

Three case studies to explore relevant features of emerging renewable energy communities in Italy

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ARTICLE INFO

Keywords:

Renewable energy communities (RECs)
Actor-network theory
Energy transition
Italy
Geographical context
Socio-economic context

ABSTRACT

The number and importance of renewable energy communities (RECs) are increasing in all European countries due to the support of EU and national policies in order to foster the energy transition through participatory strategies for distributed energy systems. However, their development is rather slow in some countries, including Italy. The paper addressed the issue of the emergence of these socio-technical configurations in Italy, after the related law which entered into force in 2020 allowing the possibility of creating them. Our study focused on the alliances among different actors (professionals, institutions, NGOs, citizens) highlighting possible trends or models for the future that need to be confirmed in further research. The approach proposed to analyse this current process is the Actor-Network Theory, aiming at drawing the assemblages of *human* and *non-human* actants at a general level. Accordingly, we selected three case studies in order to show their different ways of organising, the relevance of trust in establishing each REC and the influence of local context on the composition and features of the actor-networks.

1. Introduction

Technologies for distributed energy generation have reached a high level of maturity that facilitates the creation and diffusion of local energy systems. Nevertheless, technology issues are only one aspect of the energy debate. With the progressive involvement of local communities in the ownership, decision-making and organisation of energy production plants [1,2], a new socio-energy system based on distributed generation from renewables is emerging. In this context, the renewable energy communities (RECs) would play a crucial role in affecting the transformation of the whole system and the energy market [3]. Some specific socio-technical configurations, such as community-based initiatives, are playing an important role in this process. They are based on sharing and participatory practices or energy citizenship for spreading more sustainable energy practices in order to accelerate the energy transition. Besides, RECs are considered a key factor for a wider diffusion of on-site renewable energy sources. Anyway, some European countries introduced these configurations into their national regulatory system later than others – as in Italy – but are trying to fill their gap. Indeed, at present the number of RECs in Italy remains limited when compared to other European countries. As evidenced in the literature [4,

5], RECs are more common in Northern Europe than in Southern Europe. The United Kingdom and Germany have the largest number of established RECs, together with Denmark [6], followed by the Netherlands and Sweden, and then Italy and Slovenia [7].

In this paper, we presented some findings from a research on the Italian context carried out through a comparative analysis based on the Actor-Network Theory (ANT). This study aimed to highlight the different factors that affect the current process of creating various kinds of RECs in Italy and their level of diffusion. In particular, we investigated the different features of emerging energy communities in relation to their local contexts by comparing three case studies placed in different areas. The main research question is: Is it possible to draw some trends and/or potential models of RECs that correspond to different contexts and to different actors and resources locally available?

Due to the low number of initiatives until the moment of our analysis (October 2021), our research was aimed at drawing a picture of the current trends in RECs around Italy, without pretension of statistical significance in terms of representativeness of the three selected case studies.

Prior to 2021, there were not many studies on this specific topic. The majority of these studies focused on the wider community energy

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<https://doi.org/10.1016/j.renene.2023.04.094>

Received 10 May 2022; Received in revised form 18 March 2023; Accepted 18 April 2023

Available online 21 April 2023

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initiatives, especially cooperatives, in the Italian country [4,8,9]. Some of them included some brief analyses on possible causes of differences in the diffusion of community-based and grass-roots initiatives in the energy field between the two internal macro-areas [10]. Moreover, a provisional law, which allowed RECs to be set up also in Italy partly adopting the EU directives [11], entered into force on March 1, 2020. Also for these reasons, the contribution of this paper corresponds to an initial analysis of the RECs from a global national perspective focused on the gap and differences between North and South, which partially contradicts the previous belief of a successful concentration of these initiatives in the Northern area [10].

In recent years (2021–2023), the topic of renewable energy communities in Italy has gained importance, as evidenced by the number of studies which have investigated different aspects of the RECs in the Italian context. In particular, these studies focused mainly on technical [12,13] economical [14–16] and/or normative [17–19] aspects. Some papers included analysis of Italian case studies [5,12,14,20–23] or comparison with other countries (e.g. Refs. [24,25]). While a limited number of papers included social considerations [13,20,26] or addressed social issues [22,23,27,28]. In particular, Piselli et al. [26] evidenced that people engagement in energy communities is fundamental to reach the expected energy transition towards peer-to-peer renewable energy market. Bonifazi et al. [20] investigated key factors in REC-building process with a review of regional policy frameworks to account for the interplay between local differentiation and evolving of social practices. Stentati et al. [13] mentioned the social welfare of the community – including incentives – in the process of optimization of an energy community.

However, even the analyses focused on socio-technical aspects [23, 28] as conditions for the setting up of RECs are mainly related to the use of other methodological approaches [23] or to a different point of view of the process (i.e., the organisational model in Ref. [28]). For instance, Magnani and Cittati [23] combined two theoretical perspectives – the multilevel perspective (MLP) and the socio-technical imaginaries approach – to analyse some Italian RECs. On the one hand, these authors [23] use the MLP to analyse the RECs as a niche phenomenon that paves the way for the initiation of widespread energy transition processes by taking into consideration the pre-existing socio-technical regimes consisting of three levels: official rules, technologies and institutions. This approach is able to highlight the conditions that can favour transition processes through applying socio-technical innovations. On the other hand, the socio-technical imaginaries perspective is used to show how the imagination of an individual about a new possible society can affect a wider group in order to spread out innovative practices in the technological sphere and, more specifically, in the energy communities. Other scholars [28] focused on the internal organisational aspects that feature the emerging REC initiatives in Italy with the aim of identifying possible models of sharing resources and knowledge to understand, if possible, which organisational models are best suited to foster a wider social diffusion of the socio-technical configurations represented by RECs. Such approach is more related to the cluster analysis of threefold models based on business model canvas applied to the Italian RECs officially registered at the GSE (i.e., the state-owned company that promotes and supports renewable energy sources in Italy). Moreover, Ceglia et al. [22] analysed a REC of Southern Italy, but from the perspective of its capability to mitigate energy poverty by assessing its energy, economic, environmental and social benefits combined with the definition of a new socio-economic indicator to measure the potential of RECs in the mitigation of energy poverty.

