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Community-Centred Energy Planning: Within and beyond Administrative Borders

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Abstract: Since its introduction in 2008, the Covenant of Mayors (CoM) has helped municipalities meet EU Climate and Energy goals and thresholds through Sustainable Energy and Climate Action Planning (SECAP). The engagement of local communities holds particular significance for smaller municipalities, which can leverage collective strategies to mutually contribute to climate change mitigation efforts, thereby optimizing results. In the realm of communities, Renewable Energy Communities (REC) have emerged as a potential tool for SECAP implementation, but although they target common objectives and constitute subsequent steps of the same planning flow, their interaction is poor. This study aimed to investigate similar tools' integration by focusing on administrative and technical boundaries whose overlaps often hinder their interoperability. To this aim, the Italian framework was chosen due to the representation of its signatories in the CoM. Municipalities that have undertaken actions related to RECs within their Joint SECAPs have been compared through an analysis of the CoM datasets. Finally, two Italian case studies were selected to evaluate the impact of different territorial and institutional configurations on these initiatives, aiming to face climate change and achieve a green transition. This helped the authors propose practical recommendations and policy implications concerning this kind of community-centred energy planning solution as outlined in the concluding section.

Keywords: climate change; green transition; sustainable energy planning; renewable energy community; covenant of mayors; small municipalities; local resilience

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1. Introduction

Adapting urban environments to climate change is a growing concern for policy-makers as well as for citizens [1]. Nevertheless, despite during the last thirty years—since the 1992 United Nations Framework Convention on Climate Change in Rio de Janeiro—mitigation and adaptation have been framed as complementary and equally necessary initiatives to face global climate crisis, they have been addressed as independent targets in different moments and as following different paths [2].

Mitigation of climate change drivers has been initially considered a high priority [3], while only later has urban areas' response to climate change-related extreme weather events been targeted as necessary to reduce the dramatic impacts and shocks on local environments and communities [4].

The need to balance mitigation and adaptation issues and priorities requires indeed a strong effort in terms of integrated planning [5], not only in terms of competencies and responsibilities allocation [6], in terms of multi-level governance mechanisms [7], but also in terms of knowledge development of potential interactions among the two lines of actions [8].

Targeting mitigation and adaptation goals separately hampers the possibility to highlight synergies and potential conflicts descending from dedicated initiatives and projects [9], thus limiting the magnitude of their impacts on the urban environment [10]. In this direction, a joint and integrated approach would help to reduce negative externalities coming

from actions' implementation according to a wider and comprehensive approach to urban resilience and sustainable development [11].

Among urban sectors, energy production has been considered since the very beginning as one of the major targets of mitigation strategies, being one of the most environmentally impactful, responsible for an approximately 30% share of EU global GHG emissions [12], as well as one of the most strategic, thus critical [13]. The green transition from fossil fuels to renewable sources, innovative technologies, and the decentralization of the energy supply have therefore been the main pursued strategies [14].

Strengthened by the process of regionalisation that took place in the first decade of the 2000s, which has contributed to a gradual decentralization of infrastructural systems, particularly in the energy sector, bottom-up experiences have emerged. These initiatives came with criticalities and aspects that still need to be deepened from the point of view of multi-level management and coordination [15] in order to ensure an adequate balance between local response improvement and objectives achievement at larger scales [16].

Nevertheless, similar initiatives towards GHG emissions' reduction may lead to significant trade-offs in terms of infrastructural redundancy and adaptive capacity [17], as well as in terms of social equity and inclusion, due to high investment costs required by the renewable sources-led green transition [18].

In this direction, integrated planning appears to be extremely pivotal for supporting a green, sustainable, and inclusive transition [19]. Particularly interesting, therefore, is the Global Covenant of Mayors (GCoM) experience and the derived SECAP's initiative [20].

Born in 2008 as an EU action targeting Sustainable Energy Action Planning (SEAP), the Covenant of Mayors (CoM) gathered municipalities that were interested in developing actions addressing the green transition of cities, thus relying on the support and coordination coming from the Joint Research Centre (JRC). The main aim was to guide and help municipalities in implementing effective actions towards 2020 EU Climate and Energy package goals and thresholds [21].

Despite multiple criticalities and issues [22] concerning local vulnerabilities [23,24] and monitoring activities [24], the SEAP initiative contributed to achieving significant results in terms of energy savings and increased use of renewable sources [25], as well as in terms of CO_2 reduction [26]. It is not surprising that in 2016, CoM evolved into the Global Covenant of Mayors for Climate and Energy, thus addressing a wider range of goals, as follows:

- Mitigation;
- Adaptation;
- Energy Poverty.

These targets are addressed through the definition of the Sustainable Energy and Climate Action Plans (SECAPs), which should be progressively designed, approved, and monitored by its signatories (there are currently more than 11,000), who are committing to adopt an integrated approach to climate change mitigation and adaptation, cutting CO_2 emissions by at least 40% by 2030 and increasing resilience to climate change [21].

Table 1 and Figure 1 show the level of involvement of nations in the GCoM initiative, counting more than 100 signatories. The elaboration is based on datasets published by the Joint Research Centre on the Global Covenant of Mayors for Climate and Energy initiative [27], integrated with data about populations [28] and administrative divisions [29].

Most of the signatories are concentrated in southern Europe, with a net prevalence in Italy, Spain, and Belgium (a). This could be related to the substantial support provided by Europe for such initiatives, as well as the interest exhibited by these nations in embracing them. Also, a ratio of the value of signatories with respect to the municipalities for each state has been calculated. Smaller nations like Belgium, Portugal, and Greece present a high ratio since they also present a quite low number of local administrations (b). Italy, instead, presents a higher value besides its quite extended surface and one of the higher values of administrations. This shows the significant relevance of the GCoM initiative in the Italian context. Another intriguing aspect is the widespread presence of small municipalities,

here defined as those with a population of fewer than 10,000 residents. As reported by authors [30], in the year 2022, these accounted for 63% of the total number of signatories, with the Italian ones covering 57.8% of the overall count.

Table 1. Nations with more than 100 CoM signatories in descending order of n. of signatories.

Nation	N. Signatories	Population Involved	Involved pop./ tot. pop.	Signatories/ tot. Municip.
Italy	5148	57,570,920	0.98	0.65
Spain	2920	41,787,595	0.88	0.36
Belgium	584	2,761,470	0.24	0.99
Hungary	334	3,380,499	0.35	0.11
Ukraine	319	22,406,094	0.59	0.03
Greece	231	9,336,041	0.88	0.71
Czechia	207	2,382,795	0.23	0.03
France	193	30,993,211	0.46	0.01
Romania	191	11,570,186	0.61	0.06
Portugal	183	15,614,255	1.50	0.59
Croatia	119	2,159,699	0.56	0.21
Moldova	101	334,550	0.13	0.11

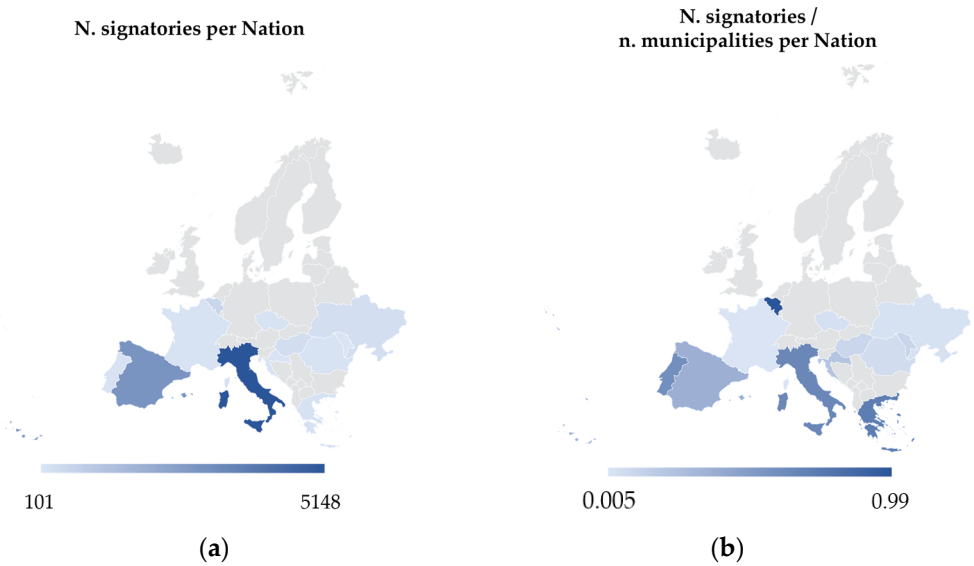

Figure 1. Representativeness of CoM signatories, showing high involvement in southern Europe. (**a**) Number of signatories per nation shows a net prevalence of them in the Italian region; (**b**) Italy also has a high proportion of municipalities involved in CoM in relation to the total number of administrative divisions.

