community", and "citizen energy community" [16]. In addition, keywords similar to "barriers" were used, such as "challenges", "hindering factors", and "constraints". At this stage of the research, only review papers and articles that have conducted a detailed analysis of EC barriers were included to avoid focusing on country-specific barriers. Additionally, searches were limited to "author keywords" to ensure that the papers explicitly address the topic of EC barriers. Finally, only papers published from 2014 onward were considered to ensure the relevance of the barriers identified, as older publications may no longer reflect current policies and energy market conditions. In total, 26 articles were retained and reviewed from the Web of Science and Scopus databases. In addition, six more reports from EU-funded projects were extracted from Google Scholar. Therefore, 32 scientific works were analysed (see Tab. 4).

Table 4
Type of documents and references utilized to identify and develop a categorization of ECs barrier.

Type of documents	Number of documents
Original articles	7
Review Papers	20
Reports	5
	Total=32

After gathering all the papers, they were reviewed, and the barriers were recorded using the NVivo program. The objective at this stage of the research was to identify patterns or themes. Thus, a thematic analysis was conducted to categorize the barriers reported in the literature according to their conceptual similarity. This process led to the development of a three-tier categorization system. First, barriers were grouped into categories that represent higher-order classifications sharing fundamental attributes, e.g., economic barriers. Second, within each category, the barriers were further grouped into classes based on their thematic connections. For instance, under the category of economic barriers, two different classes emerged: the financial barriers and the market barriers (see Tab. 3). Finally, the third level identifies specific and tangible barriers that ECs face in their setup, development, and expansion. In total, 26 barriers, 10 classes, and 4 categories were identified (see Fig. 2).

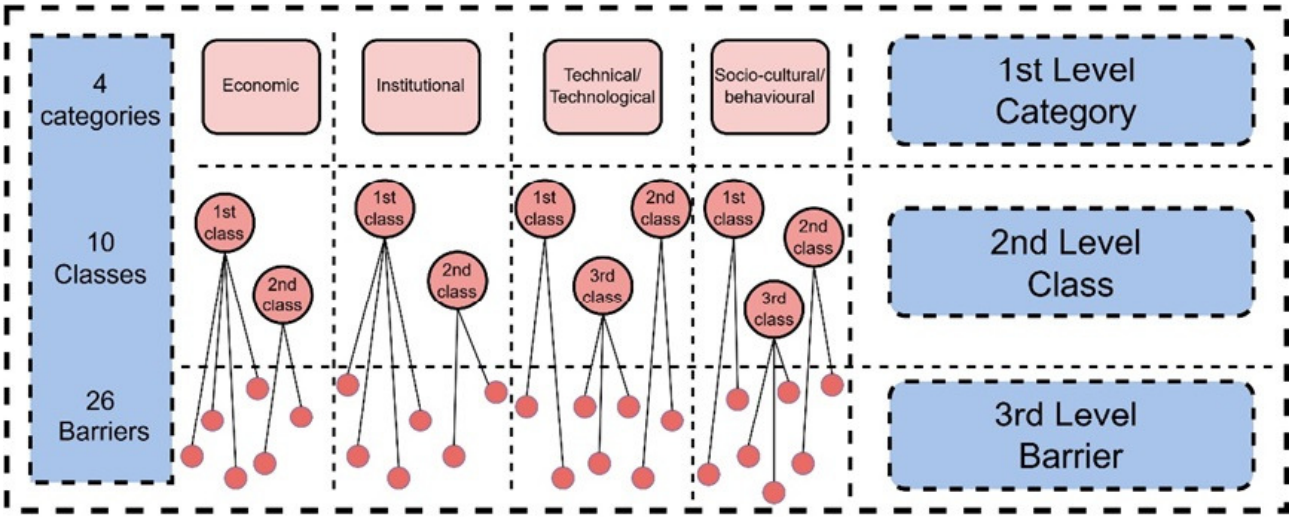

Figure 2: The three level categorization of barriers in current research.

The first category pertains to economic barriers, which refers to difficulties that ECs face in accessing finance and entering the energy market. This category includes two distinct classes: (i) *financial barriers*, which refer to the difficulties that ECs face in securing funding for their activities, and (ii) *market barriers*, which refer to difficulties faced by ECs in acting within the energy market compared to commercial and traditional market players. These challenges can be inherent to ECs characteristics, such as their small size, or caused by asymmetric market dynamics, considering traditional energy players and incumbents.

The second category is the institutional barriers, which are related to political obstruction, conflicting guidelines, lack of policy coordination as well as bureaucratic and administrative issues. Two different classes emerged under this category: (i) *the policy and regulatory barriers*, which refer to either the lack of policies and regulations or the presence of unclear and/or conflicting policies and regulations related to ECs, and (ii) the administrative and bureaucratic barriers, which refer to complex or slow day-to-day operations that an EC has to perform to function, stemming from administrative or bureaucratic issues.

The third category is the technical and technological barriers and refers to difficulties generated by limited availability and spread of technologies (e.g., smart meters, energy storage, and smart devices), inefficient and old energy infrastructures, and data protection and security issues. This category includes three different classes: (i) *the technical barriers,* which refer to the lack of land/space to build RES plants/infrastructures or the lack of technical skills to manage ECs; (ii) *the lack of efficient infrastructures*, which refers to the lack of efficient and suitable energy and IT infrastructure; and (iii) *the lack of enabling technologies*, which refers to the lack of specific enabling smart technologies and data processing tools that are necessary for the operation, optimization, and management of ECs, such as smart meters, smart control systems, digital twins, etc.

Finally, the last category pertains to the socio-cultural and behavioural barriers, and it refers to barriers that arise from either issues within the broader socio-cultural context in which ECs operate or from a lack of information or awareness among individuals about ECs and energy-related issues in general. Under this category, three classes were identified: (i) *The lack of knowledge and awareness of ECs*, which refers to the lack of understanding and/or awareness among potential EC members about the benefits and opportunities of EC initiatives, which leads to low engagement and hinders the growth of ECs; (ii) *the lack of trust*, which refers to the lack of or low mutual trust among EC members and collaborative actors, reducing citizens' willingness to participate in ECs; and (iii) *the lack of socio-cultural conditions,* which refers to barriers resulting from the lack of socio-cultural conditions necessary for the development of ECs.

Table 5
The barriers, classes and categories of barriers identified in the literature.

Category	Class	Barrier
Economic	Financial Barriers	Lack of access to traditional finance Difficult to access finance from members Lack of tailor-made finance options Lack of public funds for ECs
	Market Barriers	Lack of a level playing field (i.e. economy of scale) Presence of market incumbents

Institutional	Policy and Regulatory Barriers	Absence or lack of a clear and uniform definition for ECs Lack of a clear scope of EC's activities Lack of policy stability and coherence
	Administrative and Bureaucratic Barriers	Lack of simple and clear administrative procedures Slow administrative procedures plants
Technical/Technological	Technical Barriers	Lack of space to build RES Lack of technical skills (skilled personnel) Lack of technical expertise
	Lack of efficient infrastructures	Lack of efficient and suitable energy infrastructure Lack of IT infrastructure
	Lack of enabling technologies	Low diffusion of smart technologies Data management issues Cybersecurity and protection issues
Socio-cultural and Behavioural	Lack of Knowledge and awareness of ECs	Lack of knowledge regarding the EC concept Lack of awareness about ECs' benefits
	Lack of Trust	Lack of trust in private or public actors Lack of trust towards peers in the EC
	Lack of Socio-cultural conditions	NIMBY[1] syndrome and local backlash against RES and ECs Lack of cooperative tradition in the country or the region your EC is operating Lack of Environmental awareness in the country or the region your EC is operating

3.3.2. EC barrier validation

At this stage, ESR15 seeks to validate the previously presented barriers through a SLR utilizing the PRISMA[2] technique. Identifying relevant keywords is a crucial step in conducting an SLR, as it ensures the inclusion of all academic papers related to the barriers faced by ECs. The most relevant keywords have been identified and are presented in the following table (see Tab. 6).

Table 6
Search terms for the identification of research papers.

Set of keywords for search term (ST)	Search Term
ST-1	("Energy communit*" OR "Community energy" OR "Local Energy Communit*" OR "Renewable Energy Communit*" OR "Energy Cooperative*" OR "Citizen Energy Communit*" OR "Renewable Energy Cooperative*" OR "Community Renewable Energy" OR "Smart Energy Communit*" OR "Community Solar" OR "Solar Communit*")
ST-2	("Barrier*" OR "Obstacle*" OR "Challenge*" OR "Hurdle*" OR "Constraint*" OR "Hindering factor*")
Final ST	(ST-1) AND (ST-2)

The PRISMA guidelines involve four phases of decision-making: identification, screening, eligibility, and inclusion. In the identification phase, we identified 848 papers in the WOS database and 749 papers in Scopus using the specified search terms (see Table 6). This resulted in a total of 1,597 papers; however, after removing 560 duplicates, 1,037 unique papers were included in our analysis. During the screening process, we reviewed the titles and abstracts, leading to the exclusion of 545 papers due to their irrelevance to the topic under investigation. Consequently, 492 papers remained for full screening. At this stage, we evaluated the remaining papers for eligibility. It was determined

[1] Not In My Back Yard (NIMBY)

[2] The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) technique is the structure that is usually applied when reporting systematic literature reviews.

that 297 papers were irrelevant, resulting in a final total of 195 papers that were fully reviewed to validate the barriers. To those papers, another 5 reports were added from Google that contain policy reports and had a high relevance to the current research. Thus, a total of 200 papers and reports were reviewed for the validation of the barriers (see Fig. 3).

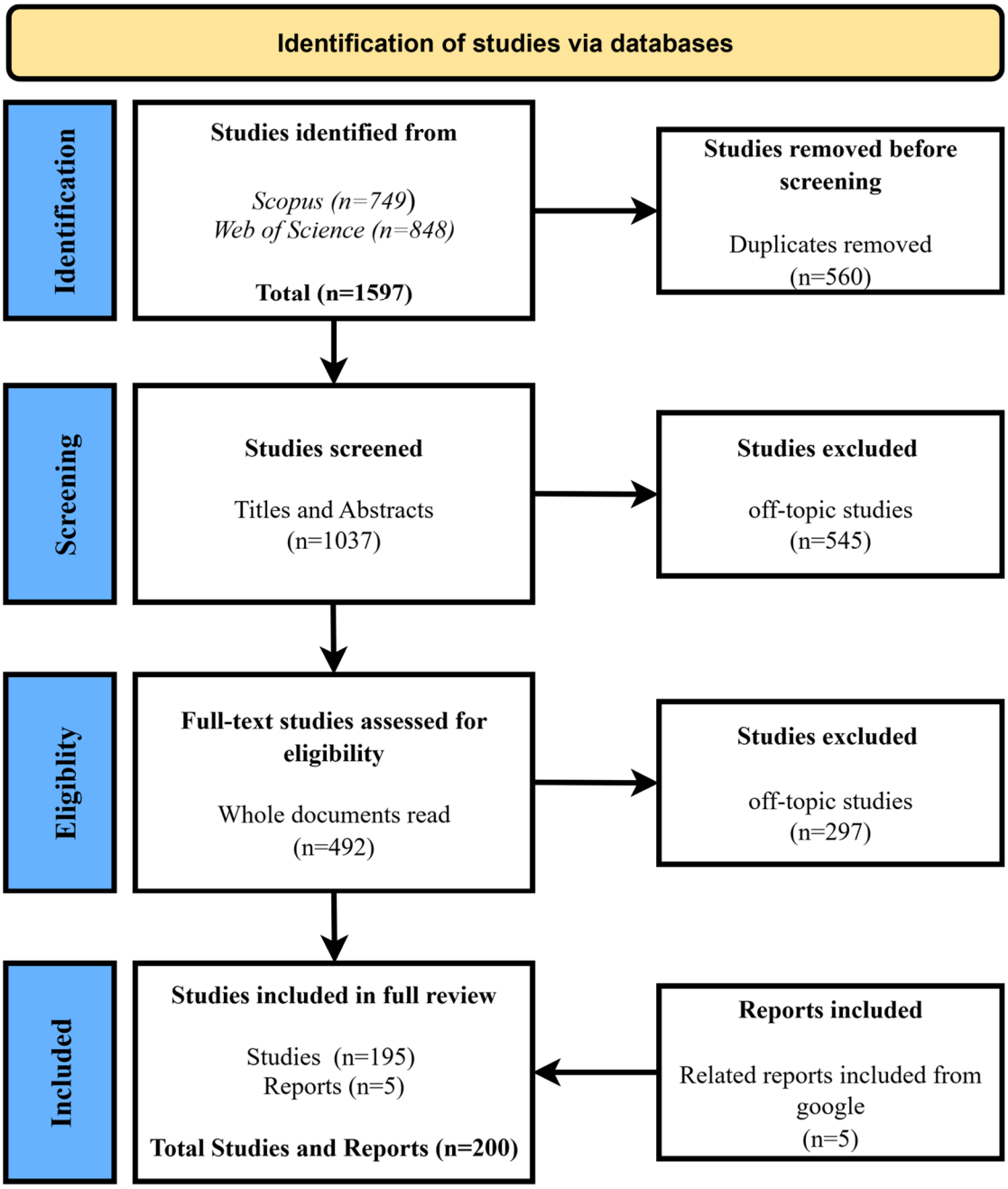

Figure 3: PRISMA diagram of paper selection for the SLR.

After retrieving the final papers for consideration, a content analysis was conducted, categorizing each barrier identified in the literature according to the previously established framework (see Tab. 5). The SLR demonstrates that the literature documents all identified barriers, albeit at varying frequencies. The following section presents a detailed analysis of the barriers and their occurrences in the literature.

Economic barriers

The category of economic barriers further divides into two distinct classes: the financial barriers and the market barriers, as previously mentioned. The SLR reveals that all these barriers appear in literature in varying frequencies. The financial barriers identified in the literature primarily highlight the lack of tailor-made financial options, which is cited in 65 studies. These barriers refer, among others, to the absence or cancellation of FiT, the unavailability of state

bank loans at subsidized interest rates, and the need for targeted tax and fee relief for ECs. Additionally, 54 studies report that the lack of public funding for ECs represents a significant barrier. The last two barriers mentioned, though with varying frequencies, include the lack of access to traditional financing, noted in 45 studies, and the difficulty of accessing finance from members, referenced in 41 studies (see Fig. 4).

Concerning the market barriers, studies have reported the presence of market incumbents more frequently than the lack of a level playing field. Specifically, 63 papers address the issue of market incumbents, whereas 56 papers reference the lack of a level playing field.

Overall, all barriers under this category have been reported with similar frequency, so it cannot be argued that there is significant variation in the frequency of their occurrence in literature. However, it should be noted that the lack of tailored financing options and the presence of market incumbents have been cited more than the other barriers.

