Renewable Energy Communities as a Tool for a Just Green Transition in Inner Areas: A Pilot Project in Sardinia (Italy)

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Abstract. Access to energy is a crucial global challenge that influences economic development, environmental sustainability, and social equity. Renewable Energy Communities (RECs) have emerged as a transformative model to promote local engagement in renewable energy initiatives, particularly in rural and marginalized areas. This study examines the role of RECs in Inner Areas, with a specific focus on Sardinia, Italy, highlighting their potential to enhance local energy security, reduce costs, and foster economic revitalization. While European and national policies, such as the Green Deal and the Italian National Recovery and Resilience Plan (PNRR), have allocated funds to support RECs, their implementation in Inner Areas remains limited due to regulatory complexities, administrative hurdles, and financial constraints. By presenting the REC design process in this context, the study explores both the opportunities and critical challenges that persist. To assess the feasibility of RECs, we propose a multi-scenario simulator designed to support decision-making by performing hourly calculations of energy flows, financial cash flows, and environmental benefits. This tool enables a preliminary evaluation of REC profitability by simulating different community configurations and considering key variables such as energy production, self-consumption, storage dynamics, and surplus energy management in compliance with Italian regulations. The study highlights the importance of strengthening institutional support, enhancing community education, and developing policy frameworks that facilitate the creation of collaborative territorial networks.

Keywords: Inner Areas · Renewable Energy Communities · multi-scenario simulations

1 Introduction

Ensuring access to clean and affordable energy is a crucial challenge that intersects with broader goals of sustainability, equity, and economic resilience. Current global and European strategies, such as the UN 2030 Agenda [1] and the European Green Deal [2], emphasize that the transition from fossil fuels to renewable sources must be

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inclusive and territorially balanced. This shift requires not only technological innovation but also strong engagement of local communities and institutions to ensure a just and participatory green transition [3–5].

In this context, Renewable Energy Communities (RECs), introduced by the EU Renewable Energy Directive (RED II) [41], offer a transformative model of decentralized energy production. These communities empower local actors through democratic participation, encouraging energy autonomy, reducing vulnerability to energy poverty, and stimulating economic regeneration, particularly in rural and marginal territories.

Peripheral regions, especially Europe's so-called Inner Areas – characterized by demographic decline, limited services, and economic marginalization – have a strategic role to play. Here, RECs can counteract spatial inequalities by mobilizing local resources and fostering community-led energy planning. However, meaningful implementation requires not only infrastructure, but also sustained institutional support, education, and inclusive governance to build public trust and participation.

In Italy, several recent policies—such as the National Recovery and Resilience Plan (PNRR) and Regional Operational Programmes—are starting to recognize and support the potential of RECs in Inner Areas. Nevertheless, further research is needed to evaluate their actual impact and to identify remaining obstacles. Understanding how these measures contribute to a more just and inclusive energy system is essential for promoting a truly equitable green transition.

This study focuses on the practical application of a simulation tool designed to support the development of Renewable Energy Communities (RECs) in marginal areas, with a specific case study in the municipality of Simala, located in the Inner Areas of Sardinia, Italy. The objective is to evaluate the feasibility and potential benefits of REC initiatives in territories that are often underserved, highlighting the specific challenges faced by peripheral regions—such as regulatory barriers, lack of technical expertise, and limited financial resources.

The proposed tool aims to assist local stakeholders—including small municipalities, policymakers, and technical partners—in estimating shared energy flows, cost savings, and revenue distributions within RECs. In doing so, it supports the planning and expansion of energy communities in nearby villages, promoting a more equitable distribution of renewable energy opportunities.

By addressing the gap between national REC policy and on-the-ground implementation in disadvantaged areas, this study contributes to the broader goal of a just green transition, a concept that underlines the importance of leaving no community behind in the energy transition process.

The paper is structured as follows: Sect. 2 outlines the research design; Sect. 3 presents the materials and methods, including Inner Areas and REC regulatory context; Sect. 4 describes the multi-scenario simulation tool; Sect. 4 introduces the case study of Simala; Sect. 5 present the results; and Sect. 6 discuss the implications of case study application and concludes with final remarks.

