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Advancing Climate Neutrality through Energy Communities and Citizen-Centered Contracts

Chinedu Okafor^{1*}, Amina Bello¹, Ibrahim Sule²

Abstract

Urban areas account for 65% of total energy use and generate 70% of global CO₂ emissions. Strong and targeted measures are essential to steer cities toward climate neutrality by 2050, with strategies designed by and for their inhabitants. In this context, the “100 climate-neutral cities Mission” sets the deadline for achieving climate neutrality at 2030. This paper, developed under the H2020 GRETA project—GReen Energy Transition Actions (GA101022317), explores energy communities and climate city contracts as central instruments for realizing the challenging vision of citizen-focused, climate-neutral urban environments. To meet this goal, the paper is arranged in the following sequence: (1) a refreshed review of European and Italian rules governing energy communities; (2) a concise presentation of the concept and core elements of climate city contracts; (3) a choice and evaluation of real-world energy community examples; (4) an outline of pilot climate city contracts that have already been established. The outcomes deliver enhanced understanding of EU-level energy community approaches and of the contractual mechanisms capable of securing mutual obligations among involved parties while promoting direct citizen involvement in the energy system. These insights support the rollout of the GRETA project’s Italian case study, including a description of its early citizen participation efforts.

Keywords Climate-neutral and smart city, Energy community, Climate city contract, Energy transition process, Citizen engagement, Energy citizenship contract

*Correspondence:

Chinedu Okafor

chinedu.okafor@unilag.edu.ng

¹ Department of Electrical Grid Analytics, Faculty of Engineering, University of Lagos, Lagos, Nigeria

² Department of Smart Energy Systems, Faculty of Engineering, Covenant University, Ota, Nigeria

Introduction

Given that climate change and the broader environmental emergency pose a severe worldwide risk, the European Union has introduced multiple energy-related goals that every Member State and local government must follow: the European Green Deal establishes the main aim of cutting emissions by 55% by 2030 and attaining full climate neutrality, meaning zero CO₂ emissions, by 2050 [1]. As a key component of the Green Deal, the EU Climate Law works to translate the 2050 targets into binding European legislation [2]. Meanwhile, the Fit for 55 package steers EU laws toward meeting the 2030 greenhouse gas (GHG) reduction objectives and the longer-term 2050 perspective [3]. A further push comes from the EU initiative known as “100 climate-neutral cities by 2030—by and for the citizens” (commonly referred to as the “Cities Mission”). This forms part of the Mission on Climate-Neutral and Smart Cities [4], which is one of the EU Missions funded through the Horizon Europe programme. Under this programme, Horizon Europe plans to dedicate EUR 360 million to research and innovation efforts connected to the Cities Mission between 2021 and 2023. The 100 Climate-Neutral Cities Mission seeks to identify, support, and highlight 100 leading EU cities aiming to reach climate neutrality by 2030, positioning them as innovation testbeds and benchmarks for other municipalities. Reaching this demanding target

requires both ecological and cultural shifts, engaging a wide range of actors, including public bodies, companies, researchers, and residents [5]. At the “Conversations on the New European Bauhaus” conference on 22 April 2021, Ursula von der Leyen highlighted that moving toward a climate-neutral Europe essentially means undergoing a cultural change, because success depends on the transition being understood, debated, and collectively embraced by citizens [6].

Over the last 10 years, the contribution of citizens to urban energy transition efforts has remained limited, hindering progress toward meeting energy objectives [7]. The most recent evaluation report from the Covenant of Mayors indicates that the residential building sector produces the highest share of emissions, responsible for 28.3% of overall CO₂-eq output [8]. This highlights that the shift to sustainable energy in privately owned homes—where citizens play the leading role—lags significantly behind other areas, a point also confirmed by statistics in the Bologna Sustainable Energy and Climate Action Plan (SECAP) [9]. As a result, citizen involvement must be strengthened by adopting more effective participation methods and joint planning approaches, while redefining the position of individuals and local groups as proactive collaborators. In addition, such participation should be made consistent and official through formal agreements between citizens, public authorities, and all other parties active in the energy transition [10]. A valuable way to establish this structured relationship is through the newly introduced legal concept of Energy Communities. These communities are considered among the most important practical steps toward achieving energy targets and are integrated into comprehensive energy planning documents, including the Covenant of Mayors SECAPs. Such SECAPs serve as practical instruments that enable public administrations to align medium- and long-term actions and fully benefit from collective initiatives [11]. Both the meaning of energy communities and the practical steps for creating them are closely linked to existing legal and regulatory frameworks at the European, national, and local levels [12]. Many of the most effective energy community projects have been launched by local public authorities—for instance, the Magliano Alpi Community in Italy (<https://cermaglianoalpi.it/>, accessed on 15 December 2021). Public bodies can take a leading role in organizing and implementing energy-saving and sustainable initiatives, while actively mobilizing citizens as essential participants in the city’s energy transition.

The Cities Mission positions citizens at the core of decarbonization efforts, acknowledging their simultaneous and interconnected functions as political decision-makers, energy end-users, generators, buyers, and asset holders. To more effectively understand and harness this citizen role in urban energy transition initiatives, the mission has established the Climate City Contract [4]. This instrument articulates the collective vision and binding pledges of all participants toward the mission’s targets, with strong emphasis on inclusive participation methods and cross-level governance partnerships. These factors are regarded as essential catalysts for sparking innovation and driving systemic change toward climate neutrality.

The main purpose of this paper is to provide a qualitative assessment of selected established energy communities, with a special focus on the citizen involvement techniques and approaches that facilitated their formation and support the achievement of their objectives.

This investigation takes place within the context of the ongoing H2020 “GRETA—Green Energy Transition” project (<https://projectgreta.eu/>, accessed on 3 December 2021), financed under the call H2020-LC-SC3-2018-2019-2020 Building a Low-carbon, Climate Resilient Future: Secure, Clean and Efficient Energy, grant agreement GA101022317. Launched in May 2021 with a 30-month duration, the GRETA project aims broadly to expand knowledge of the enabling factors and obstacles to active citizen participation in the energy system to advance both local and global decarbonization goals. The project uses case study analysis of diverse energy citizenship practices operating at different territorial scales and settings as its primary method. This approach serves to map the current state of energy citizenship and to develop and evaluate practical methodologies for initiating and sustaining it over time.

Expanding community participation in green energy transition initiatives remains difficult [13]. Many citizens have a limited understanding of the intricate mechanisms of energy markets. They are often unaware of the potential advantages available to them when joining actions, either individually or as organized groups. Persistent technical and cultural

obstacles continue to create barriers, resulting in exclusion and disparities. Consequently, novel methods and tactics are required to accelerate the clean energy shift while aligning with the principle that energy represents both a fundamental social need and a democratic imperative [14]. It is therefore essential to equip communities with robust, proven instruments alongside customized, locally adapted approaches to establish and organize relations with all stakeholders active in the transition [15]. In the GRETA project, the specific tools created to clearly state, formalize, and govern reciprocal benefits, rights, and obligations are termed Energy Citizenship Contracts (ECCs). These draw conceptual inspiration from traditional social contracts [16], citing Rousseau, as “a form of social organization in which the role of the state is to assure and guarantee rights, liberties or freedoms, and equality”) and from the recently formulated Climate City Contracts linked to the “100 climate-neutral cities by 2030” mission. For this reason, the paper’s second objective is to examine existing types of climate- and energy-focused contractual frameworks that organize and regulate citizen participation in collective endeavors. When investigating the legal connections and responsibilities among citizens themselves and between them and other involved parties, energy communities constitute the central area of study, as they embody the most mature organized expressions of citizen engagement currently operating in the energy domain.

In conclusion, the paper outlines the initial citizen participation activities undertaken in the Italian GRETA case study in Boulanger *et al.* [17].

Energy communities: legislative framework updates and the Italian legislation transposition

The notion of energy community first emerged with the Clean Energy for all Europeans package [18] and received detailed elaboration and formal definition through the Renewable Energy Directive (EU) 2018/2001 [19] and the Directive on common rules for the internal electricity market—Directive (EU) 2019/944 [20]. Regulations at national and regional levels concerning energy communities have been shaped under the overarching provisions of European Directive (EU) 2018/2001 (RED II) on promoting renewable energy sources. As set out in RED II, a Renewable Energy Community (REC) is a legal entity grounded in open, voluntary membership. It has the right to generate, consume, and commercialize energy from renewable sources, with the primary purpose of delivering environmental, economic, or social benefits to its community members, stakeholders, or the surrounding local territory. RECs may be established by natural persons, small and medium-sized enterprises (SMEs), or local authorities such as municipalities. Separately, Directive (EU) 2019/944 defines the Citizen Energy Community (CEC), whose purpose is to “recognize certain categories of citizen energy initiatives” and “provide them with an enabling framework, fair treatment, a level playing field, and a well-defined catalogue of rights and obligations” [20] p. 7. The CEC concept diverges from the REC in that its operations are confined exclusively to the electricity sector [21].