The prevalence of small municipalities gathering under the GCoM initiative, largely meeting the relevant difficulties in developing integrated and effective SECAPs, as well as in monitoring them in the long run [22], may lead to the question of whether the municipal scale may fit adequately to the needs of tailored solutions, as well as the necessity of structured institutions to address massive challenges related to mitigation and adaptation, where cooperation and joint initiatives may prove essential [31].

In this direction, interesting hints may come from the multiple initiatives, both on the EU and Italian National level, supporting bottom-up and citizen-driven actions to develop a widespread and decentralized energy supply system, thus providing them with a strongly relevant role within the green transition process through to the implementation of a diffuse network centrally supported and coordinated. Following the Renewable Energy Directive revision in 2018 [32] and the Clean Energy for All Europeans package approval in 2019 [33],

significant attention has been paid to the role and contribution of local communities to the sustainable transition of the energy sector [34].

Similar considerations led to the progressive affirmation of Renewable Energy Communities (RECs) as one of the most suitable tools for exploring the issue of decentralised management, thus enhancing the local adaptive capacity through solutions tailored to the territorial context. This constitutes only one facet of the wide range of Local Energy Initiatives (LEI) [35]. However, as the focus of this research will be limited to the Italian context, this particular dimension has been given greater attention due to its legal recognition and well-codified normative framework.

Citizens and Renewable Energy Communities have been therefore introduced into EU legislation as active participants in generating, consuming, sharing, or selling electricity, providing flexible services through demand-responsive supply and storage. Similar innovations may represent indeed both a relevant booster and a challenge in planning and re-designing energy supply system territorial patterns to support the green transition and adaptive capacity of local networks on the basis of flexible and citizen-led schemes, thus requiring coordination and integration in terms of administrative and institutional management and competencies [36].

Initially targeted as a mitigation driver, in terms of the local transition to renewable energy sources, distributed energy generation systems were addressed as flexible tools to support infrastructural development and to reduce local fossil fuel consumption, thus improving the overall sustainability of the energy sector [37].

For a long time, urban energy planning has been primarily associated with reducing consumption and related GHG emissions, thus focusing on the technical design of buildings and facilities. As a result, it has long represented a sector-specific planning approach rather than one seamlessly integrated into urban transformation processes. With the subsequent processes of liberalisation in the energy market and the increasing focus on alternative sources of production—which are inherently dependent on local characteristics [38]—there has been an increased awareness of the socio-economic value that decentralised production brings at the local level. This progressively entailed the inclusion of energy themes in the planning process [39]. Moreover, when adaptation claims surged, the need to develop a more effective territorial response to climate events led policy-makers to consider the added value that local communities may provide. RECs were consequently mainstreamed into energy planning initiatives—the SECAP, above all, within the EU context—thus combining flexibility, sustainability, and subsidiarity [40].

A similar holistic approach to energy planning targeting both mitigation and adaptation goals through bottom-up and community-centred initiatives may currently foster the achievement of the EU Green Deal just and green transition targets [41], as well as to support the post-Covid19 sustainable and resilient recovery process boosted by the NextGeneration EU [42]. The availability of a significant amount of dedicated resources—Italy constitutes the main beneficiary of the latter initiative—could finally represent an unprecedented driver for governance mechanisms and policy innovation [43].

Although the SECAP and RECs share similar assumptions and intentions, they differ substantially, being the former one is a tactical planning tool and the latter an operational one.

As the nature of these tools varies, it is important that they have distinct characteristics, functions, and targets. However, coordination and alignment between them are also necessary. In fact, multi-level adaptation strategies are known to be hampered by a lack of policy instruments able to act across different levels. Also, it is important to identify how far local authorities can be expected to work on adaptation and to define and implement adaptation strategies on their own [44], considering that the competencies and knowledge at this level may not be sufficient to deal with these relatively innovative issues.

This is particularly relevant for small municipalities, which must face both their own deficiencies and the challenges of coordinating on a supra-municipal scale to address structural weaknesses. Regarding the SECAP initiative, this occurred through Joint SECAPs.

However, it is important to note that there is no single subscription mode—this will be investigated later—and the choice of one or another subscription option is linked to communities' propensities and attitudes to work together and interact, leading to different outcomes. Additionally, the variation of involved institutional actors and their territorial reference perimeter may affect community-centred initiatives. Therefore, the present evaluation will focus on the differential impacts of REC implementation in community-centred planning.

It is worth noting that the academic debate lacks such assessments and analyses of the impacts of different Joint SECAP's submission options on the implementation of community-centred actions in the energy field. This research gap constitutes the starting point of the present work, which aims to investigate the barriers that hinder the joint application of both tools, starting with the definition of the target community and its role within the administrative context. The presence of similar barriers is therefore suggested by the limited implementation of these integrated experiences within the Italian context, despite the high number of SECAP signatories. In particular, it is analysed how the two envisaged subscription modes could develop differently in the implementation of the RECs. Similar issues may prove extremely relevant in terms of policy design, to improve actions' impacts and effectiveness, addressing the "*Fit for 55*" ambitious goals.

Starting from these assumptions, the present research aimed to investigate through the lens of community-centred initiatives the role of administrative boundaries in defining actions, responsive outcomes, and the effectiveness of energy planning policies, as these are currently hampered by a lack of coordination between the different territorial levels involved.

To give the reader a panoramic view of the proposed topics, Section 2 presents the Joint SECAP initiative as an answer to foster energy and climate planning practices initiatives for small-sized municipalities, where the implementation of multi-level mechanisms could be particularly critical due to limited resources and expertise. When small municipalities are involved, the community sphere often comes into play, constituting a valuable opportunity for concentrating efforts and encouraging citizens to work together on such initiatives. However, the community is not an institutionalized entity and it is therefore important to explore its formal and operational role within a planning framework. This is why Section 3 emphasizes the importance of community as a catalyst for activating bottom-up processes, leveraging a sense of togetherness, and sharing benefits among individuals actively participating in it. It also discusses the case of Renewable Energy Communities, which have been given a major role in the decentralisation strategies of adaptation planning and design, highlighting how their boundary constraints may challenge their integration within already established contexts.

The development of such community-centred initiatives inevitably raises the question of how this operational level can be aligned within the hierarchical structure of spatial planning that is developed by institutional and administrative actors. In particular, in the case of RECs developed within the Joint SECAP initiative, the variability of the community perimeter at the operational level must necessarily be coordinated with a further community perimeter carried out at the tactical level in order to guarantee a more effective use of the resources allocated to mitigation and adaptation, as determined by the Joint SECAPs. For this, Section 4 focuses on case studies that are currently coupling Joint SECAPs initiatives and RECs to assess the extent of their integration. The evaluation used the Italian context as a prominent example because of the high number of subscribed joint initiatives and explored how these two instruments could interact.

The submitted SECAPs' analysis was therefore developed through the use of datasets provided by the European Commission's Joint Research Centre (JRC). JRC collects, manages, and publishes open data related to the CoM initiative to ensure their availability and use for research and decision-making purposes. These datasets are structured into three frames providing information on: i. signatories and submission procedures (df1); ii. action plans, targeted mitigation and adaptation goals, impacted sectors and action details (df2);

and, finally, iii. monitoring reports of previously submitted plans (df3). The present work therefore focused on df1 and df2, to address action plans submitted jointly within the Italian context—the signatories frame will be used for this purpose—and REC-related measures that may be traced among the submitted actions dataset. Cross-screening of the two data sources allowed us to identify similar initiatives proposed within the Joint SECAPs.

Among the (few) results descending from this analysis, two case studies were isolated and then described to identify technical drivers of and barriers to the implementation of the two tools in local communities towards their green energy transition, being representative of the two-subscription mode provided by the Joint SECAP initiative. The analysis of these two case studies revealed two distinct approaches to the concept of community in tactical planning for SECAP elaboration. Community involvement in the planning process affects differentially the operational effectiveness of implementing the respective REC at the tactical level.

Finally, Section 5 includes a discussion based on the findings of the case studies analysis and considerations on integrated energy planning within the Italian framework for renewable energy communities. Based on the methodological reflections that arose from the evaluation of the two case studies, the authors propose some recommendations for policy-makers in Section 6 to face the identified barriers and facilitate the integration of the two tools into the planning process, from strategy development to operational implementation.

2. SECAP and Joint SECAP Initiatives

Addressing climate change through urban planning tools represents quite a critical issue from several perspectives. Improving territorial adaptive capacity towards weather and natural extreme events that are going to become more and more frequent and intense challenges local administrations to design and implement measures targeting partially unknown risks both in terms of the involved hazards [45] as well as in terms of the vulnerable social and economic assets [46].

Climate change drivers-related uncertainties [47] constitute indeed a major problem, also considering the urban planning scale [48]. The subsidiarity principle [49], as well as a local and place-based approach towards urban adaptation, would suggest the municipal level as the most suitable to deal with similar challenges. Nevertheless, competencies and responsibilities need to be balanced with the administration's resources and capabilities [50].

