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Original research article



REScoops acting as intermediaries, influencing the scaling of energy communities; a multi-case analysis of five pilots in Europe

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ABSTRACT

There is increasing scholarly attention to the scaling of energy communities (EC). Intermediaries have an important role here. Energy communities themselves, especially in the form of renewable energy cooperatives (REScoops), can take on this role very well. This paper addresses the question how REScoops, acting as intermediaries, influence the scaling of ECs. A longitudinal multi-case research design is adopted to answer this question. Five cases of EC pilots in different EU countries receiving intermediary support from REScoops were selected and researched over a three-year period. Data collection involved interviews, text documents, a quantitative longitudinal survey, and pilot project data. Results show that EC organisations use various forms of scaling: scaling-up, -out, and -deep. Regarding REScoops acting as an intermediary influencing the scaling of ECs, the analysis presents moderate support for positive impact. The relationship appears positive for scaling-deep and fairly positive for scaling-out. For scaling-up the relationship there was mostly within-case evidence. Scaling-up appears related to contextual factors. A fairly challenging context seems correlated to ECs deploying scaling-up strategies, using REScoop intermediary agency with the aim of changing key institutional structures, regulatory and policy frameworks that have a negative impact on ECs. This paper ends with suggestions for future work.

1. Introduction

In recent years there has been increasing scholarly attention to social innovation in sustainable energy transitions [1–3]. This particularly holds for energy communities (ECs), and the different forms in which they manifest, which have experienced a surge since 2014 [4]. This is indicated by REScoop.eu – the European federation of ECs – that represents more than two million EU citizens and 2250 organisational members [5]. The term "energy community" is widely used and interpreted among scholars related to a wide variety of activities and projects [6]. To still provide a definition amidst this conceptual mist, it is advisable to follow Bauwens et al. [4], who conducted a systematic literature review on the subject. Following the introduction of the 'EU's Clean Energy Package for All Europeans', policy circles have adopted the definitions of Renewable Energy Community (REC) and Citizen Energy Community (CEC). For practical reasons—such as legal feasibility and substantive suitability based on practical experience—we have opted for the following REC definition: Legal entities that have as a primary purpose to provide environmental, economic, or social community benefits to its members or shareholders by engaging in renewable energy activities on a not-for-profit basis. Moreover, this legal entity is based on open and voluntary participation, is autonomous, and is effectively controlled by its members or shareholders who are located in the proximity of the renewable energy facilities that are owned, developed and operated by that legal entity. In practice, the benefits of their activities accrue not only to their members or shareholders but also to the wider community [7].

ECs exist in various organisational forms. In Europe, under EU law, an EC can take the form of any legal entity including an association, a cooperative, a partnership, a non-profit organisation or a limited

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liability company [8]. In practice, an often used legal entity of EC initiatives is the energy cooperative. REScoop.eu, the federation of EC in Europe refers to energy cooperatives as 'REScoops' who distinguish themselves (from other forms of ECs) in the way they do business, officially recognised in the EU's Clean Energy Package as 'citizen' and 'renewable' ECs. This draws particular attention to their economic activities—specifically, their presence and activities in energy markets [9]. In doing so, they adopt the so-called REScoop business model. This pertains to a model where citizens jointly own, participate in, and democratically control renewable energy or energy efficiency projects, and comply with the seven cooperative principles [7].

Relevant to understanding how ECs as communities contribute to achieving sustainable energy transitions' goals is work paying attention to how they scale. In other words, how local EC practices and projects expand, reach more people and contribute to system change. For example, by maturing and professionalising an organisation, by building partnerships with stakeholders and running sustainable energy projects, or by raising awareness and educating people. In a comparative case study in Flanders, Belgium, Bauwens et al. show that there are various scaling strategies that ECs use to scale [10]. In addition to a focus on scaling mechanisms and strategies, recent literature has also increasingly addressed the conditions that influence the scaling of ECs [11,12]. Petrovics et al. focus on scaling of ECs and conditions that serve as (dis) enablers [13,14]. Moreover, considerable attention is paid to the external environment, more specifically, structural and institutional complexity [10,13].

An important condition influencing the scaling of ECs concerns the role and agency of so-called intermediaries. This refers to either organisations or individuals who mediate between actors ECs depend on - e.g., system operators, local and regional governments, project developers, technology providers, regulators, knowledge institutes, and SMEs - with the aim to move from local experimentation to widespread transformational change [14]. Central to the role of intermediaries is creating new possibilities within systems and spaces and opportunities for others [15,16]. Intermediaries have an important role in consolidating, growing and diffusing social innovations, including ECs [17]. They can be various types of actors, ranging from NGOs, governmental agencies, knowledge institutions, to individuals [16]. ECs, and their federations in particular, are well-equipped, for a variety of reasons, to take on this role themselves, for example, their embeddedness in local actor networks, the trust placed in them by local communities, experience, and built-up capacities [18].

Although the role of intermediaries in supporting and empowering ECs has been well researched, little attention has been paid to the role of REScoops as intermediaries — with the exception of the study by Huybrechts et al. [9]. While providing support, sharing knowledge, and empowerment can be viewed—from a normative perspective—as activities worth pursuing to enable ECs to achieve system change and contribute to sustainable energy transitions, no systematic study has yet been conducted on how REScoops perform these roles as intermediaries and how this influences the scaling of ECs. The present study aims to do this through a multi-case analysis of five real-world local pilots in various EU countries; in these pilots ECs act as recipients, receiving intermediary support from REScoops and REScoop federations within a dedicated, large-scale, EU-funded implementation project. The study's central research question is: How do REScoops, acting as intermediaries, influence the scaling of energy communities in five selected pilot cases across Europe?

This paper is outlined as follows. Section 2 addresses the literature study and reviews relevant theoretical perspectives. This section starts with attention to what scaling of ECs entails, then moves to the role of intermediaries in empowering ECs and the relation to scaling ECs. It ends with addressing REScoops acting as intermediary. In Section 3 the research design and methodology are presented, mostly addressing a multi-case research design. Section 4 then presents the five cases and the results of the multi-case study analysis. The results are reflected upon relevant ongoing academic debates, in Section 5. The paper ends with conclusions and suggestions for future research (Section 6).

2. Literature study

2.1. Scaling energy communities

Scaling can be viewed in different ways. First, an example of a local experiment or best practice in a general sense capable of becoming more widely adopted. In a rather general sense scaling may refer to a local-level innovation that must become widely adopted and therefore must span certain scales to contribute to (large) system change. They may include spatial jurisdictions (horizontal) and institutional levels (vertical) [19]. Second, as a local transition experiment intended to contribute to transformative system change. Adopting a transition studies' perspective, scaling may refer to mechanisms by which transition experiments can successfully contribute to (sociotechnical) transitions and have systemic impact [20]. Third, scaling can be seen as a social innovation fulfilling a social need. In the social innovation and entrepreneurship literature, scaling accounts for diverse avenues that social enterprises may use to increase their social impact and fulfil a social need [10]. In summary, scaling may refer to local or regional experiments expanding spatially and institutionally to reach more people, and achieve some sort of systemic or transformative impact while also fulfilling a social need (and achieve social impact).

In the literature, typically three mechanisms are described regarding how scaling takes place. Van den Bosch and Rotmans [20] discern: deepening (described as learning about culture, norms, values), broadening (repeating an experiment in different sociotechnical niche contexts, for example, first setting up a community solar plant and later a community wind initiative), and scaling-up (embedding a transition experiment into dominant thinking within a niche or regime). This aligns to some extent with the scaling mechanisms Moore et al. [19] and Bauwens et al. [10] discern: scaling-up, scaling-out and scaling-deep. "Scaling-up" commonly refers to changing institutions, impacting laws and policy, acknowledging that causes of emerging problems transcend particular places and are codified in formal institutions. "Scaling-out" refers to impacting greater numbers, for example by replicating or diffusing EC good practice or projects to other geographical regions. Finally, "scaling-deep" goes beyond scaling up and out, adopting more of a systemic perspective, which assumes that bringing about durable change is rooted in human behaviour, beliefs, intentions, relationships, community and culture. Scaling-deep strategies include spreading cultural ideas, educating and training people, sharing knowledge, reframing stories using participatory approaches while encouraging transformative learning. For example, by organising Communities of Practice (CoP) [19].