Furthermore, CECs prioritize returning benefits specifically to their members, stakeholders, or the local territory in which they operate, and do not require geographical proximity, unlike RECs [17]. In broader terms, CECs constitute “a potentially more inclusive model than RECs, since participation is not restricted to a specific location” [21] p. 4. The energy community concept maintains a close link with energy citizenship, an idea that delves deeper into the sociological, cultural, and technological facets of collectively shared energy systems [13, 22].

A standout innovative feature of the RED II is the setting out of targeted provisions governing the self-consumption of energy and the deployment of renewable sources to satisfy electricity, heating, and cooling needs. The drive to manage available energy resources more efficiently and sustainably — particularly amid rising population figures — finds a practical response in the principle of shared energy. This shifts the entire mindset away from isolated individual generation and usage toward production and consumption organized collectively within communities. Meanwhile, the RED II positions the generation of power from renewable sources as a vital measure to address climate change, safeguard natural systems, reduce dependence on imported energy, and advance industry and technology. The REC model opens new avenues for advancing smart cities and communities toward climate neutrality while assigning a pivotal role to active citizen involvement.

Numerous EU member states have carried out reviews and revisions of their domestic regulations to meet the requirements of this overarching European framework. The exercise has proven intricate, given the overlapping economic, social, technological, and environmental dimensions at play [23]. Within Italy, the initial incorporation of the RED II occurred via the “Milleproroghe” Decree n. 162/2019 [24] along with its later adjustments [25]. Decree 162/2019 [26] promotes closer cooperation between government bodies and private players, while enhancing engagement with local groups and residents to help achieve energy-related targets. It sets the framework for groups that share energy with the aim of joint self-consumption, centered on delivering combined economic and environmental gains. Any energy user may join these groups, regardless of whether they own a photovoltaic setup, storage equipment, or support cleaner energy sources.

The scale of each energy community is governed by a generation facility limit set at 200 kW. A notable subsequent advance on the national stage came with Decree n. 199/2021 [25], which fully aligns with the RED II. This measure expands the allowable community-scale to 1 MW, setting the ceiling for eligibility for direct support incentives. With this change, a concrete and workable national framework has at last been finalized. Even so, energy policy in Italy falls under both regional and national authority. Full operational capability for energy communities, therefore, depends on adoption across all 20 Italian Regions. So far, only a limited number of Regions have enacted relevant rules, and those predate Decree 199/2021 [26–29]. Several others, notably Lombardia and Emilia-Romagna, continue developing updated regulatory structures [30, 31]. These circumstances demonstrate that building functional energy communities is still a work in progress and remains some way from delivering tangible, effective contributions to urban energy transition. One resulting gap is the lack of standardized national directions on formalizing citizen participation efforts. As explored further ahead, communities have turned to diverse contractual solutions tailored to their size, legal setup, stated aims, and the specific traits of the participants involved.

Nationally, a broad picture of energy community formation is presented in the Legambiente ArcGIS Map [32], which charts 26 Italian initiatives. These break down into three already established communities and twenty-three still under development. Among the active, functioning examples, Legambiente specifically notes the following:

- Pinerolo (Piemonte Region)
- Magliano Alpi (Piemonte Region)
- Napoli (Campania Region)

Definition and key aspects of climate contracts at the city level

This section provides a concise survey of the key climate-related agreements operating at the municipal level, based on an examination of leading EU initiatives and strategic planning efforts aimed at climate objectives and the shift to cleaner energy. The Climate City Contract fits within the earlier referenced Cities Mission, described as “a new mechanism to deliver EU support to cities in the form of more innovation, better regulation, and integrated financing” [4]. Its creation responds to the need to affirm a more dynamic role for citizens, whose contributions can receive backing through purpose-built platforms and funding streams. Per the Cities Mission guidelines, signatories comprise the local authority (led by the mayor), local interest groups, national or regional bodies, and the EU Commission in an observer capacity. The Climate City Contract serves to record the formal pledges of all participants, thereby reinforcing citizen empowerment and enabling individuals to carve out their place in the broader energy transition. This notion is further detailed in the “Info kit for Cities” [33], issued in October 2021 by the European Union to assist municipalities preparing submissions for the expression of interest (EOI) process to join the Cities Mission. The call opened in November 2021 and concluded in January 2022.

At the heart of the mission stands the Climate City Contract. It takes the form of a voluntary, non-binding agreement cast in the style of a memorandum of understanding. The choice of the term “contract” emphasizes the firm political undertaking by the city toward its inhabitants, as well as toward the Commission and higher-level authorities. Drawing from the “Info Kit for Cities”, the pathway to net-zero emissions by 2030 covers core elements, including building blocks, governance and stakeholder engagement; the Climate Neutrality planning process; GHG emissions accounting and target setting; accounting for residual emissions; and GHG emissions roadmaps. A clear illustration of cities that have already committed to climate neutrality by 2030 is offered by the 23 Swedish municipalities engaged in the Viable Cities strategic innovation programme (<https://en.viablecities.se/> (accessed on 14 December 2021)). Nine among these Viable Cities have already prepared their Climate City Contracts 2030 (further information appears later in this paper).

In other regulatory settings, climate contracts are defined and interpreted differently. Notable examples include the Local Pact for Transition [34] and the Green City Accord [35]. According to the Energy Cities publication [34], the Local Pact for Transition refers broadly to the mechanism by which municipalities establish their own Participatory Agreement for the Climate Transition (PACT). This is achieved by adapting the Paris Agreement to the local urban context. The main purpose is to outline a detailed roadmap for reaching climate neutrality by 2050, while accounting for the municipality's specific powers and the overall climate impact of activities within the city. The Green City Accord is a European-level initiative that advances sustainable practices across five core environmental domains through formal city commitments: air quality, water, nature and biodiversity, circular economy and waste, and noise pollution. Unlike the Climate City Contract, the Accord is less focused on citizen involvement. It does not emphasize the formalization of commitments from the city and its various stakeholders to the same extent. Furthermore, the 100 cities chosen for the mission have their climate-neutrality goals advanced by 20 years, which demands intensive planning and execution efforts that rely on the full engagement and cooperation of all relevant actors.

At the city level, another prominent instrument, previously referenced, is the Covenant of Mayors [36]. Launched in 2008 across Europe, it seeks to unite local authorities that voluntarily pledge to fulfill the EU's climate and energy objectives for the period 2020, 2030, and 2050 targets. Signatories, typically Mayors or their official delegates, present the city's intended measures within the Sustainable Energy and Climate Action Plan (SECAP). A standardized procedure is employed to track energy use in both the public and private domains, while also outlining forthcoming steps for climate change mitigation and adaptation. The SECAPs are prepared according to a well-defined methodology that establishes guiding principles, operational procedures, and recommended best practices. These plans are revised every two years based on monitored urban energy consumption data covering private and public buildings, public lighting systems, mobility, and the tertiary and industrial sectors [11]. They serve as a proven instrument for public authorities to steer and evaluate their advancement toward the established climate objectives.

Materials and Methods

The examination of energy communities and climate contracts, viewed as multi-level co-creation mechanisms and practical means to boost citizen participation in the clean energy transition of cities, draws its foundation from the framework outlined in the report “100 Climate-neutral Cities by 2030—by and for the Citizens” [4]. The report presents the goals, strategy, and timeline of the mission “100 climate-neutral cities by 2030,” submitted by the Mission Board for climate-neutral and smart cities to the European Commission under the Horizon Europe framework programme. One of the core principles underpinning the mission is the ongoing cooperation among all stakeholders engaged in the climate transition, with the enhanced involvement of citizens identified as essential for meeting the 2030 energy goal.

This study also builds upon the content of the “Info Kit for Cities”, which was released as a practical resource to aid cities in preparing their applications for climate neutrality under the mission [33]. Within these documents, the Climate City Contract is characterized as a dynamic instrument that encompasses energy objectives, specific targets, strategies, and detailed action plans for the transition process. At the same time, it highlights the importance of participatory methods and collaborative multi-level governance. The two documents referenced earlier [4, 33] served to explore the connections

between the energy community framework, in light of its revised legislative context, and emerging climate contracts that actively incorporate citizens into the energy transition.

To align with this purpose, the research methodology follows a dual-track strategy:

- A qualitative review of the existing literature concerning climate, social, and energy contract concepts. This review was conducted via the Scopus database (<https://www.scopus.com/>, accessed on 18 November 2021) and Google Scholar (<https://scholar.google.com/>, accessed on 20 November 2021), with particular attention to their relevance and application within community-level energy transition initiatives;
- A bottom-up investigation based on the analysis of real-world examples of established energy communities. This component benefits from an earlier GRETA project publication [17] that provides a broader qualitative perspective on effective approaches to initiating and expanding energy communities. The current work concentrates mainly on the contractual arrangements that govern their formation, along with socially innovative practices and participatory methods as the primary enablers.