Moreover, local adaptive planning requires adequate supporting data, scenarios [51], indicators [24], and a knowledge background usually provided on a wider scale, so that significant simplifications and down-scaling are necessary. In this direction, usually, approaching the identifying reference scale and actors where the major impacts take place may be undermined by the need for relevant governance structures and mechanisms [52], where multi-level actions may prove more effective [53].

Nevertheless, focusing on the first integrated and comprehensive EU-led initiative targeting mitigation and adaptation planning—the Covenant of Mayors, CoM—the subsidiarity and bottom-up approach prevailed, supporting a municipal leading role, so that SEAPs and SECAPs were to be drawn by local administrations [54].

Differently from regional and provincial scales—usually labelled as NUTS 2 and 3 within the EU context [55]—the municipalities present variable geometries, indeed [56]. Their boundaries were historically defined independently from statistical considerations. Consequently, when referring to the local scale, municipalities counting less than 100 inhabitants as well as metropolises with more than 10 million residents may be involved. As previously introduced, even though less representative in terms of population, small municipalities counting less than 10,000 inhabitants constitute a relevant share of CoM signatories. This element proves quite critical, especially where adaptation measures and capacity are concerned, since several barriers emerge in terms of available human and material resources [57], expertise, and know-how [58] that directly translate into a limited commitment to adaptation by a large share of signatories that targets almost exclusively

mitigation goals [59]. This is even more critical when considering that the municipal level is charged with energy planning in order to achieve the objectives set at the regional and national levels.

In this sense, top-down multi-level mechanisms may contribute to a greater degree of coordination and standardisation. Referring to the Italian context, further issues come from the national system of competencies and powers allocation, which sets spatial planning rules and legislation at the regional level, thus hampering the coordination potential of the central authorities [60], as well as the definition of a shared approach towards energy-related initiatives mainstreaming within ordinary planning procedures.

Regional federalism together with the lack of an updated national law ruling urban planning mechanisms (the current one dates back to 1942) led to individual initiatives that may be differently coded and transferred, even among regions belonging to the same Member State.

Integrated planning procedures prove even more critical whenever small municipalities are concerned [61]. Similar contexts are often provided with outdated planning tools, statically reproducing the traditional approach towards the simple land use assignation. Evidently, they inadequately cope with urban transformations and rarely provide resilient and adaptive responses to climate and environmental risks. Even though SEAPs and SECAPs usually include urban planning actions, this relationship within small municipalities proves usually to be one-way.

It is not surprising, though, that to increase governance capacity and effectiveness, networking among small local administrations was considered a significant leverage [62]. The Joint SECAP initiative constitutes, therefore, the answer to the need of small-sized municipalities within the same territorial area (ensuring territorial continuity) with indicatively less than 10,000 inhabitants each, both increasing their potential for adaptation and benefitting from the consequent economy of scale; the same tool may be provided also for larger agglomerations [63].

Joint SECAPs can be presented in two modes, precisely option 1 and option 2. In both options, the joint target to be gained and document submission is shared between the group of signatories. In option 1, each signatory is required to complete its own action plan, and the impacts such as energy savings and GHG emission reduction are divided among each member sharing the measure. In option 2, the action plan is unique, and common, saving, and reduction targets are addressed by the whole group.

A similar approach may enable small municipalities to overcome frequent criticalities linked to their limited bargaining power within a territorial stakeholder's ecosystem [64], as well as to face climate impacts affecting a wider territorial context [65]. In this direction, higher levels of integration and coordination among actions and policies may be reached [66], thus enhancing their effectiveness together with greater resources' availability to design, implement, and monitor tailored measures [67].

It is therefore evident that the gathering of bordering municipalities is usually driven by a shared background and identity [68]. In this direction, indeed, a similar approach may be seen as a step toward a community-centred basis for climate change adaptation policies and planning, where no administrative borders are involved in the definition of territorial units, which may prove pivotal not only in terms of greater institutional capacity but also due to more direct involvement of territorial stakeholders [69]. Participatory mechanisms leading to vulnerability and risk assessment steps [40], as well as action design and implementation [70], may assure place-based and shared strategies, thus supporting the progressive cultural change towards more sustainable and resilient patterns and environments [71].

Considering these factors, the Joint SECAP was investigated to assess its effectiveness in supporting small municipalities in their energy and climate planning practices, also in synergy with other tools.

In detail, the Joint SECAP's impacts on the implementation of community-centred energy initiatives—namely RECs for the present research—were evaluated according to the

variability of the two submission options provided by the CoM. Their different approaches to the identification and consequent engagement of the local community would therefore constitute a key precondition for the further implementation and effectiveness of the RECs.

Figure 2 shows how many local authorities have adopted the Joint SECAP approach by March 2023 based on data submitted to the online platform for CoM subscription [63].

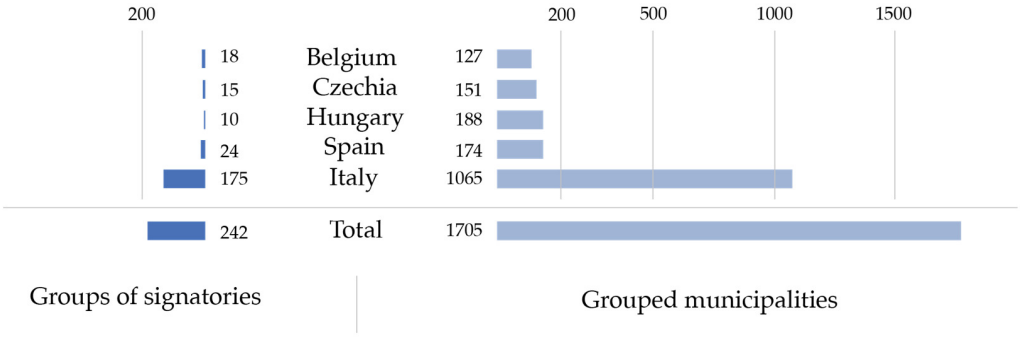

Figure 2. Groups of signatories compared to the number of municipalities they involve.

The left side of the figure shows the number of groups of municipalities that subscribed to the covenant listed for the five nations with the highest number of signatories. On the right is shown the number of municipalities included in the above-mentioned groups for the same countries.

The report highlights that 261 local authorities have submitted a joint plan, with a significant majority (67%) situated in Italy. Given the notable participation of small municipalities in the GCoM initiative, the Italian context emerges as a suitable scenario for this research, also due to the prevalence of such communities.

3. What Does a Community Look Like?

Increasing territorial adaptive capacity through bottom-up and community-centred planning approaches requires indeed to investigate how communities' perimeters may be identified [72]. The need to overcome administrative fragmentation through the definition of a wider planning boundary could be faced according to different approaches.

Several European states (such as Italy, France, and Germany) have progressively introduced new institutional bodies through administrative reforms in order to reduce the number of small municipalities and pursue resource optimization [73]. Similar structures (e.g., municipality gatherings and agglomerations) may represent indeed an initial step towards adaptation planning up-scaling. To improve local responses to climate change, it is therefore needed not only to support place-based policies and their respective effectiveness but also to assure infrastructural redundancy and decentralization. In this direction, it is therefore necessary to deepen what could be the definition, the perimeter of the community, shaping similar policies.

Throughout history, the sense of community has taken on various meanings. Typically, it is associated with a feeling of belonging and an advantage that comes with being part of a group [74]. According to [75], three elements define the historical concept of community: imagined reality, social interactions, and process, intended as something in constant evolution. Moreover, communities can be defined by factors such as age, origin, beliefs, or even formed in response to a common risk. In the era of globalization and digitalization, the concept has evolved to encompass various forms of affiliation. Modern-day communities are no longer exclusively defined by geographical boundaries, thanks to the emergence of information and communication technologies, which have ushered in new aggregation patterns [76].

The involvement of the community plays a pivotal role in the decision-making processes of urban planning. Firstly, it serves as a source of valuable insights into the genuine needs, characteristics, and unique attributes of local realities. Secondly, it is through community participation that the execution of strategies is made possible, ensuring that choices

and directions align with the preferences and acceptance of the local population. Without this involvement, decisions imposed by higher authorities may risk leading to undesirable consequences, including abandonment and neglect [77].

Given that climate change is a collective, political, and widespread matter [78], these considerations also apply to adaptation strategies [70], such as SECAPs, as well as to energy-related operative tools, such as RECs. They constitute indeed even more pivotal elements whenever small municipalities are concerned. As the authors stated in the previous sections, the CoM initiative supports in fact the submission of Joint SECAPs to support municipalities counting less than 10,000 inhabitants for the implementation of mitigation and adaptation actions. Nevertheless, in this direction, two submission modes are provided, offering two deeply different points of view concerning the community's role and concept.