Compared with this literature, the novelty of our findings mainly lies in the adoption of the actor-network theory and the focus on possible differences related to local contexts. Our aim is to analyse the process of setting up of the networks corresponding to the RECs, their composition and the role of each component including technologies, the way in which they relate and influence each other in order to constitute themselves as one truly functioning actor. This level of our analysis is

strongly related to the local and territorial perspective, considered from a socio-economic point of view.

Our findings and approach can be usefully taken into consideration in further research about internal differences of other countries, above all in the Southern European ones (e.g., Greece; Spain and Turkey), which present some macro-economic and/or socio-cultural similarities with Italy. More in general, applying the ANT approach highlights the relevance of the context in relation to community-based and participatory initiatives due to the variety of resources available in each area in terms of economic, cultural and social capital. Consequently, it would be useful to analyse different actor-networks in the energy field by using a comparative cross-country perspective.

The paper is structured as follows. Section 2 evidences the existing socio-economic differences and gap between the two Italian geographical areas (North and South). Section 3 introduces the mentioned ANT used to analyse the Italian RECs, while details on the tools and methods applied and an overview of the Italian RECs are given in Section 4. Section 5 provides a description of the three specific RECs selected as case studies. A discussion and analysis of the results, based on ANT and qualitative interviews (Section 6), allowed us to elucidate some key factors for the development and successful progress of RECs. Finally, the main findings derived from the comparison of the three case studies RECs are reported in the Conclusions.

2. Background. Northern and southern Italy: socio-economic differences between the two areas

This section aims to provide, especially for readers unfamiliar with Italian issues, a picture of the historical gap between the two Italian geographical areas, the North and the South (hereafter also referred to as Mezzogiorno). For this purpose, some economic and social data are presented. The data considered were those for 2019, before the outbreak of the COVID19 pandemic.

The North of Italy is the most economically developed area of the country, while the South is still a depressed area. It is characterised by weak industrial and productive fabric, high unemployment and a resumption of emigration.

The highest percentage of enterprises, according to ISTAT 2019 data [29], is located in the Northern regions, 50%, compared to 28% in the South of the country (Fig. 1).

In the period 2008–2014, Italy experienced the deepest and most prolonged crisis of its post-unification history. This crisis has overall widened territorial gaps and influenced resource availability, behaviour and outcomes. Between 2008 and 2014, the GDP of Mezzogiorno fell by –12.6% compared to –7.2% in the Centre-North [30]. In the following years, 2015–2018, despite the positive growth rate of southern GDP (+2.5%), due to the recovery of investment and exports, the southern economy grew at half the rate of the Centre-North (+5.2%) [30]. As a result of the stagnation in 2019, the development gap between the North

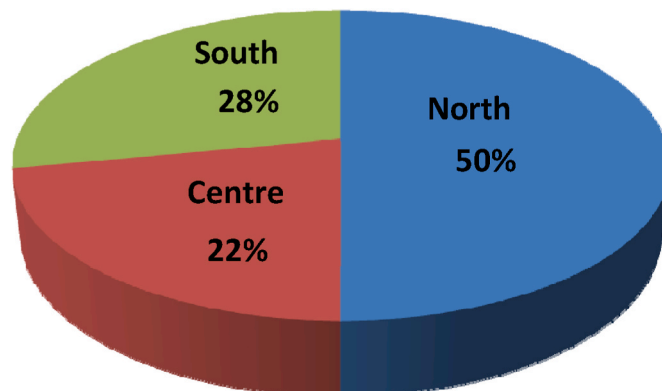


Fig. 1. Geographical distribution of enterprises – ISTAT data processing [29].

and the South widened. In terms of GDP per capita, the North-West has the highest value at around € 37,000 per year, almost double that of the South, at just over € 19,000 per year. As regards disposable income per inhabitant, households in the North-West held the highest level (22,600 euros), almost 60% higher than those in the South (14,200 euros) [31].

Italy's employment rate has fallen from 50.3% in 2008 to 41.7% in 2019. The national figure reflects employment rates for the under 35s of 29.5% in the South (minus 6.3 points compared to 2008 and about 30 points below the European average) and 49% in the Centre-North (10 points lower than in 2008 when it was in line with the European average) [30].

With regard to the unemployment data (Fig. 2), in 2019 the rate was 10% at national level, in the North the rate is 6.1%, while in the South it is 17.6%. There is also a wide difference between youth unemployment (15–24 years) and female unemployment. The rate of youth unemployment in the North is 19.4%, while female unemployment is 7.5%. The rates in the South are much higher, with 45.5% youth unemployment and 19.7% women unemployment [32].