Selection of papers about energy/climate/social contracts

To identify suitable publications for the literature review, a structured search was conducted in the Scopus database (<https://www.scopus.com/>, accessed on 18 November 2021). The query targeted the title, abstract, and keywords fields using the terms: “Energy” or “Climate” combined with “Social Contract”, “Energy Contract”, and “Climate Contract”.

The retrieved body of literature, comprising journal articles and conference papers, underwent relevance filtering based on selected subject categories deemed especially pertinent to the study (such as “Energy”, “Environmental Science”, “Social Sciences”, and others). The selection was subsequently restricted exclusively to Open Access publications.

This procedure produced a set of 71 peer-reviewed documents. The authors performed an in-depth analysis and review of these materials, followed by an additional refinement stage that narrowed them down to those most closely aligned with the central research questions. **Figure 1** illustrates the methodological steps applied during the literature selection process.

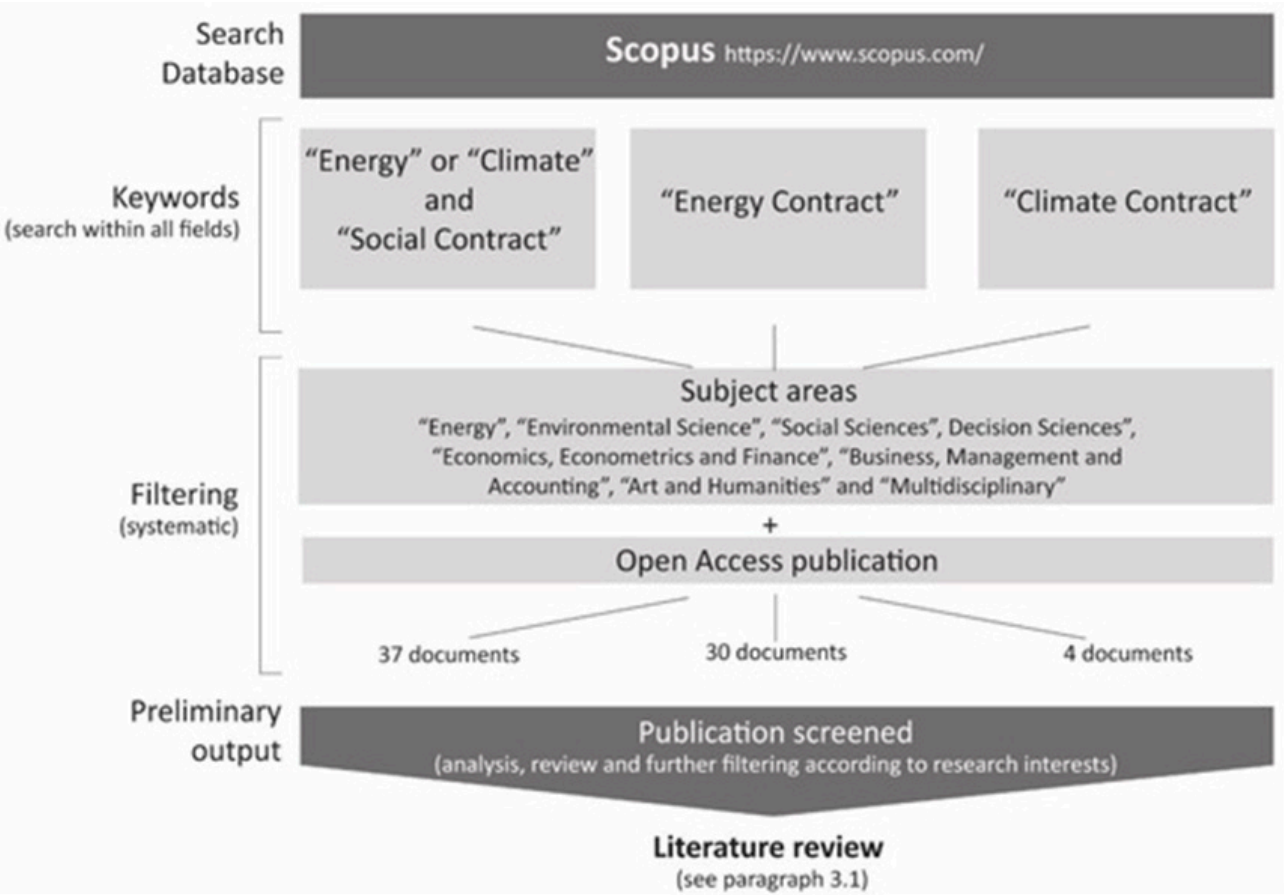


Figure 1. Literature review methodological approach.

Additional searches using identical keywords were also conducted on Google Scholar (<https://scholar.google.com/>, accessed on 20 November 2021). When combining “Energy” or “Climate” with “Social Contract”, the platform returned 18 hits in total, six of which were pertinent but had already been captured in the Scopus query. Searches for “Energy Contract” and “Climate Contract” yielded several hundred entries; however, the bulk of these materials fell outside the scope of the current study, as they focused on commercial, economic, administrative, or technical matters.

Taken together, these database queries delivered mostly weak or unrelated findings. Strikingly, the specific phrase “energy citizenship contract” yielded no results in either Scopus or Google Scholar. This outcome underscores that scholarly discussion of energy contracts operating at the community scale—especially those that formally embed citizen participation—remains scarce and calls for deeper exploration and debate.

Selection of case studies

As indicated previously, the literature review on Climate City Contracts was supplemented by an investigation into real-world examples of established energy communities or comparable initiatives (hereafter, referred to as energy communities to keep the text concise). Particular attention was paid to the legal instruments or binding agreements that connect all parties, shape their interactions, and define each participant’s rights and responsibilities [37]. The chosen examples were taken from up-to-date publications and the latest cutting-edge research conducted at both European and country-specific levels [38–40], focusing on operational energy communities that have extensively used inclusive, participatory methods.

This work on case studies further benefited from advancements within the GRETA project, notably the activities underway in Work Package 5, entitled “Community Transition Pathways for decarbonization across geographical levels” (WP5) and led by the University of Bologna. WP5 aims to pinpoint the primary drivers of the rise and development of energy citizenship, analyze how it interacts across various territorial scales, and determine the circumstances in which such citizenship practices can help achieve broader decarbonization policy aims. As part of this package, an initial group of energy communities and related entities was identified, and key details for each were compiled into a dedicated template. Among the fields covered were: Presence of innovative business plan; Presence of normative framework that enables the energy community’s creation; Presence of innovative technologies; Presence of innovative cooperation streams; Presence of innovative contracts; Keywords that better describe the case study; Critical elements of the community; Positive and replicable elements; Main milestones towards the creation of energy community; Other interesting elements.

For the aims of the present article, a narrower range of data was extracted, assembled, and grouped to allow straightforward comparison between cases and to facilitate a thorough critical assessment. The resulting information, summarized and arranged in **Table 1**, includes the following elements:

Table 1. Main features of the selected case studies: location, dimension, contract typology, stakeholders, and evaluation of citizens’ engagement.

Case study	Scale	Contract type	Stakeholders	Citizen engagement level
Oborniki Slaskie 1 (Poland)	Local	Bioenergy community (in the process of being established)	Local authorities, citizens	Aware
Tirano 2 (Italy)	Regional	Energy Cooperative	Local municipalities, the district heating company, research centers, and citizens	Aware
Thessaly 3 (Greece)	Regional	Energy Community	Municipalities, SMEs, and local associations	Aware
Basque Country & Navarra (Spain) 4	Regional	Energy Cooperative	Local municipalities, industry, and citizens	Involved
Courant d’Air 5 (Belgium)	National	Social Enterprise Cooperative	Natural or legal persons who subscribe to the statutes	Involved
Marstal Fjernvarme 6 (Denmark)	Local	Social Enterprise Cooperative	District heating company, general consumers	Aware
Svalin 7 (Denmark)	Local	Energy Community (co-housing)	Residents	Involved
Enercoop 8 (France)	National	Social Enterprise Cooperative	Consumers and producers	Aware
SAS Ségala Agriculture et Energie Solaire Cooperative 9 (France)	Regional	Energy Cooperative	Farmers	Involved
Som Energia 10 (Spain)	National	Energy Cooperative	Consumers and producers	Involved

Solbyn Association 11 (Sweden)	Local	Cooperative housing association	Building company, citizens	Involved
Magliano Alpi 12 (Italy)	Local	Energy Community	National and local public authorities, local industries, research centers, and citizens	Involved
Melpignano 13 (Italy)	Local	Energy Cooperative	Local authority, industry, university, and citizens	Involved
Banister House Solar 14 (United Kingdom)	Local	Energy Enterprise	Industry, citizens	Involved

1- <https://www.becoop-project.eu/pilot-areas/poland/> (accessed on 15 December 2021); 2- <https://www.becoop-project.eu/pilot-areas/italy/> (accessed on 15 December 2021); 3- <https://www.becoop-project.eu/pilot-areas/greece/> (accessed on 15 December 2021); 4- <https://www.goiener.com/> (accessed on 15 December 2021); 5- <https://www.courantdair.be/wp/> (accessed on 15 December 2021); 6- <https://www.solarmarstal.dk/> (accessed on 20 December 2021); 7- <https://www.housingevolutions.eu/project/svalin-co-housing-p2p-energy-community/> (accessed on 15 December 2021); 8- <https://www.enercoop.fr/> (accessed on 20 December 2021); 9- <https://energie-partagee.org/projets/segala-agriculture-energie-solaire/> (accessed on 15 December 2021); 10- <https://www.somenergia.coop/> (accessed on 20 December 2021); 11- <http://www.solbyn.org/> (accessed on 20 December 2021); 12- <https://cermaglianoalpi.it/> (accessed on 20 December 2021); 13- <https://www.comunirinnovabili.it/cooperativa-di-comunita-di-melpignano/> (accessed on 15 December 2021); 14- <https://www.repowering.org.uk/> (accessed on 15 December 2021).