Each of the three scaling mechanisms has its own scaling strategies. For example, scaling-up has strategies like lobbying and framing of political and policy debates to change regulatory frameworks. Scaling-out has strategies like enthusing individuals and organisations in other regions to set-up replication sites. Scaling-deep has strategies like sharing narratives, knowhow, and offering training and education to enthuse people involved in a local experiment or pilot to improve their skills, capacities, and motivate them. Moore et al. [19] identified several additional cross-cutting strategies, such as seeking for alternative resources or building of networks and partnerships [19,21]. The latter refers to what is known as "scaling across" [10]. To a certain extent this is related to "scaling by accumulation", where a local experiment is linked to other experiments (typically within the same sociotechnical niche). In this process, intermediaries play a key role in facilitating interaction between experiments that exist simultaneously [17]. This is important because when lessons learned from experiments in different locations are compared and aggregated, they can contribute to a more stable innovation trajectory at a higher level of aggregation [22]. What scaling-up, scaling-out, and scaling-deep have in common is that they

are shaped by a range of factors and issues operating at both the community and system level. These include problems like lack of capacity, the absence of working business models, or mismatch with policy or regulatory frameworks. Addressing constraining factors while utilising enabling factors is considered necessary to scale or even "mainstream" ECs, for example in domestic energy markets [23].

Although the literature assumes that all three mechanisms contribute to scaling, the situation proves to be more nuanced in the case of ECs (as a form of social innovation). A systematic review of social innovation and community energy transitions concluded that social innovation – including ECs - has an important role in local energy transitions (i.e. scaling-deep and to some extent scaling-out) but has limited power to challenge regimes and scale-up [24]. Incidentally, this finding also appears to apply to cities and local government [25].

2.2. Intermediaries influencing the scaling of energy communities

The distributed nature of renewable energy has given rise to new forms and scales of energy governance. Accompanying the trend has been the emergence of intermediaries, whose role it is to mediate between actors – from state to industry - with the aim to move from local experimentation to widespread transformational change [14]. Central to the role of intermediaries is the "relational" and "in-between" character of their work [15], while creating new possibilities within systems and spaces and opportunities for others [16]. Moreover, intermediaries have an important role in consolidating, growing and diffusing innovations, including social innovations like ECs [17].

Intermediaries can be various types of actors [26] – from NGOs, governmental agencies, Energy Service Companies (ESCOs), consultancies, academic institutions, local government, business network platforms to individuals [16]. They can adopt different roles and methods to scale community activity, which includes linking with policy and supporting shared action. Places where intermediaries operate are referred to as intermediary spaces. Here, they connect different sorts of actors In these spaces intermediaries engage in negotiations: within communities, between communities, vis-à-vis private developers, or vis-à-vis regulators [27]. However, the interaction with actors is subject to social and power dynamics [14].

Intermediaries can also serve as a support network [28]. These networks can support ECs involved in various scaling mechanisms. Scaling mechanisms are tied to a specific set of actors. In cases ECs interact primarily with province-level intermediaries, municipalities and other regional ECs, scaling-out and accumulation are supported by intermediaries. If intermediaries are to support ECs in scaling-up, intermediary support would mean involving a wider set of actors (like national government, politicians, industry or the EU) [29]. Experience shows that this often leads to partnerships where ECs collaborate with government and industry, for example jointly developing onshore wind parks [30].

Intermediaries not only facilitate learning processes of local energy projects, but also provide support and aggregate impact. Moreover, they also help shape more robust local energy initiatives by connecting existing local and external activities [31], building communities' ownership, building capacities, transferring knowledge and technology, developing financing models, and co-shape policy [32]. Other intermediary activities include: bridging interests, addressing accountability gaps, and overcoming financial constraints [33]. Nevertheless, when coordinating support for local energy projects, intermediaries often encounter difficulties linked to social and political circumstances [17].

A key role intermediaries have is in aligning innovations with institutional configurations, connecting energy transitions to broader societal developments [26]. For example, by engaging in activities that support energy justice, acting as a bridge between low carbon initiatives and deprived communities by addressing energy poverty [34].

2.3. REScoops acting as intermediaries

ECs can also act as intermediary themselves. This applies especially for REScoops, some whom have historically taken on a role of intermediary, particularly because it aligns well with their cooperative identity [9]. Paying attention to awareness raising, education and training can be seen as adhering to two of the cooperative principles: educating and training people, as well as stimulating collaboration and empowering other cooperatives [18]. Moreover, REScoops are well-positioned to act as intermediary. They possess relevant experience—having started out as small EC initiatives themselves—and a broad skill set, built up over many years. Moreover, REScoops have become familiar with institutional structures and regulatory frameworks through numerous projects and experiences. They also often have champions and ambassadors who can help local initiatives in different ways. Finally, REScoops maintain an extensive network connecting them to other ECs as well as to the public and private actors that play a key role in either enabling or hindering local initiatives. Linked to this are the coordination and access to governance structures that REScoops have within such networks [35].

Possessing several of these characteristics, or combinations thereof, is particularly common among REScoop federations. These federations are found on the regional, national and international level. For example, respectively AGEM in a set of municipalities in the 'Achterhoek' region in the Netherlands, Energie Samen at the national level in the same country, and REScoop.eu at the EU level. Federations represent ECs as a social movement, and several like REScoop.eu and Energie Samen have been at the forefront of developing and supporting ECs for at least a decade [36]. The former – founded in 2013 and organised as cooperative itself - has set-up and implemented actions to empower ECs and REScoops and increase the overall recognition of the movement towards policy makers. It became the representative body for REScoops and community power initiatives across Europe. Intermediary agency by REScoop.eu involved inter alia international exchange of best practices and mutual support, support of new and immature REScoops by offering a mentoring system as well as developing and making available of a toolbox to foster the engagement of citizens and local actors in renewable energy projects [9]. In doing so, the federation draws on EU-funded projects, including "REScoop 20-20-20" (focusing on business models and best practices), "REScoop Plus" (promoting energy savings among REScoops and citizens), and "SCCALE 203050" (scaling up REScoop practices and projects into collective citizen initiatives in the field of sustainable energy). The federation was also effective in lobbying lawmakers and policymakers in Brussels to incorporate ECs into legislation. This effort succeeded with the development of the EU's Clean Energy Package, which can be seen as a key policy to overhaul European energy markets, empowering citizens as active participants in the energy sector supporting a decentralised energy transition [37].

Nowadays, REScoop federations are found 'intermediating' with local REScoops and other actors, with the aim to scale their business model, projects, best practices and tools to encourage renewable energy transitions from the local to international level. In addition to the aforementioned projects at the EU level, there are numerous national and regional initiatives where REScoops contribute to the energy transitions through intermediation. For example, the 'Local4local' project in the Netherlands, where REScoops and other actors empowered local collective initiatives to develop and implement a bottom-up, community model for a sustainable, collective energy supply and "energy-sharing" where end-users pay no more than the "cost price +" for their energy [38].

3. Methods

3.1. Research design

A mixed method exploratory multi-case study research design was

adopted entailing five case studies of EC pilots in five EU countries. The research design chosen was to examine the five case studies in their natural setting and real-life context on a longitudinal basis [39]. Each of the five case studies entailed a study of an EC pilot that was subjected to research over a three-year time span (2021–2024) focusing on organisational development, setting-up and running sustainable energy projects, and scaling. The five pilots were part of an overarching project in which local EC pilots would be at the receiving end of intermediary support by selected REScoops and federations, also between REScoops and ECs in different countries. The starting point of this project was that although the community energy movement had grown substantially in recent years, a number of barriers remained preventing it to reach its full potential to scale as part of Europe's energy transition. In response to this, the project aimed to support ECs to flourish from the bottom up and help remove some of the remaining stumbling blocks at the legislative and contractual level. In general, the project aimed to scale ECs - in multiple ways - contributing system change to sustainable energy transitions in Europe. Organisationally, the project was built around two main axes. First, pilot activities and second, the production of a toolkit containing multiple reports, tools, guidelines, good practices and multimedia. The latter was to be disseminated from and to the five EC pilots as well as other EC initiatives with the aim to build capacities and scale (adapted from: [36]). The focus of the project was on developing a step-by-step approach to support emerging energy development projects. This would be tested and validated in five pilots [40].