2 Research Design

This contribution aims at presenting the preliminary outcomes of the valuable support that a research team of the University of Cagliari is providing to the Municipality of a small rural village called Simala, sited in an inner area of the Sardinia Region, to establish a new renewable energy community. The process herein described may be summarized through the following crucial steps:

1. **Citizen engagement through public meetings:** this stage of the process turned out to be crucial to explain the main operating principles of RECs to common unskilled citizens and, at the same time, involve them in the project
2. **Data collection:** Directly during public meetings and also indirectly through subsequent contacts with interested people, useful data related to potential consumption and production profiles of the potential REC members are collected
3. **Multi-scenario simulations:** Based on collected data from the involved citizens and on a specific set of input data, multi-scenario simulations are performed through an excel-based simulator (implemented for this specific purpose) to assess both the energy and the economic balance of various REC configurations.

All steps mentioned above are fundamental to support the REC promoter to make informed decisions and enable the success of the REC project.

3 Materials and Methods

3.1 Renewable Energy Communities and Inner Areas

Access to energy is both a critical challenge and a major opportunity in today's world, shaping economic development, environmental sustainability, and social equity. Global and European policies emphasize that the shift from fossil fuels to renewable energy is not just a technological transformation but a multidimensional process that must integrate social, economic, and environmental considerations. In this context, international frameworks such as the UN 2030 Agenda – particularly Sustainable Development Goal 7 (SDG 7) [6] – and European initiatives like the Green Deal [2] highlight the importance of a balanced territorial development [7] and the need for collaborative action among governments, businesses, and civil society.

To ensure a more resilient and inclusive energy system, it is essential to develop decentralized and local and community-driven renewable energy solutions [8]. These measures not only strengthen local resilience and reduce dependence on external energy providers but also drive economic growth, combat energy poverty and ensure that vulnerable communities are not left behind in the transition process.

Within this framework, Renewable Energy Communities (RECs), formally introduced in Europe by the Renewable Energy Directive 2018/2001 (RED II) [9], emerge as a transformative model. RECs promote local engagement in renewable energy initiatives through social innovation and democratic participation, empowering communities to take an active role in a sustainable and inclusive energy future [10]. By decentralizing energy production and distribution, these communities enhance local energy security, lower energy costs, combat energy poverty, and stimulate economic revitalization.

In this context, rural and marginal territories – often overlooked in traditional energy planning – play a crucial role in the development and expansion of RECs initiatives [11]. In particular, areas identified by the European Union as "Inner Peripheries" which face challenges such as demographic decline, inadequate infrastructure, and economic marginalization, are increasingly recognized for their untapped potential in this transition [12, 13]. In these contexts, RECs can offer a solution to de-territorialization process, which has led to the concentration of services and activities in metropolitan areas and the resulting impoverishment of peripheral territories [14, 15]. Small municipalities, which characterize the settlement type in Inner Areas, can directly manage renewable energy infrastructure and facilitate partnerships between local stakeholders. Furthermore, REC initiatives can create new employment opportunities in the renewable energy sector, fostering local economic diversification and enhancing energy autonomy.

The successful implementation of energy communities in Inner Areas requires more than just technological infrastructure. It necessitates strengthened community education, long-term institutional support, and policies that empower local actors to take ownership of energy transitions. The protests against large-scale renewable energy projects, which were implemented without adequate local involvement, have sparked significant resistance and low public acceptance [16, 17].

These events highlight the importance of ensuring local engagement and participation in energy planning, as ignoring community concerns can lead to opposition and undermine the success of renewable energy initiatives. In contrast, bottom-up energy initiatives ensure local engagement and participation in energy planning, leveraging territorial resources, and fostering energy literacy, as an essential element encompassing awareness, attitude, and behavior toward sustainable energy consumption [18].

In Italy, the Inner Areas, a specific category of Inner Peripheries [19–21], play a crucial role in the development of RECs. Although the 2014–2020 National Strategy for Inner Areas (SNAI) adopted in 2012 to revitalize these areas, does not explicitly consider this potential [22–26], the Italian National Recovery and Resilience Plan (PNRR), through Mission 2 "Green Revolution and Ecological Transition" (Investment 1.2), allocates 2.2 billion euros to establish renewable energy systems with a capacity of at least 200 kW in municipalities with populations under 5,000 inhabitants [27], many of which are located in the Inner Areas. These interventions enable an alternative approach to traditional renewable energy production, which often depends on large-scale systems that occupy vast agricultural land, compromising both its productivity and landscape value [28–30].