- Location (North/South Europe): the chosen case studies span both Northern and Mediterranean areas of Europe.
- Dimension of energy community: the size and reach of these initiatives matter for the research, since they reveal the community's scale and therefore the likely magnitude of its influence on the population.
- Typology of community's contract: the nature of the contractual or legal foundation supporting each energy community was reviewed, highlighting parallels and distinctions through direct comparison.
- Stakeholders: the core participants and drivers of every energy community were mapped to clarify which actors initiate and steer the overall strategy.
- Level of citizens' engagement process: this factor is particularly important, as it reveals how energy communities connect with climate city contracts and can help embed and secure citizens' active contribution to the transition.

In total, the research presented in this paper examined 14 energy communities together with energy citizenship initiatives. This collection emerged from cross-referencing examples found in the academic literature, European project documentation, and the inventory assembled under GRETA WP5."

Results and Discussion

Contract literature analysis within the selected documents

Linking the notion of a social contract to the clean energy shift and the move toward sustainable systems demands a major overhaul of how societies function. Such a change hinges on obtaining clear legitimacy and buy-in from citizens. Messner [41] points out that "like the low-carbon transformation, the process of industrialisation was above all an energy regime change. However, industrialisation cannot be solely reduced to a fundamental change in the energy system.

Similar to the ideas, concepts, and theories of the Enlightenment in advance of the industrial revolution, the sustainability discourses can be interpreted as cognitive and normative innovations serving to prepare the way for economic and technological transformation processes" [41]. The writer reviews the emerging building blocks of a sustainability-focused social contract, beginning with a historical survey of the idea and condensing scholarly discussions of the social arrangements needed for low-carbon growth and lasting development.

Ziegler [42] notes that discussions of the social contract have mostly remained in the realm of theoretical and philosophical reflections on fairness, thereby sidelining its real-world usefulness and opportunities. To avoid overlapping terms, "social agreement" is proposed as a grounded version of the social contract. It does not attempt to cover everything but instead zeroes in on a defined area, for instance, energy delivery. The article shares various practical instances of these context-driven social agreements.

Pihl *et al.* [43] conduct a horizon scan that pulls together the most noteworthy takeaways from recent advances in cross-disciplinary climate change research (mainly those published in 2019–2020). The work condenses observations from the extensive, multi-field domain of climate research, spotlights essential conclusions, and emphasizes those that offer strong support for policy decisions grounded in evidence. Drawing on their review, the writers propose enduring adjustments to governance systems and the creation of a new social contract to address climate issues, informed by experiences with the pandemic. They frame both climate change and COVID-19 as broad systemic threats that individual governments, community groups, or businesses cannot tackle in isolation. The study stresses that "systemic risks will require innovative, adaptive, reflexive, transparent, participatory and accountable approaches to governance. Rapid, networked, transformative responses that foster greater trust and more just relationships between diverse actors will be indispensable to creating a thriving and equitable global future for all" [43].

A frequent topic in the examined papers revolves around identifying which political entities possess the rightful authority to launch and steer an updated social contract. They also examine the possible contributions from energy governance at global, regional, national, or local scales in achieving needed shifts in conduct, economic patterns, and technology [44], as well as the contributions that urban centers [45] or networks of equal partners sharing sustainable resources and services [46] could make.

Cassen *et al.* [47] connect the push to renegotiate the social contract to specific tax and budget adjustments, as well as financing tools to expand and spread small-scale low-carbon trials. The goal is to drive major overhauls in physical systems and fundamental changes in how people act. They also highlight the serious hurdles, which vary widely across the EU and depend on each nation or region's political context and global decarbonization trends.

Hewitt *et al.* [48] conducted a comprehensive review of the literature on the societal aspects of renewable energy sources. They gathered, outlined, and charted projects from 7 EU nations, including the UK. Their purpose was to identify features of Social Innovation (SI) across various types of citizen-initiated renewable energy efforts, grouped as community energy (CE). The shared element across these projects is the strong role given to citizen involvement in dealing with energy matters. Social Innovation proves useful here, as it tackles broader societal issues by reshaping common practices, aiming to boost the overall quality of life through active input from civil society. Because it centers on participation in the energy sphere, community energy counts as one expression of Social Innovation and ties into the process of "creative reconfiguration of social relations" in the energy sphere.

The writers observe that "the strategic approaches to energy transition currently being advanced by European policy-makers remain firmly anchored to this earlier 'technology-focused' innovation paradigm, and do not seriously contemplate any form of genuine reconfiguration or 'new social contract for energy'" [48]. This study further reviews key societal aspects of community energy, including legal frameworks, organizational models, types of energy involved, and municipal projects that incorporate citizen roles.

Within the special issue focused on Social Innovation and the Energy Transition, Hoppe and de Vries [49] explain that “social innovation may also entail to issues like introducing new energy practices (i.e., related to the likes of production, storage, distribution, and use), new behaviors and relationships for supporting and managing social groups or new solutions that contribute to low carbon energy transition and at the same time to solving social problems.” They portray social innovation in energy transitions as “innovations that are social in their means and contribute to low carbon energy transition, civic empowerment and social goals about the general wellbeing of communities” [49].

In addition to examining the social dimensions of contracts arising in energy transition efforts, scholars have also explored the idea of climate contracts. Gudde *et al.* [50] suggest that a local area climate contract could serve as the cornerstone of an updated governance structure to align national policies with local ambitions under a common Net Zero agenda. According to the authors, “a Local Area Climate Contract is therefore proposed functioning within a new governance framework of cooperation based on agreed Climate Freedoms” [50]. These climate freedoms are governed by заранее defined rules and are intended to dismantle obstacles that hinder local authorities from addressing the climate crisis. They grant local bodies greater leeway to secure funding, coordinate stakeholders, and provide infrastructure, goods, and services to reduce carbon emissions. The proposed governance model not only clarifies relations between central and local government but also opens avenues for citizen participation, thereby creating “the opportunity to reinvigorate the social contract between the individual and the local authority” [50].

In Isaksson and Heikkinen [51], climate contracts are described as formal arrangements between municipalities and major energy firms to advance sustainability transition objectives. The discussion is grounded in the experience of the Hyllie district located in Malmö, Sweden. The researchers track developments after the contract was signed and evaluate its real-world effects on sustainability progress. Their work concludes that “the greatest potential of the climate contract lies not in its direct impact on reducing energy demand and climate emissions, but in the institutional innovation that it represents” [51], primarily because it establishes a fresh model of cooperation between public institutions and private companies. Evidence shows that cities can pursue ambitious, long-term sustainability goals more successfully when they enjoy explicit backing from both regional and national governments. The Malmö climate contract is further examined in Parks [52]. By closely reviewing lessons from Malmö, the author assesses how the strategic outlook embedded in a climate contract can influence urban transformation and whether such contracts bear direct responsibility for driving the city’s energy transition. A broad initial vision of the transition route should be part of climate contracts, yet this vision may later be refined in response to evolving socio-technical realities. The author notes that “in such techno-promissory moments, the vision is no longer translated into the socio-material relations of assemblages; instead, it is the state of socio-material assemblages that becomes translated into new promises.” [52].

The bulk of academic work on energy contracts focuses on the rules governing local energy trading between buyers and sellers, or among different prosumers. For this study, contracts that focus solely on market mechanisms are not considered directly relevant and are therefore set aside. Only a handful of papers are mentioned here because they explore methodological routes for creating contracts specifically in energy community settings. Kirli *et al.* [53] propose a systematic approach to smart energy contracting, centering on “the two mainstream application areas identified for smart contract use: energy and flexibility trading and distributed control” [53]. Turning to consumer preferences, Chakraborty *et al.* [54] “present an automated peer-to-peer (P2P) negotiation strategy for settling energy contracts among prosumers in a Residential Energy Cooperative (REC), considering heterogeneous prosumer preferences” [54]. In a similar vein, Wang *et al.* [55] introduce a P2P energy-sharing framework for energy community models in which, by employing an energy contract to oversee exchanges, “participants form an alliance and can trade energy with each other to maximise individual benefit without a central controller” [55]. Placing stronger weight on the position of prosumers [56] presents a decision-support platform for bilateral negotiations that features 10 combinable strategies to be applied throughout the bargaining process in electricity markets.