3.2. Case selection

The project specifically aimed at scaling ECs in various facets, involving multiple pilots in different contexts, with ECs in pilots at the receiving end of intermediary support by REScoops and two of their federations. Variation between the ECs in pilots referred to different criteria for example: organisational maturity, size (membership), business model, technology used in projects, and country of origin. This reflects both frontrunners, mainstream, and laggards in terms of experience but also variation in contextual factors regarding institutional structure, (degree of) regulatory and policy support, and incumbency. The set of cases that reflects the variation of ECs in Europe on the criteria mentioned assuming that this variation would also cover a diverse set of scaling mechanisms and strategies EC pilots would deploy. The five pilots (cases) were: Les Économes (France), focusing on behavioural change and energy savings; LICHT Leuven (Belgium), focusing on renewable heating and energy savings; Parentium (Croatia), focusing on solar PV and monumental building renovation; 050Buurtwarmte (The Netherlands), focusing on renewable district heating; and Hyperion II (Greece), focusing on collective solar PV.

The set of cases combined exploratory yet 'typical' and 'diverse' cases of CE projects in Europe, with the aim to explore variation (in type of projects, size, technology, and scaling) and contribute to theory development [41,42]. However, in the present study the purpose was more to elaborate theoretical insights regarding the inter-relationship between intermediaries and the scaling of ECs. Background information of the selected cases is presented in Appendices 1 and 2. Table A1 (Appendix 1) presents an overview of key characteristics for each of the five cases. Table A2 (Appendix 2) presents key information on implementation of the project, with a summarised description of the implementation process, information on stage of implementation and information on selected key performance indicators (KPIs). They include: households reached, renewable energy generated, primary energy savings triggered by the pilot, estimated CO_2 reduction per annum, and investments (in €).

3.3. Data collection

Data available to the researchers included both qualitative data (via text documents, workshops, reports, and interviews with stakeholders) and quantitative data (i.e., surveys and data on key performance indicators (KPIs) of ECs regarding organisational aspects, but also KPIs on the sustainable energy projects they set up), while also providing opportunity for validation of research approach methodology and preliminary results. The main tool for data collection was the "Energy Communities Development Progress Tool" (EC-DPT) [41]. It refers to a digital data collection and analysis tool developed with the objective to systematically collect data among the five pilot cases in terms of how ECs develop, scale, and run their sustainable energy project, while providing empirical data and an evidence base (see for more details Appendix 3).

To monitor the progress of the five EC pilots, data were collected at four moments in time: T [1] at the start of the project (M0, month 0; June 2021); T [2] mid-term (M21; March 2023); T [3] halfway completion (M30; November 2023); and T [4] at the end of the measuring period (M36; May 2024). At all stages both qualitative and quantitative data were collected. Pilot leaders were requested – and managed – to complete a survey and provide data on pilot project KPIs in the EC-DPT for each of the four data collection moments. In total, four rounds of data collection, including interviews, were conducted with each of the five pilot leaders and support staff, totalling seventeen interviewees (see Table 1). In summary: Number of surveys: four per pilot (T1–T4); Total: twenty (whereby pilot teams did not have to enter data into the EC-DPT from scratch every time, but could use previously entered data as a starting point.); Number of interviews: four per pilot (T1–T4). In total: twenty. Eventually, seventeen individuals were interviewed (meaning some were interviewed up to four times). Interviews with pilot team members were conducted to discuss developments, progress, scaling and related organisational development of their pilot, as well as emerging issues. Transcripts of the interviews were made and checked with the interviewees for validation. Fig. 1 presents a visual representation of data collection processes in this project.

3.4. Data analysis

Data analysis consisted of two parts: (i) Analysis of quantitative data using the EC-DPT; and (ii) analysis of qualitative information by establishing case narratives and via interpretive qualitative data analysis. Quantitative data analysis entailed studying longitudinal progress and impact of the five pilots. This allowed for analysis of a time series with four measurements, which enabled establishing trends for each of the items on organisational maturity and scaling, as well as project KPIs. Qualitative analysis entailed establishing case histories and narratives for each of the five cases, and qualitative data analysis of the interview data. For each of the five pilots, descriptions and characte ristics were presented regarding objectives set, performance through the time period of the project, description of the process, challenges encountered, and types of scaling observed. Next, information was structured to provide information on: background, objective(s), realisation, and encountered challenges. In addition, an interpretive analysis was conducted to highlight different forms of scaling: i.e. scaling-up, scaling-out, and scaling-deep as well as intermediary strategies and actions. In addition, data indicating transformative change and impact were also analysed, focusing on observed indications of system change, adaptation of institutional frameworks, as well as renewable energy generated and impact on CO_2 emissions. The latter two used calculations made on project data delivered by the pilot project teams.

Following a reconstruction of the case descriptions, coding was performed based on theoretical concepts relevant to this study: intermediary agency (and subcategories of strategies), scaling mechanisms and strategies, and encountered problems (with subcategories). A deductive approach was adopted during the coding process [43]. After coding, a table was compiled (see Table 4 in Section 4) and analysed for potential relationships between intermediary agency, on the one hand, and scaling by ECs, on the other. The study also examined whether contextual problems might influence these relationships. Preliminary

Table 1
Overview of interviews conducted.

Pilot	Organisation (function)	# of interviewees
050 Buurtwarmte	Grunneger Power (communication and participation officer, heat project development)	2
	Buurtwarmte (knowledge developer, project leader)	2
Parentium	ZEZ (senior project manager and president of the assembly, project leader)	2
	City of Poreč (civil servant, project leader)	2
Hyperion II	Electra Energy (co-founder, senior policy advisor)	1
Les Économes	Enercoop (project manager, European project manager)	3
LICHT Leuven	Ecopower (communications and member relations officer)	2
	City of Leuven (civil servants, project leader)	3
Total		**17**

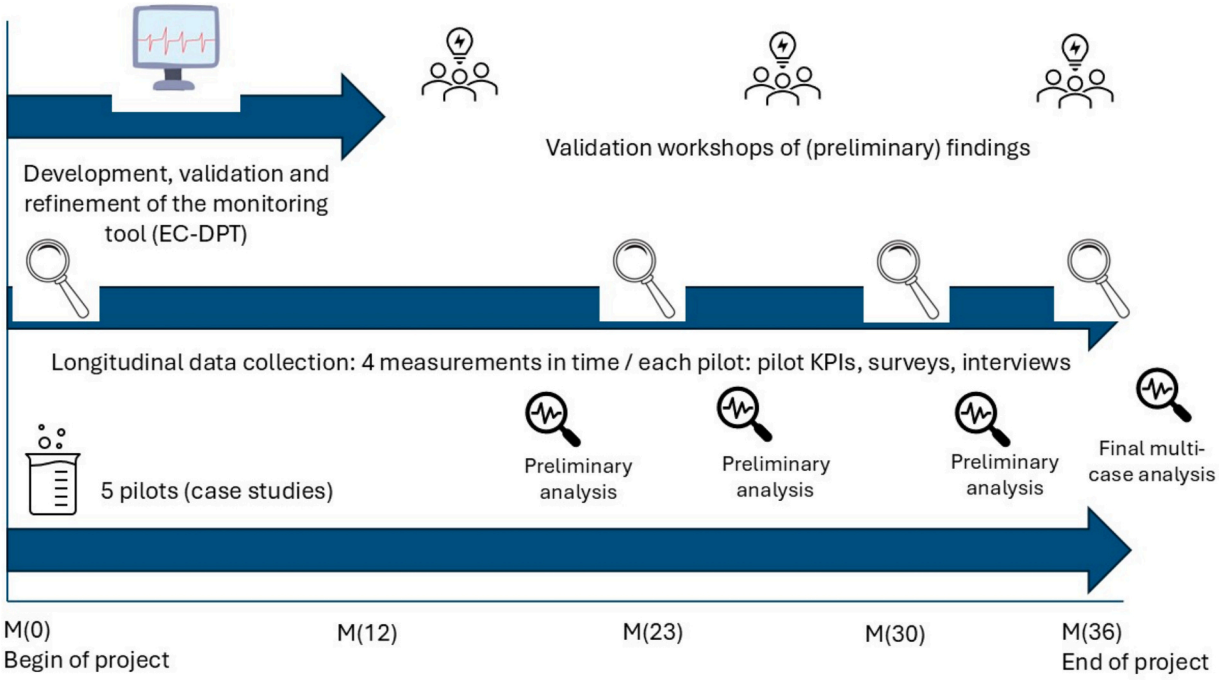


Fig. 1. Visualization of data collection processes.

results were discussed and validated with EC experts, practitioners, and pilot leaders at project progress meetings.