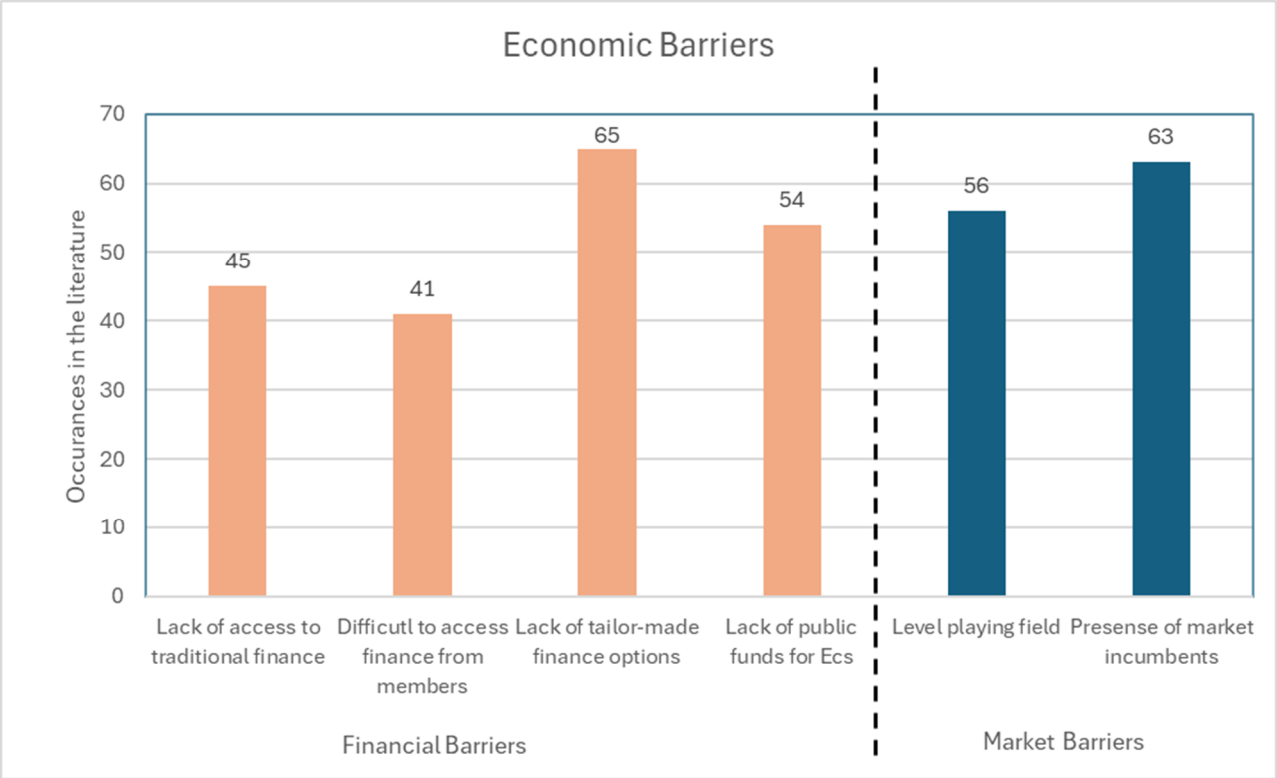

Figure 4: The frequency of occurrence of economic barriers identified in the literature.

Institutional Barriers

The barriers in this category are divided into two classes: policy and regulatory barriers and administrative and bureaucratic barriers. Figure 5 illustrates that all of these barriers have been reported in academic literature with varying frequencies.

Figure 5 illustrates that the lack of policy stability and coherence is cited significantly more often than other barriers, with 76 papers referencing this barrier. This is followed by the lack of clear scope of the EC's activities, mentioned in 38 papers. Lastly, the absence or lack of a clear and uniform definition of ECs is noted in 26 studies.

The barriers related to the second category, specifically administrative and bureaucratic obstacles, are reported with varying frequencies. The lack of simple and clear administrative procedures is cited almost twice as often as the slow administrative procedures; the former is mentioned in 43 studies, while the latter appears in only 27 studies.

Overall, there is a notable variation in the appearance of barriers within this category, with the lack of policy stability and coherence being reported significantly more often than other barriers. The lack of simple and clear administrative procedures is the second most frequently mentioned barrier in this category; however, it is cited much less often. These issues may stem from the fact that EU countries have implemented the EU directives that define ECs, while only a few countries have yet to acknowledge ECs in their national legislation.

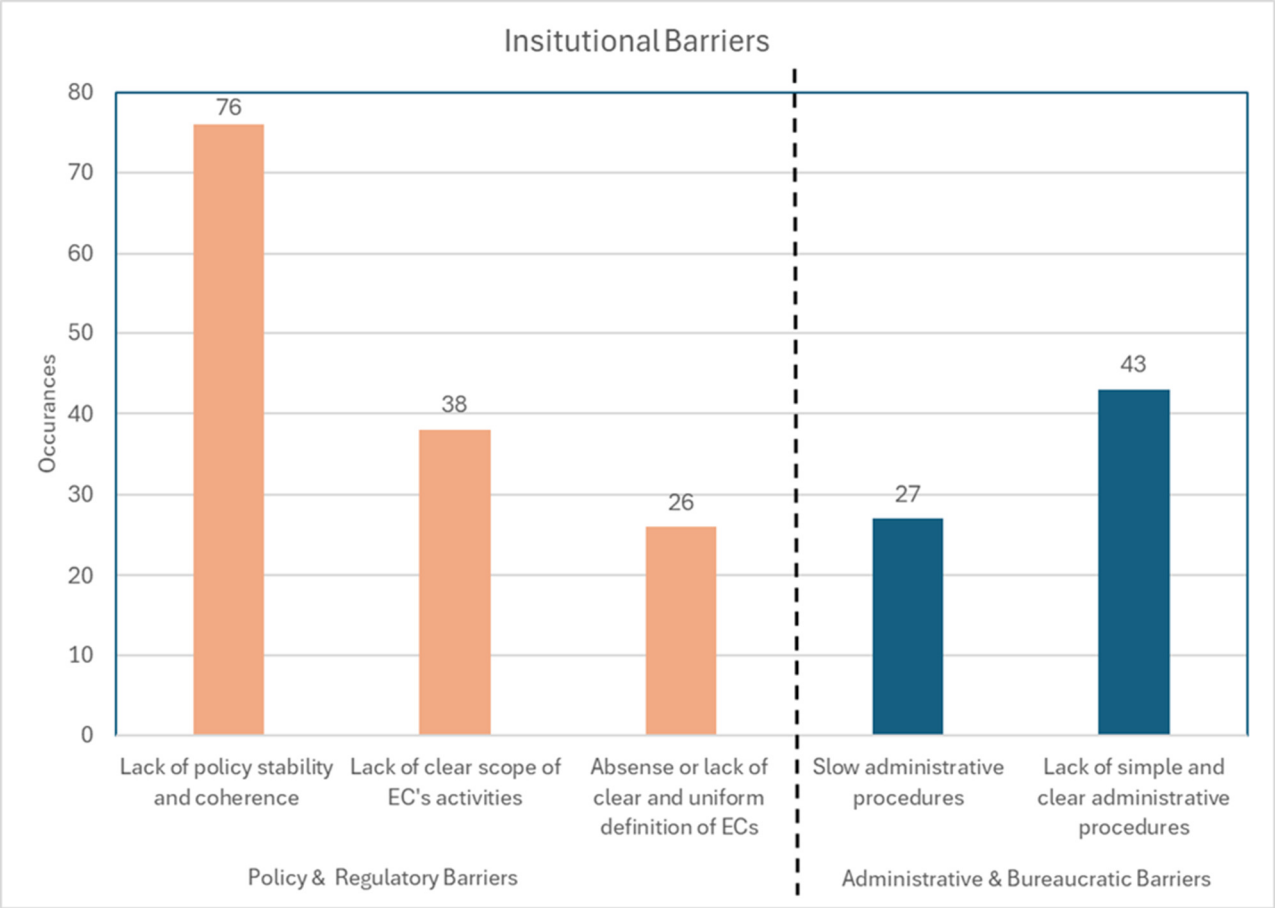

Figure 5: The frequency of occurrence of institutional barriers identified in the literature.

Technical/technological barriers

This category includes three distinct classes of barriers: technical barriers, the lack of enabling technologies, and the lack of efficient infrastructure. While all barriers within each class are present in the literature, there is a significant difference of occurrences noted (see Fig. 6).

The technical barriers class indicates that the lack of technical expertise is the most frequently cited barrier, appearing in 81 studies. Following this, the lack of technical skills is referenced in 66 papers. In contrast, the barrier related to the lack of space for building RES plants is mentioned much less frequently, with only 27 studies citing this issue.

The barriers related to the second class in this category, specifically the lack of enabling technologies, demonstrate some differences in their frequency of occurrence in literature, although not as pronounced as those in the previously mentioned class. The most significant barriers in this class include data management issues, which appear 32 times in the literature. This is followed by the low diffusion of smart technologies and issues related to cybersecurity and protection, which are reported with similar frequencies, 19 times and 18 times, respectively.

The final class of barriers in this category pertains to the lack of efficient infrastructure, and there is a significant discrepancy in the frequency of reported barriers within this class. Specifically, the lack of efficient and suitable energy infrastructure is mentioned three times more frequently than the lack of IT infrastructure, with the former appearing in 58 studies and the latter in only 16.

In conclusion, while all barriers related to technical and technological challenges have been documented in the literature, there is a significant disparity in the frequency with which these barriers are reported. Specifically, the lack of technical expertise, the lack of technical skills, and the lack of efficient and suitable infrastructure are mentioned much more frequently than other barriers.

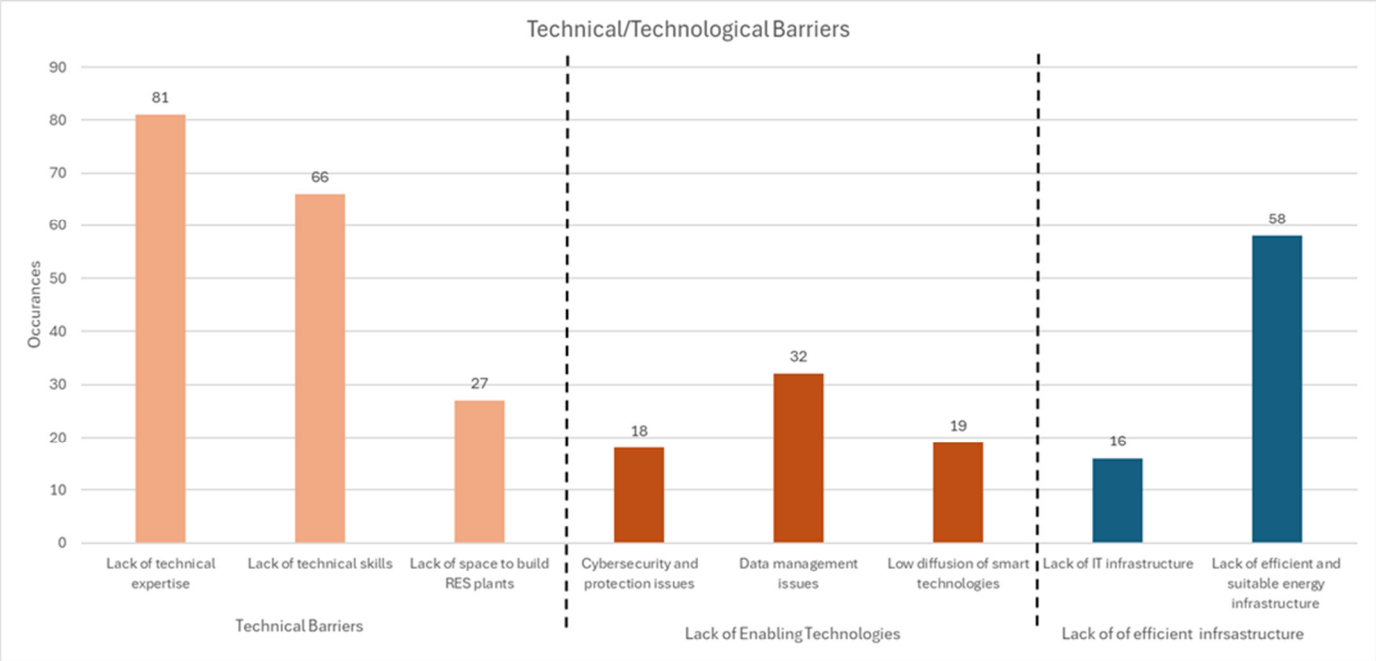

Figure 6: The frequency of occurrence of technical/technological barriers identified in the literature.

Socio-cultural/ behavioural barriers

In the final category of barriers, socio-cultural/behavioural barriers, there is a homogeneity regarding the frequency of barrier occurrences. Specifically, this category encompasses three classes: the lack of trust, the lack of socio-cultural conditions, and the lack of knowledge and awareness of ECs. Each barrier within these classes has been documented in the literature.

The first class, the lack of trust, encompasses both lack of trust towards peers within the EC and lack of trust in private or public entities. Notably, the former has a slightly higher number of citations, with 23 studies compared to the latter's 18 studies.

In the second class in this category, the lack of socio-cultural conditions, it is observed that the barrier of lack of cooperative tradition is cited more frequently than others, with 39 studies reported. Additionally, the NIMBY syndrome and local backlash against RES and ECs are noted, with 32 papers reporting these barriers. Furthermore, the barrier of lack of environmental awareness has been identified in 22 studies.

Finally, concerning the last class within this category, 31 papers have highlighted the barrier of insufficient knowledge regarding the EC concept. This is slightly more than the second barrier, which is the lack of knowledge and awareness about the benefits of EC, as reported in 24 studies.

In general, the differences in the frequency of barriers within this category are not as pronounced when compared to the other categories mentioned earlier. However, the lack of a cooperative tradition is noted more frequently than the others, followed by the NIMBY syndrome and local backlash against RES and ECs, as well as the insufficient knowledge regarding the EC concept.