Citizenship’s engagement analysis within the selected case studies

Recent EU energy policies regard citizen participation in collective energy initiatives as an essential approach and an effective pathway for accelerating the green transition. In particular, energy communities aim to expand the adoption of renewable energy sources by introducing novel sharing arrangements in which citizens act as the primary participants [57]. It is worth noting that the 14 case studies examined here do not all qualify as formal energy communities. The legal framework for establishing energy communities, as set out in EU directives, is not yet available in all member states due to the absence of national or regional regulations. Because this research seeks to reflect all major geographic zones across the EU, the case study review was expanded to encompass other collective renewable energy efforts involving prosumers [21].

This section summarizes the outcomes of the case study analysis, highlighting their core features and the conditions that support their success. Special emphasis is placed on the participatory approaches that shaped citizen engagement processes.

The 14 case studies were deliberately chosen to represent both Northern and Mediterranean regions of Europe, as displayed in Figure 2.

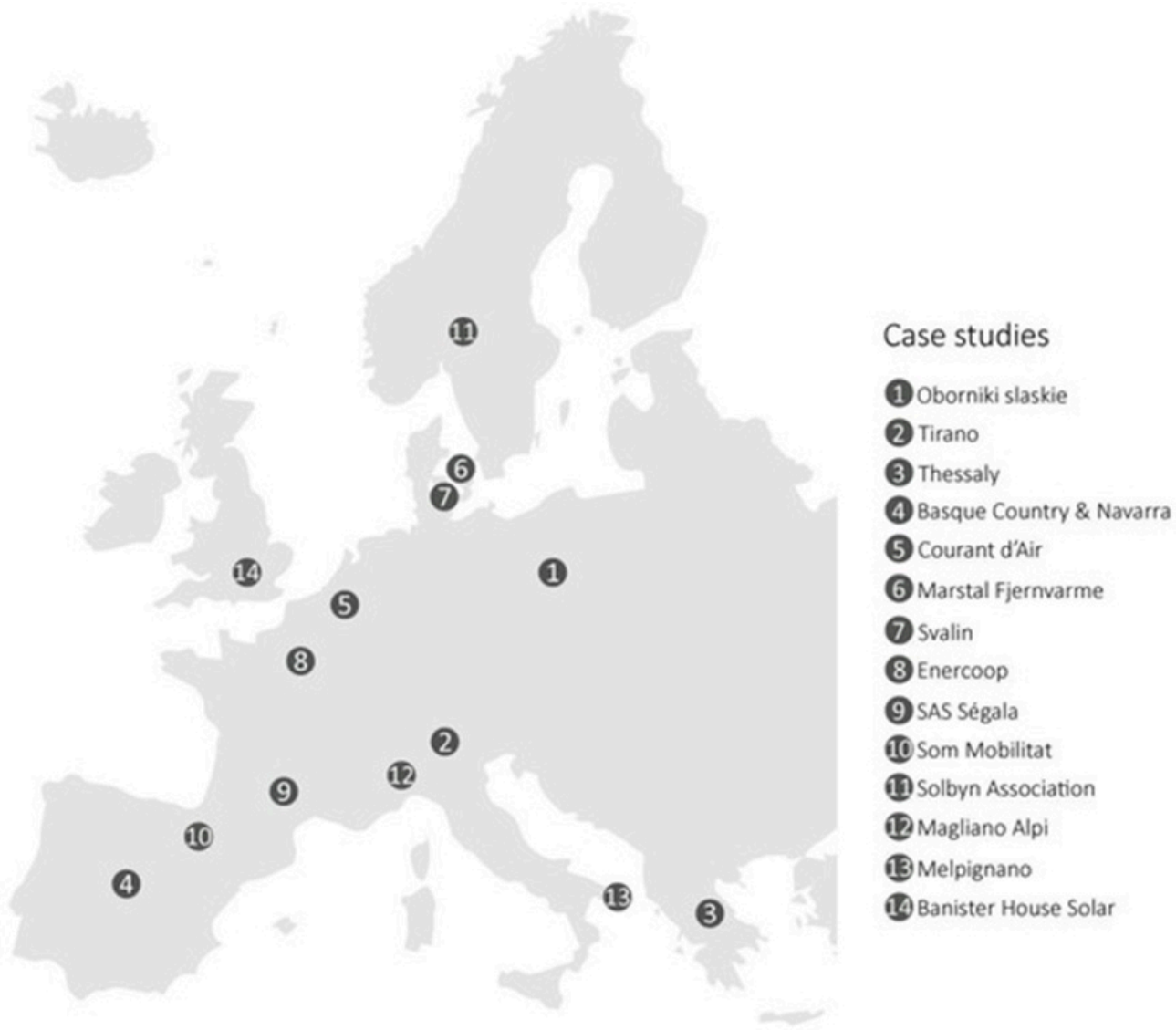


Figure 2. Distribution of the analyzed case studies. Infographic made by the authors.

The enabling factors examined for each case study are summarized in **Table 1** and elaborated further in the text below.

Dimension of the case studies

Three distinct scales were defined for the dimensions of the case studies:

- “local” – where the energy community operates within an urban or rural zone connected to a single city;
- “regional” – encompassing urban zones that span the jurisdiction of several cities;
- “national” – enabling participation from people across the entire country.

The chosen scale provides a clear sense of the energy community’s reach, particularly regarding how many citizens are affected and how deeply they can be engaged. Local and regional energy communities tend to rely heavily on nearby renewable energy installations that serve the community directly. At the local level, these installations are usually rooftop solar photovoltaic systems mounted on buildings, as observed in Svalin (Denmark), Magliano Alpi (Italy), Melpignano (Italy), and Banister House Solar (UK). Renewable generation can also involve solar thermal collectors feeding into shared district heating systems, such as the Marstal Fjernvarme project (Denmark), or combinations of photovoltaic panels and wind turbines, such as the Solbyn eco-village (Sweden). At the regional level, installations often include large-scale rooftop or open-countryside photovoltaic arrays—for instance, the SAS Ségala Agriculture et Energie Solaire Cooperative (France), which was formed specifically to deploy solar PV on farm buildings. Biomass facilities supplying district heating networks in regional settings are located in Tirano (Italy), Thessaly (Greece), and the Basque Country & Navarra (Spain). At the national level, any citizen can join the community either by purchasing renewable energy produced locally by the community’s own facilities, as practiced by Enercoop (France) and Som Energia (Spain), or by buying shares to support renewable energy projects specified in the community’s governing documents, as seen with Courant d’Air (Belgium).

Contracts’ typology

Energy communities prioritize distributing the financial gains they generate among their own members instead of seeking profit for outside parties [58]. To clearly outline and secure the terms of collaboration, a variety of legal forms are employed to facilitate citizen involvement in the energy system [33]. In the present study, the term “contract” is used broadly to describe any formal agreement that spells out a clear pact among individuals or groups. It does not need to be a legally enforceable document. A comprehensive overview of the regulatory landscape surrounding Renewable Energy Communities (REC), Citizen Energy Communities (CEC), and jointly acting renewable self-consumers across nine EU countries and regions is provided in **Table 2** [21].

Table 2. Focus on relevant citizens’ engagement initiatives.