Research reliability and replicability were ensured by the adherence to strict procedures together with the clear and transparent communication of research processes and documenting of methods. Additionally, workshops with experts and pilot projects were organised throughout the three-year process (see Fig. 1), during which preliminary and final findings were presented, discussed, and validated. See Table 2 for an overview of the processes and methods used from data treatment and analysis.

4. Results

4.1. Case narratives

In this section each of the five cases is described in terms of the role of background information, the role of the donor intermediary REScoops, the scaling mechanisms and strategies employed in the pilot, the

Table 2
Overview of the process from data sources to data treatment, analysis and results.

Data source (for each of the five cases)	Character	Data treatment	Data analysis	Theoretical framework used for analysis	Results
Text documents Interviews (t0,1,2,3)	Qualitative Qualitative	Establishing case narratives and reports for each of the five case studies	Text interpretation and abductive coding of scaling types, strategies, conditions, social impact and problems. Validation workshops.	EC-Scaling classification. Conditions framework for EC scaling [12]	Results on scaling types, strategies, conditions for scaling, and social impact
Survey data (t0,1,2,3) (in EC-DPT)	Quantitative	Establishing dataset on survey data with time series on questionnaire items for each of the five case studies	Interpretation of time series within -and between- cases. Validation workshops.	Several items reflecting indicators on intermediaries and scaling	Results of survey data time series analysis
Project KPI data (t0,1,2,3) (in EC-DPT)	Quantitative	Establishing a dataset with time series on KPI data for each of the five case studies	Interpretation of time series within cases. Validation workshops.	N/A	Results on KPI data time series analysis (on quantitative impact)

problems encountered, and the outcomes.

4.1.1. 050Buurtwarmte

050Buurtwarmte is a district heating project focusing on the city and surroundings of Groningen, in the Netherlands. The pilot's objective was to explore a neighbourhood approach, deploying an engagement technique with the aim of reaching a high buy-in of local households for large investment projects. The national EC federation "Energie Samen" in collaboration with "Buurtwarmte" (a cooperative affiliated with Energie Samen that helps local initiatives set up thermal ECs) would support the initiative to reach a large number of citizens joining a district heating project, while managing the complexity of the project. In addition, Energie Samen would support the development of the EC - including its governance model – by organising community workshops (i.e. public meetings) and meetings to facilitate and coordinate the pilot community's core group. Within the project the local energy cooperative Grunneger Power was to implement a collective district heating system. The project sought to use a combination of different heat sources: an aquathermal energy source from local surface water, underground thermal storage, and a district heat pump.

The pilot team put time and effort into citizen engagement activities hoping to convince local citizens to sign up for the community-owned district heating network. In addition, a lot of energy was invested into the overall positioning of the project vis-à-vis the municipality of Groningen and local (public) heat company 'Warmtestad'. However, the two were not familiar with working with ECs, particularly not in (complex) heat projects. The municipality questioned the ability of Grunneger Power to raise sufficient funds to take on such an ambitious and capital intensive project. Over the project duration the role of Grunneger Power shifted from developing and implementing a district heating system to citizen engagement and unburdening households. To get this done the cooperative deployed a project team of its own, including people who went door-to-door to provide to inform and persuade households to become members. Later a working group was established to tailor information to the needs of the residents. In addition, residents were invited to participate in community project teams and look into new and other projects, join strategic meetings, and find representation in the district heating project through a citizen council.

As of January 2024, 80 households signed contracts to connect to the DH system. Based on the experiences Grunneger Power had with residents in the project, several services were adjusted. Despite not realising a community owned heating network, a lot of useful knowledge emerged from the project, particularly related to legal issues. In hindsight, as a pioneer in the field of community-owned heat supply, the pilot encountered numerous challenges. Next to suffering from a lack of understanding on the part the municipality and the local heat company, the team of the EC central to the pilot was of the opinion that it was not given a proper chance to professionalise its activities because Energie Samen granted support (in Dutch this is referred to as "opgroeirecht") to other initiatives. In addition, there was, at the time, no legal basis nor framework regarding thermal heat communities in national legalisation. The legal and regulatory issues were considered important and were eventually adopted by Energie Samen to develop advocacy with the aim of seeking recognition for thermal ECs and changing legislation to that effect. The pilot team considered offering EC members a position within the existing structures to be the most significant challenge. In addition, other challenges were encountered. Techno-economic and operational problems occurred including changes in staff and difficulties to engage with and persuade households to participate. Despite the setbacks replication sites were set-up in collaboration with Energie Samen and Buurwarmte, although not all of the same project size and complexity, and with a particular focus on getting local communities excited about and engaged in establishing thermal ECs. They managed to replicate to seven sites nationwide, for example, in The Hague, Bilthoven, and Enkhuizen, involving nearly 1500 households. However, in the end the ambitious goals of realising both the Groningen pilot and the replication sites were hardly met. Nevertheless, significant steps were taken regarding scalability—not least placing necessary adjustments to national legislation on the agenda.

4.1.2. Parentium

At the start of the project in 2021, there were virtually no ECs in Croatia. Among local advocates for community energy there was a need to set up the first professionally working EC in the country, and to set a best practice approach serving as a beacon for others who would want to follow them. The pilot sought to develop new and viable financial models for building retrofits, in a way that could provide both community value and financial returns for local citizens. Through collaboration between a local energy cooperative (ZEZ) and the City of Poreč-Parenzo, the pilot aimed to provide replicable and scalable community engagement and innovative financing models for urban revival in Croatian cities. The pilot was supported by the project central to the present paper, which helped in offering guidelines to set-up the governance of the EC, a monitoring tool to allow for reflective learnings as well as several capacity building efforts.

Concrete actions mostly revolved around development and implementation of an energy voucher system to refurbish local schools and kindergartens, including fitting them with solar rooftops. The process of implementing the voucher model was characterised by long-lasting and bureaucratic procedures, and legal barriers that prevented the pilot team from initiating any next steps. Multiple delays were caused by the national Ministry of Finance, which was considered not responsive. In Summer 2023, there was a sudden breakthrough when the voucher model finally received the green light from the Ministry of Finance. However, this meant that the next step was to get a contract signed, which fell under the authority of another Ministry, and no information was provided on how to engage with it to achieve that objective. Without its approval, the pilot team argued that no mayor of any municipality in the country would sign a contract. In the absence of an operational voucher system, the pilot team decided to become active running alternative activities to reach local community members in Poreč.

Whereas the implementation of the voucher model proved most difficult and was eventually halted, the project helped to start the conversation about energy communities and to put a fair degree of pressure on the national government to start paying attention to the community energy movement. In a sense the pilot team became an intermediary itself helping setting up two NGOs that would serve as ECs, organising advocacy meetings and making 300 contact activities and sharing information to citizens about energy savings and RETs. To summarise, providing tools and blueprints for organisational development by intermediary agency of REScoops in the project was the key for deep-scaling the pilot project. Nonetheless, the implementation in the challenging institutionally centralised national environment was troublesome, yet informative regarding starting EC initiatives in Croatia. Finally, negotiations with three potential replication sites had started by 2024.

4.1.3. Hyperion II

The Hyperion II pilot focused on scaling a collective solar PV plant project, providing 300 kWp, that would provide virtual self-consumption to 120 cooperative members (i.e. 110 residential owners and 10 local SMEs). The electricity production of the plant was estimated at 446,000 kWh per year with a generation licence for 25 years. In a collective virtual net-metering scheme members would be owning a portion of the installed collective solar PV plant. Hyperion was looking to develop and scale an EC around a collective self-consumption mechanism. The pilot aimed to demonstrate a stable financial and contractual model to develop a large citizen-driven EC (with about 300 members). In addition, the pilot would also experiment with mechanisms to support local energy poor households. Pilot activities were undertaken including design, land plot assessment, meetings with

members and stakeholders, and financial planning. A feasibility study was performed with a positive outcome (i.e. a feasible project plan and business case). Later the permit process was successfully completed. Other activities included distributing a two-page leaflet to residents with energy savings advice and preparing a competition among members focusing on increasing awareness about the benefits of energy savings. By Spring 2024 two milestones had been achieved. First, the solar PV plant had been constructed and became operational in the sense that it became ready to produce electricity and feed into the electricity grid. A significant step was taken when 120 households gained access to a renewable energy supply.