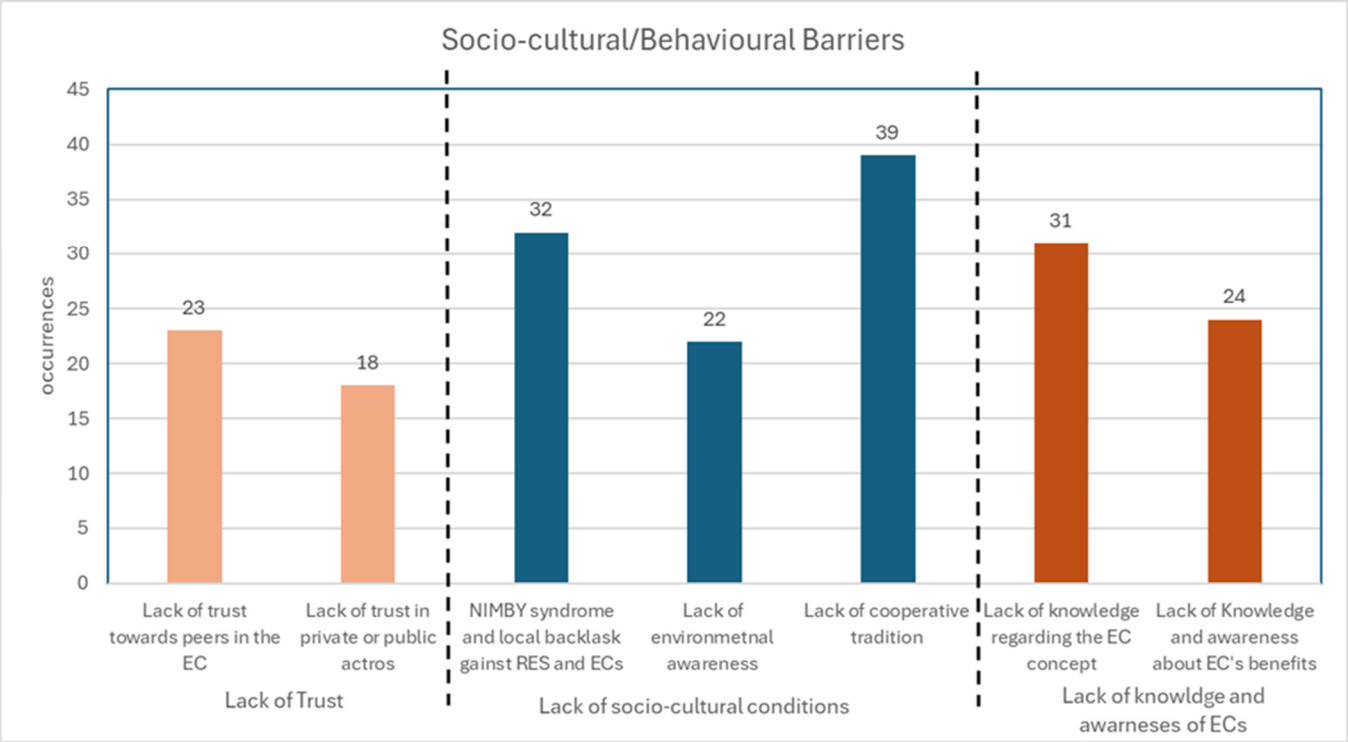

Figure 7: The frequency of occurrence of socio-cultural/behavioural barriers identified in the literature.

In summary, all the barriers are present in the literature, although they appear with varying frequencies. The barriers that appear more often in the literature are the lack of technical expertise, which appears in 81 documents, followed by the lack of policy stability and coherence, which has been cited in 76 documents. Three additional barriers are mentioned in the literature more than 60 times: the lack of technical skills, the absence of customized financial options, and the dominance of market incumbents. All these barriers fall within the first three categories: economic, institutional, and technical/technological. In contrast, barriers classified as socio-cultural and behavioural are less frequently mentioned in the literature. The most cited barrier in this latter category is the lack of a cooperative tradition in the country or region where EC operates, having been referenced in 39 documents (See Tab. 4).
Finally, some new barriers appear in the literature review that cannot be assigned to categories presented here. Specifically, five papers in the literature review state that the lack of support from local governments for EC projects is a substantial barrier to their success. Moreover, the literature presents certain barriers that correspond to specific types of EC activities. Specifically, scholars mentioned the environmental barriers, stating that climate change affects natural resources, which in turn can affect the implementation of EC activities that are sensitive to environmental changes, such as energy production by biomass. However, these barriers are related to specific types of activities or have been mentioned only a few times in the literature and are therefore not included in our analysis.

Table 7
Frequency of occurrence in the literature of barriers faced by ECs.

Barriers	Recurrence
Category: Economic Barriers	
Class: Financial Barriers	
Lack of access to traditional finance	45
Difficult to access finance from members	41
Lack of tailor-made finance options	65
Lack of public funds for ECs	54
Class: Market Barriers	
Lack of a level playing field	56
Presence of market incumbents	63
Category: Institutional barriers	
Class: Policy and regulatory barriers	

Absence or lack of a clear and uniform definition of ECs	26
Lack of a clear scope of EC's activities	38
Lack of policy stability and coherence	76
Class: Administrative and bureaucratic barriers	
Lack of simple and clear administrative procedures	43
Slow administrative procedures	27
Category: Technical/ Technological barriers	
Class: Technical barrier	
Lack of space to build RES plants	27
Lack of technical skills (skilled personnel)	66
Lack of technical expertise	81
Class: Lack of efficient infrastructures	
Lack of efficient and suitable energy infrastructure	58
Lack of IT infrastructure	16
Class: Lack of enabling technologies	
Low diffusion of smart technologies	19
Data management issues	32
Cybersecurity and protection issues	18
Category: Socio-cultural and behavioural barriers	
Class: Lack of knowledge and awareness of ECs	
Lack of knowledge regarding the EC concept	31
Lack of awareness about ECs benefits	24
Class: Lack of trust	
Lack of trust in private or public actors	18
Lack of trust towards peers in the EC	23
Class: Lack of socio-cultural conditions	
NIMBY syndrome and local backlash against RES and ECs	32
Lack of cooperative tradition in the country or the region your EC is operating	39
Lack of environmental awareness in the country or the region your EC is operating	22

3.3.3.EC barrier assessment

The last step entails the design and launches of a survey addressing EC initiatives located in the EU. The survey aims to gather novel quantitative and qualitative data; therefore, questionnaire consist of 2 thematic blocks: EC characteristics (including location, maturity, number and type of members, activities performed, etc.), and EC barriers: List of barriers, break down into 4 categories (Economic, Institutional, Technical/Technological, and Socio-cultural and Behavioural barriers).

The relevance of Economic, Institutional, Technical/Technological, and Socio-cultural and Behavioural barriers in setting up, developing and operating EC initiatives in the EU. For assessing the barriers, respondents have to rate the relevance of barriers by ranking them from "0" to "5". Responses marked as "0", indicating either the absence of a barrier or insufficient knowledge or no relevance by the respondent and "5" means very high relevance. Furthermore, to maintain transparency and analytical consistency, invalid responses have been excluded.

The survey is created using the Qualtrics software and will target "EC representatives", defined as individuals holding management and/or organizational roles within the EC initiative. In total, 1629 contacts of EC initiatives collected from 19 European countries, both in northern and southern Europe. The survey has been launched in the second half of September 2024. By June 30, 2025, we received more than 153 responses. However, only 122 of these were considered valid for the analysis. However, the survey will remain open to enable a more comprehensive investigation into the relevance of identified barriers. Also, this survey was conducted with five rounds, three rounds of surveys conducted in the "English" language, but to get more responses and assist the respondents to be comfortable with

their mother language, it was translated into Italian, French, and Spanish. The overall useful response rate is 122 among 1629, or 7.50%.

Regarding general Characteristics of ECs, the analysis revealed the following:

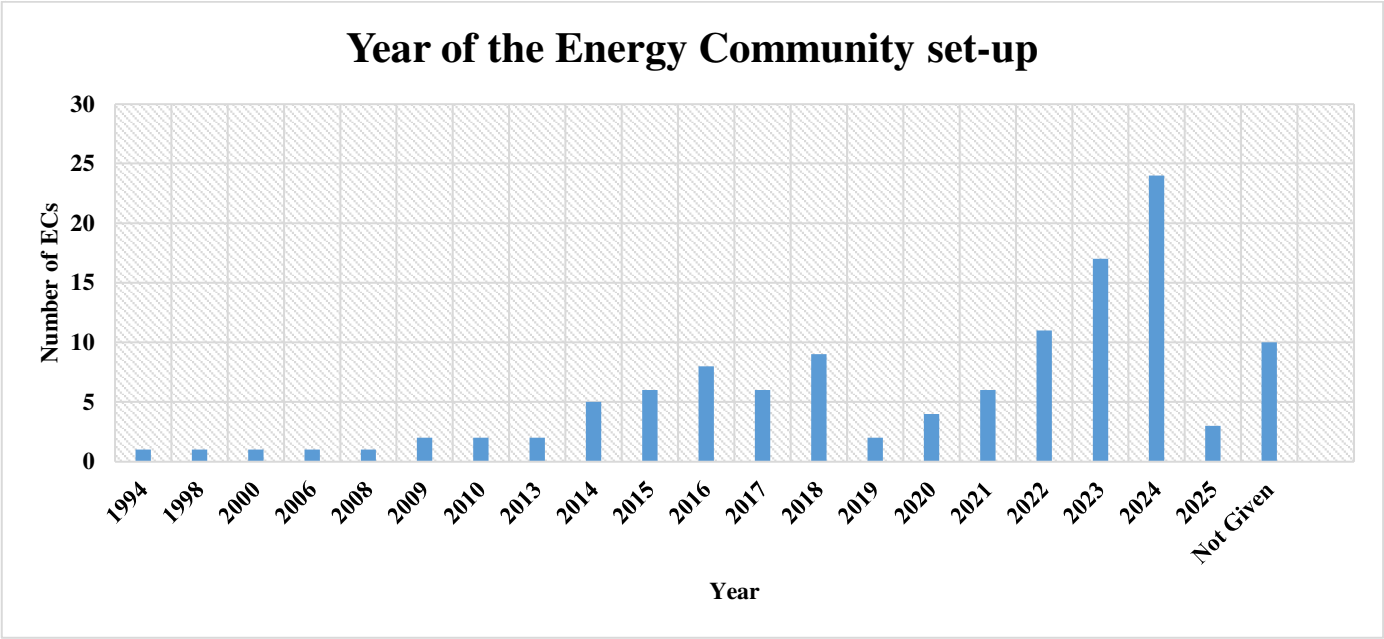

Figure 8: Year of ECs set-up.

Figure 8 shows the distribution of EC establishment years from our dataset. The highest proportion of responses is in the "2024" category (see figure 8). The third largest group indicates that many participants either chose not to disclose this information due to privacy concerns or that the ECs are still being established, so the year of setup cannot be specified yet. The year 2023 has significant activity with 17 ECs, while 2022 has 11 ECs and 2018 recorded 9 ECs. The years 2009, 2010, and 2013 each show two ECs in our survey sample. In contrast, earlier years like 2006, 2008, and before 2000 have minimal activity, with only one EC each.

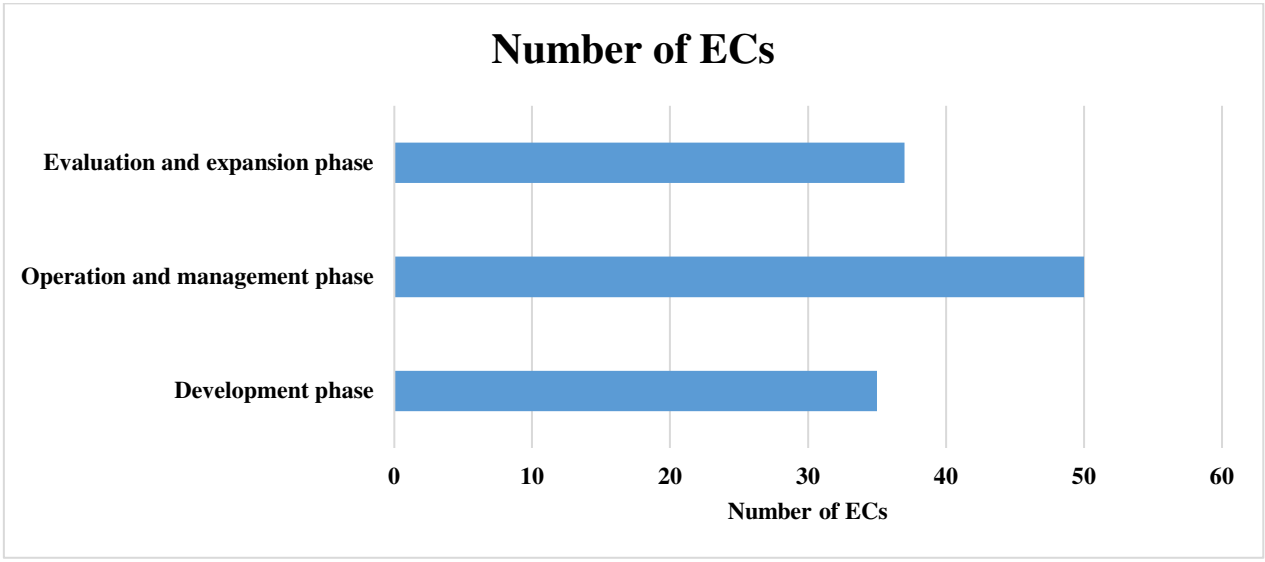

Figure 9: Maturity stages of ECs.

Figure 9 shows the maturity stages of ECs, emphasizing the recent growth of EC initiatives. This trend matches the timeline in Figure 8, which showed increased activity after the publication of EU directives. Specifically, 35 ECs in the dataset are currently in the development stage, indicating ongoing expansion of the EC concept. Additionally, 50 ECs have progressed to the operation and management phase, while 37 ECs are in the evaluation and expansion phase. These findings highlight the dynamic nature of EC establishment and the gradual progress of these initiatives through different stages.