A community cannot always be strictly defined by administrative boundaries, as what binds its members together and the challenges they encounter often extend beyond these limits. These boundaries have in fact traditionally been drawn in response to the needs of governments and agencies, often lacking in coordination and alignment [79]; therefore, strategies for cross-boundary cooperation are essential for achieving shared goals [80].

A shared interest may group, for instance, public transportation users, thus turning them into a specific kind of community. Mobility infrastructures and services are closely linked with local frameworks. Despite efforts having been made to relate to real catchment areas, people crossing territorial boundaries, such as commuters, frequently encounter challenges stemming from the fragmentation of transportation systems, especially in inner regional areas [81]. The addressing of common interests is still strongly linked to administrative boundaries [82], and this is also reflected in sectorial planning, as flexible community-centred measures hardly affirm.

As far as SECAPs are concerned, the first submission option actually targets the overcoming of administrative and bureaucratic barriers hampering small municipality's initiatives. The possibility to reduce procedural burdens through the definition of a joint action where duties and responsibilities are shared constitutes the main goal, while municipalities autonomously define their own action plans. On the other hand, the second option targets on an operative level the design of an integrated plan, where the local community—going beyond administrative municipal borders—defines and implements its organic and comprehensive pathway towards more resilient and sustainable behaviours.

A similar issue is emerging in the idea of promoting a more diffused energy model, instead of the centralized traditional one, to support green transition policies. Traditionally, the high-voltage grid links large-scale power plants with consumers over considerable distances. This model demands substantial investments for network expansion and involves power losses in energy transportation [83]. The intention is to gradually adopt more efficient technological solutions such as small-scale systems, thus fostering bottom-up energy production and avoiding fossil fuel sources required for high-distance and high-voltage energy transmission [84]. Promoting energy transition through local production directly involves citizens, making them not only responsible consumers but also prosumers [85], raising public awareness and encouraging the adoption of more conscious habits and consumptions. In this context, energy communities are conceived to encourage bottom-up processes, gradually shifting energy infrastructure's management from central government to distributed entities across the local scale.

Community-based sustainable initiatives have gained interest for their ability to capture local knowledge, to speed up their impact, and to engage in their typical democratized decision-making process [86], but energy infrastructures and policies are still poorly versatile and adaptable to already existing community levels. In the following section, issues concerning the difficult relationship between Renewable Energy Communities and administrative boundaries will be presented.

3.1. Renewable Energy Communities (RECs)

The EU Clean Energy Package, together with the Renewal Energy Directive (RED II), set ambitious targets to improve energy system resilience and reduce dependency on energy import, "allowing householders, communities and business to become clean energy producers" [32]. This drives towards the goal of a green transition and encourages the shift to a more sustainable, bidirectional, and decentralized energy generation system [37,87,88]. In parallel, it is important to meet energy consumption targets, not only reducing direct consumption in civil buildings and facilities but also addressing the growing demand for electric mobility in the coming years.

Self-consumption aims to respond to both problems, allowing citizens to use, store, and sell the energy they produce themselves, reducing issues associated with grid overload and consequent damages to infrastructures. This leads to a distributed energy system that is more resilient and manageable and promotes greater knowledge and responsibility in the habits of the population.

Groups of citizens interested in collaborating to produce, consume, and manage energy made from renewable sources are encouraged to form and fund Renewable Energy Communities (RECs). Many configurations and names could be referred to this initiative across the world. In the EU framework, these are defined as legal entities based on open and voluntary participation, members of which are natural persons, SMEs, or local authorities, including municipalities. RECs are subjected to proximity between members and the production plants that should be part of the community itself. This requirement is intended to ensure that their goal is to deliver environmental, economic, and social benefits to the local communities in which they operate, rather than simply seeking financial gain for individual or multiple members [32].

For the Italian context, some insights can be located within the implementation of the aforementioned Directive through national legislation [89], as well as in the technical regulations published by the Italian Regulatory Authority for Energy, Networks, and Environment (ARERA) [90]. In an Italian Renewable Energy Community, shared electricity is defined as the energy generated by a facility spatially connected to the energy community, with a peak power not exceeding 200 kW. It is expected that this limit will be expanded to 1 MW in accordance with upcoming dedicated regulations. The energy used by a REC's participants is incentivised. In addition, the community receives direct compensation when the excess production is sold to the national grid, in case the production exceeds the current demand. For this reason, participation in a REC is not allowed to be the primary commercial or industrial activity of a subject.

This ensures that initiatives are driven by groups of residents, businesses, local organizations, or local authorities, without major corporations viewing the initiative as a commercial investment. These measures aim to prevent any potential exploitation by individuals seeking to profit from them, while promoting favourable outcomes for local communities.

Economic, social, and environmental benefits could be directly accessible to citizens, stakeholders, and local administrations, or they could be shared among them as part of the local framework. Some of these include:

- Cost savings for users, as self-generated energy reduces demand on the national grid;
- Resilience and manageability of the distribution network, as a consequence;
- Financial benefits, gained through energy sharing, which is incentivized with an economic bonus;
- Socio-economic benefits for the local community, since incentives and savings could be re-invested in local projects;
- Positive urban and environmental impacts driven by growing interest in abandoned areas as suitable for shared generation plant installation.

RECs are an interesting model for empowering a just energy transition [91]. In particular, their strength consists in the ability to activate bottom-up processes focusing on enhancing citizens' knowledge and responsibility, adopting nudging processes to help them change their behaviours towards more sustainable choices and attitudes. The sense

of the community in these realities is empowered by the idea of commonly tackling climate change, sharing facilities, and practices acting together.

Local communities have traditionally been delineated by a sphere of influence generally defined by geographical characteristics. Nevertheless, RECs introduce a distinct perspective, as they are characterized by two fundamental concepts: the 'virtual regularity model', which seemingly transcends physical proximity among its participants; and the spatial constraint related to a primary distribution substation network. The next section will address these themes.

The Theme of Proximity

The virtual configuration, as opposed to the physical setup, avoids the necessity for technical interventions on the network's infrastructure, as energy is shared through the existing network. This allows each participant to retain the freedom to choose their provider and to enter or exit the group at any time [92]. The virtual configuration also allows the quantification of energy that is shared between participants, or sold when production exceeds demand, in order to evaluate economic incentives and refunds.

The primary substation is the electrical plant that transforms energy from high voltage to medium voltage in order to be distributed to buildings and facilities. The Italian regulation framework imposed that for a REC implementation, it is mandatory that all members and production facilities subtend to the same area identified by the substation. This limit has been chosen since the European directive defines that RECs should have a territorial dimension and should be developed near renewable production plants but does not provide a common meter, so each member state decides for itself [93].

Fina and Auer [94] analysed three approaches to defining the proximity constraint imposed by the European directive: one referred to geographical boundaries, which leads to some inconveniences in such variable territories; the second relies on postal codes as a means to immediately permit people to know if they could join a community, but which seems discriminative for smaller municipalities; the latter criterion is based on 'energy proximity', associating the possibility of joining a community solely with entities situated within the same portion of the power grid. This poses issues whether related to the low-voltage or to the medium-voltage cabin. In the former case, it involves citizens, while in the latter, enterprises and facilities could also participate. In Italy, for example, it is envisioned to modify the limit of the grid from the low voltage to the medium one.

In the first case, primarily citizens are involved, whereas in the latter, companies and enterprises, which have higher consumption, have the opportunity to participate. In Italy, this grid limit is expected to change, moving from the low-voltage cabin to the medium-voltage one.

So, thanks to the virtual model, being part of a Renewable Energy Community does not involve the necessity to live in the same building or neighbourhood, but every participant should respect a technical limit that is set by the network infrastructure for energy withdrawal and transfer.

3.2. RECs Perimeters and Barriers

A REC's perimeter should be transparent, letting participants join without any type of discrimination [94]. In fact, one of their purposes is also to lead to a fair energy transition and this is particularly important for those territories characterised by geographical barriers and inland dispersion phenomena, as in the case of Italy.

The use of the 'grid proximity' limit certainly allows for a more efficient and practical management of energy share and savings, especially considering the adoption of the virtual model. This also ensures that companies can choose to participate not for profit, as this model does not allow an income, but as actors who can share knowledge, skills, and facilities to promote local projects and activate bottom-up processes.

On the other hand, setting a such fixed and not versatile boundary could turn this limit into a barrier, denying the establishment of a community that had already been formed

under certain conditions and that cannot be recognized from the energy point of view. Some researchers [95] reported situations in which, after public announcements about the benefits and the advantages of being part of a REC, citizens found themselves unable to participate in the intended project because of belonging to another electrical substation.