Case study	Citizen engagement initiatives	Links to initiatives
Basque Country and Navarra (Spain)	New business line for various consumer types; a map of social services	https://www.goiener.com/red-goiener/?s (accessed on 15 December 2021)

Courant d'Air (Belgium)	Educational program for citizens and schools; Coophub platform for data management and sharing with the cooperative	https://www.courantdair.be/wp/activites/sensibilisations-et-informations/ (accessed on 15 December 2021) https://www.coophub.eu/manuel-utilisateur/ (accessed on 15 December 2021)
Svalin (Denmark)	Own energy generation; outdoor lighting system that changes color according to CO ₂ emissions; real-time energy data measurement systems; energy community hub	https://www.housingevolutions.eu/project/svalin-co-housing-p2p-energy-community/ (accessed on 15 December 2021)
SAS Ségala Agriculture et Energie Solaire Cooperative (France)	Citizen energy campaign; quality label and shared energy card; shared energy data; educational program	https://energie-partagee.org/decouvrir/energie-citoyenne/label-charte-energie-partagee/ (accessed on 15 December 2021) https://energie-partagee.org/decouvrir/energie-citoyenne/chiffres-cles/ (accessed on 15 December 2021)
Som Energia (Spain)	Participation tool; local groups for information sharing; shared data maps; laboratory and educational program in schools	https://www.somenergia.coop/ca/participa/#espai-participa (accessed on 20 December 2021) https://www.somenergia.coop/ca/participa/#grupslocals (accessed on 20 December 2021) https://www.somenergia.coop/ca/participa/escola-de-som-energia/ (accessed on 20 December 2021)
Solbyn Association (Sweden)	Eco-village; tenant-owner association; association board composed of residents; community cultivation and forest garden cultivation	http://www.solbyn.org/about (accessed on 20 December 2021)
Magliano Alpi (Italy)	Energy4Com platforms; PODs maps; GOC—Community Cooperative Group	https://cermaglianoalpi.it/index.php/chi-siamo/ (accessed on 20 December 2021)

Melpignano (Italy)	Members-citizens-users system; “Live the Water” project aimed at reducing the use of plastic water bottles	https://www.comunirinnovabili.it/cooperativa-di-comunita-di-melpignano/ (accessed on 15 December 2021)
Banister House Solar (United Kingdom)	Community-owned solar energy project; promotion of local leadership; meetings with the community; energy surveys; educational program	https://www.repowering.org.uk/wp-content/uploads/2020/05/Banister1pgReport_2015.pdf (accessed on 15 December 2021)

The examination of the selected case studies highlights the following primary types of contracts or agreements:

- Cooperatives and social enterprise cooperatives, in which members jointly produce and consume renewable energy on a non-profit basis by following an approved statute [59]. Private actors typically launch these. Notable examples include the initiatives in the Basque Country & Navarra (Spain) and Courant d’Air (Belgium), whose statutes are accessible via their official websites.
- Associations, generally operating at the local scale and frequently started through public efforts, such as the project in Magliano Alpi (Italy). In this model, the energy community serves as an association that connects energy producers and consumers. It is formed after the municipality issues a public call for expressions of interest, and the association’s founding document is signed.
- Energy enterprises, where participants mainly act as consumers of renewable energy. These are usually driven by companies specializing in supplying and installing renewable energy technologies for shared use. Private entities predominantly initiate them. One illustration is Banister House Solar in the UK, a community-owned energy enterprise based in Hackney.

Involved stakeholders

The stakeholders participating differ depending on the community’s aims and the selected business approach. Across all the chosen case studies, citizens constitute a central element and are commonly partnered with industrial players and public bodies. Such public-private partnerships are often vital for reconciling various requirements and devising optimal strategies for rolling out renewable energy projects, especially by engaging industry in technology deployment and attracting additional investors. Public administrations frequently fulfill a dual function: they may act as the driving force behind the community’s formation, as occurred in Magliano Alpi and Melpignano (Italy), and they may also supply suitable sites—such as rooftops or public land—for mounting photovoltaic systems. The upfront capital needed to acquire and install renewable energy equipment is typically financed through public subsidies and/or structured through customized public-private partnership models. For example, the initiatives in Oborniki Slaskie (Poland), Tirano (Italy), Thessaly (Greece), and the Basque Country & Navarra (Spain)—all supported by the Horizon 2020 BEcoop project (<https://www.becoop-project.eu/>, accessed on 18 November 2021) to establish bioenergy communities—feature a prominent industrial role focused on expanding biomass capacity and generating clean energy. Nevertheless, citizen participation plays a key role in adapting new business offerings to the specific needs of local users.

Citizens' engagement level

The assessment of how deeply citizens are engaged in the selected case studies draws on the findings of the GRETA project (WP1: Framework to understand and predict the emergence of energy citizenship). This framework describes a progression through several stages of energy citizenship:

- Moving from unaware to aware energy citizens: They gain basic knowledge of energy-related challenges;
- Moving from aware to involved energy citizens: They begin making practical changes by applying energy-saving actions within the system;
- Moving from involved to active energy citizens: They take the step of joining an energy community;
- Moving from active to advocate energy citizens: They start encouraging and recruiting other people to join the community.

For this paper, the case studies were deliberately chosen to represent engagement at two key transition points: from the aware stage to the involved stage, and from the involved stage to the active stage. This choice allows examination of the specific initiatives used to support engagement. **Table 1** presents the criteria applied to determine the level of citizen engagement, together with brief explanations:

- From aware to involved (**Table 1**): Citizens participate primarily as consumers who receive renewable energy from the community, yet they have only minimal direct contact with it. Industrial partners and public bodies largely drive the initiative;
- From involved to active (**Table 1**): Citizens function as both consumers and producers and actively take part in the educational programs and community-organized activities.

Citizens' engagement initiatives

Table 2 below highlights a more focused selection of the analyzed case studies, emphasizing the most noteworthy citizen engagement activities and including the corresponding web links.

Analysis of engagement activities and the stakeholders involved reveals that successfully establishing and running an energy community depends heavily on residents' contributions. Economically, the way citizens participate shapes the overall business approach. A clear example is the Basque Country and Navarra (Spain), where services are tailored to users' specific needs. On the technical side, citizen involvement affects how energy is distributed and tracked. The reviewed cases showcase several creative digital solutions for data handling and exchange, such as the Coophub platform developed by Courant d'Air (Belgium), the quality certification and shared energy card used by SAS Ségala Agriculture et Energie Solaire Cooperative (France), the public data maps provided by Som Energia (Spain), and the Energy4Com platforms introduced in Magliano Alpi (Italy).

The Svalin project in Denmark is a good illustration of how awareness of the link between energy production and consumption can be raised through practical monitoring tools. These systems help residents identify the most suitable times to use electricity based on current CO₂ emission levels. One particularly effective feature is an easy-to-read outdoor lighting installation that uses color signals to indicate periods when electricity consumption has the lowest environmental impact.

The case studies also demonstrate the value of well-designed education and information campaigns, showing that regular meetings and community events are vital for sustaining participation. Notable examples include the training programs for residents and schools offered by Courant d'Air (Belgium), the collective gardening and forest cultivation activities in

Solbyn eco-village (Sweden), the “live the water” campaign in Melpignano (Italy) aimed at cutting plastic bottle consumption, and the ongoing meetings and resident surveys organized by Banister House Solar (UK).

Another key factor is the formal inclusion of citizens through an elected governing board that handles day-to-day administration of the community, as practiced by the Solbyn Association (Sweden). This kind of self-governance works especially well in smaller, well-established local groups. Still, introducing direct citizen representation—whether via boards or associations—can also serve as a strong motivator for larger-scale communities. In the case of Som Energia (Spain), which operates nationwide, members can join local discussion groups to exchange information and ideas.

First implementations of the climate city contract. The swedish viable cities programme

Cities in Europe already have access to a wide range of existing programs and schemes at regional, national, and international levels that support the move toward climate neutrality. Many have begun implementing related policies, and the target of achieving neutrality by 2050 is increasingly accepted, as shown by the additional pledges made by Covenant of Mayors signatories in April 2021 [36]. Even so, only a handful of cities have so far committed to reaching full climate neutrality by 2030. The Cities Mission aims to make the most of these ongoing efforts by using a cross-cutting, demand-driven approach that builds connections and accelerates the overall transition [60]. The call for expressions of interest is due to close in January 2022, with the list of selected cities expected in March 2022. Consequently, the collaborative process for developing Climate City Contracts has not yet officially launched.

One important early effort to test the Climate City Contract approach is taking place in Sweden as part of the Viable Cities strategic innovation programme. The programme aims to accelerate climate adaptation measures in Swedish cities in accordance with the 2030 Agenda, while also helping the Swedish economy recover from the effects of the coronavirus pandemic. Digitalisation and active citizen involvement serve as the main drivers of this initiative. The 2030 Climate Contract serves as the central instrument through which the parties express their shared commitment to raising ambition for sustainable urban development and climate adaptation through long-term, mutual obligations. These contracts further seek to establish Sweden and its cities as leaders in the EU’s urban climate transition [61].

In line with the Cities Mission, 23 Swedish cities — which together account for 40% of the national population — have announced their goal of becoming climate-neutral by 2030. Nine of these cities have already prepared their own 2030 Climate Contracts. The primary partners in the programme are the municipalities, the Swedish Energy Agency (Energimyndigheten), the Swedish Agency for Innovation Systems (Vinnova), the Swedish Research Council for Sustainable Development (Formas), the Swedish Agency for Economic and Regional Growth (Tillväxtverket), and the KTH Royal Institute of Technology in Stockholm, which serves as the host organisation. The 2030 Climate Contract serves as the key cooperation mechanism linking cities with the national government and must be reviewed and updated annually based on achieved results. The nine cities that have released the first version of their contracts are: Enköping, Järfälla, Gothenburg, Lund, Malmö, Stockholm, Uppsala, Växjö, and Umeå. The Umeå contract is publicly available in English (at <https://static1.squarespace.com/static/5dd54ca29c9179411df12b85/t/5fd369cad16683056e51ab28/1607690700282/1134044+Umea%CC%8A+kommun+engelska+T.pdf>, accessed on 15 December 2021) and provides a clear example of the standard format used by all participating cities. The contract is divided into the sections summarised in the table below (Table 3).