Demographic decline also affected the Mezzogiorno. It is estimated that in the period from 2019 to 2065, Italy's population should shrink by 6.9 million inhabitants, 5.1 million less in the South and 1.8 million less in the North [30]. Three quarters of national losses are therefore concentrated in the South. In 2018, more than 138,000 residents left the Mezzogiorno, 20,000 of whom chose a foreign country as their residence, a much higher proportion than in past years. One third of the total are university graduates. Almost two-thirds of Italian citizens who left the Mezzogiorno for a region in the Centre-North in 2018 had at least a second-level qualification: 38% had a high school diploma and 30% a university degree. The loss of highly specialised human capital appears in all its severity when one considers that in the Mezzogiorno, among the resident population aged 15 and over, 32% have a high school diploma and only 11% have a university degree [30].

Concerning the issue of poverty, it can be seen that the South has a higher incidence of poverty both for families and individuals. According to ISTAT [33], from 2005 to 2020, poverty levels in Italy increased by almost 4% points from 5.5% to 9.4%. In terms of abject poverty, the Mezzogiorno recorded 11.1% in 2020 (Fig. 3) [33].

Differences in electricity consumption are also significant as they

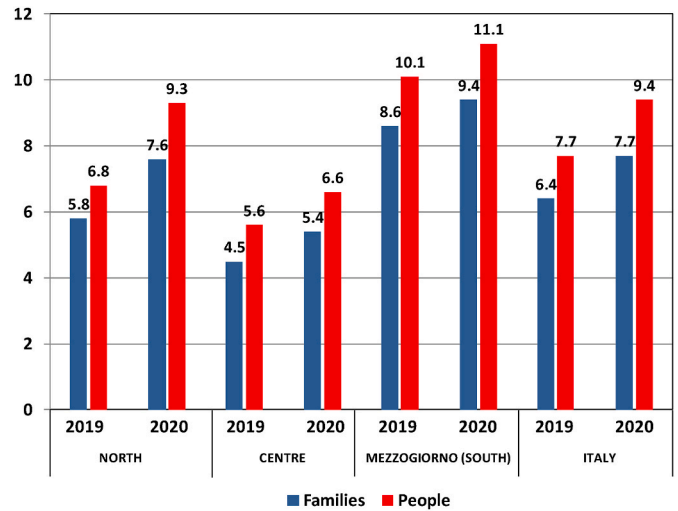


Fig. 3. Poverty incidence (%) in Italy by residence area: for Families and Individuals, years 2019/2020 – ISTAT data processing [33].

reflect the level of development in the two areas of the country. Based on data from Terna [34] – the Italian national grid service provider – for 2019, it can be noted that the North accounts for a consumption of 173,404 GWh, a share equivalent to 57% of the total (Fig. 4), of which 50% is concentrated in the four regions (Piedmont, Lombardy, Veneto, Emilia-Romagna) with the largest production factories in the whole country. While the consumption of electricity in the South is barely half (25%) this figure. The similarity of the percentages shown in Figs. 1 and 4 is remarkable, and demonstrates that the greater electricity consumption in the North can be correlated to a more widespread and developed industrial tissue in the North of Italy.

Data on energy poverty also show a diversity between the two geographical macro-areas of the country. Here, energy poverty is conceived in terms of accessibility and affordability of energy services as a direct or indirect result of insufficient access to cheap, reliable and safe energy services. In other words, a household or an individual deals with

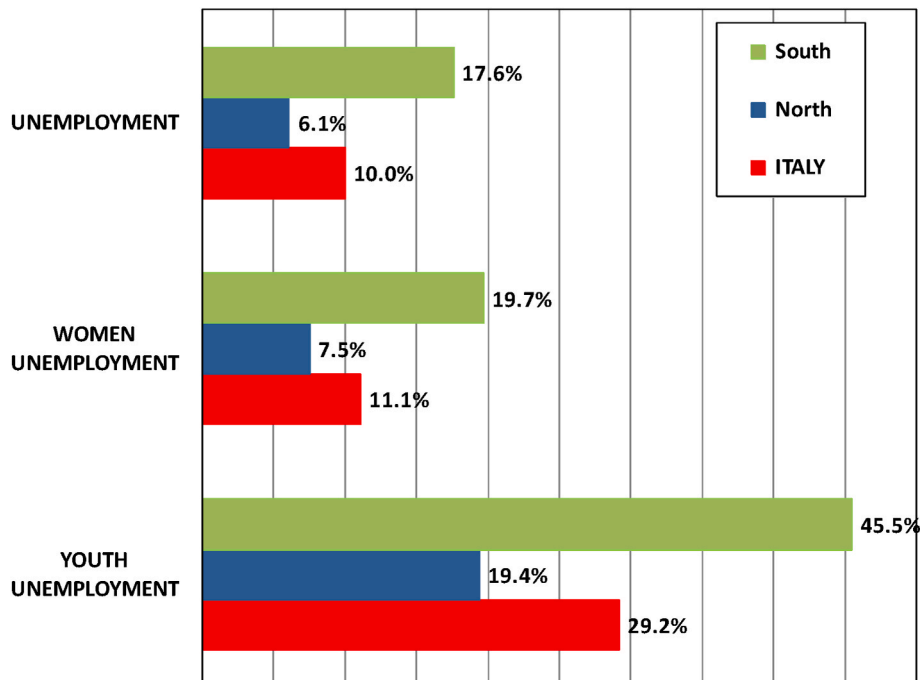


Fig. 2. Unemployment data 2019 – ISTAT data processing [32].