An example of a well-established community, facing common targets and geographically widespread could be found in religious institutions. Italy is home to a considerable number of them, which play an important role in various social activities. RECs principally envision social benefits so it is desirable that a clerical entity could join. In fact, the Italian Episcopal Conference explicitly calls upon parishes to actively engage in the establishment of energy communities, not only to significantly contribute to the country's carbon neutrality, but also to generate income that can support social initiatives and strengthen community bonds through shared decisions for the common good [96]. This kind of institution, especially parishes, attracts people and families from a region of influence that does not necessarily coincide with the boundary of a grid network. In these cases, the energy community rarely could overlap with the existing community, but this does not nullify the usefulness of the tool; it only reduces the ability to activate social projects, which is one of the main goals of these kinds of institutions.

Similar problems also emerge in small municipalities and rural areas where different families, even if spatially close, may be served by more than one different primary substation. Moreover, these kinds of administrations usually lack technical competencies, preventing already established communities from being also recognized under the energy point of view. Joint initiatives, as for the above-mentioned SECAPs, could merge the effort and skills of single entities towards common goals.

It is indeed self-evident that similar flexibility in the definition of a REC's boundaries may actually prove critical whenever their implementation is targeted within Joint SECAP initiatives. Community perimeters set at the tactical level—within SECAP action—may not overlap with the operational one. Moreover, when submission option 1 is chosen, the promotion of RECs may be hampered by the absence of territorial continuity since coordination among municipal actions is not required, and they can pursue individually different strategies and independent actions.

4. Case Study

In the previous sections, the Joint SECAP and REC have been presented as initiatives aiming to achieve the common goal of an energy transition relying on renewable sources, a widespread and resilient energy network, and the active involvement of local communities. Being the former is a planning tool, it defines the community to which it refers by administrative boundaries, while the latter, representing a decentralised model for energy production, needs to comply with technical boundaries. As previously stated, the planning flow leading from the tactical level to the operational one should require integration and alignment among the proposed and implemented community-centred energy actions to support a seamless strategy development. Nevertheless, especially when small municipalities are concerned, the limited number of actually operating RECs, despite the high number of Joint SECAP submissions, highlights the potential presence of significant bottlenecks hampering the process. With the intention of investigating the integrated application of both initiatives, the purpose of this research was to evaluate their interoperability with a focus on the constraints influencing the double perimeter setting procedures.

The key variable of this evaluation will be the Joint SECAP submission mode. In this direction, the role and relevance of the 'community' concept—and descending impacts on actions, design, and implementation—within the investigated planning flow would be deepened in terms of potential interferences with actual community-centred energy, actions, development, and impacts.

This section will address a comparison of two case studies investigating to what extent the community-based initiatives for a green transition can be effectively implemented through the use of both Joint SECAPs and RECs. The implemented methodology will be

explained in the following section. Nevertheless, some initial considerations of the case studies' selection need to be pointed out.

Case studies were drawn only from the Italian context, since energy-related policies and the legal framework strongly vary on a national basis, even within the European Union. Deriving disciplines and vocabulary represent in this direction a strong barrier towards comparative analyses. The limited number of case studies is due to the research setting choices. In this direction, a case study is not intended as statically representative, but as a test bed to observe potential interactions according to the Joint SECAP subscription options (namely 1 and 2).

4.1. Materials and Methods

In order to evaluate the relationship between the Joint SECAPs and RECs strategies within the Italian context, an analysis has been performed based on datasets published by the Joint Research Centre (JRC), which provides reports and insights on submission, publication, and monitoring procedures of SECAPs within the Global Covenant of Mayors for the Climate and Energy initiative [27]. Among the available datasets, concerning the signatories' inventory and submission procedures (df1); action plans, targeted mitigation, adaptation goals, impacted sectors, and action details (df2); and monitoring reports of previously submitted plans (df3) present research that benefitted from the df1 and df2 database to investigate ongoing experiences of interactions between the Joint SECAPs and RECs. In detail, the 4th release of the JRC dataset from March 2023 was selected and analysed.

The signatories' dataset frame (df1) provides information on the municipalities and institutions engaged in the initiative. This includes details on nationality, involved population, submission date, and chosen typology (individual, joint option 1 or 2), as well as other data (identification codes, above all) to support a crossed analysis among different datasets. In the present case, df1 was used to identify and separate the Joint SECAPs from the individually submitted ones, to frame the characteristics of the respective signatories, as well as to select the case studies belonging to the Italian context.

The action plans dataset (df2) provides information on action plans, as well as details on individual actions proposed in each plan by each signatory. The reported data relate to the characteristics of the actions, such as a brief description, targeted timeframe, impacted urban sectors, as well as an evaluation of energy consumption and GHG emissions' reduction that can be achieved through their implementation. The present dataset also classifies actions according to their potential contribution in terms of mitigation, adaptation, and energy poverty (the three goals of the GCoM). As far as the present work is concerned, this specific dataset was analysed to identify actions related to renewable energy communities.

The subsequent step concerned cross-dataset analysis to identify which of the selected RECs-related actions from df2 were submitted within a joint action plan developed by Italian municipalities (from df1). Such a cross-screening was performed by the authors through the use of the identification code system provided by the JRC both for action plans, as well as for individual actions, that ensures dataset interoperability for users and researchers.

The operational steps taken to develop similar analyses are described below:

- The Joint SECAP entities (227) were identified from the dataset 'df1_Signatories_4th Release'. The criteria for this identification were the details provided in the 'adhesion_type' column, taking into account both Joint SECAP option 1 and option 2;
- The Italian Joint SECAP entities (181) were selected by applying a filter in the 'country_name' column;
- The records (67) from the 'df2_Action_Plans_4th Release' dataset were extracted based on their title (action_title_EN) containing the phrase 'renewable energy communit'. This was conducted due to the presence of both 'community' and 'communities' within these data;

- The 'organization_id' code was selected as the identifier to define records present in both lists: Italian Joint SECAP and RECs-related actions;
- This made it possible to identify, in the list of signatories, those 10 from Italian regions that both applied for a joint plan and proposed projects related to RECs.

These 10 municipalities belong to three different groups. Two of them are based in the Emilia Romagna region, in northern Italy; while the other group is based in the Sicily region, at the extreme south of the island. Table 2 provides information about the three cases of the Joint SECAP signatories obtained through data elaboration.

Table 2. Joint SECAP signatories that submitted REC-related actions.

Case	SECAP Option	Group Name	Region	Municipality	Population Involved	First Adhesion	Action Start
a.	1	Unione Pianura Reggiana	Emilia Romagna	Correggio Rio Saliceto San Martino Campagnola Fabbrico Rolo	25,485 6178 8166 5600 6778 4062	26/07/13 24/07/13 04/07/13 29/06/13 23/07/13 30/07/13	2021
b.	1	Avola, Noto, Pachino, Portopalo di Capo Passero, Rosolini	Sicilia	Avola Noto Portopalo di Capo Passero	32,000 23,600 3827	18/09/12 26/02/13 01/08/12	2022
c.	2	Nuovo Circondario Imolese	Emilia Romagna	Nuovo Circondario Imolese *	130,001	28/06/13	2020

* Union of municipalities.

Joint SECAPs can be presented through two modes, precisely option 1 and option 2, as mentioned in Section 2, whether goals, targets, and impacts are shared or pursued individually. For the analysis, it was chosen to compare two cases, respectively, referring to options 1 and 2. In detail, case studies b and c were selected to evaluate potential variations of Joint SECAP–RECs interactions according to the subscription option.

The Energy Proximity Map

To visualize technical boundaries imposed by the primary substation on the formation of a renewable energy community, the authors referred to the interactive map provided by the Energy Services Provider (GSE, in Italian) [97]. This tool has been developed to allow potential participants to check under which substation they are located, and the consequent possible configurations they could set up or be involved in.

The map is designed through a WebGIS containing two principal layers: 'Aree Convenzionali' that represents the boundaries set up by the 25 Italian energy distributors, each represented with a different colour (Figure 3), and 'Comuni', which identifies municipality perimeters based on data from the Italian National Statistical Institute updated in 2023.

Other layers could be added to the map from other data sources supported within Geographic Information System (GIS) platforms, this boosts analytical performance, allowing users and professionals to consider other important aspects for the RECs' design. Information such as land use, vegetation coverage, surface irradiation, etc. could be helpful for the first localization of the production infrastructures, but also for community reconfiguration after dramatic events such as earthquakes or fires. However, for the purposes of this study, it is sufficient to refer to the two main layers.