Other recent policy developments in Italy have demonstrated a growing institutional commitment to expanding Renewable Energy Communities (RECs) in Inner Areas. Notably, during the 2021–2027 planning cycle, several Regional Operational Plans (POR) have included the establishment of RECs as a specific objective, allocating funds to promote them. For instance, regions such as Lombardy, Emilia-Romagna, Lazio, Campania, Sicily, and Sardinia have launched initiatives to support the development of RECs, with resources partially provided by EU structural funds [31].

However, further research is indeed necessary to evaluate the effectiveness of these measures in overcoming existing challenges. While the transposition of the enabling framework for RECs has progressed, and specific measures have been introduced in

the national support scheme for renewables, an assessment of barriers and potential for the development of energy communities is still missing. These efforts can foster a more inclusive and diversified energy landscape, ensuring sustainable development while empowering Inner Areas.

While the transposition of the enabling framework for RECs has progressed, and specific measures have been introduced in the national support scheme for renewables, an assessment of barriers and potential for the development of energy communities is still missing. An analysis conducted by the authors using data from "Ricerca sul Sistema Energetico - RSE" (Research on the Energy System), the research company of "Gestore Servizi Energetici - GSE" (Energy System Operator), updated as of March 2025, shows that only a small number of municipalities in these regions, classified by SNAI as peripheral or ultra-peripheral areas, have an active REC, 16 out of the 70 RECS nationwide [32].

In this context, Sardinia has 13 RECs, four of which are active, while nine are in the planning or implementation phase. However, only three are located within peripheral areas, highlighting the challenges these regions face. Regulatory complexities, administrative hurdles, limited technical expertise, and financial constraints continue to hinder the feasibility of such initiatives [33]. Efforts in this direction can foster a more inclusive and diversified energy landscape, ensuring sustainable development while empowering Inner Areas. RECs general operating principles.

Renewable Energy Communities (RECs) are citizen-driven energy actions aimed at contributing concretely to the clean energy transition, by increasing public acceptance of renewable energy projects and fighting energy poverty conditions [34].

A REC is a true community of people, which not only may include common households but also small-medium enterprises (SMEs), local or territorial authorities (including local administrations, research and training bodies), religious and third sector bodies which voluntarily become partners to constitute a non-profit legal subject, with the sole aim of producing and sharing energy from renewable sources, obtaining economic, environmental and social benefits for the community.

REC members may assume the following roles in the community:

- *Producers,* which own renewable energy production systems, and they wholly make the produced energy available for the REC
- *Prosumers,* which own renewable energy systems, directly self-consume a quote of the produced energy and feed the surplus energy into the power grid
- *Consumers,* which virtually consume the clean energy supplied by *Producers* and *Prosumers* of the REC.

RECs are yearly rewarded with public economic incentives based on the energy which is virtually consumed by all members (i.e. the so-called *shared energy*). As a matter of fact, the shared energy corresponds to the quote of the surplus energy fed into the grid which is virtually and simultaneously withdrawn from the grid by the REC members. Additionally, *Producers* and *Prosumers* may sell the surplus produced energy to the Energy Services Manager (called GSE). Besides the economic benefits, RECs also generate environmental benefits in terms of avoided CO2 emissions enabled by the increased production of clean energy. Moreover, ensuring greater accessibility to clean energy also to vulnerable people, RECs may provide a true contribution to the energy

poverty fight, thus potentially generating also social collective benefits. Inner areas, due to their specific vulnerabilities, may therefore take strong advantage of RECs economic, environmental and social benefits being involved with a key role in the green transition.

4 Simala's REC: A Case Study

The REC project described in this paper is located in the municipality of Simala, a small town in the central-western part of the Sardinian Region, within the province of Oristano (see Fig. 1). As of 2024, the population has declined to 293 inhabitants from 467 in 1991 [30], reflecting an average annual decrease of 1.2% over the past 32 years. This demographic shift underscores a predominance of elderly residents, primarily retirees, who face a heightened risk of energy poverty.

According to the 2011 ISTAT census, the aging index (the ratio of the over-65 population to the 0–14 age group, multiplied by 100) stands at 383. Additionally, only 2.8% of the population is under the age of six, compared to a regional average of 4.8% and a national figure of 5.6%. Household sizes are shrinking, averaging 2.3 members in 2011, while nearly 30% of elderly residents live alone. Moreover, 43% of households lack a nuclear family structure, consisting of either single-person households or individuals without direct family ties.