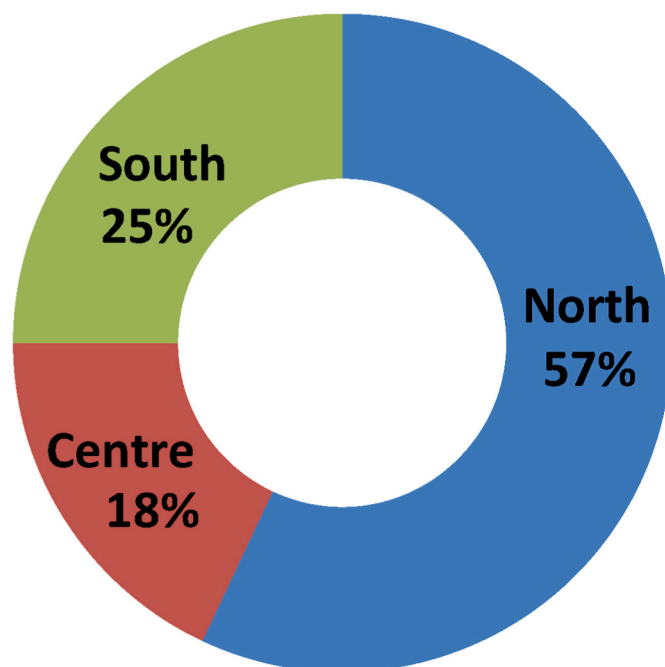


Fig. 4. Electricity consumption in Italy, 2019 – Terna data processing [34].

energy poverty when they cannot access energy services that guarantee adequate living comfort (heating and cooling, electricity or gas for cooking, mobility, etc.) [35,36]. According to the 2020 report of the “Italian Observatory on Energy Poverty” [37], energy poverty affects 8.8% of Italian households nationwide. In the South, energy poverty has a prevalence rate of more than 25%. In the southern regions, families with more than five members, those where the head of the family is under 35 years old and those headed by women over 50 are particularly affected. In Campania, Calabria and Sicily, between 13% and 22% of the population lives in energy poverty. The situation could even worsen, according to the OIPE, due to climate change. Rising temperatures will lead as a direct consequence to a greater need for cooling. As a result, it is estimated that some 500,000 households could fall into energy poverty with serious consequences for human health.

3. Theory

We analysed the emergence of RECs in Italy by applying Actor-Network Theory as a theoretical lens. Indeed, according to the *flat and relationist ontology* [38–40] drawn by Latour [41–43], Callon [44,45] and Law [46–50] within the STS (Science and Technology Studies) – see the groundbreaking work of Latour and Woolgar [51] –, these kinds of socio-technical configurations (the RECs) can be considered alliances or assemblages between social actors and technologies. Consequently their related action can be observed as an action pursued by a global actor. In other words, we can consider each alliance of this kind as a global entity acting for achieving common goals resulting from an internal negotiation process. Indeed, this approach refuses the conventional boundaries between the social and the material. It considers *non-human entities* based on STS scholarship [44] (technologies as well as scientific knowledge, devices, social representations, etc.) as equal actants compared with the *human/social ones* (individuals, organisations, associations, etc.). One of the most important consequences of this assumption concerns the success of the network that is possible only if all actors cooperate with each other. This flat and relational ontology is one of the strengths of the ANT. Indeed, this allows technologies and scientific knowledge to be considered as mediators capable of transforming relational processes, rather than mere intermediaries [43]. This gives them the role of carrier of information or meanings made by

others. Consequently, in our case, the analysis derived from this approach is to be carried out at a micro level or more precisely at the network level [52] by taking into account the internal relations between the actors. In this paper, we considered especially the specific features that some RECs conceived as actor-networks are assuming in their emergence in Italy. In this way, we could trace a set of differences and similarities among these configurations in order to link them to their specific contexts. Thus, it is possible to set up a variety of networks acting in the same field as a function of the different spokesperson/actor and of the different starting (socio-economic and cultural) conditions.

We followed the path drawn by Callon in his essay about the *translation process* [44] for analysing how each REC and its related network is being built. Callon divided the process of creating an actor-network into four phases: *problematization*, *interessement*, *enrolment*, and *mobilization*.

- 1 The first phase, called *problematization*, is considered an “obligatory passage point” (OPP) [44] in relation to the building process of the network. It is an issue or problem that the actors should resolve by negotiation with each other.
- 2 The second phase is the *interessement*, a sort of connecting phase. Indeed, this step leads particularly *non-human actants* to be interposed in order to connect many actors through a variety of possible strategies. More specifically, the RECs are usually characterised by some main *non-human actants* like: renewable energy installations (photovoltaic plants, wind turbines, etc.); a system to share production and consumption among members; devices (smart meters, apps, displays, etc.) providing information about the incentives for demand response [53,54] to every member; a platform for sharing information and communication among members regarding production and consumption data; and – in some cases – energy storage systems such as batteries. If the *interessement* is taken successfully, each actor (*humans and non-humans*) of the network can play a specific and different role.
- 3 The crucial phase in the translation process is the third one called *enrolment*, which “designates the device by which a set of interrelated roles is defined and attributed to actors who accept them” [44]. The basic assumption is that this set of roles is not pre-established but rather the result of a negotiation process among actors including technologies. The latter have to accept their role, taking into practice some related actions in order to cooperate with humans (individuals, organisations, communities, groups, institutions, etc.) to achieve the same objective. The *enrolment* is crucial precisely because it allows the network to reach a cooperative mechanism of acting as a whole actor, although it is not a fixed entity but rather can change by adapting to the possible changes made by the *actants*. This is related to the concept of *obduracy* [42].
- 4 The fourth phase of *mobilization* of the allies is achieved if they find a spokesperson representative of their assemblage. If this condition is reached, the network is finally able to mobilise its allies as a global actor, based on shared meaning and objectives, structured and cooperative strategies.