A key setback concerned the counterproductive ways in which the EU directives (REDII, IEMD) were transposed into national law, resulting in a ban on the use of existing legal forms by already existing ECs. who were consequently unable to start any new projects. The new law came with a new definition of ECs, which classified them either as REC or CEC. In practice this meant that ECs like Hyperion did not fit the new definition. This required them to create a new legal entity. This was considered very burdensome and problematic, and eventually delayed several pilot activities.

The Belgian energy cooperative Ecopower played an important role in the overall process, as they inspired Hyperion to set up working groups dedicated to specific topics such as citizen participation, advocacy, new technology, and energy conservation. As a consequence, a legal working group, and a poverty working group were established. This triggered an overall feeling of joint ownership in the development process among EC members. Another important development concerned the General Assembly – with 80 EC members attending - approving a gender balanced board (with three women and two men). Childcare was arranged to enable mothers and families to participate (following insights deriving from the "SCCALE 20 30 50 inclusivity guide for energy communities", delivered by REScoop.eu [55]). Participation in the project central to this paper, participating in its events and using the EC-DPT tool for monitoring and reflective learning were considered helpful by the pilot team members because they helped raising attention to a lot of things important to ECs, such as developing a data management plan, creating working groups, and paying attention to social inclusion.

4.1.4. *Les Économes*

The pilot aimed to support ECs in promoting “energy sobriety” (i.e. encouraging behaviours to achieve energy savings; [44]) and collective purchasing among their members. The French energy cooperative Enercoop would train twenty of its members to become “ZeroWatt” ambassadors. In turn, they would develop a citizen group to help reduce and improve energy consumption, organise collective buying, or provide access to financial support mechanisms for stimulating energy saving behaviours. A key tool ambassadors would be using to promote energy sobriety was the card game ‘Milwatteur’. Game workshops were to be organised to encourage people to participate.

At the same time, Les Économes built a website (in collaboration with Enercoop) and strengthened its partnership with the City of Paris and the Académie du Climat, a forum set up by the Paris city council to advance the discussion on climate mitigation action. The community moved away from monthly meetings and started having shorter meetings around certain topics. Through these meetings Les Économes managed to improve the ‘Milwatteur’ game, while organising structural discussions regarding collective purchasing of energy saving materials, their business model, and future events. Meanwhile the EC tried to professionalise. However, this process eventually stopped. No formal steps were undertaken because this was deemed unwise in the absence of having a business model and opening a bank account.

The pilot encountered numerous challenges of which many had to do with project management, particularly champions and experienced staff members leaving following the Covid-19 pandemic, and having difficulties to find appropriate replacements. Professionalisation steps were taken, but failed (e.g., the business model). Building partnerships (with other organisations) and engaging citizens proved difficult. As for the use of the card games, the game workshops saw hardly any follow-up. In hindsight, other than training the ZeroWatt ambassadors little was achieved. By 2024 there were fifteen members and eight active citizens. The demonstration pilot reached about 150 people who played either the game of “Millwattheur” or “The Wheel of Fortune”. Use of the EnergieID (an online measurement and verification tool that helps households and organisations gain insight into their energy use) was considered and discussed with donors (City of Leuven and Ecopower) but was eventually not adopted. Les Économes was replicated in three sites (i.e. Payes d'Aigues, Lyon, Rennes), where about 80 people were reached. The impact of the replications was considered slow and limited.

4.1.5. *LICHT Leuven*

In the LICHT Leuven pilot, the City of Leuven and energy cooperative Ecopower explored long term collaboration models to support the development of ECs within the city's territory. This would involve establishing a support organisation through a partnership of the city and the energy cooperative to help develop ECs of different types while tackling a range of challenges and organising activities. Organisationally, the pilot contained four projects: (1) Development of non-residential solar production (on public, semi-public and private buildings). It was expected that investments in solar PV were to be made for at least ten large installations (>35 kWp) here, or >350 kWp in total. (2) Development of a DH system and efficiency projects for residential buildings, where local partners would support the development of small solar PV installations for an average of 3 kWp per household for 50 households. The partners were expected to offer an alternative investment model for an equal budget for roof isolation and energy efficient devices. This could provide in total 5 MWh savings on heat and 2 MWh on electricity. (3) District Heating: 40 households would be involved. (4) An energy sobriety ambassador programme using EnergieID. This online platform allowed groups to interact and share energy data, in order to develop energy consumption behaviour considered 'sober' [18]. The City of Leuven and Ecopower were looking to actively involve at least 250 citizens during the project in the four priorly mentioned projects. To achieve this, workshops and training sessions would be organised in different city districts, and support civic energy groups to address legal, contractual and financial issues. Pilot activities included: monitoring, implementing and energy monitoring through EnergieID, input dashboard design (monitoring tool), and a technical energy scan campaign, public events, communication and water campaign. What can be considered significant were energy scans helping citizens to save energy by giving them a better understanding of their household's overall energy consumption, and enabling them to get a sense of what would be sensible energy measures in their homes.

For the four projects in the pilot, an explanation is provided regarding what has taken place. Project 1: Energy scans: LICHT Leuven offered technical energy scans, investigating the possibilities for citizens to invest in solar PV panels and/or heat pumps in their homes. Communication around this activity was launched in 2022 and attracted a lot of interest. Project 2: Energy monitoring: The objective here was to persuade 400 citizens to partake in energy monitoring actions that would help them become better aware of their actual energy consumption. In hindsight, the use of EnergieID was considered helpful in supporting people becoming aware of their energy consumption and making them more aware about energy and climate issues, while helping them to initiate energy saving actions in their daily lives. Project 3: Community building: The objective was to involve 500 citizens into community engagement activities. However, this turned out to be ambitious. At the end of 2022, the pilot team had to put this activity on hold as a direct result of the energy crisis. Setting up a group of residents with the potential to become an EC was postponed until early 2023. The community meetings were used to engage people in discussions regarding renewable energy, energy savings and energy poverty. In addition, the pilot team explored how feasible it would be to replicate

the "Power Up" model (from another EU funded implementation project) in Leuven. Around this time, the pilot also reached out to other organisations which could help effectively engage and reach out to specific groups from within the community in an attempt to seek collaboration and establish a good working relationship. Project 4 (the solar farm) proved difficult because it was hard to find sufficient rooftop space available for installation of the target number of solar PV panels. In Spring 2023, one roof was under consideration for the installation of solar PV panels for which the pilot team started the negotiation process. In this context, the pilot team collaborated with ECOOB, a local energy cooperative. Within the collaborative model people could participate by buying a share of ECOOB. Things were considered running smoothly because people did not have to pay for the service that ECOOB was offering.

The moderately positive performance of the pilot can to some extent be attributed to the local government being determined to undertake action and work on the energy and transition issues. Nevertheless, the pilot met several challenges, from staff turnover to noticing that quantifying energy savings was challenging and suffering from lack of data or information. LICHT Leuven had six replication sites. Topic-wise they employed a wide variety, ranging from information sessions on energy savings, to development of a wind park and solar rooftop carports. Compared to the primary pilot sited in Leuven, the replication sites witnessed more modest development.

4.2. Multi-case analysis

Table 3 presents an overview of scaling mechanisms and strategies observed in the five cases.

Table 4 summarises key observations from the five case studies, addressing intermediary support by REScoops EC pilot teams received, scaling mechanisms deployed, project performance, (contextual) problems encountered and reflection on the theoretical relation of interest (i.e. intermediary influence on scaling mechanisms deployed) with "—" meaning (very) absent; "-" meaning moderately absent; "0" meaning neutral; "+" meaning moderately present; and "++"meaning (very) present.

The multi-case analysis shows moderate support for the positive impact of REScoops acting as intermediaries to support the scaling of EC initiatives. The relationship appears positive for scaling-deep and fairly positive for scaling-out. The exception is the Les Économes pilot, which received a lot of intermediary support but did not perform well in terms of scaling. However, this was to a large extent due to organisational and HRM factors, in particular staff turnover and trouble in finding qualified replacements. Moreover, engaging with residents proved more challenging than anticipated in the pilot. On the other hand, there is the case of LICHT Leuven, where the impact of intermediary agency by REScoops on scaling (and also on project performance) was not that high. A possible explanation is that the organisational maturity (i.e. the level of professionalism) of the pilot team – though mainly consisting of municipal civil servants - was already very high and did well in having necessary capacities on board, and therefore did not require much support from intermediaries. For scaling-up the relationship appears more neutral as no direct positive relationship can be established (other than evidence in the 050 Buurtwarmte and Parentium cases). We also looked into the relationship of intermediary support by REScoops on overall project performance and found limited support for a positive relationship outside within-case evidence in the Hyperion II and LICHT Leuven cases.