The local housing stock is characterized by relatively large units, averaging approximately 126 m^2 per dwelling, with nearly 90% owner-occupied. However, the overall state of conservation is far from optimal. Only 48% of buildings are in good condition – a decline from pre-2011 levels – while nearly 10% are in a state of severe disrepair. Despite a rising potential for use, approaching 30%, the underutilization index exceeds 50%, and due to depopulation, new development is virtually non-existent. In essence, the local housing stock is substantial in relation to the population yet increasingly obsolete and underutilized, with figures well below the Sardinian regional average.

This analysis highlights the urgent need for measures to counteract both depopulation and population aging, as well as the consequent progressive abandonment of residential buildings.

The project of the REC could play a crucial role in addressing these challenges. Reducing energy costs would provide much-needed relief to the predominantly elderly population, which is particularly vulnerable. Furthermore, although the elderly population is generally less familiar with new technologies and tends to resist change [35], they can still play an active role in the efficient operation of an energy community. Their constant presence at home enables more effective management of energy consumption. With proper guidance, they could adopt energy-efficient behaviors that maximize self-consumption of the electricity generated by the REC's systems.

Additionally, establishing an associative entity could help counteract the deterioration of the housing stock. The REC could initiate maintenance programs, serving as a technical support hub for its members and pooling multiple users to reduce renovation costs. This collective approach could foster both economic sustainability and community resilience.

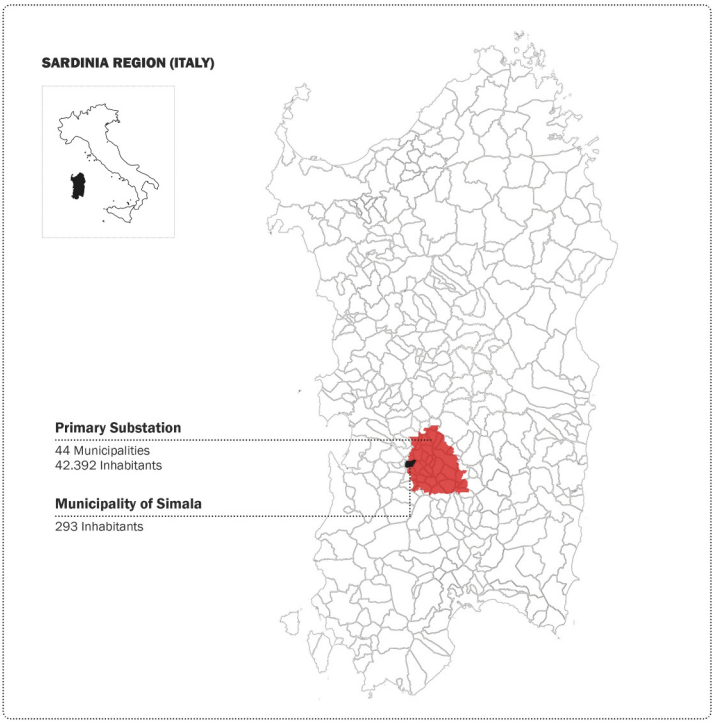


Fig. 1. The Municipality of Simala and its Primary Substation, which serves 44 municipalities.

4.1 Multi-scenario Simulator

Performing technical, economic and environmental analysis is a fundamental step in the establishment pathway of a new REC to preliminarily assess the profitability of a REC project based on an accurate evaluation of the expected economic and environmental benefits for the community, by also considering direct and indirect social impacts. In this regard, it is worth remarking that energy communities are not static entities, as they may go through relevant transformations in their original configuration during their lifecycle. In accordance with the latest Italian regulations [36], new renewable energy communities are entitled to receive from the Italian Energy Services Manager (*i.e.* the so-called GSE) a cash back yearly incentive proportional to the so-called "shared energy" for the next 20 years, and additionally, producers and prosumers may sell the surplus produced energy to the GSE.

All this considered, an accurate simulator may provide a powerful decision support tool to enable an hourly calculation of the REC energy flows, of the related cash flows and of the REC-generated environmental benefits. In this perspective, an Excel-based simulator has been developed to allow multiple-scenario simulations considering different potential REC configurations.