In this paper, as the global phenomenon of RECs as well as the selected case studies were not yet operative when we accomplished our analysis (October 2021) or their activity was in a starting phase, we focused on the first three steps. In fact, it would have been premature to analyse the mobilization step.

An overview of the literature shows that the ANT has been applied especially at a micro level to different ways of building up actor-networks [44,45,55,56] and in the energy community field of research, too [52]. This perspective is evaluated as a criticism by van der Schoor et al. [57] who, instead, adopted the ANT in order to “describe larger networks, linking ‘local’ and ‘global’ networks” [57] in relation to the obduracy of energy cooperative initiatives in three provinces of the North Netherlands as well as to the relations with outside networks and the commitment of members of local energy initiatives [58,59]. More

broadly, the ANT has often been combined with other theoretical lenses and methodologies to analyse the processes of socio-technical innovations [60] and transitions [61,62] and/or to assess the results of research about the public engagement of citizens in the energy transition [63,64], but also to examine political conflicts in the environmental and renewables field [65]. In this context, the perspective followed by van der Waal et al. [52] is closer to ours, as these authors used the ANT to describe the alliances of actors in relation to some Dutch RECs. Indeed, our analysis is also rather focused on the micro level. It concerns more precisely the emergence of those RECs created after and based on the normative framework introduced in Italy in 2020.

4. Tools and methods

4.1. Description of the methodological approach

Our analysis was carried out on two levels, the macro and the micro, through using partly different methodological tools as a function of their appropriateness in relation to the subject considered. This approach is in agreement with the good practices for appropriate methods in energy social science evidenced in literature [66], where the importance of contextual conditions is highlighted.

At the macro level, we used both quantitative (data collection) and qualitative methods. We created a database to monitor the emergence of RECs in Italy and include the main elements that characterise these initiatives. It should be remarked that the “landscape” of RECs in Italy is in constant evolution and their number is increasing very rapidly. The detailed list of the 24 RECs existing in the Italian country (until January 2023) is reported in Appendix (see Table 3). Then, based on some selected variables (quantitative and qualitative), we summarised the main features of the RECs in Table 1. This table allowed us to evidence some peculiar features of the energy communities of the two Italian macro-areas (North and South¹), which will be described in detail in Paragraph 4.2.

We also participated in some relevant public meetings about the

Table 1
Summary of characteristics of RECs in North and South Italy (RECs established until January 2023).

	Number of RECs	Typology of RECs	Dimensions (number of people involved and area concerned)	Typology of actors	Funds (Public, Private, Mix)
Northern Italy	12	Top down (All)	Greater dimensions	Local authorities + companies and/or research institutes and universities	Mix of private and public
Southern Italy	11	8 Top down 3 Bottom-up (related to the energy poverty issue – Sardinia, Sicily)	Smaller dimensions (both in relation to the extension of the area and to the number of members)	Local authorities + NGOs (foundations)	Mix of private and public

¹ Central Italy is not mentioned in this table because the number of RECs present in this area (only 1) is not statistically significant.

setting up and managing process of RECs, which involved many stakeholders such as environmental organisations (associations, alliances, foundations, etc.), politicians (local and national), technicians, and researchers. These events were: the public presentation of a Report on energy communities by Legambiente [67]; many meetings of the Alliance against Energy Poverty (Alleanza contro la povertà energetica), including a great event of two days called “A new green deal against energy poverty” launched in the TV channel of the organisation. In this case, we carried out an observation of the narratives and representations of RECs in the public sphere. More recently, we updated the list of Italian RECs based on the 2021 Report of Legambiente [68] and on the virtual map of RECs on the website www.comunirinnovabili.it held by the same organisation [69]. This combination of tools allowed us to draw an overview of the phenomenon at a national and global level. In addition, but linked to this specific focus, we carried out an analysis of the socio-economic contexts especially in relation to the historical gap between the South and the North of Italy – whose origins and reasons have been the subject of debate and controversy (see, e.g. [70–72]). A comparison of the main macro-economic indicators (GDP, job rates, etc.) was made in order to test some possible correlations between the differences revealed in the shape and features of the RECs/actor-networks and their context.

At a micro level, we selected three case studies [66] to explore in more detail both in relation to the characteristics of each REC and the link with their wider social environment. This choice was made after considering in depth 5 initiatives placed in the North (2) and South (3). The final selection of three case studies is based on criteria related to the relevance of two different territorial contexts: a small village and an urban neighbourhood. The selection of the first context allowed us to compare one case from the North and one from the South by analysing two small RECs built up in two small rural villages (see the data in Table 2). Moreover, we decided to add a third case related to a marginal urban context. This was made in order to investigate the current potential of RECs in this kind of environment in Italy and its setting up. However, due to the low number of RECs promoted until that moment (24, see Table 3), these case studies cannot be considered representative models of the whole phenomenon in Italy, but rather an attempt to identify some possible future trends that will have to be tested in further research.

From this perspective, using a qualitative methodology [73], we collected semi-structured interviews [66] with the practitioners of five RECs (19 in total: 2 for Magliano Alpi; 2 for Napoli East; 3 for Ferla; 3 for GECO project in Bologna and 9 for the REC “Comunità Energetica e Solidale” in Messina). The objective was to gain more information about these initiatives in relation to the different geographical and socio-economic contexts as well as the rationale of the internal organisation they are elaborating and implementing. As our approach is based on the ANT, we focused our questions especially on how the roles (*enrolment*) of each actor involved are organised and managed and how their mutual relationships – regarding both *human* and *non-human* actors – are structured.

A flowchart that summarises the methods used and the steps of analysis carried out for the purpose of our study is shown in Fig. 5.