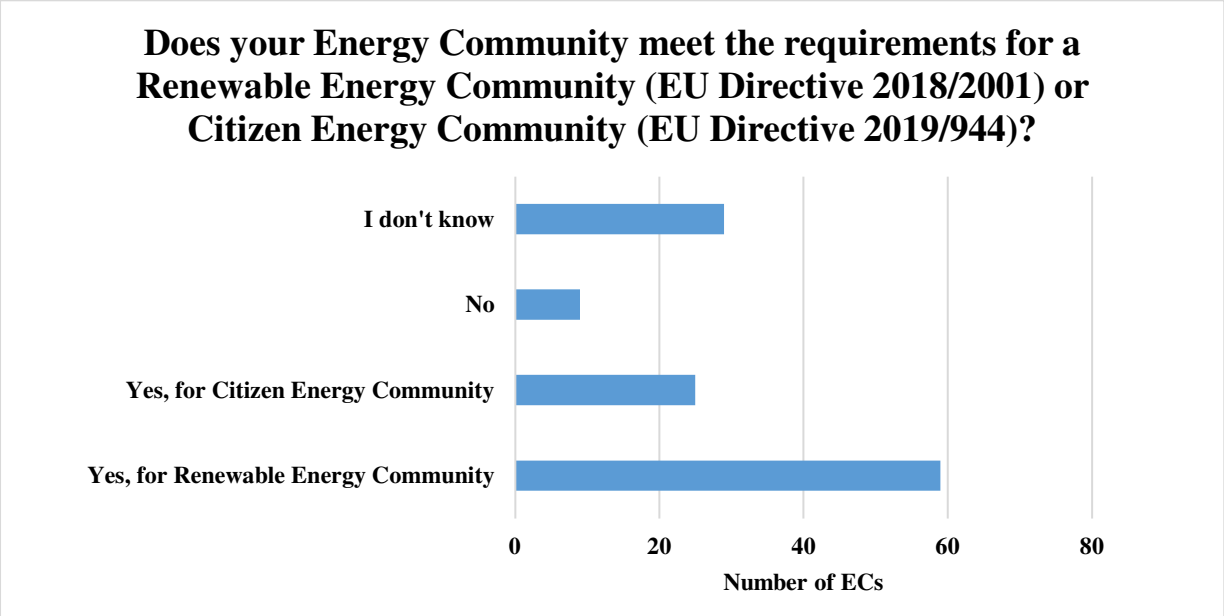

Figure 10: Compliance of ECs with EU REDII and IEMD

Figure 10 shows how ECs comply with EU REDII (Directive 2018/2001) - REC and EU IEMD (Directive 2019/944) - CEC requirements in our sample. Most ECs, specifically 59 out of 122, identify as Renewable Energy Communities (RECs), while 25 ECs see themselves as Citizen Energy Communities (CECs). Notably, 29 ECs chose the option "I don't know", likely reflecting their current development stage and the absence of a finalized strategic plan, which delays choosing a legal form. Additionally, 9 ECs responded "No", possibly because the two EU directives have not been fully integrated into national legislation in some countries. This distribution highlights the dominance of RECs in the dataset and the uncertainties or legislative barriers ECs face in adopting formal classifications.

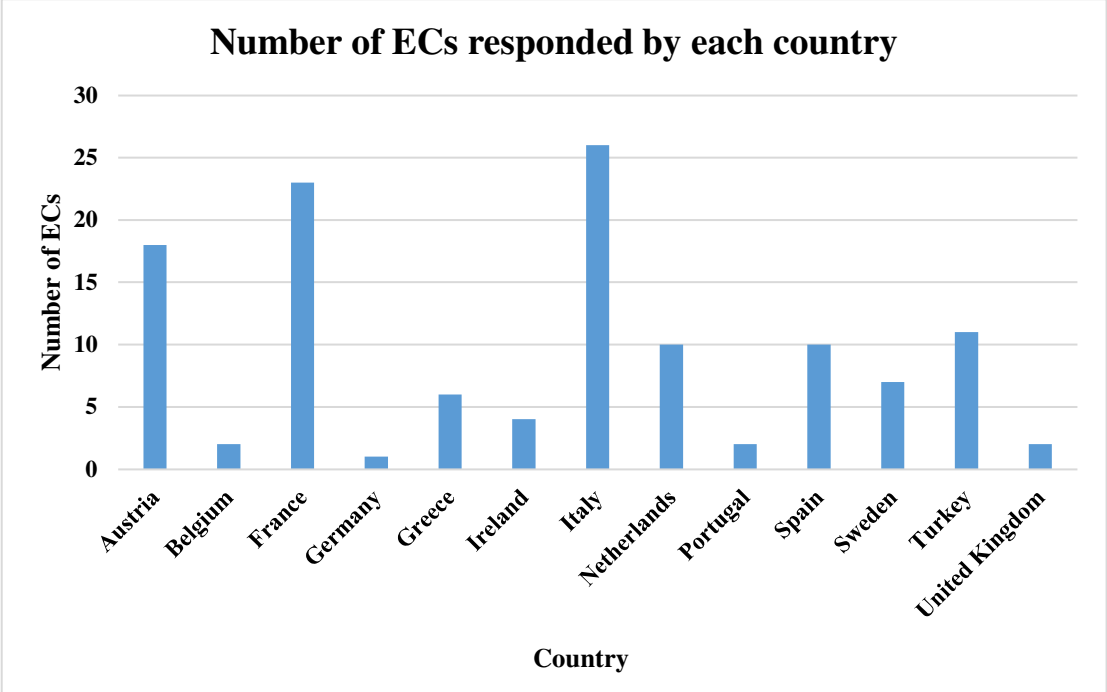

Figure 11: Geographical distribution of ECs.

The geographical distribution of ECs in our survey shows that Italy (26 ECs), France (23 ECs), and Austria (18 ECs) have the highest numbers of ECs. Turkey has 11 ECs, while Sweden accounts for 7 ECs in our analysis. The Netherlands and Spain each report 10 ECs. Additionally, Greece has 6 ECs, while Belgium, Portugal, and the United Kingdom each have 2 ECs, and Germany has 1 EC. The lack of data from other regions, such as Eastern Europe, may indicate either

a smaller presence of ECs in our current database or limited survey participation. To address this gap and better understand how barriers differ across countries, another round of survey distribution will be conducted, focusing specifically on countries that were underrepresented in this initial phase.

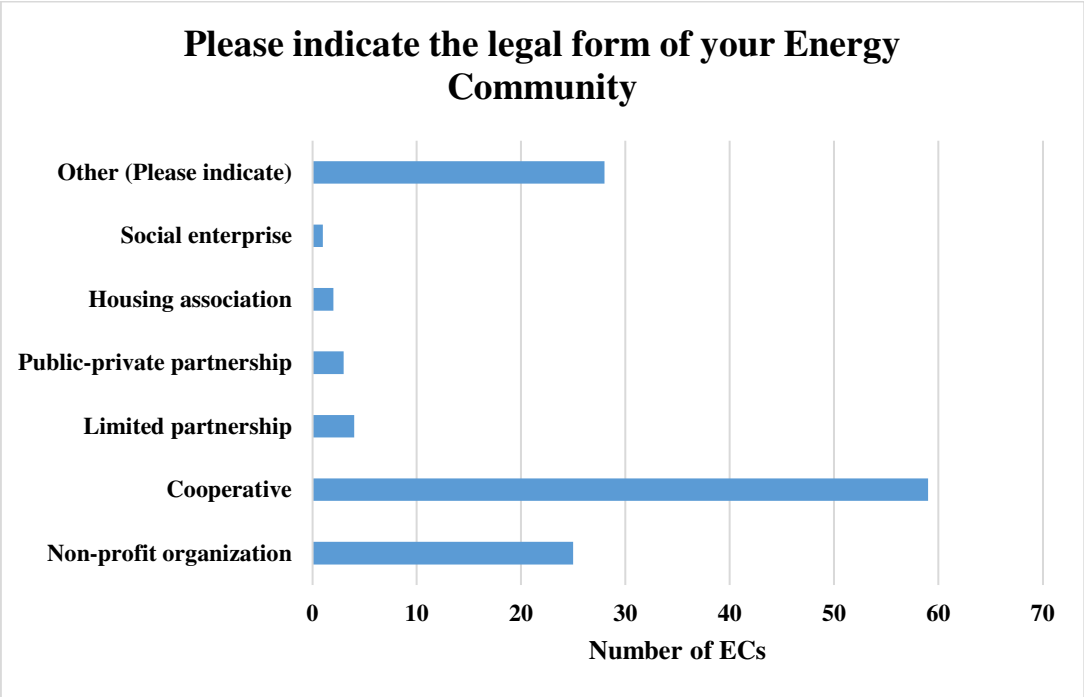

Figure 12: Legal forms of ECs.

Figure 12 shows the legal forms of the surveyed ECs. About 59 ECs follow the "Cooperative" legal form, which is the most common. The "Others" category, including various unspecified legal forms, comes next with around 28 ECs. The large number of unspecified legal forms is due to many ECs still being in the development phase and not yet having a set legal form. Non-profit organizations make up roughly 25 ECs. Other legal forms, such as limited partnerships (4 ECs), public-private partnerships (3 ECs), housing associations (2 ECs), and social enterprises (1 EC), are less common. These findings show a strong preference for cooperative models among ECs, emphasizing shared ownership and collaborative governance.

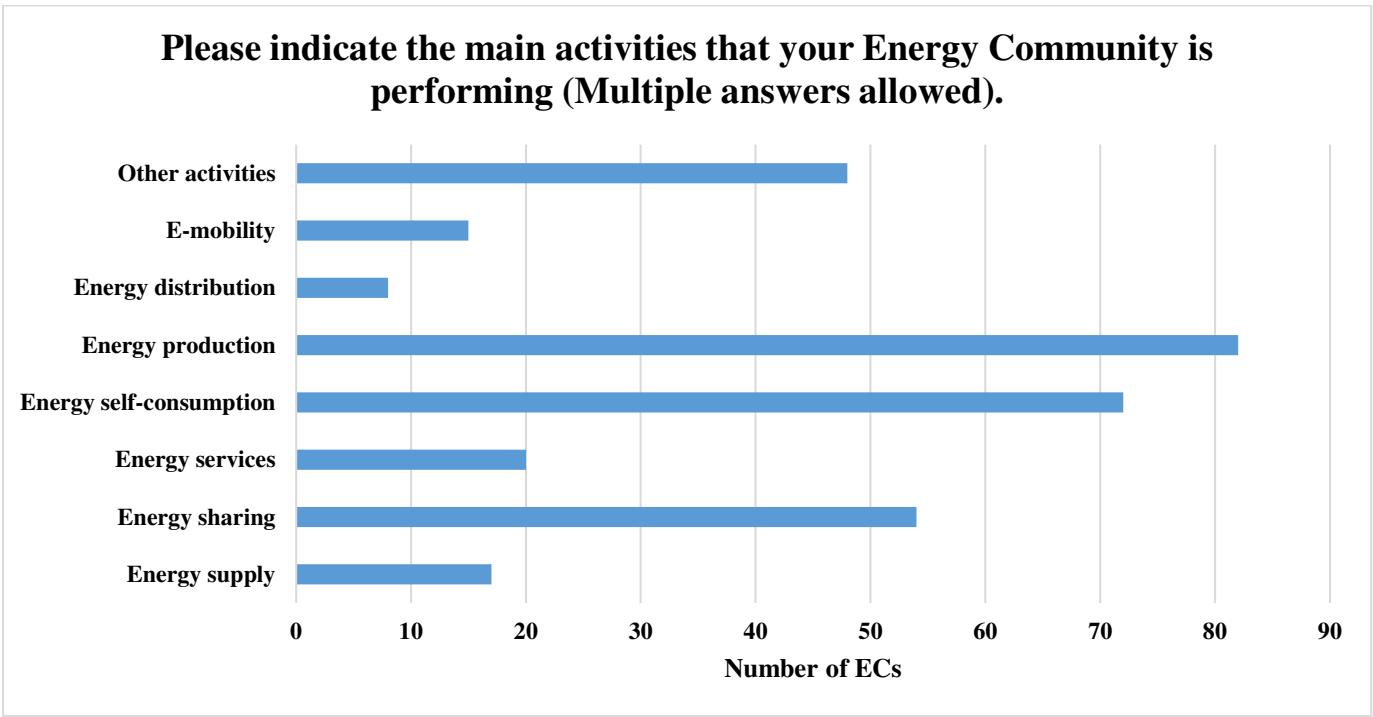

Figure 13: Main activities performed by ECs.

Figure 13 shows the main activities performed by ECs. The most common activity is energy production, with about 82 ECs involved in this area among the respondents. Energy self-consumption is next, with over 72 ECs participating. Energy sharing and energy services are also significant, with 54 and 20 ECs, respectively. Other activities like energy supply (17 ECs), e-mobility (15 ECs), and energy distribution (8 ECs) are less common, each involving fewer than 18 ECs. These results emphasize the key role of energy production and self-consumption in the operations of ECs.

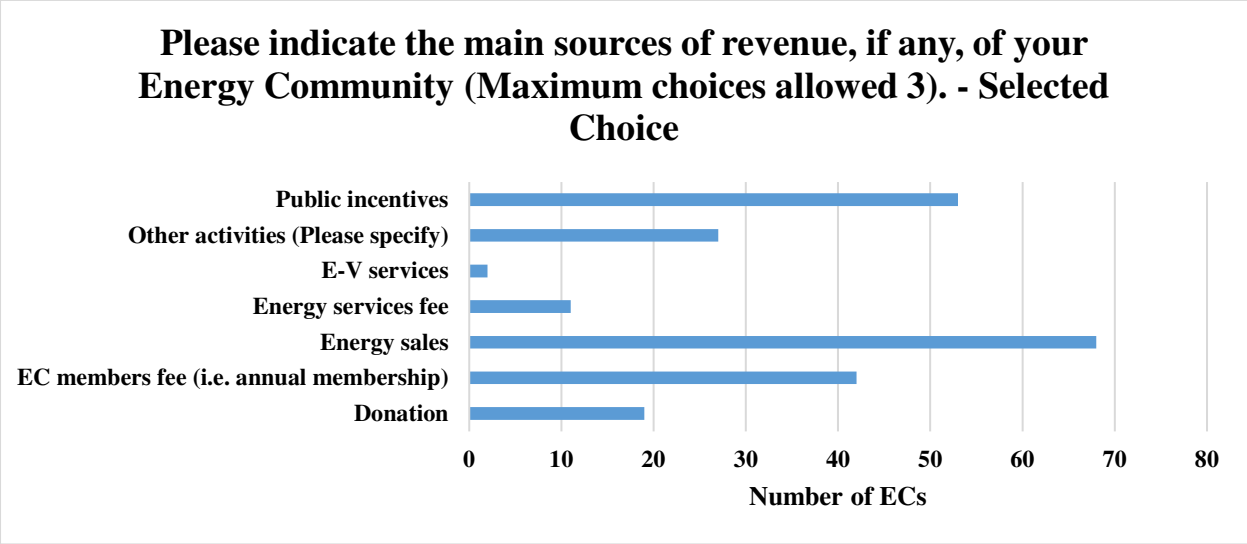

Figure 14: Main source of revenue of ECs.

Figure 14 highlights the main revenue sources for ECs in our sample. The leading source is "energy sales", chosen by 68 respondents, followed by "public incentives", selected in 53 cases. "Membership fees" contribute to the revenue of about 42 ECs, while "other activities" and "Donations" account for significant but smaller sources, involving roughly 27 and 19 ECs, respectively. "Energy services fees" (11 ECs) and "E-V services" (2 ECs) are minor income sources. These findings suggest that ECs mainly depend on market-based income (through energy sales) and government support (via public incentives) to operate.

After reviewing the data, it is clear that the barriers identified in this survey were considered relevant by respondent EC. Survey participants evaluated the barriers differently, with some finding them very important and others considering them less significant. In the following sections, we present and analyse them.

Economic barriers

The first Economic barriers considered refer to Financial barriers. Over 122 answers received, and 121 responses were considered for this barrier class. Four distinct barriers are analysed: "Lack of public funds for ECs", "Lack of tailor-made finance options", "Difficult to access finance from members", and "Lack of access to traditional finance".