The proposed simulator requires the following input data:

- Number of potential members of the energy community, distinguished by category (producers, prosumers, consumers).
- Energy demand of potential members of the REC (estimated or user-provided).
- Technical data concerning new photovoltaic (PV) systems to be installed (e.g. peak power, Balance Of System - BOS, location and related solar irradiance, tilt, azimuth and number of solar panels).
- Technical data concerning battery energy storage systems (BESS) to be installed (e.g. storage capacity, battery efficiency, depth of discharge, hourly charging and discharging rates).

Based on input data mentioned above, the presented simulator returns the hourly-calculated values of the following energy flows:

- The clean energy produced by the PV systems owned by producers and prosumers of the REC. The energy directly self-consumed by prosumers when the related PV systems are actively operating.
- The energy consumed by consumers and prosumers (when PV system is not fully supplying prosumers loads).
- The energy stored in BESS.
- The surplus produced energy to be sold to the GSE by producers and prosumers.
- The total amount of energy hourly is withdrawn from the electricity distribution network by all REC members.
- The so-called shared energy (*i.e.* the energy virtually shared between REC members, which is hourly calculated as the minimum value between the surplus produced energy injected into the power grid by producers and prosumers, and the energy simultaneously withdrawn from the electricity distribution network by the energy community).

The proposed simulator hourly estimates the produced energy based on the peak power of PV systems, the PV panels efficiency and the solar global irradiance. The solar global irradiance on the tilted and oriented surfaces of PV panels is analytically calculated in compliance with the Italian standard concerning climatic data related to cooling and heating of buildings [37], by taking advantage of PVGIS [38] hourly data concerning the global and the diffuse solar irradiance on the horizontal plane of a typical meteorological year (TMY) dataset selected from a 2005–2020 period.

As far as the estimation of the energy consumed is concerned, the proposed simulator allows to use both user-provided real consumption data and standard consumption profiles, obtained from average consumption values of real consumption data. However, since electricity bills generally present data aggregated by months and time slots, to make energy flows calculation more accurate, hourly coefficients have been first extracted from 12 residential load curves (i.e. three per season, one for working days, the second for days before holidays and the third one for non-working days, made available by Gallanti et al. [39] and then applied to hourly values of residential consumptions. For non-residential users, simulations were based on real monthly electricity consumption data provided by users, broken down by time slot and then evenly distributed hourly.

Hourly values of production and consumption provide in turn an accurate basis for an hourly estimation of the remaining energy flows of the REC (the surplus energy fed into

the power grid, the energy withdrawn from the grid and the shared energy). This accurate hourly calculation of expected energy flows allows for an equally precise estimation of expected cash flows. The economic feasibility of potential REC scenarios can thus be assessed based on detailed estimates of the following costs and revenues:

- The initial investment costs (CAPEX) for the installation of new PV systems.
- The operation and maintenance costs (OPEX).
- The money saved in electricity bills deriving from the directly self-consumed energy by *prosumers.*
- The revenues from the surplus produced energy, sold by *producers* and *prosumers*
- The revenues from incentives granted for the *shared energy.*

The proposed simulator assumes a reasonable market electricity price of 0.25 €/kWh to estimate savings in electricity bills. Regarding revenues from the sale of surplus energy, the energy produced by prosumers and producers and injected into the power grid is valued according to the hourly energy zonal price (ZP_h) made available by the Italian Energy Services Operator (GSE). Specifically, the proposed simulator estimates the yearly revenues from the sold energy by using hourly values of the zonal price (ZP_h) for the Sardinia region (*i.e.* the so-called SARD) referred to the 2024 and made publicly available on the GSE portal.