4.2. An overview of emerging energy communities in Italy

Given this background, the setting up of Italian RECs is still in progress. Indeed, we considered the cases of RECs established until January 2023, as reported in Table 1. In particular, a series of indicators are listed in this table: number of initiatives and projects in relation to each area, dimensions, typology of energy communities, typology of actors involved, funders.

In considering these indicators, we have taken as a reference the experimentation phase initiated in 2020 and triggered by the partial adoption of RED II (Renewable Energy Directive 2018/2001), which made it possible for the first time to formally establish Renewable

Table 2
Comparison of the three RECs selected as case studies.

REC	Place/area	Actors (<i>humans and non-humans</i>)	Role
Energy City Hall	Magliano Alpi (Piedmont, Northern Italy), small town of 2166 inhabitants	1 Municipality	1 Promoter, political, administrative and social facilitator, REC member, management of shared platform
		2 Polytechnic of Turin	2 Technical and energy system (PV systems)
		3 Energy4Com startup	3 Analysis of energy production and consumption flows, management of all energy services
		4 Four (4) households	4 REC members
		5 Law on RECs	5 Normative device
		6 GSE	6 Implementation of economic incentives
		7 ARERA	7 Regulatory
		8 PV plants	8 Energy production
		9 ENEL	9 Big player
CommON Light	Ferla (Sicily, Southern Italy), small town of 2351 inhabitants	1 Municipality (Mayor)	1 Political, practitioner, funder, administrative and social facilitator, REC member
		2 Lawyers from the University of Catania	2 Normative; internal regulation; constitutive act of REC (legal form: association); rules for the distribution of incentives
		3 Technical officers of the Municipality	3 Technical and energy system
		4 Two (2) households	4 REC members
		5 Two (2) commercial activities	5 REC members
		6 Municipal deliberation on energy transition	6 Communicative and policy device
		7 Law on RECs	7 Normative device
		8 ARERA	8 Regulatory
		9 GSE	9 Implementation of economic incentives
		10 ENEL	10 Big player
Energy and Fair Community of East Naples	S. Giovanni a Teduccio – East Naples (Campania, Southern Italy) Marginal district (25,000 inhabitants) of a great town (Naples, 938,507 inhabitants)	1 Legambiente Campania	1 Promotion, bureaucratic and organisational support, facilitator, environmental educational
		2 Fondazione Famiglia di Maria	2 Social cohesion, entrust, empowerment
		3 Engineer of ItaliaSolare/3è	3 Technical (PV systems)
		4 Women of the district	4 Social capital, support of the project, building REC, public narration, social mediation
		5 Fondazione con il Sud	5 Economic and political support
		6 Local administration	6 Obstacle
		7 ENEL	7 Grid interface

Table 2 (continued)

REC	Place/area	Actors (<i>humans and non-humans</i>)	Role
		8 PV systems	8 Production of renewable energy; positive representation of the population; social redemption
		9 Law on RECs	9 Normative device
		10 ARERA	10 Regulatory
		11 GSE	11 Implementation of economic incentives

Energy Communities (RECs) in Italy. The combined provisions of Law 8/2020 (which converts into law Article 42/bis DL 162/19 - Decreto Milleproroghe), the regulatory model identified by ARERA – Regulatory Authority for Energy, Networks and Environment – (Resolution 318/2020) and the incentive system defined by the Ministry for Economic Development – MiSE (Ministerial Decree of September 16, 2020) enabled the establishment of RECs and collective self-consumption schemes.

Due to the experimental character, defined by Law no. 8/2020, some constraints have been set, such as: RECs can develop and own renewable energy plants with a maximum power of 200 kW, connected to the local low voltage distribution network; plants owned by RECs and members must be connected to the same medium/low voltage secondary transformation cabin; NGOs and third sector entities cannot participate in RECs. From what emerged from our survey, these constraints limit and hinder the full development of RECs.

The interviewed stakeholders hope that with the full transposition of the European Directive they can be removed. Indeed, the new Italian regulations [74] – effective from March 1, 2023, or the date of application of the implementing decrees by the Italian Ministry of Environment and Energy Security, whichever is the later – will remove the mentioned restrictions.

For all these reasons, we selected those criteria to draw a first overview of the emerging initiatives at a national level, focusing on the promoting actors and funders and, as a consequence, on the typologies of RECs and their geographical placement. To do so, we took into account different sources: in particular, as already mentioned, reports and meetings of the main Italian associations active in the environmental field (Legambiente) [67] as well as in energy poverty (Alleanza contro la povertà energetica); the websites of each initiative and/or the promoters (especially the Municipalities); specific news from magazines and journals. At this stage, the RECs are spread in a balanced way between the North and South of the Italian country, at least with regards to the number of these initiatives, while there is only 1 REC in the Centre so far (map in Fig. 6). The reason for the scarcity of RECs in central Italy seems contingent, and a turnaround in the future cannot be excluded. Some significant differences are emerging, as summarised in the already mentioned Table 1, which is based on the selected indicators. The most relevant differences concern the size of energy communities and the type of actors involved. Indeed, the initiatives set up in the North are revealing greater dimensions in relation to both the number of their members and the extension of the area concerned by the initiatives. Instead, in the South the energy communities are generally smaller.