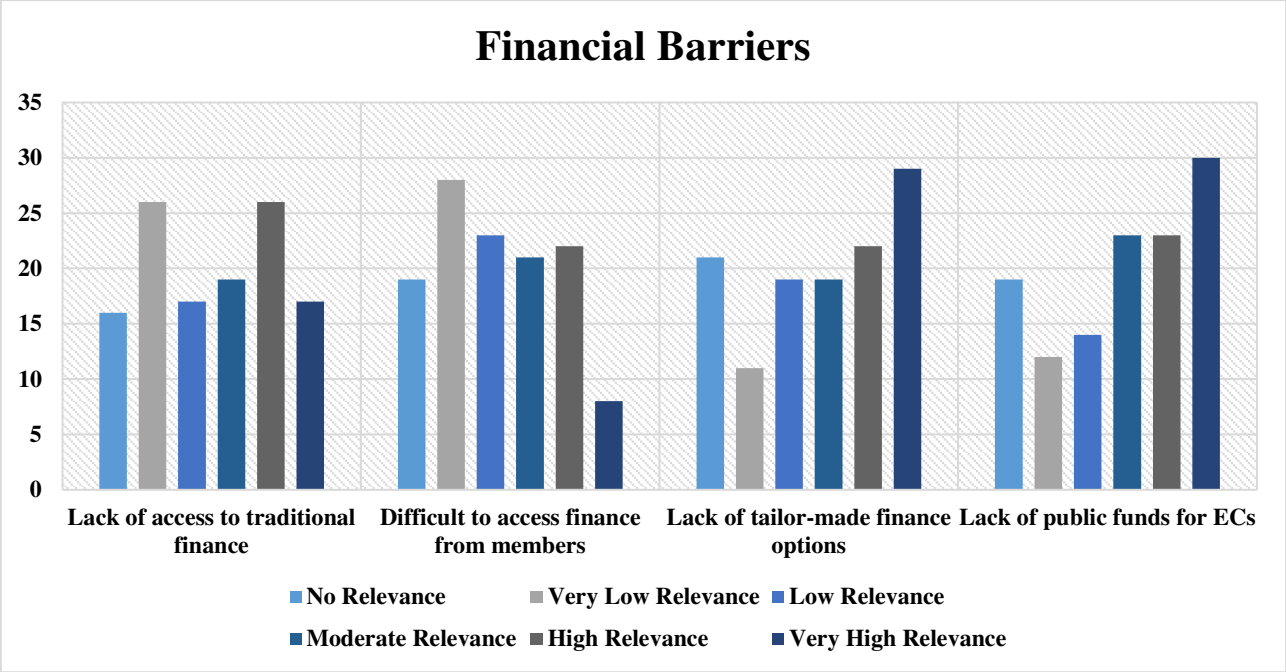

Figure 15: Financial barriers.

The findings show that the "Lack of public funds for ECs" is the most commonly identified barrier with very high relevance. Public funds are often essential for covering initial capital costs, especially in community-driven renewable energy projects that usually need significant upfront investment. The absence of adequate public financial support, ECs are forced to depend on private investments or member contributions, which can be insufficient or unsustainable. The high relevance of this barrier is also linked to the results reported in figure 15 on primary revenue sources, which indicates that most ECs in our sample depend on public incentives.

This barrier is closely followed by the "Lack of tailor-made finance options", highlighting how important funding availability and customized financial mechanisms are for the development of ECs. 29 EC respondents also rated these barriers as very highly relevant, reinforcing their role as major challenges to the growth of ECs. This barrier is especially critical for small projects, where it's even more difficult to secure enough funding from members because there are not financial options specifically designed to meet the unique needs of small ECs, which often find it less attractive to pursue traditional funding.

In contrast, "Difficult to access finance from members" and "Lack of access to traditional finance" are more often linked to very low relevance rankings. The former is especially common in low-income or economically disadvantaged areas, where community-driven projects can provide the most benefits but are less likely to receive sufficient financial support from members. This situation is also connected to the niche nature of ECs, which mainly remain accessible to high-income citizens with strong environmental commitments. This contrasts with the goals of ECs as outlined by the EU in its descriptions of RECs and CECs, which highlight the aim to fight energy poverty and promote open participation for all citizens in energy democratization. The last barrier is strongly related to the perceived high risk by financial institutions when investing in ECs, due to their smaller scale, limited credit history, and dependence on community involvement. These factors can lead to unfavourable loan terms or even outright rejection of loan applications. Furthermore, the complexity of energy market regulations and the need for specialized knowledge in evaluating renewable energy projects can further discourage traditional financial institutions from working with ECs. This analysis highlights the vital need to address financial barriers, especially through public funding and customized financial solutions, to support ECs. Overcoming these barriers requires a multi-layered approach that includes policy changes, innovative financing methods, and greater awareness among financial institutions. Public funding programs, such as grants or subsidies, can help reduce the initial cost burden, while developing tailored financial products like green loans or community bonds can improve access to capital.

The second Economic barriers considered refer to Market barriers. Over 122 answers were received, 121 responses were considered for this barrier class.

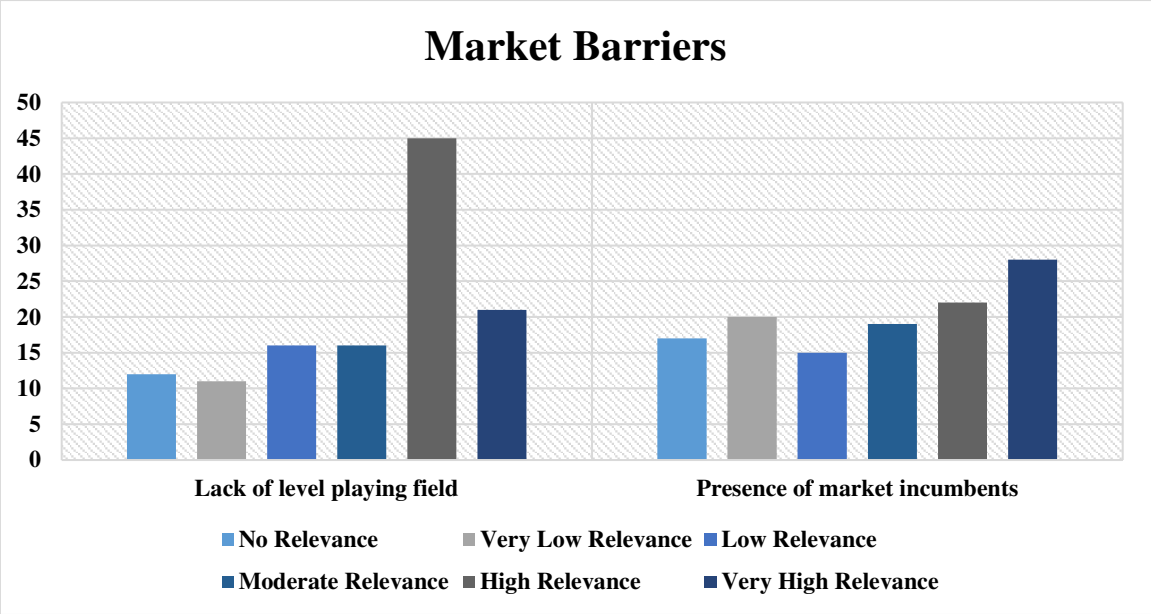

Figure 16: Market barriers.

The graph 16 illustrates the perceived relevance of market barriers focusing on two specific obstacles: the "Presence of market incumbents" and the "Lack of a level playing field".
The "Lack of a level playing field" is widely seen as a major obstacle, with most respondents rating it as having "High Relevance". This shows that many believe the current market setup is unfairly tilted, favouring energy providers over community-based projects. For instance, large energy companies often have better access to resources like financing, infrastructure, or regulatory support, which ECs usually lack. Additionally, administrative processes such as permitting, grid access, and regulatory compliance tend to be more complicated and expensive for ECs, putting them at a disadvantage. These structural inequalities restrict ECs ability to grow and compete effectively, especially in markets dominated by traditional energy providers.
On the other hand, the "Presence of market incumbents" shows a more diverse distribution across relevance categories, with responses ranging from "Very Low Relevance" to "Very High Relevance". While some respondents view incumbent actors as a major challenge due to their dominance, others view their impact as less critical, indicating that the barrier depends on the context and varies by region or project. In competitive markets with policies that support renewable energy, market incumbents may be less problematic, as ECs are allowed space to innovate and grow. Conversely, in markets where a few companies control energy production and distribution, market incumbents are more likely to pose significant challenges for ECs.
To overcome these obstacles, policymakers could implement measures to promote fairer competition and lower market entry barriers for ECs. Additionally, encouraging collaboration between ECs and larger energy providers could help foster competition and create opportunities for knowledge-sharing and innovation.

Institutional barriers

The first Institutional barrier considered refers to Policy and regulatory barriers. Over 122 answers were received, 121 responses were considered for this barrier class.

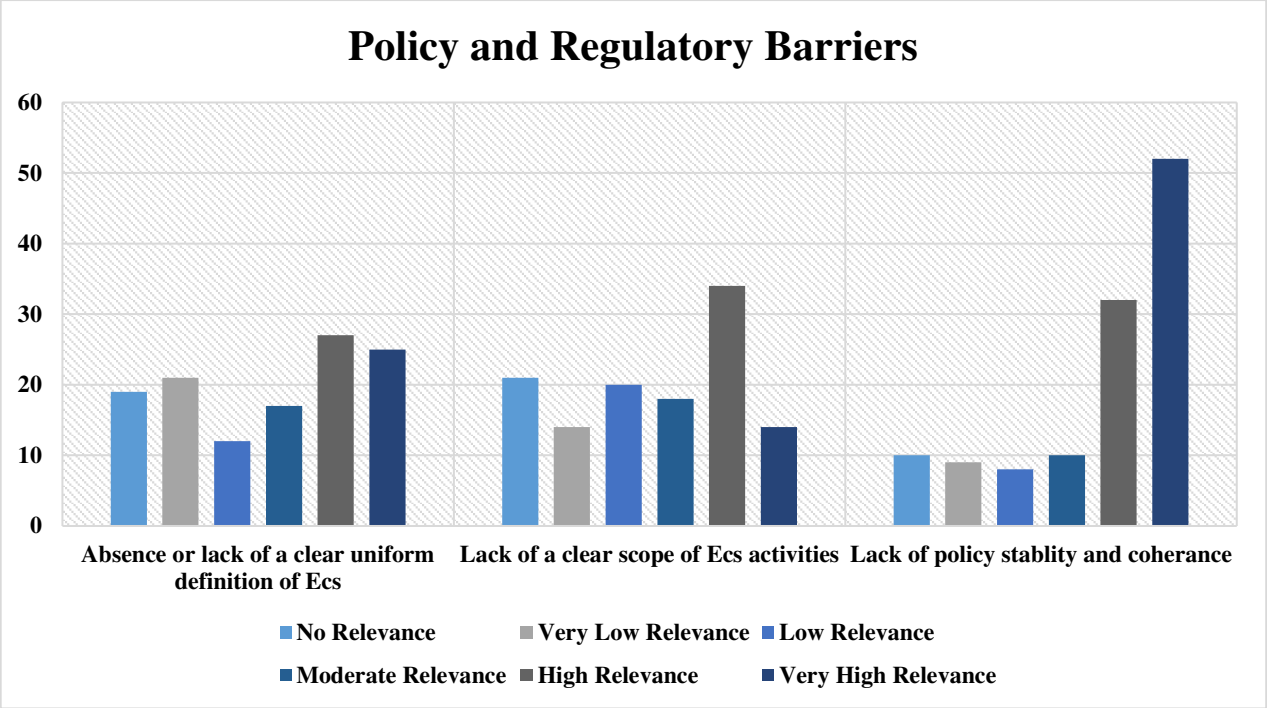

Figure 17: Policy and regulatory barriers.

The graph presents the perceived relevance of policy and regulatory barriers affecting the development and functioning of ECs. Three specific barriers are evaluated: "Lack of policy stability and coherence", "Lack of a clear scope of ECs' activities", and "Absence or lack of a clear and uniform definition of ECs".

The "Lack of policy stability and coherence" emerges as the most significant barrier, with the highest number of respondents (from 52 ECs) identifying it as "Very High Relevance". This reflects widespread concerns about the unpredictability or inconsistency of regulatory frameworks that govern ECs. Unstable or incoherent policies may discourage investments, delay project implementation, and create uncertainty about long-term viability (also in terms of incentives, see the Italian Premium tariff assured till 2027). For instance, frequent changes to energy policies can undermine trust and confidence in the system, making it challenging for ECs to plan and execute their projects effectively.

The "Lack of a clear scope of ECs activities" is also a highly ranked barrier, with many respondents perceiving it as "High Relevance" (from 34 ECs). This indicates that there is confusion or ambiguity about what activities ECs are allowed to undertake under current regulations. For example, some ECs may wish to expand their roles beyond renewable energy production to include energy efficiency services or sharing services (i.e., EV-charges or EVs sharing), but unclear rules can restrict such initiatives.

The "Absence or lack of a clear and uniform definition of ECs" is another key issue, although it is slightly less often rated as "Very High Relevance" compared to other barriers. It is important to point out that this barrier has been addressed in many countries, such as Italy and France, where clear laws defining ECs have been established in line with EU directives. However, in many other countries, full transposition of these directives is still in progress, leading to a blurred understanding of the EC concept. This lack of consistency can also make it harder for ECs to collaborate across regions or expand.

The distribution of responses emphasizes the importance of respondents' locations. For example, ECs operating in countries with advanced energy policies may face fewer issues related to policy stability or definitions (such as the Netherlands, Belgium, and the UK in our sample), while those in emerging markets might face significant obstacles. Additional analysis is necessary to better understand how the maturity of policy frameworks influences this barrier, as our sample size is too small to establish clear correlations.

The second Institutional barriers considered refer to Administrative and bureaucratic barriers. Over 122 answers were received, 121 responses were considered for this barrier class.