Table 3
Scaling strategies observed, subdivided by type of scaling.

Scaling mechanism	Strategy	Pilots in which strategy was observed
Scaling-deep	Making handbooks, guidelines and/or tools available	Buurtwarmte 050, Hyperion II, Les Économes
	Organising member feedback	Buurtwarmte 050, Les Économes
	Key staff members coaching EC members	Hyperion II, Licht Leuven, Les Économes
	Embedding learning in strategy and operations of the EC organisation	Primarily: Licht Leuven, Les Económes. To a lesser extent: Parentium and Hyperion II.
	Use of online tools and media for learning purposes	Hyperion II
Scaling-out	Having replication sites	Hyperion II, Licht Leuven, Les Économes, Buurtwarmte 050, Parentium
	Promoting EC principles in external events to a large audience	Primarily: Hyperion II; To a lesser extent: Licht Leuven, Les Économes.
Scaling-up	Direct or indirectly involved in actions to have current policy or regulations changed	Parentium, Buurtwarmte 05

Learning from within-case analyses on the importance of context (i.e. by emphasizing problems related to legal issues, incumbency, residents, and ownership of energy (system) assets) we analysed the relation between context and scaling on the one hand, and context and project performance on the other. The analysis showed it was difficult to establish a relationship between context and scaling. However, there appears to be a fairly positive relationship between context and project performance. This means, for example, that pilots with a low degree of project performance appear located in challenging contexts as observed in the 050 Buurtwarmte and Parentium cases. Especially in the latter, incumbency, legislation and difficulties to engage residents negatively impacted the project progress despite having a strong pilot team with the necessary capacities for project delivery. The same roughly holds for Parentium, despite facing an even more challenging context and initially (in 2021) having a less experienced pilot team. Moreover, in Croatia it is essential to have the key permit from the ministry; otherwise, simply put nothing can be done. This condition was not met.

These findings prompt an investigation into how context can influence the use of intermediaries and scaling strategies. Here, the 050 Buurtwarmte case provides an illustration on how scaling strategies, besides directly achieving potential transformative change, also have an indirect effect through dynamic cycles and feedback loops. In this case, a contextual barrier that led to accumulation in collaboration with the national EC federation, scaling-up to the national level with REScoop intermediary support to influence policymaking, and scaling-deep that, as education and capacity building from the national federation, led to improved skills among members and employees of the local EC organisation. These improvements then enabled a more effective engagement to convince households to participate in a local heating project (i.e. connection to a sustainable DH system). We also checked for the relationship between context and scaling-up (as a subcategory of scaling) and found support for a moderately negative relationship. Practically, this would mean that having a challenging context (e.g., as regards the legal basis and incumbency) corresponds to having EC initiatives developing and deploying scaling-up strategies, for example, to have obstructive regulatory frameworks and policy adapted in favour of ECs.

5. Discussion

When confronting the results of our analysis with debates on the role of intermediaries in empowering and scaling organisations, the following observations are made. In line with the literature, REScoops were found to be an important actor in consolidating and diffusing ECs as social innovation [9,17]. In line with [15,16,29], they were active in getting actors involved and intermediating between them, for example residents, municipalities and national level policy makers. Nonetheless, they were mostly active in helping ECs build capacities, for example by offering support, sharing best practices, making digital tools available, and by supporting learning. In summary, a reflection on the findings reveals the crucial importance of the role played by intermediary REScoops—specifically in their interaction with ECs as they build

Table 4
Overview of the multi-case analysis.

Name of case	Problems encountered (contextual)	Intermediary support from REScoops	Scaling mechanisms observed by receiving EC	Project performance	Reflection on theoretical relation of interest
050 Buurtwarmte	Legal basis: − Incumbency: − Engaging residents: − Investments: − HRM: − Ownership of assets: − Organisational maturity: + **Context: −**	Capacity building support: ++ Mentor network: + Use of tooling: 0 Involvement in EC networks: + **Overall: +**	Scaling-deep: +/0 Scaling-out: + Scaling-up: ++ **Overall: +**	Achieving initial objectives: − Learning: + Setting things in motion: + **Overall: 0**	Intermediary → scaling: + Intermediary → project performance: 0
Parentium	Legal basis: – Incumbency: – Engaging residents: − Investments: 0 HRM: + Ownership of assets: – Organisational maturity: − **Context: –**	Capacity building support: + Mentor network: ++ Use of tooling: + Involvement in EC networks: 0 **Overall: +**	Scaling-deep: + Scaling-out: 0 Scaling-up: +/0 **Overall: 0**	Achieving initial objectives: − Learning: + Setting things in motion: +/0 **Overall: 0**	Intermediary → scaling: +/0 Intermediary → project performance: 0
Hyperion II	Legal basis: – Incumbency: – Engaging residents: + Investments: + HRM: + Ownership of assets: + Organisational maturity: + **Context: −/0**	Capacity building support: ++ Mentor network: + Use of tooling: + Involvement in EC networks: ++ **Overall: ++**	Scaling-deep: ++ Scaling-out: + Scaling-up: − **Overall: +**	Achieving initial objectives: + Learning: + Setting things in motion: + **Overall: +**	Intermediary → scaling: + Intermediary → project performance: +
Les Économes	Legal basis: 0 Incumbency: 0 Engaging residents: – Investments: + HRM: – Ownership of assets: + Organisational maturity: 0 **Context: 0**	Capacity building support: + Mentor network: + Use of tooling: + Involvement in EC networks: + **Overall: +**	Scaling-deep: +/0 Scaling-out: − Scaling-up: − **Overall: −/0**	Achieving initial objectives: − Learning: 0 Setting things in motion: − **Overall: −**	Intermediary → scaling: 0 Intermediary → project performance: −
LICHT Leuven	Legal basis: 0 Incumbency: ++ Engaging residents: − Investments: + HRM: − Ownership of assets: − Organisational maturity: + **Context: 0**	Capacity building support: 0 Mentor network: + Use of tooling: + Involvement in EC networks: 0 **Overall: +/0**	Scaling-deep: +/0 Scaling-out: + Scaling-up: 0 **Overall: +/0**	Achieving initial objectives: + Learning: + Setting things in motion: + **Overall: +**	Intermediary → scaling: +/0 Intermediary → project performance: 0

relationships within, between, and beyond these communities. This is particularly true regarding the development of learning and reflective capacities within dynamic, iterative cycles. The mentoring, guidance, and tools provided by the intermediary were generally well received; they led to increased awareness, more appreciation of justice values, and the adoption of new working methods and forms of inter-organisational governance. Support was also beneficial in cases where the institutional context obstructed ECs to scale like the Parentium case in Croatia. Intermediary REScoop support was called in, which produced an impact by offering tailor-made support to the Croation EC team, advising the EC how to deal with institutional hindrance and by putting the Central-European case on the agenda with the European Commission. Subsequently, these experiences—along with those regarding obstructive institutions, governance, and incumbency from other EC pilots—were translated by the REScoop federation into a policy brief addressed to the EU [45].

The cases provide insight of ECs deploying scaling-deep strategy to delivering social impact, especially concerning gender balance [46]. To stimulate the latter, especially in terms of social inclusion the energy cooperative Electra in the Hyperion II case made its board more diverse, while implementing supportive measures to accommodate this (e.g., by offering childcare to allow mothers to attend meetings). This occurred after the pilot team had been informed about the importance of inclusion and ways to implement and embed it in ECs through guidance, self-reflective monitoring (using items in the EC-DPT that address inclusion and discuss this with the monitoring support team), the distribution of an inclusivity guide for ECs developed within the project by the REScoop federation and a university [47], and participation in a workshop and webinar organised by REScoop.eu and others. This is a clear example of REScoop.eu and other partners acting as intermediaries to promote and embed justice and inclusivity—through 'deep scaling'—within ECs such as Elektra (in line with: [34]).