In accordance with the Italian regulations concerning RECs [36], the energy virtually shared between energy community members is subject to a reward tariff ($SE_{rt,h}$) defined by the following formulas:

$$SE_{rt,h} = 60\,\frac{€}{MWh} + \left(\min(\max(0; 180 - ZP_h)\,; 40)\right)\,\frac{€}{MWh} \tag{1}$$

$$SE_{rt,h} = 70\,\frac{€}{MWh} + \left(\min(\max(0; 180 - ZP_h)\,; 40)\right)\,\frac{€}{MWh} \tag{2}$$

$$SE_{rt,h} = 80\,\frac{€}{MWh} + \left(\min(\max(0; 180 - ZP_h)\,; 40)\right)\,\frac{€}{MWh} \tag{3}$$

where the Eq. (1) is used for PV systems with a peak power greater than 600 kW, while the formula (2) applies to systems with a peak power between 200 kW and 600 kW. Expression (3) is adopted for PV systems with a total power lower than or equal to 200 kW. Moreover, the shared energy is also rewarded through an additional tariff of €10.57/MWh (2024 value) to repay the reduction in the use of grid infrastructures. Furthermore, the proposed simulator includes a basic estimation of the potential environmental benefits generated by RECs. Specifically, it calculates the potentially avoided CO2 emissions by multiplying the total amount of the produced clean energy by a conversion coefficient of 0.702 tCO2/MWh [40].

5 Results

After the engagement activities carried out by the research team, different potential members have been identified and involved in the project. The Municipality may be considered the main promoter of the REC project. Additionally, the Municipality decided to become an active member of the REC, assuming two different roles:

- a *consumer* through its headquarters.
- a *producer*, providing a PV system of about 25 kWp to be installed on the roof of a temporary unused building.

Even though 23 citizens have expressed interest in being involved in the REC project during engagement activities, only three commercial activities and ten families have been identified as potential members as they provided real consumption data from electricity bills. The related annual consumptions are summarized in Table 1.

Table 1. Annual electricity consumption of potential REC members.

Activity	Member type	Consumptions (kWh/year)
Municipality headquarter	Consumer	24740
Cultural center	Consumer	1133
Farm	Consumer	2177
Shop	Consumer	7627
Residential	Consumer	2664
Residential	Consumer	3028
Residential	Consumer	2349
Residential	Consumer	1897
Residential	Consumer	2242
Residential	Consumer	3574
Residential	Consumer	2741
Residential	Consumer	3951
Residential	Consumer	1524
Residential	Consumer	7094

The public and commercial activities have generally an hourly distribution that concentrates electrical loads during the daily hours. The same cannot be observed usually in residential consumers. However, in the specific case of a rural village, a different pattern can be observed. Figure 2 shows the distribution of the annual electrical consumption (2498 kWh/year) of the average residential member of the Simala REC per time slot. It is evident that in Simala residential electrical loads are mainly concentrated during daily hours. This peculiar condition is due to the high percentage of retired old people living in the village of Simala, that occupy houses during the day. This aspect brings a certain population vulnerability to light, but as far as the REC balance is concerned, it is a positive aspect since such load profiles increase the immediate consumption of PV systems production.

The simulation of REC energy balance has been carried out considering a hypothesis of 25 kWp PV, corresponding to the size of the PV system that the Municipality is going to install. The related monthly production is summarized in Fig. 3 even if all energy flows

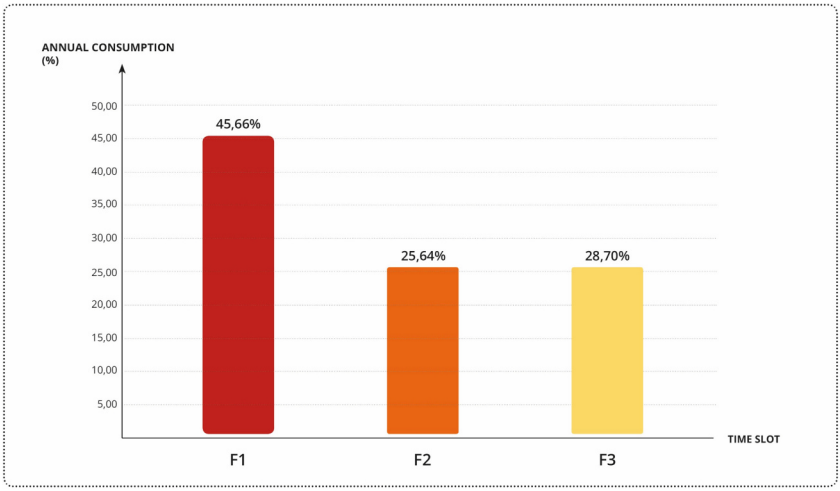


Fig. 2. Annual percentage of electrical consumption of an average residential member per time slot (F1 refers to daily hour in ferial days, F2 evening and Saturday daily hours, F3 nights and Sunday) assumed as standard residential profile in simulations.