As far as it concerns the actors involved, local authorities and especially municipalities are playing the main role in both areas, but this is probably an effect of the rules introduced by the recent law, as already mentioned. However, an interesting difference concerns the presence of companies as well as universities/research institutes in the North. They are not totally absent in the South but are playing a reduced role in shaping RECs. On the other hand, in the South, non-governmental organisations (NGOs) are trying to create some bottom-up initiatives

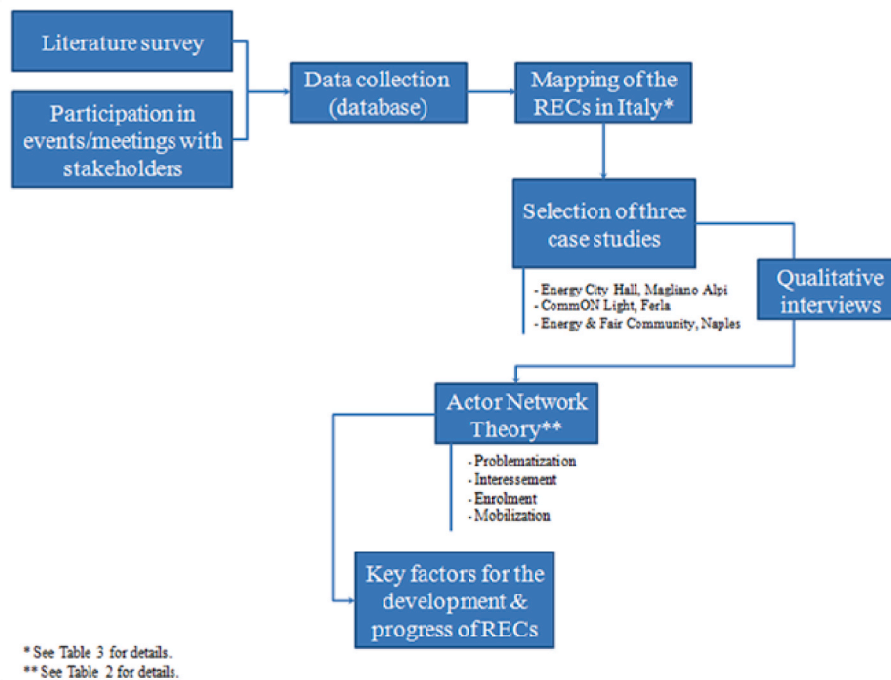


Fig. 5. Summary of the methods and steps of the analysis.

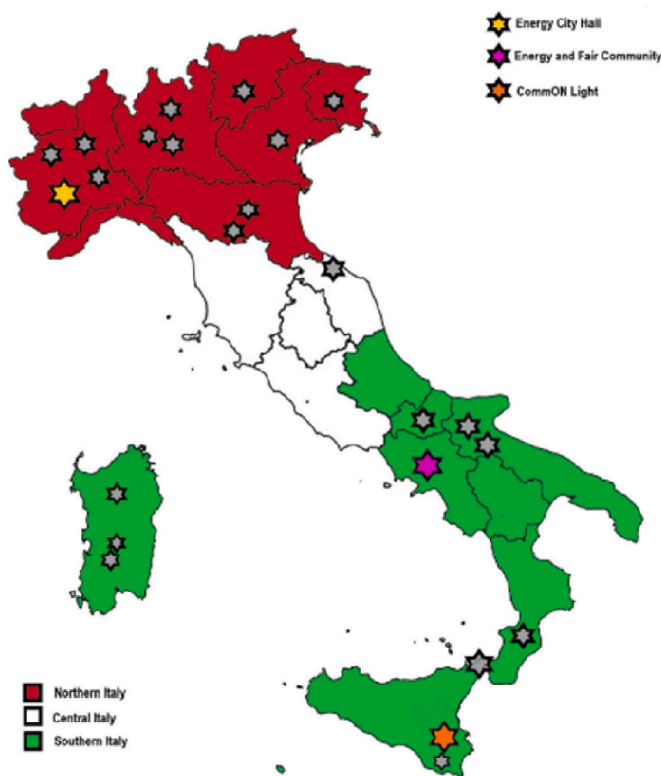


Fig. 6. Geographical distribution of the Italian RECs (see Table 3 for details).

together with local authorities. This is an important feature to be underlined because it is not possible to find similar experiences in other areas of the country. Moreover, it should be noted that the bottom up RECs are related to some urban (marginalised) districts in two important Southern towns (Naples and Messina) unlike the other RECs that are emerging in small and sometimes more isolated villages. In relation to

the typology of RECs, we considered “bottom-up” those initiatives built up by NGOs rather than institutional actors despite their dimensions (indeed, regarding our selected cases, often small municipalities are the main practitioners of these initiatives).

5. Results

5.1. The case studies

We selected three case studies placed in different areas of the Italian country (Piedmont in the North, Sicily and Campania in the South) based on networks composed by different actors and, consequently, oriented by different rationales and ways of acting. Moreover, the context affecting each REC is different, so that it can be connected with those differences. As Italian RECs are emerging and still unclear phenomena, we do not have the possibility of drawing the main models representative of the range of types. However, we noticed that particular initiatives have being built up in relation to different contexts. In other terms, we selected these case studies because everyone is the result of a different socio-economic background and representative of this as well as of a different vision of the REC, of its possible relations with the context and their related needs. Consequently, from a future perspective, these initiatives could be replicated within similar contexts corresponding to each case. To sum up, the case of *Energy City Hall* shows as its specific characteristic the purpose of developing the local economy in the energy and environmental fields through the RECs. The *CommOn Light* case is based on a strong community feeling at a local level aiming at sustainable goals in a sharing dimension. The *Energy and Fair Community* is a totally different model aiming at reaching energy justice [75–80] through fighting energy poverty and, thus, replying to the specific needs of the marginalised area [81] in which this initiative is being carried out. In order to draw this description and analysis, we will show the first three steps of the *translation process* of each case study according to Callon’s perspective based on ANT, as revealed in advance.