Another key insight from the study is that the contexts in which ECs operate can pose the greatest challenges to scaling up. This applied to Western, Central, and Southern European contexts alike, but it was a particularly significant hindering factor in the latter two regions (i.e. Croatia in the Parentium case and Greece in the Hyperion II case). Nevertheless, both cases demonstrate that ECs do not simply give up; instead, they engage with other REScoops and their federations, leveraging their intermediary role to help find solutions. In short, institutionally challenging contexts that constrain the scaling potential of ECs can provide fertile ground for intermediary agency. In this sense, the present study provides moderate criticism regarding the claim by Dall-Orsoletta et al. [24] that social innovation – i.e. ECs - has an important role in local transitions but has limited power to challenge the regime and scale-up. The cases of 050 Buurtwarmte, Parentium, and

Hyperion II confirm this. However, in the first two instances, this systemic resistance prompted the involvement of REScoop federations, which acted as intermediaries to assist in coping with power dynamics in lobbying and efforts to influence national decision-making processes (in line with: [14]). Although this did not immediately result in adjustments to policy frameworks, it did set a transformative process in motion among policymakers, fostered greater awareness, and reached new groups of citizens who subsequently launched energy community initiatives. Future research could examine this further, focusing on both the role of the intermediary and the resulting effects.

Whereas the theoretical focus on intermediary agency in this paper is with REScoops, the empirical cases also present intermediary involvement by other organisations like municipalities, often considered important if not crucial to an EC's organisational development [25,48–50]. However, some of the cases in the present study offer a varied picture. In the Parentium and LICHT Leuven pilots, the collaboration between municipalities and ECs was very strong and contributed positively to both organisational development and scalability. However, there was also poorer collaboration, as in the 050 Buurtwarmte pilot project, where the municipality did not acknowledge the EC as a professional partner. This had a counterproductive impact and delayed the project. Another important intermediary was Energy Cities, a network of over 1000 local governments working on energy transitions, which stepped in as an intermediary to assist, for example, by listening to stories and problems by ECs, transferring knowledge by sharing experiences, tools and guidelines, and having EC pilot teams participate in workshops they organised.

6. Conclusions

The question, "How do REScoops, acting as intermediaries, influence the scaling of energy communities?", was answered using a multi-case study research design of five energy community (EC) pilots in different EU countries.

Results show that ECs use various forms of scaling: scaling-up, -out, -deep. Scaling-deep and -out were observed in each of the five pilots. Scaling-up (e.g., attempting to have institutional frameworks adapted at the national level) was only observed twice, and occurred in pilots encountering major barriers due to lack of a legal status and not being acknowledged nor having rights in legal frameworks. Regarding the ways REScoops acting as intermediary, impact the scaling of ECs, the multi-case analysis presents moderate support for the positive impact of intermediary support by REScoops. The relationship appears positive for scaling-deep and moderately positive for scaling-out. For scaling-up the relationship appears difficult to establish either as positive or negative other than the within-case evidence. Learning from within-case analyses on the importance of context by addressing problems related to legal basis, incumbency, residents, and ownership of energy (system) assets we also analysed the relation between context and scaling on the one hand, and context and project performance on the other. Results show that it is difficult to establish a relationship between context and scaling. However, there appears to be a moderately positive relationship between context and project performance. For example, challenging contexts (e.g. having a poor legal basis for ECs and fair share of incumbency resistance) are associated with a low degree of project performance (i.e. in the 050 Buurtwarmte and Parentium cases). There also appears to be a moderately negative relationship between context and the use of scaling-up strategies. A challenging context seems related to initiatives deploying scaling-up strategies, with the aim of bringing about change to key institutional structures, regulatory and policy frameworks that have a negative impact on ECs.

Like most studies the present study has limitations. First, in terms of selection bias and external validity, with the study being limited to pilots in five EU countries (three Western European, two South-Eastern European), which reveals another case of Eurocentric bias in contemporary research on ECs [51]. It is advised that future research in scaling ECs selects (pilots with) cases in countries outside (at least Northwestern) Europe. Given the unsupportive institutional context observed in the present and other studies in Croatia and Greece [44,52], we propose that future research take this aspect into account when selecting cases—a topic that is particularly interesting to examine from a political-economic and legal perspective. To address one of our main findings – i.e. that context appears to have an important role vis-à-vis both the intermediary agency of REScoops as well as ECs' capability to scale - we deem research into challenging context and intermediary agency by REScoops an important future avenue of research. It can address questions like, how do challenging contexts impede ECs' capability to scale and what types of intermediary mechanisms and strategies can be deployed by RESoops (federations) to empower these ECs and increase their capacities?

Another limitation regards timing of the study with data collection being limited to three years (2021–2024) and partially taking place during the COVID-19 pandemic (which did have an impact on the functioning of some of the ECs). For long-term (organisational) developments and impact measurement, research designs are necessary that allow for extended periods. For measuring effects, especially in terms of transformative change a longer-term time-scope is needed. In future work this could be done by adopting a longitudinal research design that follows selected ECs for over five years, to measure indicators in organisational development, scaling and transformative change. A third limitation concerns selection of pilots implementing a wide variety of technologies, which require different organisation, ownership and business models. After all, there is a vast difference in terms of technique and complexity between organising card games about energy sobriety and developing and seeking to implement a complex district heating system at the city district level. This makes it difficult to systematically compare cases. Selection of pilot cases implementing the same technology would allow for better systematic comparison and analysis of cases. A fourth limitation concerns an aspect of the data collection part of which was self-reported by pilot team members (although triangulated by researcher observations, interviews, and workshops). While the present study used indicators on sub-items of conditions influencing scaling ECs [13] not all of these sub-items could be measured in the pilots, for example, formalising the organisation, matching expectations with (external) stakeholders, the use of participatory processes, and democratised distribution of knowledge. Future researchers are advised to adopt ways to include these.

As the current study explored only five pilot cases, we suggest future research adopts a large(r)-N research design that allows for systematic statistical analysis and/or modelling (e.g., [53]). It is suggested to make an effort to connect to existing databases presenting organisational and project information of hundreds of EC initiatives throughout Europe [54] and see how data can be sourced or collected on organisational and scaling indicators that belong to EC initiatives that are already in that database. We also suggest future research in extending research to selecting mainstream ECs, and not just frontrunners.

CRediT authorship contribution statement

Thomas Hoppe: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Michiel Fremouw:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Nthabi Mohlakoana:** Writing – review & editing, Writing – original draft, Validation, Resources, Project administration, Investigation, Formal analysis, Data curation. **Joy Clancy:** Writing – review & editing, Writing – original draft, Validation, Investigation.

Declaration of competing interest

All authors state they have nothing to declare and report no conflict of interest.

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Appendix 1

Table A1
Overview with background to the pilot cases.