(included the produced energy) are hourly estimated. As for the rest of the regional territory, the high insulation makes the use of PV systems for REC quite profitable.

A well-designed and well-balanced energy community should pursue the objective of maximizing the percentage of the energy produced, which is virtually self-consuming by the REC members (i.e. the shared to produced energy ratio). For this aim, three different scenarios have been simulated. The first (Scenario 0) refers to a realistic number of 25 potential members; the second (Scenario 1) foresees an increment of residential members up to 35; the third (Scenario 2) up to 55. For the three scenarios the ratio between shared energy and produced energy is: 84.7%; 92.3%; 98.4%. Considering that the maximum REC potential in terms of virtually sharable energy turned out to be already almost reached with a percentage of 84.7% of the produced energy which resulted to be shared for the first (Scenario 0), the hypothetical number of REC members required to be only slightly increased to finally maximize the shared energy with the third scenario (Scenario 2).

In Fig. 4 the monthly energy flows for the most performing scenario are presented. The balance of REC is optimal since all energy production is simultaneously virtually consumed by REC members within a one-hour time interval. Note that in this peculiar configuration there are no prosumers, so the self-consumed energy is zero.

The next step of simulation has been to check if the optimal energy configuration provides also the best economic outcome. The PV systems installation costs have been neglected since the Municipality is providing for it and it is not charged to the REC. The yearly costs directly attributable to the community are the following: costs for the management and administration of the CER (including maintenance costs of the monitoring platform) assumed equal to 3000 €; rent of the metering devices (50 € per

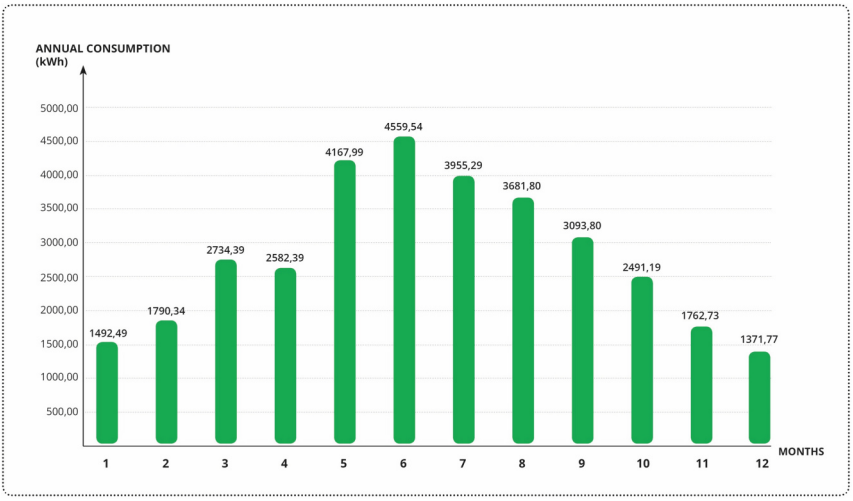


Fig. 3. Monthly energy production of a 25 kWp PV systems in Simala.

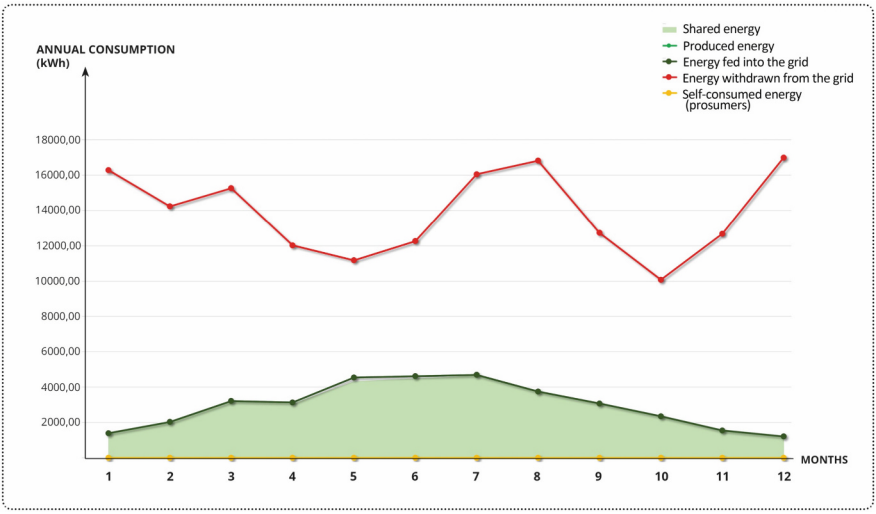


Fig. 4. Monthly energy flows for the most performing scenario (2). The energy produced is fully consumed by the REC.

device). While the platform cost is fixed, the metering devices' increases by the number of members.