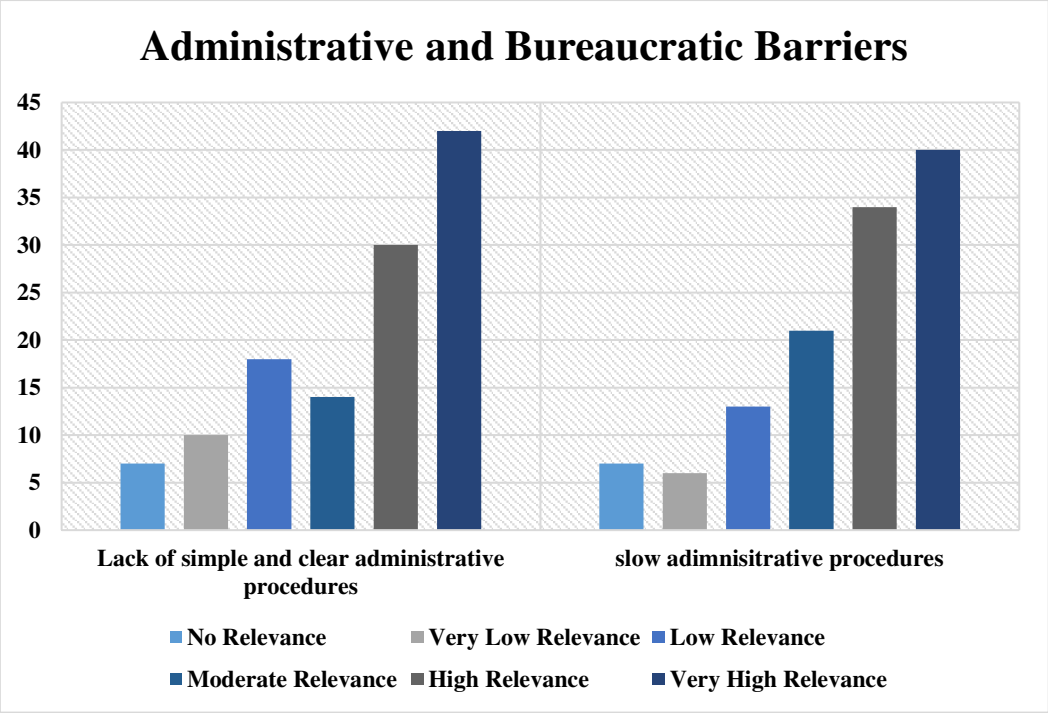

Figure 18: Administrative and bureaucratic barriers.

The graph presents the perceived relevance of administrative and bureaucratic barriers affecting ECs, specifically focusing on "Slow administrative procedures" and the "Lack of simple and clear administrative procedures".
The "Slow administrative procedures" barrier is the most critical issue, with the most respondents rating it as "Very High Relevance". This shows that delays in processing permits, licenses, and other administrative requirements are a major obstacle for ECs. Such delays can significantly delay project timelines, raise costs, and discourage stakeholders from participating in or starting EC projects. For instance, long approval processes for renewable energy installations or grid connection agreements can cause missed opportunities to implement energy projects on time. When the timeframe for obtaining public finance is also tight (see the Italian time limits for accessing PNRR funds for ECs), a slow administrative system can completely prevent starting an EC, impacting its ability to access public funds. This barrier is also linked to the "Lack of policy stability and coherence" mentioned above.
The "Lack of simple and clear administrative procedures" also received significant recognition as a major barrier, with many respondents rating it as "Very High Relevance". This issue points to the complexity and opacity of the regulatory environment, which often demands specialized knowledge. For ECs, especially smaller initiatives, unclear administrative requirements can add extra burdens, raising the risk of errors or compliance issues. For example, vague project approval guidelines or differences between local and national regulations can make administrative processes more complicated, discouraging potential EC participants. This barrier is particularly important in the context of home energy renovations. A solution proposed by the European Commission, as outlined in Directive 2018/844/EU on the Energy Performance of Buildings (EPBD), Directive 2018/2002/EU on Energy Efficiency (EED), and the strategy "Renovation Wave for Europe" (COM (2020)662), is the One-Stop-Shop (OSS). This model offers a centralized physical or virtual location, or both, where customers can access multiple products and services in one place [17]. A similar approach is now being used to promote, support, and guide ECs by pooling expertise and knowledge to reduce the time and effort required by non-experts. In fact, through the recast of EPBD (Directive (EU) 2024/1275), Member states are required to provide information, technical assistance, and training to all relevant actors, including ECs, following an integrated and multi-service OSS concept. Other solutions to overcome this barrier include introducing standardized guidelines, reducing paperwork, and using digital platforms to speed up processes.
It is important to highlight that at the EU level, many initiatives and support services for ECs have been implemented in recent years to overcome barriers. These services aim to inform, support, and empower citizens, local authorities, and businesses to establish EC initiatives. The most notable initiative was the Energy Communities Repository (which ended in 2024), which collected EC experiences across the EU and provided comprehensive analysis of policy, governance systems, investments, and impacts. Another key service is the Rural Energy Community Advisory Hub, designed to accelerate the development of sustainable EC projects in rural areas of the EU. The hub identifies best practices and offers technical assistance and networking opportunities to support local authorities, businesses, farmers, and citizens in setting up their own rural ECs. The Support Service for Citizen-led Renovation is an EU

Commission initiative aimed at empowering ECs to lead energy-saving renovation projects. By assisting selected pilot projects to overcome financial, legal, technical, and informational barriers, this service promotes the delivery of future-proof residential buildings and encourages citizen participation in the energy transition. Additionally, the European Energy Communities Facility in 2024, with a budget of €7 million, aims to support the development of at least 140 local projects focused on business plans. The first call for grant support is expected in 2025, providing financial resources to strengthen citizen-driven energy initiatives.

Technical/Technological barriers

The first class of barriers considered under this category refer to technical barriers. Over 122 answers were received, 121 responses were considered for this barrier class. The graph illustrates the perceived relevance of technical barriers impacting ECs, focusing on three specific challenges: "Lack of technical expertise", "Lack of technical skills (skilled personnel)", and "Lack of space to build RES plants".

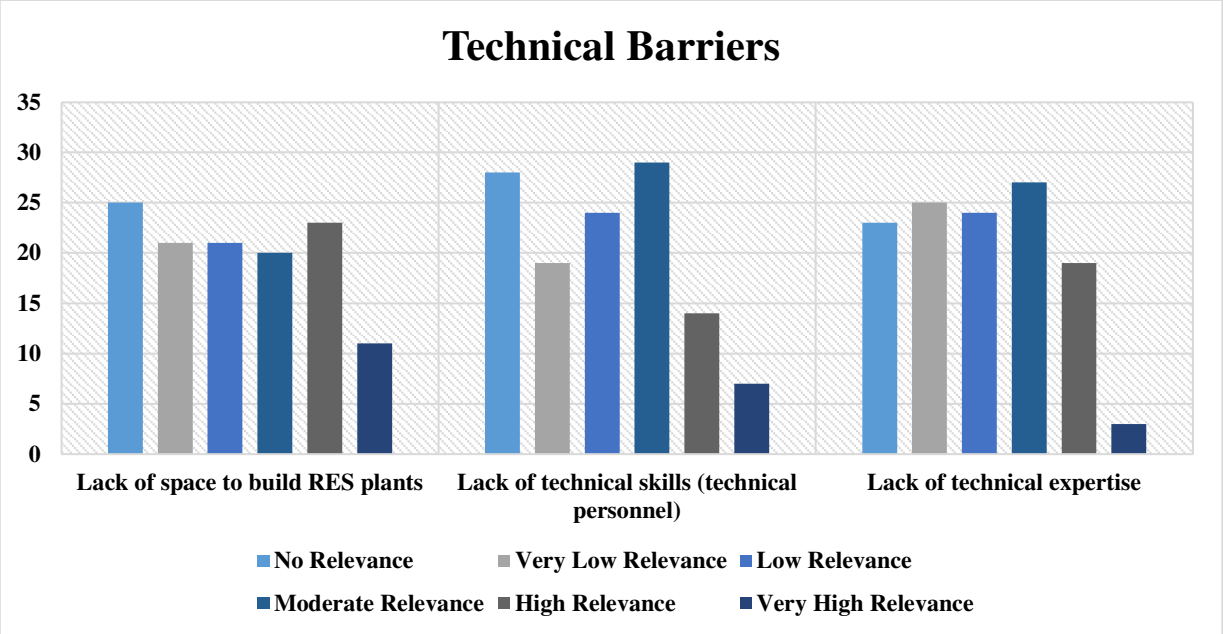

Figure 19: Technical barriers.

The "Lack of technical expertise" is rated as having "Moderate Relevance" by 27 respondents, while the majority of the 72 participants in the survey considered it to be of even lower importance. This suggests that, in many cases, ECs have access to sufficient general knowledge or external technical guidance to support their activities. However, for a smaller number of respondents, this barrier is of high to very high relevance, possibly reflecting differences in local contexts or the complexity of administrative procedures required to access funds or licenses. In fact, this barrier is closely related to the institutional one called "Lack of simple and clear administrative procedures", since when administrative procedures are unclear and complicated, the importance of technical skills to navigate this complexity increases.

The "Lack of technical skills (skilled personnel)" is more evenly spread across the relevance categories, with many respondents rating it as "Moderate Relevance". This highlights the difficulty of finding adequately trained personnel to manage EC operations, including maintenance or energy management. For ECs in less developed areas or those operating on a small scale, the availability of skilled workers might be limited, affecting their ability to implement and maintain EC initiatives. To deal with this barrier, it is crucial to rely on external experts and managers (maybe by setting up a collaboration with third parties) who can provide technologies, maintenance services, or advanced energy management platforms to improve energy production and use. These types of services offered by utilities and energy providers are increasing in the EU.

The "Lack of space to build RES plants" appears as a minor barrier, indicating that space constraints are generally not a significant issue for most ECs. However, for some respondents, this barrier is highly or very highly relevant, likely due to specific geographic or regulatory factors. For example, densely populated urban areas or regions with strict land-use policies may struggle to allocate space for renewable energy projects like solar panels or wind turbines. This challenge can limit the growth of ECs, especially in areas with high energy demand but limited physical space.

The second Technical/Technological barrier considered relates to the Lack of efficient infrastructures. Over 122 responses were received, and 121 responses were included in this barrier category. The graph illustrates the perceived

relevance of infrastructure-related barriers to ECs, specifically focusing on the "Lack of IT infrastructure" and the "Lack of efficient and suitable energy infrastructure".

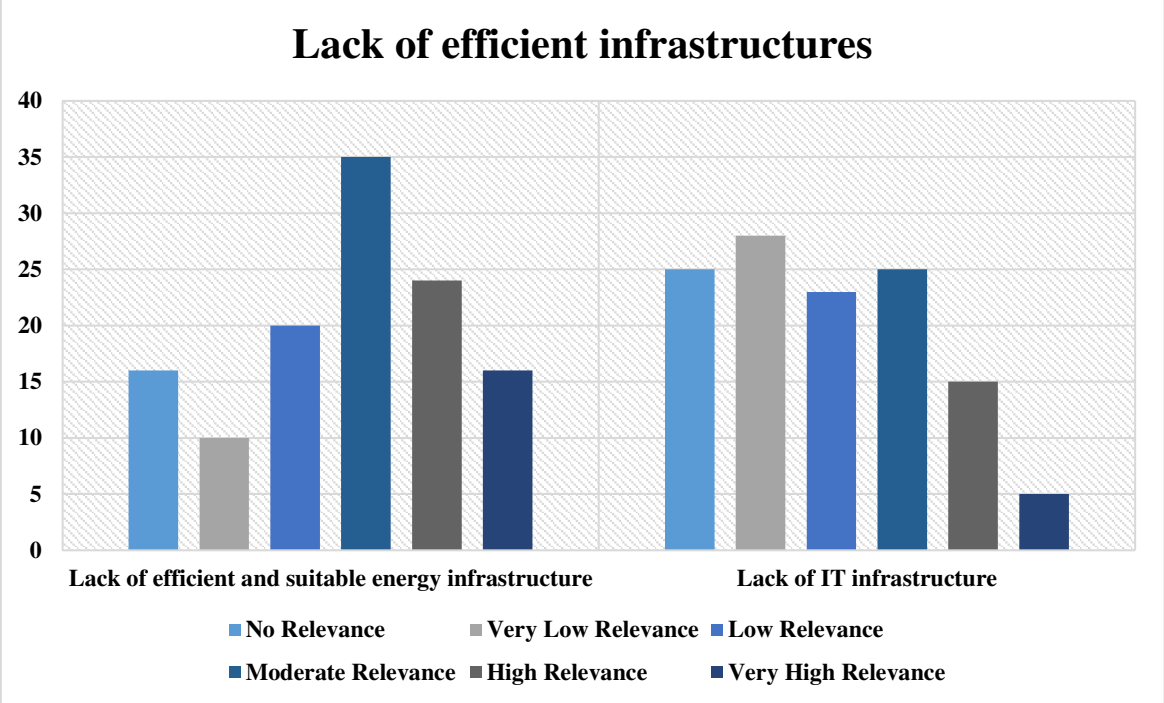

Figure 20: Lack of efficient infrastructures.

The lack of efficient and suitable energy infrastructure emerges as a critical challenge. This obstacle is especially significant for ECs, where grid access may be limited due to management issues or grid saturation. A large percentage of respondents rated this barrier as "Moderate Relevance" (35 respondents) or higher, highlighting its impact on ECs ability to implement renewable energy projects. For instance, overloaded grids or outdated infrastructure can delay the integration of decentralized energy systems, restricting both scalability and operational efficiency. Addressing this issue requires investments in modernizing the grid, expanding capacity to support RES, and implementing advanced grid management systems to reduce bottlenecks and inefficiencies.

The "Lack of IT infrastructure" is rated predominantly as "Very Low Relevance". However, advanced energy management systems, such as digital monitoring platforms, depend on strong IT infrastructure to ensure accurate data flow and optimal decision-making. In areas with limited digital connectivity or outdated IT systems, ECs may encounter operational difficulties, such as delays in responding to system issues. The last Technical/Technological barrier considered refers to Lack of enabling technologies. Over 122 responses were received, with 121 considered for this barrier class.

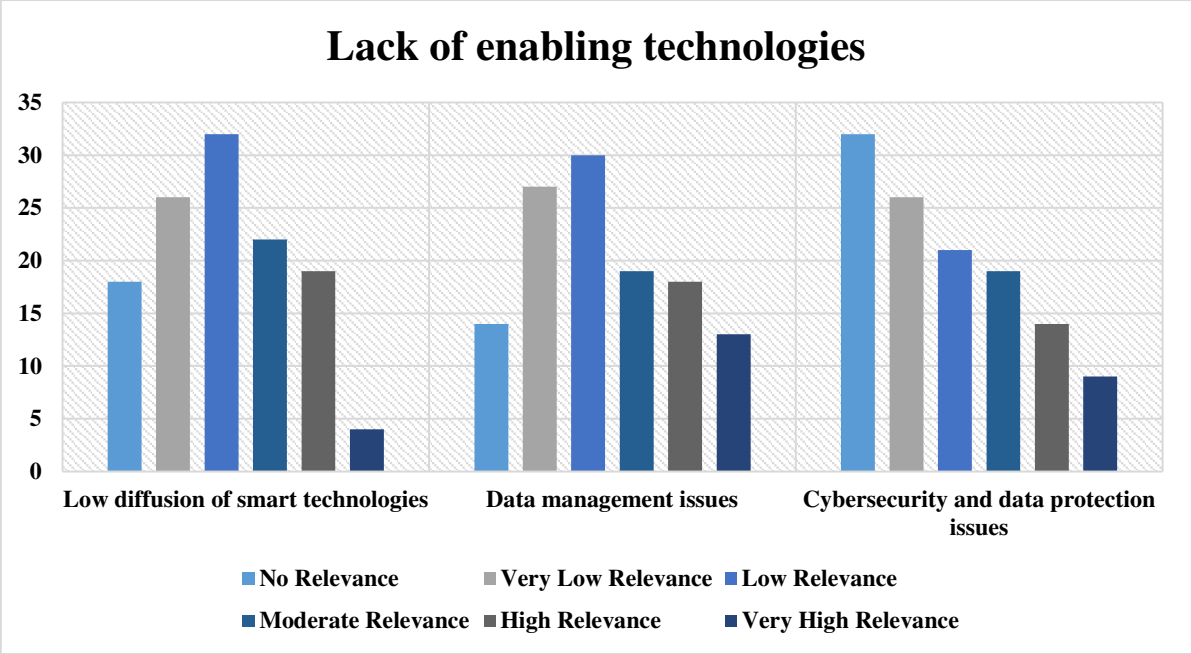

Figure 21: Lack of enabling technologies.