Table 3. Sweden's climate city contract structure.

Section	Description
1. Purpose of the Climate City Contract 2030	Objective of the Climate City Contract 2030

2. Involved Parties	Participating entities and signatories
3. Municipality's Commitments	Municipal climate goals and targets; Strategy; Governance; Interaction and collaborative efforts with the business sector, academia, and citizens/civil society; Climate investment plan/climate city deficit/financing; Digital tools for implementation; Regional innovation hub for climate-neutral municipalities; Reporting and follow-up assessments
4. The Viable Cities Programme Commitments	Commitments undertaken by the Viable Cities programme
5. Commitments by the Governmental Authorities	Obligations and commitments made by public authorities at the national level
6. Strategic Development Projects in 2021	Key strategic initiatives planned for 2021
7. Joint Work on Follow-Up Reviews, Evaluation, and Updating	Collaborative efforts concerning monitoring, assessment, and revisions
8. The Contract Signed by All the Involved Parties	Final agreement endorsed by all participating parties

The following presents the content of the Umeå Climate Contract, focusing only on the most relevant parts of the sections outlined in the table above.

Section 1: The purpose of the Climate City Contract 2030.

This Climate Contract seeks to speed up climate adaptation in cities within the 2030 Agenda framework, while supporting Sweden's economic recovery in the aftermath of the coronavirus pandemic.

Section 2: Parties.

Municipality; Swedish Governmental Authorities (the Swedish Energy Agency, the Swedish Agency for Innovation Systems, the Swedish Research Council for Sustainable Development, the Swedish Agency for Economic and Regional Growth).

Section 3: Municipality's Commitments.

– The Municipality's climate goals and targets: The common Viable Cities target is climate neutrality by 2030. Umeå has set an additional objective to achieve full neutrality across the entire municipality by 2040. It also aims to lower consumption-based greenhouse gas emissions to 2 tonnes of CO₂ equivalent per person per year by 2040, and to further reduce them to 1 tonne of CO₂ equivalent per person per year by 2050. The Municipality and its municipally owned companies aim to achieve climate neutrality by 2025.

– Strategy: Municipalities already maintain various existing plans and programmes and are preparing a dedicated policy and action programme to align them with climate objectives. Umeå has a Strategic Plan covering 2016–2028 and a master plan supported by specialised strategies (such as the Strategy for Business Development, Energy Policy, Travel Policy, traffic management programmes, and others). These elements will be combined into the Umeå Municipal Group's policy and action programme, which will serve as the roadmap to achieving Climate Neutral Umeå by 2030.

- Governance: Governance structures are built on collaboration and co-creation among the parties and citizens. To support this approach, Umeå Municipality is establishing multiple innovation platforms designed to improve adaptability, strengthen innovative capacity, and develop new solutions.
- Interaction and cooperative efforts with the business community, academia, and citizens/civil society.
- Climate change investment plan/climate city deficit/financing.
- Digital support for implementation: Developing digital tools is regarded as a critical enabler for enhancing dialogue, increasing stakeholder and resident engagement, and supporting the co-creation of the 2030 Climate Contract. Technologies, including open data, the Internet of Things, Augmented Reality, and others, will lay the groundwork for envisioning future scenarios and tracking progress. A Digital Impact North collaboration forum is under development, with emphasis on circular business models.
- Regional innovation hub for climate-neutral municipalities.
- Reporting and follow-up reviews.

Section 4: The Viable Cities programme commitments.

Implementation of the Viable Cities innovation programme relies on a wide-ranging partnership. It contributes to Sweden's overall pledge to fulfil the objectives of the 2030 Agenda for Sustainable Development and the Paris Agreement, while establishing the country as an international frontrunner in transforming cities. The programme engages participants from diverse scientific fields, industrial sectors, small enterprises, and civil society groups.

Section 5: Commitments by the governmental authorities.

National authorities assist municipalities in carrying out their mission-driven efforts and create a structured platform for joint action through the Viable Cities programme. This includes sharing practical experiences, offering regulatory guidance, supporting research and innovation activities, and issuing funding opportunities. These authorities also facilitate municipalities' involvement in the EU Horizon Europe programme.

Section 6: Strategic development projects in 2021.

Strategic development projects were undertaken in cooperation with other municipalities inside the Viable Cities Transition Lab (<https://en.viablecities.se/viable-cities-transition-lab>, accessed on 18 December 2021). This central initiative of Viable Cities aims to develop the capabilities required for a successful climate transition jointly and to strengthen citizens' roles by leveraging digitalisation and automation. The strategic development projects completed cover three main areas: collaboration and joint efforts with the business sector, academia, civil society, and citizens; long-term investment planning to address climate change and its socio-economic effects; and digital tools to support climate change and the energy transition.

Section 7: Joint work on follow-up reviews, evaluation, and updating.

Municipal performance under the Climate City Contract 2030 is assessed annually to monitor results.

Section 8: The Contract.

This final page of the document bears the signatures of all the parties involved.

Certain contracts also include an appendix containing more detailed descriptions of the municipality's climate adaptation plans and its specific implementation pledges.

Coordination across local, regional, and national government levels, along with the active involvement of all key stakeholders, is a defining characteristic of all 2030 Climate City Contracts.

The Climate City Contract adopted by the City of Malmö draws on the knowledge, programmes, and outcomes gained from a specialised climate agreement developed for the Hyllie district since 2013. The Hyllie Climate Contract was built on a public-private partnership focused on deploying smart city technologies, with an energy target set for 2020 (https://www.youtube.com/watch?v=zIPNQhvd_Ms, accessed on 22 December 2021). Since 2020, the district has operated entirely on locally generated renewable energy. It has introduced advanced solutions, including energy storage, smart buildings, integrated smart grids, biogas stations, electric vehicle charging infrastructure, and energy balancing systems. This district-level climate contract, which aligns public and private actors' actions, offers clear benefits to residents, visitors, and businesses in the area and can be scaled or replicated in other neighbourhoods. As demonstrated by the Hyllie roadmap, such local initiatives can function as effective pilot projects that provide replicable models for city-wide policies and actions, while also inspiring collaborative transition strategies among partner cities.

The following section describes an Italian case study that illustrates a potential pathway for developing climate contracts at the district level.

This paper positions energy communities as the practical setting for developing climate city contracts. These contracts are designed to organise and formalise citizen participation, enabling citizens to become real partners in the climate transition process. The study offers an overview of the different types of contracts currently used in energy communities, the forthcoming Climate City Contract to be introduced under the EU Mission "100 Climate-neutral Cities by 2030—by and for the Citizens", and the various engagement commitments observed in energy communities and comparable initiatives. Climate City Contracts are presented as city-scale instruments through which the EU provides municipalities with support via regulations, financial resources, and innovation. They will be signed by the city Mayor representing local stakeholders, the European Commission, and national and regional authorities.

Persistent uncertainty regarding the national legal frameworks for energy communities in most EU member states continues to hinder their development and rollout, even though the European Commission has outlined a general strategy [1, 3, 4]. The traditional top-down adoption of EU directives at regional and local levels can be significantly accelerated by a complementary bottom-up dynamic in which territorial policies are shaped through participatory processes and co-designed with stakeholders and citizens.

In the GRETA project, energy is regarded as a basic social requirement, a deeply embedded practice, and an arena for meaningful civic involvement. The notion of energy citizenship connects directly to democratic involvement and active participation in the sustainable energy transition [62]. Such participation can take many forms and occur at different scales — ranging from simple individual decisions that influence only household consumption to active membership in energy communities and broader advocacy for climate action. With this in mind, the project examines and evaluates possible shifts between various stages of engagement. It also develops practical roadmaps and transition routes that citizens or communities can follow, referred to as Community Transition Pathways (CTPs).

Energy Citizenship Contracts (ECCs) are introduced as formal agreements that outline the terms and conditions under which citizens take part and contribute within their socio-energy community or setting. Drawing on the understanding of Climate City Contracts and the review of engagement practices and contract types observed in energy communities, ECCs are designed as integrated policy tools. They combine local targets and objectives with wider strategies and programmes. The primary goal of ECCs is to enable communities to strengthen energy citizenship and establish fair agreements with other actors in the energy system and at different levels of governance. The hoped-for outcome is a realistic, usable instrument that can be applied and adapted in various regulatory environments and decision-making

processes related to urban resilience planning. In the long term, it aims to encourage active stewardship of urban and human ecosystems through joint collective efforts. Defining possible ECCs constitutes the main deliverable of the CTPs, which guide communities through successive stages of citizenship engagement (Figure 3) and produce concrete energy policy recommendations to promote the adoption of ECCs in different settings.