According to Italian legislation RECs can have the following sources of revenue: reduction of supply bills (only for prosumer members that in this configuration are absent); incentives for energy fed into the grid and sold to the GSE based on the energy market price in Sardinia (the simulator is able to calculate hourly values and multiply them for hourly production); premium tariff incentives (TIP) calculated on the basis

of shared energy. For PV systems with a power ≤200 kWp such as those foreseen for Simala REC, it is 120.0 €/MWh [31]. It is evident that there are fixed costs and costs that depend on the number of members, as well as revenues that depend only on the PV power (feed-in tariff) and revenues that depend on the number of members that affect the shared energy as shown above. The overall cost/revenue balance for different configurations is summarized in Table 2 and Table 3.

Table 2. REC costs analysis per scenario. * The last scenario refers to the doubling of scenario 0 to another village.

Number of residential members	Management and administrative costs (€)	Monitoring system costs (€)	Total (€)
25	3000,00	1250,00	4250,00
35	3000,00	1750,00	4750,00
55	3000,00	2750,00	5750,00
61*	3000,00	3050,00	6050,00

Table 3. REC revenue analysis per scenario. * The last scenario refers to the doubling of scenario 0 to another village.

Number of residential members	Feed-in tariff (€)	Shared energy tariffs (€)	Total (€)
25	3061,42	3932,96	6994,38
35	3061,42	4288,75	7350,17
55	3061,42	4570,61	7632,03
61*	6122,92	7856,72	13979,60

It is evident that both costs and revenues increase by the residential members number. To understand which is more affected by the expansion of REC, the total amount per member has been compared in Table 4.

The last row of the previous tables refers to a scenario where the REC is doubled in another village doubling also the PV power, the public, commercial and residential consumers. While from a mere energy point of view scenario 2 seems to be the most sustainable, an economic analysis shows that expanding the REC within the same context without expanding production is not profitable.

6 Discussion and Concluding Remarks

The advancement of Renewable Energy Communities (RECs) offers a strategic pathway toward a just and inclusive green transition, particularly in Inner Areas that face long-standing economic and infrastructural disadvantages. By promoting community-led, decentralized energy systems, RECs contribute not only to environmental goals but also

Table 4. REC cost/revenue analysis per scenario and member. * The last scenario refers to the doubling of scenario 0 to another village.

Number of residential members	Total costs per member (€)	Total revenues per member (€)	Difference (€)
25	170,00	279,78	109,78
35	135,71	210,01	74,29
55	104,55	138,76	34,22
61*	99,18	229,17	129,99

to social equity and territorial cohesion, key pillars of a sustainable energy transition. RECs can enhance local energy security, reduce dependence on external providers, and generate socio-economic benefits for marginalized territories.

This study has explored the specific challenges and opportunities associated with implementing RECs in marginal territories such as Inner Areas, focusing on the case of Sardinia, Italy. The findings underline that while RECs hold significant transformative potential, their widespread diffusion is still constrained by regulatory complexity, limited administrative capacity, and funding barriers. Small municipalities, in particular, require targeted support to initiate and sustain such initiatives.

The proposed multi-scenario simulation tool represents a concrete step toward addressing these gaps. By enabling local actors to assess the economic, technical, and social dimensions of REC implementation, the tool supports informed decision-making and facilitates tailored energy planning at the local level. Nonetheless, achieving a truly just green transition in Inner Areas will require more than technological solutions. Coordinated policies, long-term institutional commitment, and active community involvement are essential to ensure that no territory is left behind. Future research should deepen the analysis of REC impacts over time, refine participatory governance models, and develop integrated planning approaches that align local energy resilience with broader sustainability objectives. In this perspective, RECs are not just an energy innovation, they are a lever for systemic change, capable of empowering communities and bridging territorial divides within the European green transition.

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