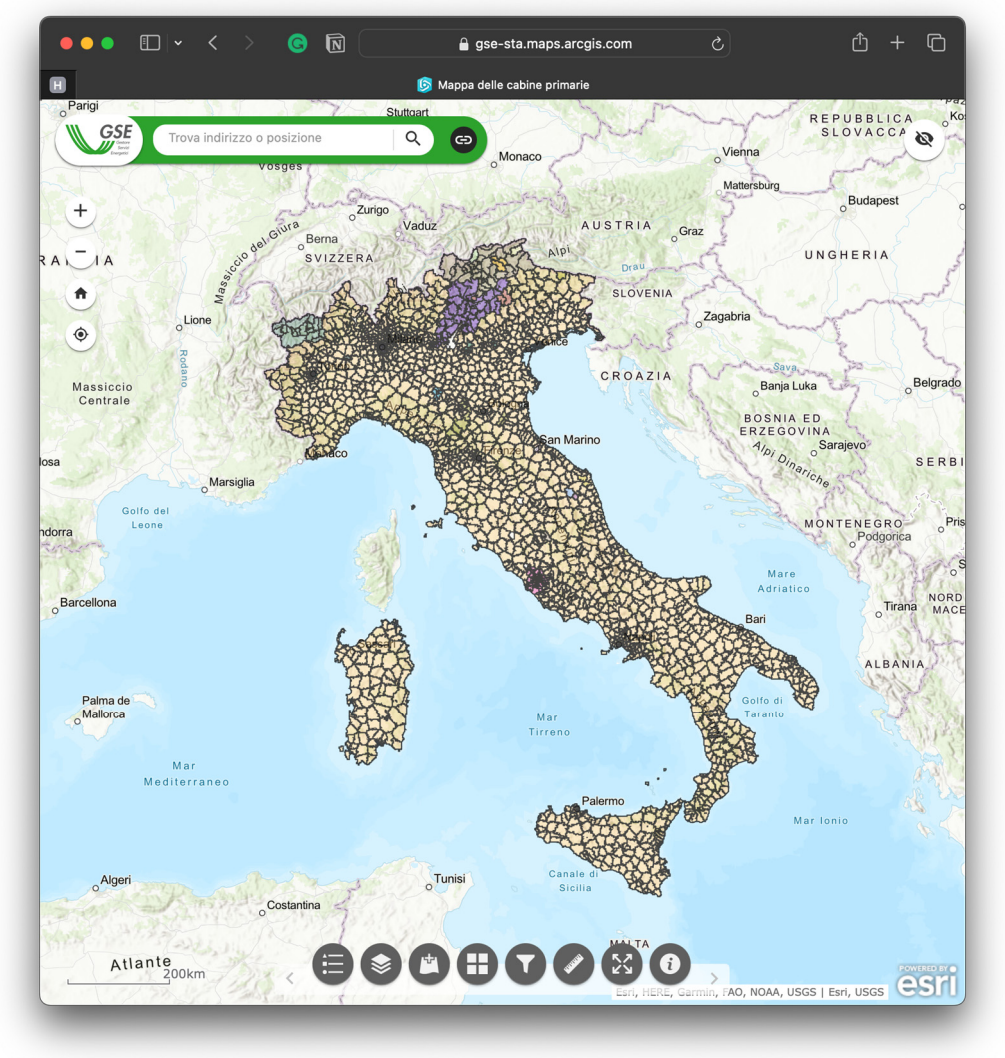

Figure 3. WebGIS provided by GSE for principal substation boundary identification. Given the plurality of energy distributors across the country, the 'Aree Convenzionali' layer shows with different colours the areas served by a different energy distributor.

4.2. Case Studies

The selected case studies are spatially located in Northern and Southern Italy. This allows the authors to perform an interesting comparison based on their differences in geographical characteristics and Joint SECAP configuration. The main issue addresses criticalities in setting up Renewable Energy Communities as a joint action between SECAP signatories, due to the problem of the electrical grid boundaries intersecting administrative ones.

4.2.1. Case b: Avola, Noto, Pachino, Portopalo di Capo Passero, Rosolini

Case b refers to the Sicilia region, one of the major islands in Southern Italy. This Joint SECAP was presented through option 1 mode, meaning that the plan is committed jointly, but each signatory can envisage specific individual actions. It is the case of REC-related actions that are not mentioned as shared measures; instead, they are addressed by individual action plans. Three out of five signatories, namely Avola, Noto and Portopalo di Capo Passero, in fact, precisely refer to Renewable Energy Communities with an action titled as: "Promotion of the establishment of renewable energy communities". On the other hand, although Pachino and Rosolini touch upon related subjects, such as photovoltaic and renewable energy, they do not explicitly cite them.

Figure 4 highlights the region in which REC actions are envisioned. It also shows how this region is zoned by the 'energy proximity boundary', depending on the primary energy substation (grey line).

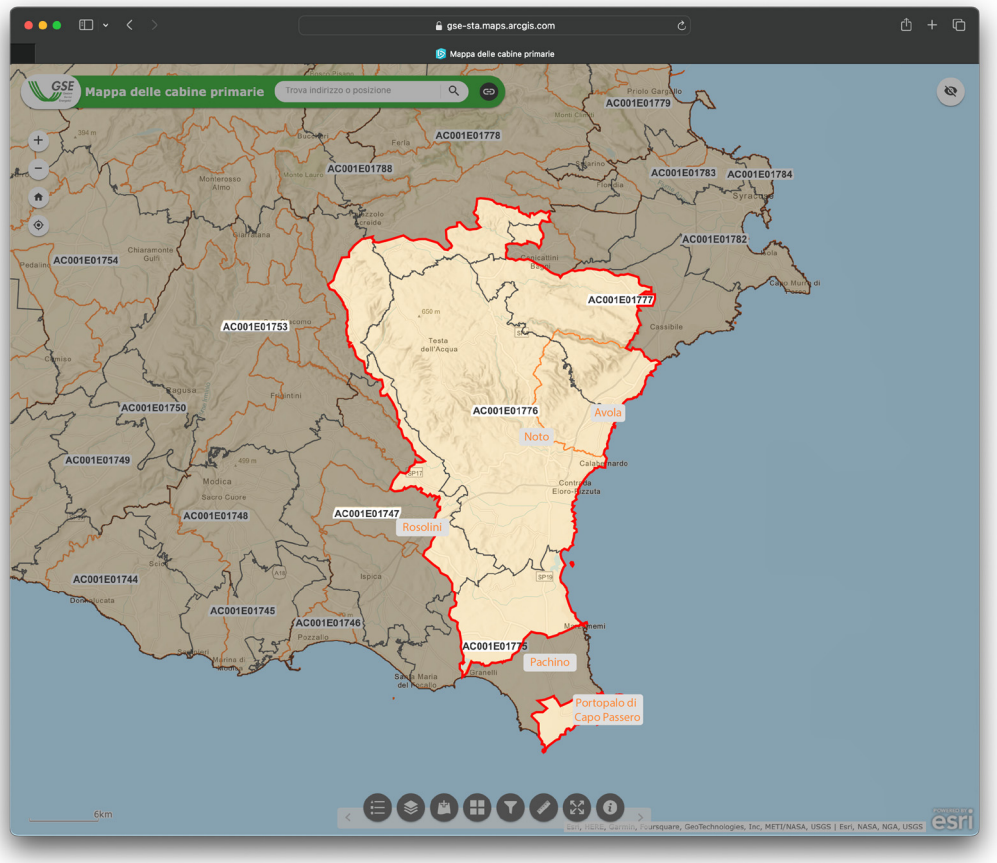

Figure 4. Case b. Overlap of municipalities' administrative boundary (orange line) with primary distribution substation territorial subdivision (grey line). Municipal regions that have explicitly included REC-related actions in their SECAPs are highlighted.

The area is divided into three different administrative regions (orange line), and it is served by six different primary substations. Due to its southern location and its climate classification, this area benefits from good sunlight exposure, making it an ideal candidate for photovoltaic energy production, a widely favoured system in both SECAP strategies and RECs. Urbanized zones are primarily situated along the coast and other smaller centres are located inland. Most of the land is dedicated to agriculture, creating potential space for the installation of small-scale energy production plants for local energy communities, even considering opportunities offered by agri-photovoltaics systems [98]. Rosolini, for example, has included in its SECAP actions related to the installation of renewable energy plants in order to reduce the cost of electricity in the agricultural, artisanal, and industrial sectors.

Conversely, the northern mountain area and the coast, which bounds the territory, consist of natural barriers that cannot be easily overcome. These geographical constraints are amplified by the substation limit. Some critical aspects are:

- The town of Avola is actually split into two parts by the grid boundary that separates users and citizens potentially willing to form an energy community;
- The municipality of Noto, which is quite extended (554.98 km^2), includes six different substations. In particular, in the perimetral and marginal areas, the possibility to set a community is constrained by both kinds of limits, forcing participants to look outside the municipality limits for other entities interested in establishing a REC;

- The entire municipality of Portopalo di Capo Passero, in the extreme south, is isolated since the bordering town of Pachino did not address any action about energy communities.
- The municipality of Rosolini has very similar objectives but lacks an explicit reference to the RECs, which hinders the coherence and uniformity needed for joint planning actions.

It has to be said that, with the exception of the first limitation, the last three do not represent such a strong barrier, since citizens are free to set up RECs independently of their administrations' objectives. Anyway, citizens would probably be nudged to look for other participants within the municipal limited areas in order to both take full advantage of and contribute to the objectives of the SECAP initiatives, and also to share the benefits of RECs among already established local communities.