The graph emphasizes the importance of technological barriers faced by ECs, especially the "Low diffusion of smart technologies", "Cybersecurity and data protection issues", and "Data management issues". Among these, the "Low diffusion of smart technologies" is seen as the most significant barrier. This highlights the slow adoption of key technologies, such as smart meters and automated control systems, which are vital for optimizing energy management. Smart meters can deliver near real-time feedback on energy use, helping consumers better manage their consumption, save energy, and reduce their bill, for example, by adjusting their energy usage based on different energy prices throughout the day. According to the EU Agency for the Cooperation of Energy Regulators (ACER, 2023), only 54% of European households had an electricity smart meter by the end of 2022, with over 80% penetration in 13 EU countries at that time.

In contrast, "Cybersecurity and data protection issues" are rated as less critical overall but remain a major concern for some ECs, especially those relying on advanced digital platforms for energy management. These systems are vulnerable to data breaches or system attacks, which could disrupt operations and increase members' fears.

"Data management issues", related to the challenges of data collection, processing, and use, vary in importance. They are particularly relevant for ECs aiming to implement advanced data-driven solutions, such as demand-response systems or predictive analytics. Poor data quality, fragmented datasets, and the lack of proper digital tools impede ECs' ability to make informed decisions and optimize energy use.

Socio-cultural and behavioural barriers

The first Socio-cultural and behavioural barrier considered refer to Lack of knowledge and awareness of EC. Over 122 answers received, 120 responses were considered for this barrier class. The graph highlights the relevance of barriers related to knowledge and awareness about ECs. It examines two specific challenges: the "Lack of awareness about EC's benefits" and the "Lack of knowledge regarding the EC concept".

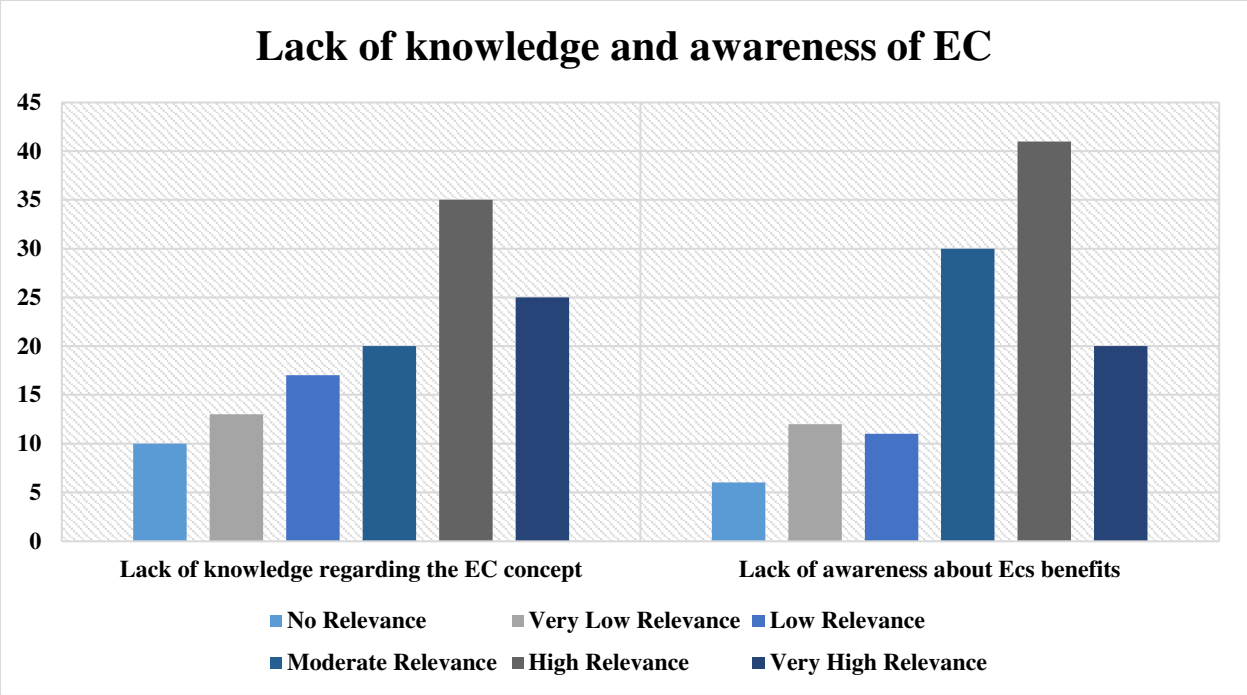

Figure 22: Lack of knowledge and awareness of EC.

The graph highlights the relevance of barriers related to knowledge and awareness about ECs. It examines two specific challenges: the "Lack of awareness about EC's benefits" and the "Lack of knowledge regarding the EC concept".

The "Lack of awareness about EC's benefits" is identified as a significant barrier, with many respondents assigning it "High Relevance" (35 respondents) or "Very High Relevance" (25 respondents). This finding underscores the challenge of communicating the advantages of ECs, such as economic savings, environmental benefits, and community empowerment. Many potential participants and stakeholders may be unaware of how ECs operate or the direct and indirect benefits they offer. The lack of understanding can limit people's engagement, reduce support for ECs, and diminish participation in renewable energy initiatives. As seen before, an EC requires effort (economic resources, time, and commitments) from its members. Thus, well understanding the benefits generated by being part of one of those initiatives can make a difference in scaling up and rolling out EC initiatives around Europe. In countries where there is a strong and maybe historical background on environmental matters, this barrier appears less prominent than in other countries where economic disadvantages and crises limit the commitments of citizens toward environmental issues. However, EC can contribute to fighting energy poverty and become a driver for low-income people who face economic limitations. This opportunity, for reasons that intercept financial and market barriers, along with institutional ones, might be lost.

Similarly, the "Lack of knowledge regarding the EC concept" is also perceived as highly relevant by respondents. This indicates that beyond the benefits, a fundamental understanding of what ECs are and how they function is often missing among potential members and stakeholders. Misunderstandings about what an EC is, requires, and provides can create resistance, particularly in regions where ECs are a relatively new concept.

Addressing these barriers requires a concerted effort to improve information, education, and awareness about ECs. Public awareness campaigns can play a key role in highlighting the benefits of ECs, particularly their potential to reduce energy costs, enhance sustainability, and foster public-private partnerships and collaboration among local stakeholders and community engagement in energy transition. It is crucial to increase awareness also in terms of EC operational structures, legal aspects, and technical and administrative requirements towards citizens, local stakeholders, and even public authorities at the local level that might lack knowledge about this topic. This is particularly crucial to avoid rebound effects within institutional and technical barriers as seen before.

The second Socio-cultural and behavioral barrier considered refer to Lack of trust. Over 122 answers were received, and 120 responses were considered for this barrier class. The graph examines trust-related barriers to ECs, focusing on "Lack of trust towards peers in the EC" and "Lack of trust in private or public actors".

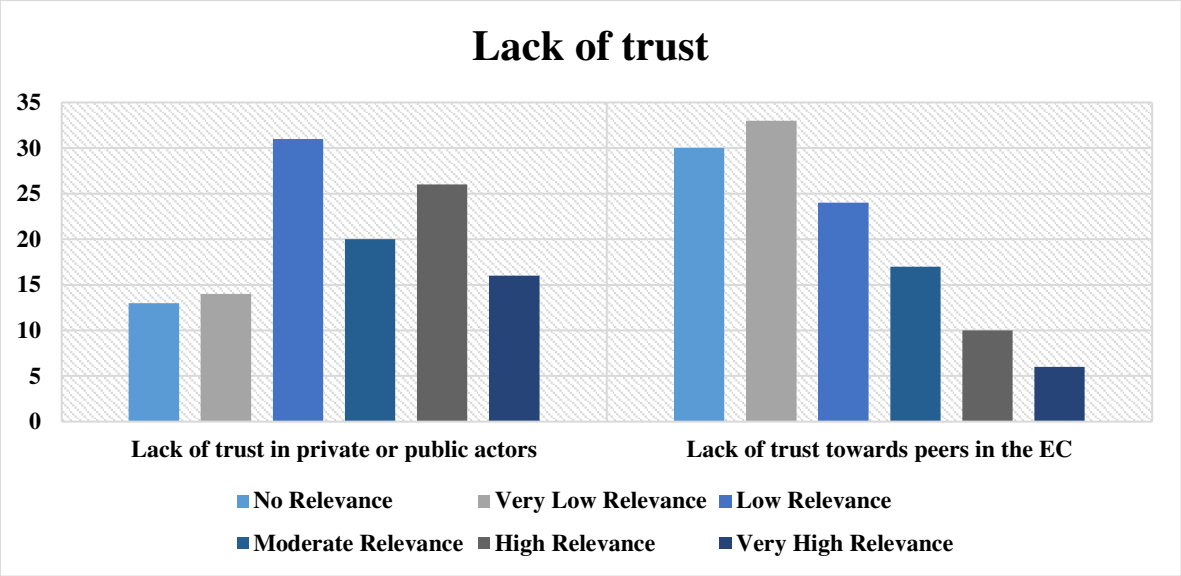

Figure 23: Lack of trust.

The "Lack of trust in private or public actors" emerges as a major barrier. This reflects a perception that external stakeholders, such as private companies, local authorities, or national governments, may not act in the best interests of ECs or their members. Concerns about profit motives, mismanagement, or lack of transparency in regulatory and operational processes contribute to this distrust. For example, ECs may hesitate to collaborate with energy utilities or public authorities if they believe their interests will be overlooked or dismissed. Trust in public actors is essential for ECs to access regulatory support and funding. However, as previously noted, public authorities at the local level are often unaware of ECs and unable to offer proper support or enhance these initiatives, leading to feelings of exclusion and isolation among EC members. Conversely, trust in private actors is vital for partnerships involving technology providers or investors, which can significantly reduce technical and technological barriers.

In contrast, the "Lack of trust towards peers in the EC" is generally rated as "No Relevance" or "Very Low Relevance" by most respondents. This suggests that EC members largely trust each other, likely due to shared goals and a collective interest in the community's success. However, internal conflicts, unequal contributions of resources and revenues, and differing priorities can weaken trust and disrupt collaboration within ECs. Mechanisms such as transparent governance structures and regular communication can strengthen cohesion. Building trust also involves demonstrating competence. Members need confidence that the EC has technical, administrative, and financial expertise to meet its goals. Training programs, external advisory support, and partnerships with experienced organizations can enhance the EC's capabilities and reassure members of its potential for success. This is especially important to lower financial barriers like "Difficult to access finance from members", as many ECs, particularly small-scale initiatives, rely heavily on member funding to operate. Lack of trust could hinder their willingness to invest capital, worsening access to credit issues.

The final socio-cultural and behavioural barrier concerns the "Lack of socio-cultural conditions". Over 122 responses were received, with 120 responses considered relevant to this barrier. The graph explores socio-cultural challenges, focusing on three main issues: "Lack of environmental awareness in the country or region where the EC operates", "Lack of cooperative tradition in the country or region", and "NIMBY syndrome and local backlash against RES and ECs".

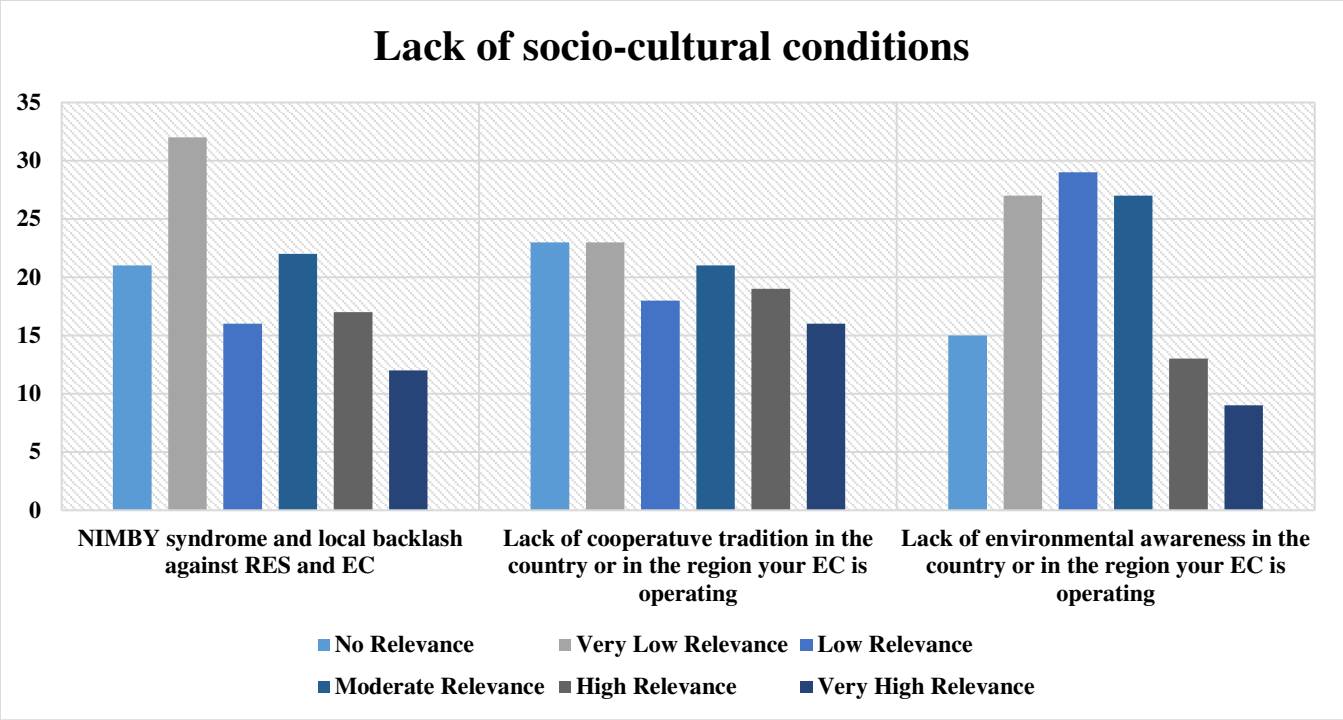

Figure 24: Lack of socio-cultural conditions.