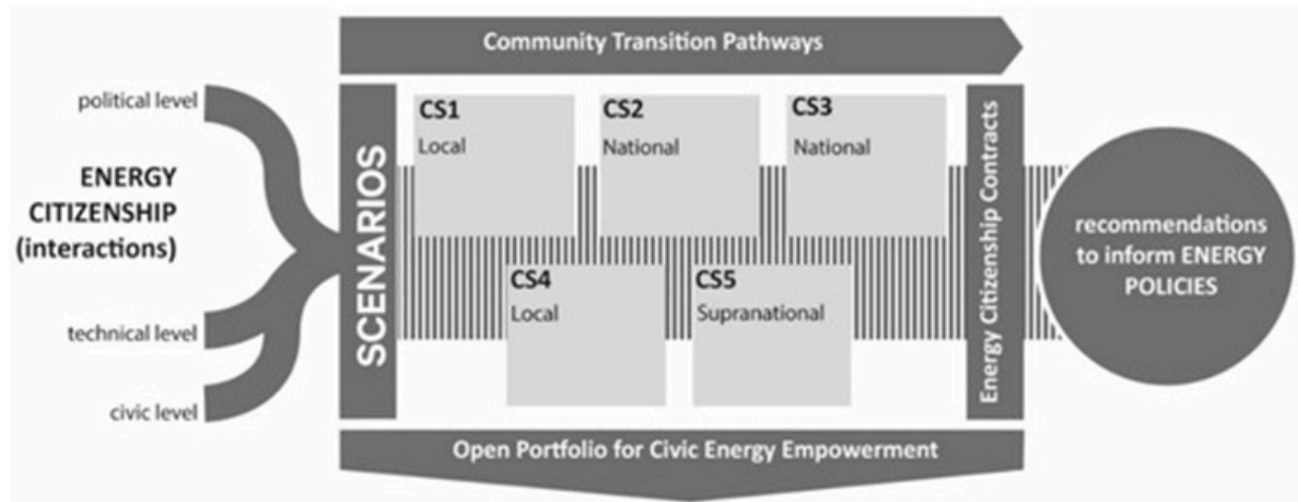


Figure 3. GRETA Project. Community Transition Pathways (CTPs) towards Energy Citizenship Contracts. Infographic made for the GRETA proposal, originally made by Martina Massari, and re-elaborated for the publication by the authors.

The central methodology of the GRETA project relies on a detailed examination of case studies drawn from varied geographic areas, scales, and types of energy citizenship. The purpose is to uncover the systemic and emerging factors that shape this phenomenon, enabling the design and testing of pathways to enhance awareness, increase participation, and deepen engagement. These case studies serve as experimental living laboratories where bottom-up initiatives, developed jointly with citizens, are tested. Such initiatives act as preparatory steps that can eventually lead to the creation of Energy Citizenship Contracts in partnership with local authorities and other stakeholders. In fact, before and alongside the formal adoption of climate contracts through standard decision-making procedures, a vital experimental phase needs to be incorporated. While searching for innovative ways to meet urgent global and local targets for resilience and sustainability amid uncertainty and rapid change, cities and urban bodies are becoming more open to experimentation. These experiments frequently emerge outside conventional government structures, are led by actors other than municipal authorities, and usually combine local and global aims with multi-level, polycentric governance and collaborative design processes.

To support urban institutions in better aligning, integrating, and reinforcing contributions from bottom-up and third-party actors toward global objectives, tools such as collaborative platforms and climate assemblies have been created, as demonstrated in the review of the most advanced energy community case studies. The GRETA concept and development of ECCs are positioned within this experimental and co-design framework for the ecological transition.

The Italian case study in the GRETA project concerns the mixed-use Roveri-Pilastro district, spanning roughly 400 hectares in the north-eastern sector of Bologna. Constructed in the 1960s to meet rising demand for social housing and to accommodate immigrant populations, the district consists of two distinct neighbourhoods: Pilastro, mainly residential, and Roveri, dominated by industrial facilities. The area gains a significant advantage from the presence of the CAAB-FICO industrial partner, home to the largest photovoltaic installation on industrial rooftops in the European Union (Figure 4).



Figure 4. Roveri-Pilastro district aerial view. Infographic made by the authors.

In this framework, the GECO initiative—supported by the European Institute of Innovation & Technology (GECO—Green Energy Community, EIT Climate KIC TC_2.2.15_190736_P125-1; <https://www.gecocommunity.it/>, accessed on 20 December 2021)—is dedicated to establishing the city's first local energy community, consistent with the implementation measures outlined in the Bologna SECAP. The project is coordinated by AESS together with the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), and the University of Bologna (UNIBO), and it involves collaboration with CAAB/FICO and the Pilastro-District Nord Est development agency. A fuller account of the GECO project's aims and operational actions, especially those linked to GRETA [17] (pp. 14–15). Both initiatives, GRETA and GECO, share the overarching goal of encouraging and examining how a local energy community can emerge and evolve.

Within this context, GRETA and GECO are collaborating to organize participatory initiatives that actively involve residents from the Roveri–Pilastro district, aiming to provide information, stimulate involvement, and initiate the co-design stage of the Community Transition Pathway. Among the first engagement measures that have already been implemented are:

- Urban trekking activities, which are environmentally oriented walking tours that guide residents through the urban setting while presenting the built environment from an alternative perspective, with attention to selected themes (e.g., air and noise pollution, energy-related practices, and energy sharing). The first trekking activity in the Pilastro–Roveri district was held on 19 June 2021, followed by two additional events arranged in July and September.
- Interviews conducted with residents to explore their perception of what a citizenship community represents, whether they feel connected to a community, and in which ways they might contribute to the energy transition process. Several interviews with Pilastro residents have been completed and are currently under analysis.
- Educational and informational activities, such as the Energy Days organized on 10 and 11 December 2021. During these events, participants discussed and reflected on the following questions:
 - “Which elements could support citizens in moving from conventional electricity consumption toward participation in a renewable energy community?”
 - “What approaches could encourage neighborhood residents to monitor electricity usage within their homes?”
 - “What types of additional services might be offered by an energy community?”

Findings from these initial activities reveal a fragmented landscape, with uneven levels of awareness of climate-related matters and varying degrees of information, participation, and engagement. Different levels of commitment to energy and sustainability were observed, ranging from individuals with limited awareness to those already recognizing potential

intervention measures to support the area's transition. Furthermore, the two local communities in the district show distinct characteristics: the Pilastro area is largely residential, while the Roveri area is predominantly composed of workers. The events conducted to date have highlighted the need to adopt more targeted, customized approaches.

The participatory processes implemented in the GRETA Italian case study serve as preliminary experiments to outline co-developed pathways for transformation and to gather a structured, shared vision that will inform the project's forthcoming stages. This experimental bottom-up method is intended to complement multi-level authorities within the traditional decision-making framework. At the same time, participatory practices may help residents better understand climate and energy dynamics and the complexity of decision-making processes, thereby fostering an atmosphere of trust and cooperation.

Conclusion

This study seeks to simultaneously examine energy communities together with climate, energy, and social contracts as central elements for advancing cities that are both citizen-oriented and climate-neutral. It also draws on the research developments of the ongoing H2020 GRETA project, with particular attention to the engagement dynamics within energy communities and to the review of existing contractual examples that can serve as references for designing ECCs. Within GRETA, ECCs function as primary mechanisms that connect citizen involvement, commitments from local and international policy makers, transition objectives and strategies, and a regulatory structure intended not only to support energy communities but also to strengthen their broader social contribution.

Although challenges remain in translating EU directives into the national legislation of Member States and in assessing how effective these measures are in advancing the energy transition, many citizens across Europe are increasingly coming together to create new forms of cooperation, governance arrangements, contractual models, business approaches, and innovative financial solutions that enable renewable energy generation, self-consumption, and sharing. The transformative capacity of energy communities should therefore be reinforced through regulatory and legal systems that provide support, ensure commitment, and promote equality and justice, ultimately allowing citizens to participate in the energy market and actively contribute to the green transition.

As noted by Campos *et al.* [21], “given the costs, as well as organizational and knowledge needs required for groups of citizens to set up a local project, it is important to prevent the exclusion of more vulnerable communities and lower-income families. Citizen Energy Communities (CEC) may involve a wide range of citizens in the energy transition who are not able to participate in place-based communities. Yet, legal frameworks seem to ignore this collective”.

Accordingly, the GRETA project aims to clarify the significance of energy justice across the various levels of energy citizenship and to investigate approaches that empower citizens to address exclusion by leveraging collectively agreed pathways—the ECCs—established among communities, policy makers, urban actors, and other essential stakeholders within the energy system.

Given that the GRETA project is currently in its first year of implementation, additional research findings and activities are anticipated, alongside the examination of a larger number of EU case studies. In relation to the project's current results, this paper introduces an initial group of participatory events conducted within the Italian pilot case study. As the project progresses, further actions and practical initiatives related to citizen engagement in Bologna will be incorporated, and their outcomes will be evaluated, analyzed, and reported in subsequent publications.

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Ethics statement

None

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