In this sense, it could be said that the population involved in the CoM initiative forms a community that goes beyond the single administrative boundary. More efforts could be made to build communities sharing different interests, missions, and targets, in many ways signing a common plan for emission reduction and setting up RECs combining opportunities and incentives to grow together. In this direction, more efforts in sharing actions aimed at similar targets could foster participation and be a solution to overcome boundary problems. Moreover, a more systematic coherence and clarification of terms and definitions referring to the same action could be useful to facilitate the joint achievement of common objectives.

4.2.2. Case c: Nuovo Circondario Imolese

Case c refers to the Emilia Romagna region, located in Northern Italy. Unlike the previous example, this Joint SECAP was signed through option 2 mode, meaning that the plan is committed jointly by an entity that overlaps and includes the group itself. Nuovo Circondario Imolese gathers 10 administrations under a so-called 'union of municipalities' that is a local administration conceived to strengthen the administrative organization and foster collaboration to improve service quality and availability for citizens, especially for smaller municipalities [99]. The spatial planning process is then a shared practice by the components of the union, as well as the definition of climate and energy strategies and policies.

In this way, it is easy to understand how even climate strategies are addressed jointly by all of the components of the union, thus including RECs as well. The respective action is titled "Creation of renewable energy communities", a more impactful label than the previous case, namely, 'targeting REC's promotion'.

The extension of this group is presented in Figure 5 as an overlap of administrative boundaries (orange lines) and grid ones (grey lines). The different colours shown, namely yellow and green, correspond to the respective distributors serving different areas. In this instance, there are two such distributors. However, this differentiation has no relevance for the current context, as we only refer to its outline.

The union is composed of ten municipalities that are served by eleven primary substations. In this case, it is more evident a fragmentation of the whole area due to both the administrative boundaries and the substation constraints.

As in the previous case, perimetral zones could meet more difficulties in setting up the community, especially because these areas present a lower density and potential users could be more widespread. On the other hand, the largest town (Imola) is once again divided in two by the grey line, which means that citizens interested in jointly producing and using energy can be assigned to two different substations, hampering the community's sense of togetherness.

Again, administrative boundaries are not unavoidable constraints, but, in the logic of a community-led initiative, it would be preferable for citizens to be able to join other users who belong to the same municipality, thus enforcing pre-existing boundaries that link people who were born or used to live in the same city, town, or village.

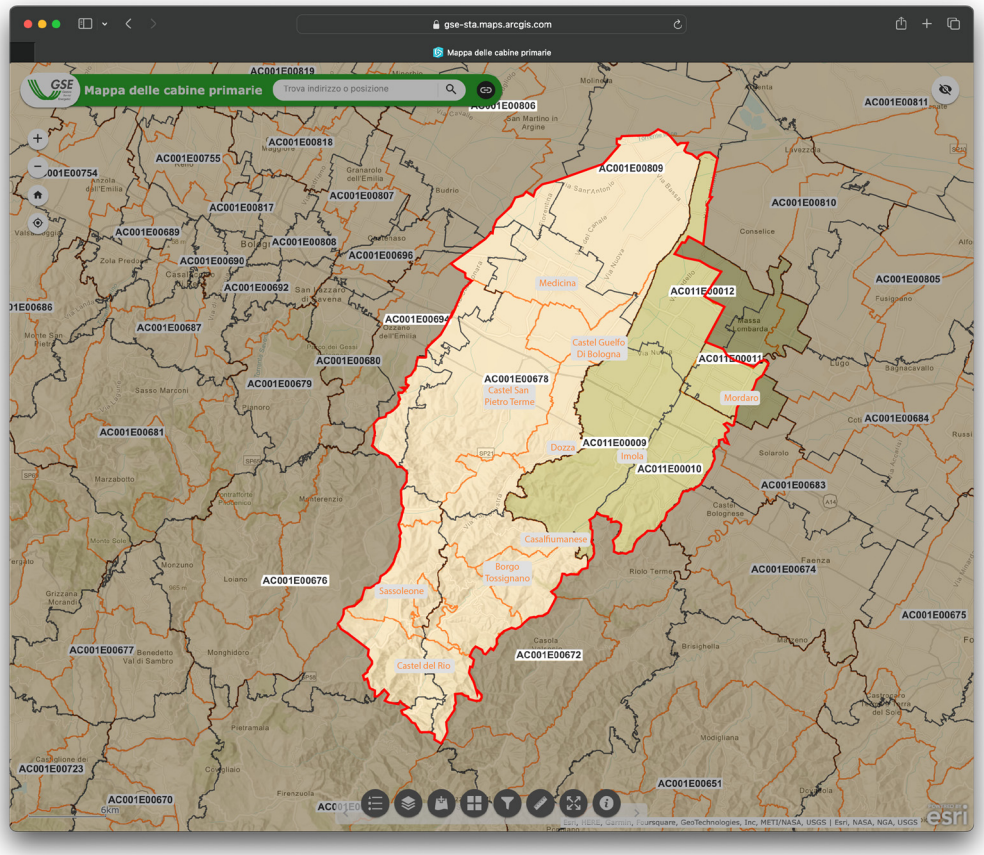

Figure 5. Case c. Overlap of municipalities' administrative boundary (orange line) with primary distribution substation territorial subdivision (grey line). The region of the group of municipalities is highlighted. All of them jointly presented SECAP action related to RECs.

It is worth mentioning that on the website of the group, many references to RECs can be found [100]. The online page facilitates citizens in a user-friendly exploration of RECs' functioning and benefits. In particular, it is mentioned that over the past few months, energy consumption data of public facilities has been collected, and also some public areas potentially intended for the installation of photovoltaic systems have been defined. In May and June, the municipalities of the Nuovo Circondario Imolese organised meetings for businesses and citizens to explain the aim, functioning, and tangible benefits of establishing Energy Communities.

Until 15 December 2023, citizens and businesses had the opportunity to express their non-binding interest in joining one or more Renewable Energy Communities. These adhesions will be evaluated by technical advisors that will investigate local characteristics and urban constraints to support the launch of the SECAP action, thus showing a strong synergy between the two climate-related tools and strategies.

In the two identified cases, despite the inclusion of dedicated measures in the planning tools, the uptake of RECs is currently minimal. The authors faced difficulties in obtaining information about the realizations or ongoing projects in the areas identified as case studies. Issues and barriers are highlighted for each case, but it is also necessary to figure out that similar poor advancements can be attributed to the immaturity and delays in the regulatory framework, as well as the operational challenges faced by citizens in implementing RECs. In this context, the Nuovo Circondario Imolese has proven to be more proactive by embracing a participative approach that extends beyond energy community initiatives. Residents of the region are directly involved in meetings and events organized within the scope to make them aware and part of the planning process.

Except for virtuous cases such as this, these kinds of activities are being led by Energy Service Companies (ESCOs), whose role is currently gaining importance with the diffusion of community-based energy projects. ESCOs are energy divisions of a utility company or energy service provider that support citizens with technical, bureaucratic, and financial issues related to RECs' configuration and realization [101]. As interest in these initiatives continues to grow, ESCOs often contribute to knowledge sharing by organizing events and public forums. This collaborative approach helps foster community engagement and awareness around renewable energy projects. Despite their significant contribution, the involvement of a public institutional body with administrative and planning competencies could help with addressing community boundary issues and ensuring compliance and coherence between the strategic and operational levels.

5. Discussion

The presented analysis of the JRC dataset, as well as of the above-mentioned case studies, may support several considerations.

First of all, among the great amount of Joint SECAP initiatives within the Italian context, just a few include RECs-related measures, despite representing nowadays a highly recommended action to improve smaller municipalities' resilience [102]. A similar gap may be due to several reasons.

5.1. Planning Barriers for Small Municipalities

The present work started introducing local-based planning tools (SECAPs) for achieving the green transition and developing climate change adaptation and resilience. These kinds of initiatives rely on community engagement and citizen participation, whose contribution can be enhanced through incentives that encourage the adoption of more sustainable habits, for example, renewable energy production and sharing (e.g., through RECs).

Within this framework, long planning and implementation procedures may constitute a relevant barrier. Especially as far as smaller municipalities are concerned, the lack of human and economic resources may hamper action design and starting, so the presented planning tools may be easily outdated. Moreover, as emerged from the case study analysis, since energy transition through RECs may constitute a quite recent solution in public debate, several plans may have been submitted before their wide spreading. This was taken as a potential hint for a lack of coordination and led to further investigation of possible obstacles and barriers.

Secondly, small municipalities' mayors and representatives may not be fully aware of their potential role in implementing such solutions. In this direction, the Joint SECAP may include more 'traditional' measures due to the lack of complete knowledge of recent innovations in both energy and governance schemes [103]. The infrequent selection of RECs as tools to support mitigation and adaptation strategies may be due, in part, to a limited attitude towards smart and disruptive solutions. It is important to note, based on the dataset analysis, that out of 181 Italian Joint SECAPs, only three groups included actions related to Renewable Energy Communities.