	050Buurtwarmte	Parentium	Hyperion II	Les Économes	LICHT Leuven
City and country	Groningen, The Netherlands	Porec-Parenzo, Croatia	Thiva region and Athens, Greece	Paris, France	Leuven, Belgium
Technology	District heating (with renewable energy source); Thermal insulation of homes	(Sustainable) Renovation of monumental buildings; Installing solar-PV panels on school buildings.	Developing a collective solar PV plant to generate green power which is distributed and consumed by households in Athens	Household energy savings via behavioural change.	Installing heat pumps and solar PV panels. Household energy savings.
Objective (s)	To explore a neighbourhood approach, an engagement technique looking to reach a high buy-in of local households for large investment projects. The national energy cooperatives' federation Energie Samen supports local REScoops to reach a high share of citizens joining a district heating project, while managing the complexity of the deployment of such a DH system.	The pilot involves collaboration of a municipality and a REScoop with the objective to create a local EC, and to develop an innovative and viable financing model for deploying energy efficiency and RES measures for cultural heritage buildings. This includes development and implementation of an 'energy voucher' system with local schools and kindergartens.	To develop and scale an EC around a collective self-consumption mechanism. The pilot aims to demonstrate a stable financial and contractual model to develop a large citizen-driven EC (with about 300 members). This would become the first fully integrated EC system in Greece. The pilot will also experiment with strategies to support energy poor households.	Raising awareness about energy saving behaviours - 'energy sobriety' - by using serious games ((i.e., 'ZeroWatt'). And to support ECs to generate household energy savings and collective purchasing. In line with this, serious game ambassadors aim to trigger behavioural change among residents across France through peer-to-peer training and communication.	The pilot involves collaboration between a municipality (City of Leuven) and a REScoop (Ecopower). A support organisation will be developed to establish ECs of different types while tackling a wide range of challenges and organising several activities.
Description	050Buurtwarmte is a district heating project to be implemented by the energy cooperative Grunneger Power. A combination of different heat sources is used: aqua thermal energy source, underground heat and cold storage, and a district heat pump using renewable energy. A neighbourhood approach with ambassadors was adopted to persuade households to connect to the envisaged DH system.	Community energy in Croatia is in a nascent state. There is a need to set up the first professionally working REScoop in the country, to serve as a best practice. Through collaboration between a REScoop (ZEZ) and the City of Poreč-Parenzo, the pilot aims to develop replicable and scalable community engagement and innovative financing models for urban revival in several Croatian cities.	The pilot is about scaling of a collective solar PV plant project. This consists of a 300 kWp solar PV investment that will provide virtual self-consumption to 120 members of a REScoop (110 residential owners and 10 local SMEs). The electricity production of the plant is estimated at 446,000 kWh per annum with a generation licence for 25 years. In this collective virtual net-metering scheme members own a portion of the remotely installed collective solar PV plant.	The pilot is based on peer-to-peer learning. Enercoop will train 20 of its members on technical aspects and facilitation techniques. These community leaders will become "ambassadors", building a citizen group to help reduce and improve energy consumption, organise collective buying, or access financial support mechanisms relating to energy efficiency. A key tool ambassadors will use is the *energy sobriety* serious game 'Milwatteur', informing participants about energy saving behaviours they can potentially adopt.	The pilot entails a collaboration between the City of Leuven and Ecopower. They will explore long term collaboration models in order to support the development of energy communities in the city territory. The pilot entails four projects: 1) energy scans; 2) energy monitoring using 'EnergieID'; 3) community building targeting participation of at least 250 citizens; and 4) solar farm. The pilot also includes an *energy sobriety* ambassador program. Workshops and training sessions will be organised in different city districts and support energy groups to help them address legal, contractual and financial issues.

Appendix 2. Overview of implementation and performance of pilots

Table A2
Overview of pilots: implementation and performance on KPIs.

	050Buurtwarmte	Parentium	Hyperion II	Les Économes	LICHT Leuven
Description on state of development/ realisation	The pilot projects are in various stages of development. There are seven replication sites, each of them in an early stage of maturity (inspiration stage). Over the project duration the role of REScoop 'Grunneger Power' shifted towards citizen engagement, as well as unburdening households. As of January 2024, citizens showed interest in potentially connecting to a district heating system. 80 households signed contracts to connect to the DH system. Potentially, the pilot could end up with 135 contracts (i.e., intention agreements signed).	Implementation of the voucher model was significantly delayed. Solar PV options on a kindergarten building were limited to its chimney, which would bring additional cost and therefore negatively influence the business case. Therefore, alternative buildings were considered for RES development. Replication sites were in the inspiration and preparation stages. Two NGOs were founded with the aim to become ECs.	The pilot was in the operational stage with the collective solar PV plant becoming operational in March 2024. In addition, 120 households earned access to clean energy from their own respective solar PV installation. In Spring 2024 the operational focus shifted to demand response among 128 of its members. RES production and CO2 emissions reductions were expected to reach their pre-set targets. By 2024, a replication site had been running for a year and had achieved most of its targets.	There were about fifteen members in the pilot and about eight active citizens. In 2024, about 250 people were reached with the serious game 'Milwattheur'. Focus on building new partnerships to exploit the serious games. About 25 people took an interest in playing another game - 'The wheel of fortune'. There were three replication sites with one in the operation stage and two in the inspiration stage.	By 2024 the four projects were doing well. The heat pump was running and energy scans were performed. The 350 kWp goal was met through projects with non-residential buildings. There were five replication sites. They differed in terms of: stages of maturity, ranging from inspiration to operational stage.
Stage	Implementation	Inspiration, Preparation	Operation	Implementation	Operation [41]
Households reached [projected vs. involved]	236 vs. 151 (64%)	30–50 vs. 0 (0%)	120 vs. 70 (58%)	250 vs. 303 (121%)	1423 vs. 2057 (145%)
Estimated renewable energy production (MWh/yr) [estimation of planned -achieved]	1394 vs. 15 (1%)	4 vs. 0 (0%)	660 vs. 165 (25%)	N/A	872 vs. 722 (83%)
Estimated primary energy savings triggered (MWh/ yr) [estimation of projected – achieved]	N/A	930 vs. 930 (100%)	N/A	238 vs. 173 (73%)	1305 vs. 1305 (100%)
Estimated CO2 emission reduction (tons/ yr) [projected – achieved]	27,527 vs. 20 (1%)	20 vs. 20 (100%)	300 vs. 105 (35%)	N/A	254 vs. 254 (100%)
Investments (€) [projected – spent]	27,000,000 vs. 2,650,000 (10%)	327,000 vs. 324,000 (99%)	500,000 vs. 340,000 (68%)	N/A	744,801 vs. 744,801 (100%)

Appendix 3. Use of EC-PDT

The EC-PDT uses a survey containing over a 100 items spread over different development stages of CE organisational maturity (the more mature, the more items/questions raised) and thematic fields, primarily aimed at providing an EC with feedback on its level of organisational maturity and suggesting actions to take to increase this. The EC-DPT uses thematic domains, such as social (community), social (board and strategy), socio-demographic characteristics, organisation and strategy, financial, technical, policy and politics, and learning (each with sub-items of their own). Next to the survey, the EC-DPT allows for systematic measurement of selected key performance indicators (KPIs) of projects that EC organisations run. These projects may employ a wide variety of measures and technology like sustainable heat (e.g., installing a sustainable district heating system or heat pumps), energy savings and 'energy sobriety' (i.e. targeting energy conservation behaviours), solar PV, wind energy plants, bio-energy like biomethane production, or smart grids. Project KPIs include: households engaged (projected vs. involved); renewable energy production (planned vs. achieved; MWh/year); primary energy savings triggered (planned vs. achieved; MWh/year); CO_2 emissions reductions triggered; tonnes/year); total amount of money invested (euro); financial investment decision made (yes/no).

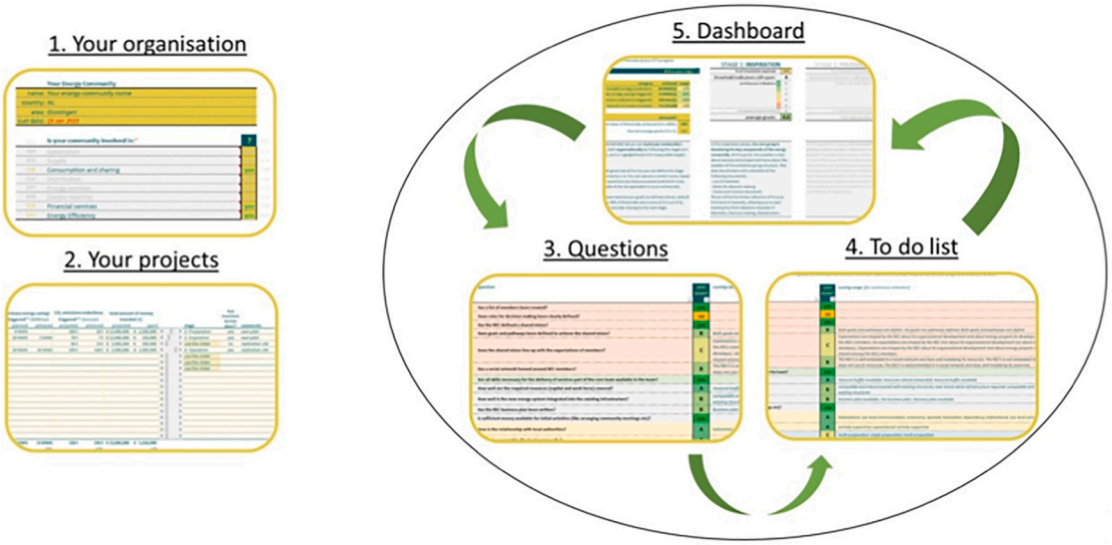


Fig. A1. Graphic overview of the step-by-step approach ('workflow') that EC pilot teams had to follow to submit quantitative data to the EC-PDT (involving both completing a survey and providing project data as input).

Data availability

Data will be made available on request.

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