The graph examines socio-cultural barriers by focusing on three main challenges: "Lack of environmental awareness in the country or region where the EC is operating", "Lack of cooperative tradition in the country or region", and "NIMBY syndrome and local backlash against RES and ECs".

The "Lack of environmental awareness" emerges as a significant obstacle, with many respondents rating it as "Very Low Relevance", "Low Relevance", and "Moderate Relevance". This emphasizes how important environmental awareness is in gaining support for ECs. In areas where awareness of environmental issues like climate change and renewable energy is low, people may lack motivation to engage with or support EC initiatives. Without understanding the long-term benefits, ECs may find it hard to involve stakeholders and citizens. This lack of awareness not only reduces participation but may also fuel scepticism or opposition to change.

The "Lack of cooperative tradition" is another key barrier. While not seen as critical everywhere, it can have a major impact in certain contexts. Cooperative traditions, which involve collaborative decision-making, resource-sharing, and mutual support, are essential for the success of ECs. In countries or regions with weak or no such traditions, communities might struggle to build the social bonds and organizational structures needed to sustain ECs. Conversely, countries with a history of collective practices, like cooperatives and associations, like Scandinavian countries, tend to accept and understand the benefits of community-driven initiatives like ECs more easily.

The "NIMBY syndrome" and local resistance against RES and ECs is mostly rated as "Very Low Relevance". This phenomenon reflects opposition to renewable energy infrastructure, like wind turbines or solar farms, due to perceived local inconveniences or aesthetic concerns. Overcoming this barrier requires careful planning and active community engagement. Involving residents early in the planning process and listening to their feedback can help reduce opposition. Transparent communication about the benefits of ECs, along with efforts to address specific local concerns, can foster trust and lessen resistance. Offering incentives, such as discounted energy rates or direct financial benefits to affected communities, can also help garner support.

Summary of the most encountered barriers by ECs from our survey

Looking at all barriers, we can make a list of the most relevant barriers across technical, regulatory, financial, and socio-cultural categories of barriers according to our sample of respondents. Based on this analysis, the ten most relevant barriers are:

1. Lack of policy stability and coherence
2. Lack of simple and clear administrative procedures
3. Slow administrative procedures
4. Lack of public funds for ECs
5. Lack of tailor-made finance options
6. Lack of a clear scope of ECs activities
7. Lack of awareness about EC's benefits

8. Lack of knowledge regarding the EC concept
9. Presence of market incumbents
10. Lack of level playing field

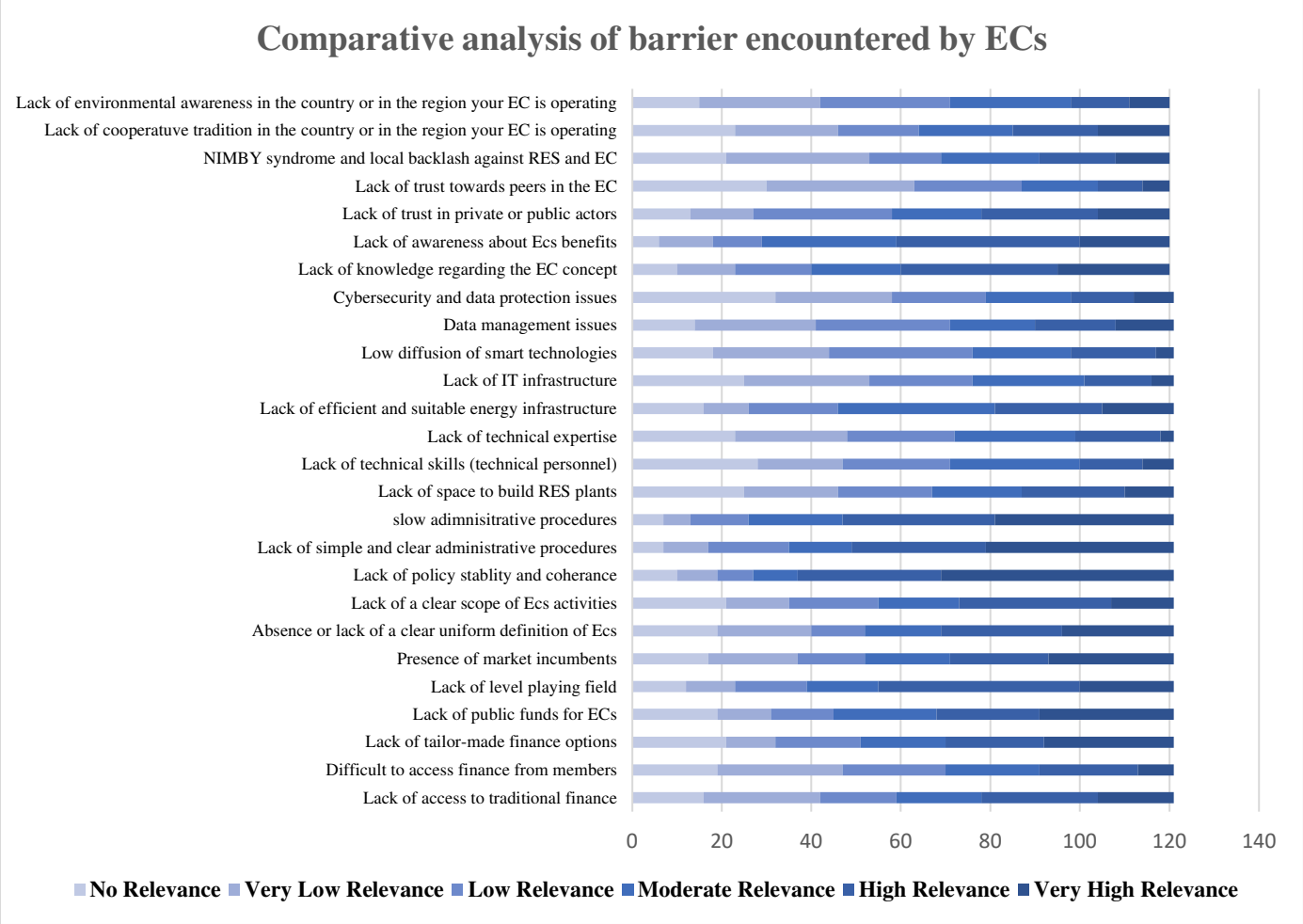

Figure 25: Comparative analysis of barriers.

3.4. Energy Communities enablers

There are several types of enablers of ECs, including technical, institutional, social, and economic. A technical enabler is a technological solution, including both hardware (equipment) and software, that enhances operations and management while reducing project costs, including EC projects. A social enabler is a combination of personal behaviours (traits of EC members), policies, and awareness that promotes participation (interaction among EC members) to achieve social goals. Economic enablers are mechanisms, policies, and support systems that promote the economic growth of projects. Institutional enablers can positively influence an organization, institution, or community, helping end users (EC members) access services.

3.4.1. Key EC enablers assessment by Literature

To identify the key enablers of ECs in the literature, a traditional literature review process is conducted by searching Google Scholar with two keywords, namely "energy communities" and "enabler". After analysing current literature found that Economic enablers are (a) access to financial support including subsidies or grants, (b) a cooperation bank that facilitates low-interest loans, (c) crowdfunding which helps ECs by allowing members to choose and support projects that need funding from a social or local standpoint), and (d) self-ownership for locally produced energy [18]. Moreover, institutional enablers are (a) a liberalized market enables direct energy trading, encourages the involvement of prosumers, promotes the integration of RES, and developing economies of ECs with competitive markets, (b) a stable regulatory framework for ECs, (c) CO_2 taxation assist emerging economies by increasing fossil fuel prices, making RES more competitive, and enhancing the self-consumption of ECs, (d) reduced installation cost of RES than traditional energy, and (e) state financial support or debt securities. Social enablers are (a) trust, and community-based networks, (b) values including self-ownership of RES and RES-based energy production locally either onsite or through VPP, [22], and (c) Social learning [19]. Technical enablers are (a) DES which can work as an enabler to promote a sustainable and resilient

energy future by generating energy at its point of use, reducing reliance on centralized grids, and improving grid flexibility and local energy security [20], (b) RES technology options available, (c) Smart meters which are essential tools for a modern energy system, changing utilities and consumers by increasing grid efficiency and providing innovative services such as real-time consumption data, dynamic pricing, and more accurate billing, (d) net metering, and virtual net-metering, (e) blockchain which is a popular option as a security enabler [21] that can be integrated with ECs [22], (f) Virtual Power Plants have developed into advanced facilitators of various energy assets which can be considered as enabler [23]), (g) microgrid facilitating peer-to-peer [18], and (h) EVCSs where EV can play as energy storage and EVCS can sellback energy during RES generation [24]. Figure 2 illustrates the enablers of ECs.

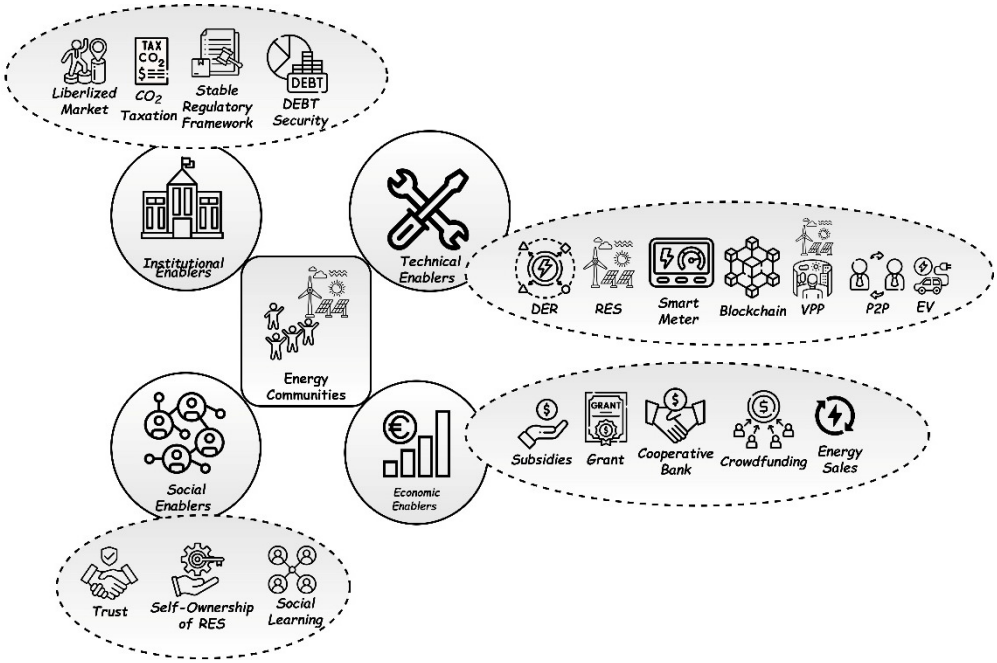

Figure 26: Comparative analysis of enablers.

3.5. Contribution to the WP objectives

The research conducted by ESR15 and ESR14 contributes directly to the overarching objectives of WP5, which focuses on developing green economy models and management systems to support the transformation of the energy system. This deliverable corresponds to Task 5.4 under WP5, which aims to identify the enablers and barriers that influence the replicability and transferability of BMs for green energy systems. The research focuses specifically on ECs, which represent a citizen-led, decentralized approach to energy production and management. ECs are instrumental in advancing WP5's objectives by enabling distributed renewable energy generation, fostering prosumer engagement, and supporting flexible demand-side energy strategies. The studies presented here offer valuable empirical and analytical insights into the challenges and opportunities facing ECs across Europe. ESR15's initial work investigated how different EC ownership models affect funding mechanisms and access to capital. The results showed that ownership structure plays a significant role in determining financial barriers and opportunities. ECs initiated and managed solely by citizens often struggle to raise internal funds, while those involving a broader coalition of actors face fewer financial constraints. This analysis supports WP5's first and third objectives by offering a categorization of EC types and suggesting policy pathways to facilitate capital access for underfunded ownership models. Furthermore, the SLRs and survey research conducted by ESR14 and ESR15 contribute to the WP's goals. The development of a validated typology of barriers-categorized into regulatory, technical, financial, and social domains-offers a comprehensive understanding of the constraints ECs face. ESR15's use of the PRISMA methodology to identify the most frequently cited barriers in the literature, coupled with ESR14's survey collecting primary data from 122 ECs, provides robust evidence to inform targeted policy actions. In addition to identifying barriers, the research also addresses enabling conditions. A literature-based mapping exercise identified four main categories of enablers-technical, institutional, economic, and social. These enablers were linked to the practical implementation of ECs and aligned with WP5's aim of promoting sustainable, inclusive, and replicable energy solutions. These insights are valuable for future BM development under WP5.

4. Conclusions

The current report provides information regarding the research outcomes of IRP14 and IRP15 in relation to D5.4, focusing on enablers and barriers to foster the replicability and transfer of BMs for green energy systems. In this context, ESR14 and ESR15 concentrate ECs, which are legal entities established to empower local stakeholders, including citizens, SMEs, and local authorities, to produce, consume, and manage their energy. The aim of the research presented here was to examine the various barriers that ECs encounter, as well as to explore the enablers that can help overcome these barriers, thus contributing to the objective of WP5 and the current deliverable.

ESR14 and ESR15 collaborate to achieve the above-mentioned objective but also develop research strategies independently. Specifically, ESR15 conducted a survey to analyse how the ownership model of ECs impacts the funding mechanisms they employ, as well as to identify the financial barriers faced by these ECs. In this work, ESR15 developed a questionnaire and gathered primary data related to the general characteristics of ECs, as well as data regarding the ownership model, funding mechanisms, and main financial barriers they face.

Nevertheless, ESR14 and ESR15 aim to extend the analysis of barriers. They are trying to identify, analyse, validate, and assess all possible types of barriers that ECs face. Hence, a semi-structured literature review was conducted to identify and categorize all different types of barriers faced by ECs. These barriers were later validated through a SLR carried out by ESR15 with the support of ESR14. Finally, a questionnaire was developed by ESR14 with the support of ESR15 to collect primary data from ECs in Europe and assess the relevance of the barriers.

Finally, in the current report, the results of studies conducted by ESR14 and ESR15 regarding the enablers of ECs were presented. ESR14 specifically performs a literature review and compiles all of the research on the enablers that can facilitate the establishment, growth, and expansion of ECs. ESR15, which focuses on Greece, aims to provide tailored policy recommendations that address the reported policy barriers hindering the development of ECs in the country.

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