5.2. Lack of Innovation Enablers

These two first elements may lead to a broader evaluation. It has long been discussed whether municipalities may be pivotal for energy and adaptation strategies due to the subsidiarity principle [104], and similar bottom-ups initiatives rely on that. Nevertheless, the limited resources (both in human and financial terms) available for smaller municipalities may not be enough to support a proper transition towards more green and resilient territories. Greater support and coordination from intermediate institutions may help build a more coherent knowledge through dissemination and communication campaigns [105] as well as support local administration in the implementation steps. This may lead to quicker and more informed and conscious planning and operational processes.

As described in the case studies' section, knowledge transfer and communication are currently carried out by ESCOs. They support citizens interested in implementing CERs from the technological and financial point of view, although they cannot be part of them as profit-making entities [101]. This is because these private entities pursue economic and entrepreneurial interests, and although companies may be interested in promoting the use of renewable energy sources and reducing energy consumption, there is a risk that conflicts and inequalities will be exacerbated by profit and individual interests. Their role is certainly important to enable the design process, but it would be preferable for a public institution to take charge of such activities since they are supposed to pursue the common good and promote the spread of benefits and advantages for the community.

The authors believe that the action of public institutions is needed to ensure more coherence and coordination on both levels: the planning and the operational one. In fact, the described case studies show that even where the operative tool (REC) is included in the planning one (SECAP), some problems arise precisely because of the different nature and potential perimeters of the two. One of the main issues is represented by the attempt to overlap the technical boundary (e.g., the area of influence of the primary substation) with the administrative one—thus, reflecting the community perimeter. This denies the possibility for already established communities to join under the same REC, thus leading to a bottleneck hampering the planning process of community-centred energy initiatives and to a non-complete achievement of the SECAP objectives.

The operational step may benefit relevantly from a multi-layer mechanism also due to legal and technical issues [106]. Direct joint action between European institutions and local administrations bypasses indeed governance levels where laws and policies are shaped, namely at the national and regional scales. A similar gap may limit local action's effectiveness due to the presence of technical and legal constraints, like the one concerning electricity substations. It is therefore evident that, despite significant commitment coming from local stakeholders, the presence of technical boundaries splitting the same municipality into two parts in terms of electricity distribution and a respective legal framework supporting the implementation of RECs within the same substation—whose limits are indifferent to administrative borders—may effectively reduce RECs' outcomes and impacts.

In this direction, an intermediary close to the community and sensitive to the interests of its members would be needed, thus overcoming at the same time the fragmentation of the local scale and owning adequate resources and expertise to enable the development of such actions.

5.3. SECAP Submission Options and Community Identification

Moreover, looking at community-centred SECAP initiatives, it should be argued that submission options 1 and 2 may have significantly different impacts on the effective implementation of actions. Despite requiring a more limited commitment and joint effort from signatories, option 1 does not necessarily require integrated actions, thus hampering the possibility of benefiting from the up-scaling of local initiatives on a community basis [107].

As far as the presented case studies are concerned, it is therefore easy to highlight that the fact that the Pachino municipality did not include RECs within its actions package, which will affect deeply potential outcomes coming from the creation of a local REC, thus segregating the Portopalo di Capo Passero municipality. The same also applies to Rosolini, whose action has a title not directly related to RECs, since the same objective of promoting renewable energy and reducing consumption refers mainly to the production and agricultural sectors.

Case c, indeed, shows greater potential in terms of action effectiveness and impacts. Even though a greater institutional effort is required to gather into a common subject planning shared and integrated initiatives, once the submission is completed, option 2 paves the way to an easier coordinated and shared framework for action implementation. Community cohesion and willingness to bring mitigation and adaptation actions forward jointly constitute a key driver to support effective impacts and relevant outcomes, namely

the gathering of administrative resources seems to be insufficient when similar community-centred actions are concerned.

In this direction, being casual or not, it is interesting to highlight that in case b, the chosen name for REC-related action deals with 'promotion', while in case c, the target is the 'creation' of such a community, thus communicating the perceived difference in terms of potential barriers. Choosing option 2 plan submission has made it possible to achieve uniformity in the description of the RECs, which is lacking in Sicily and probably hinders their smooth implementation.

Also, the role of the Union of Municipalities as an intermediary of the local community has made it possible to speed up some operational steps such as the mapping of facilities consumption and of public spaces suitable for renewable energy production. Meetings and public dissemination events promoted the implementation of one or more RECs, with the help of technical partners for their design according to local characteristics.

In case c, the Union covered a role that, on one hand, must be close to the citizens in order to support them, as ESCOs currently do, but which, at the same time, must have the skills, resources, and competencies to ensure a fair and balanced distribution of the benefits offered by local-based energy initiatives.

Similar evidence suggests that the way the community is perceived within the planning process, also in terms of roles and recognised responsibilities, has a profound effect on the potential outcomes of the initiative.

6. Conclusions

The present work has been developed to investigate the role that community-centred initiatives may play in sustainable energy planning. As far as small municipalities are concerned, a planning flow from the tactical to the operational level may meet significant bottlenecks due to the role and commitment of the local community. In detail, it has been highlighted how communities are not inherently provided with geographically predefined boundaries. Nevertheless, strategic and tactical planning requires them to be institutionally recognized through an administrative perimeter. Whenever further kinds of limits are provided at the operational level (e.g., technical for RECs), potential conflicts may emerge. The community's relevance, its institutional recognition, and the consequent actions' effectiveness may vary significantly, thus leading to potential criticalities when administrative and community boundaries do not overlap.

Similar issues have been addressed through the analysis of the Joint SECAP initiative supporting small municipalities to gather and submit shared sustainable energy and climate adaptation plans and its interrelationship with Renewable Energy Communities, relying on the involvement of local communities to support a widespread and sustainable energy production targeting greater resilience and proximity.

In this direction, referring to the Italian context (it is the EU country accounting for the most relevant share of the Joint SECAP signatories), several barriers concerning community boundaries have been highlighted. Legal and technical constraints frequently provide further perimeters not overlapping with administrative ones, thus hampering the effectiveness of the planned actions.

Communities may constitute a relevant driver for bottom-up initiatives, but their effectiveness is still strongly influenced by higher institutional levels so that a multi-scalar and multi-layer governance approach should be enhanced.

Although representing an initial step towards community-centred planning mainstreaming, given the great relevance of resilience and proximity issues referring to the great challenges connected to climate change and socio-economic instability, future research may enlarge the focus from RECs to other forms of bottom-up energy-related initiatives and their relations with the more comprehensive framework of legal and technical planning and policies.

Similar issues may prove to be pivotal as far as policy design is concerned. The present research has pointed out some critical issues and opened up the possibility of future works

fostering community-centred energy planning academic debate. In this direction, different methodological steps progressively led the authors to achieve some findings that may be useful for the future implementation of these kinds of energy policies:

- As far as the Joint SECAP mainstreaming of bottom-up energy initiatives is concerned, starting from barriers met by small municipalities in LEIs implementation, to support a further understanding and easier implementation of local actions aimed at energy transition, a greater level of standardization should be promoted, both in vocabulary and the respective legal framework. Similar commitment at the EU level (through JRC and CoM institutions, for instance) would help with knowledge sharing and transfer on a transnational level. This may prove particularly pivotal since similar place-based initiatives risk constituting stand-alone experiences. This issue represents a quite relevant threat for small municipalities whose actions, although on a limited scale, may achieve a greater magnitude of impact through networking and agglomeration.
- Related to REC enablers within Joint SECAPs, as suggested by the presented case studies, the presence of institutions/organizations supporting the local community through technical and legal advice, enhancing cooperation among different stakeholders, and fostering knowledge production and sharing may represent a key enabler. Similar intermediate actors could help with overcoming local fragmentation as well as promoting a shared approach towards community-centred energy planning. Networking could play a crucial role in assisting small municipalities in initiating interactions with regulatory agencies and infrastructure management companies. This collaborative approach facilitates the co-designing of new solutions to overcome technical barriers, ensuring that already established communities may also be recognized from an energy perspective.
- As far as Joint SECAP submission options are concerned, the highlighted barriers related to administrative fragmentation could for instance suggest that similar bottom-up initiatives may benefit from the requirement of substantial (rather than just formal) joint proposals. In this direction, Joint SECAP option 2 should be favoured, giving municipal aggregation a stronger operational basis, while the formal requisite of option 1 has shown a critical weakness in the implementation step due to potential threats in terms of territorial continuity and up-scaling. Following the approach introduced for other kinds of place-based initiatives—cohesion policies, above all—an aggregative pre-requisite could constitute a significant starting point to foster municipal engagement and active involvement towards more sustainable, resilient, and inclusive communities.

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