5.1.1. Energy City Hall

The Energy City Hall was established on March 12, 2021, and is located in Magliano Alpi (Cuneo, Northern Italy), a small town of 2166

inhabitants. The promoters of this project are the Municipality of Magliano Alpi and the Energy Center of the Polytechnic of Turin. More specifically, the Municipality of Magliano Alpi decided to adhere to the “Manifesto of the Energy Communities for an active centrality of the Citizen in the new energy market” promoted by the Energy Center of the Polytechnic University of Turin (*problematization*).

The Municipality of Magliano Alpi provided a 20 kW photovoltaic system, installed on the roof of the Town Hall. The system is connected to the Point of Delivery (POD) of the municipality and can share the energy produced and not self-consumed with the REC, currently formed by the users of the library, the gym and the schools, in addition to the four residents who were the first to join the starting nucleus. The two Electric Vehicle (EV) charging stations, which can be used free of charge by residents, will also be connected to the same system (*interestment*).

The strategic objective is to aim at reducing the energy consumption of public buildings and producing energy from renewable sources, playing an active role as a Public Administration in the development of innovative models for the revitalisation of the area. The mission is to increase the citizens’ trust in institutions to make them aware protagonists of the energy transition and participants in the environmental and economic benefits that RECs can bring. All this means that the promoters of this initiative have elaborated and implemented a strong link between humans and non-humans actors. The latter play the role of enabling the reduction of energy demand and affecting the sensitiveness of other human actors and their lifestyles in relation to the usage of clean energy and their reduction in consumption through participation in a community-based initiative. This major goal must also be achieved by sharing information about energy production and consumption by individuals and the community as a whole, through a platform (see Table 2).

The Polytechnic of Turin played a decisive role with a strong technical and engineering background, key elements in the creation of this energy community. The municipality purchased smart meters, which were connected to all PODs participating in the REC. In parallel to the shared energy calculations that the GSE will provide, the management platform Energy4Com was chosen. This is an innovative startup featured by social mission and values. It signed a collaboration agreement with the municipality for the analysis of energy production and consumption flows and the management of all energy services (*enrolment*).

The members of the REC are private citizens, professionals, craftsmen, and obviously the Municipality of Magliano Alpi as a public authority, all connected to the same transformation plant.

The REC wants to become a catalyst for “local short supply chains”, with high added value and strong cognitive and technological value. In fact, not only private citizens were involved, but also local technicians and craftsmen. For this reason, the Municipality is also aggregating a “GOC” (Gruppo Operativo di Comunità/Community Operating Group), a cooperativist group aiming at creating a “short supply chain of technicians, designers, installers and maintainers”. The global goal is to start and strengthen a process of skills aggregation in the area also crucial in order to create development and jobs.

5.1.2. CommON light

The REC called CommON Light, set up in May 2021, is located in Ferla (Sicily, Southern Italy), a small town of 2351 inhabitants. The promoters of this initiative are a group of researchers in environmental law from the University of Catania and the local authority of Ferla. Indeed, the researchers, after having studied the RECs from their disciplinary point of view for a long time, wanted to practically apply these kinds of experiences (*problematization*) seizing the chance given by the national law. They knew the history of environmental engagement of Ferla led by its Mayor through a series of projects and policies towards a more sustainable lifestyle for the population and built on trusting bonds between citizens and local administrators. Consequently, the researchers proposed to the Mayor a project of setting up an energy community in his town and he, in collaboration with his colleagues,

immediately accepted their proposal (*interestment*). This specific initiative is based firstly on the concept of community and is oriented towards the process of building this kind of tie among people interested in the project of REC. Based on this crucial idea, each actor plays a different role in the process (*enrolment*). The Municipality plays the role of funder and owner of a photovoltaic (PV) plant of 20 kW already installed on the rooftop of its headquarters. Due to some technical rules imposed by the law, the REC, beyond the Municipality, is composed of two other households and two commercial activities and they had to pay only 20 € for creating the REC in its legal form (association). Within this project, the main actor is the Municipality and its officers and technicians who supported and will support the other members in every step of the process in relation to both technical and bureaucratic needs. An important political device, named in the interviews as a sort of ethical manifesto of this initiative, is a municipal deliberation related to local ecological policies and strongly oriented towards energy transition. This device attributes a larger meaning to the REC initiative, including it in a global political idea and intervention in order to help all citizens of this small town in achieving challenging environmental and ecological goals. The lawyers of the University were engaged in the writing of the formal act to allow the creation of the REC and in elaborating the model for distributing incentives among members. Finally, the other REC members are playing the role of confident participants in this initiative. In this case, the most important non-human device so far is the set of political and legal products which play the role of educating the local population. The aim is to increase awareness about environmental and energy issues, as well as orienting lifestyles according to more sustainable behaviours from social, economic and environmental points of view, but also from a community-based perspective (see Table 2).

5.1.3. Energy and Fair Community (Comunità Energetica e Solidale) of East Naples

The REC project that started in March 2021 in Naples is one of two energy community initiatives in Italy involving marginal urban neighbourhoods. Indeed, the REC is promoted by Legambiente Campania, the regional section of the most important Italian environmental association, which immediately caught the possibility of creating this kind of initiative by the new national law approved in March 2020 (*problematization*). Legambiente strengthened its relationship with Fondazione con il Sud (Foundation with the South), an NGO promoting economic, social and cultural progress in Southern Italy, financing and implementing many projects in this direction. Through their partnership, the idea of a REC was elaborated, aiming not only to share production and consumption from renewables but also and, especially, starting a process in order to fight energy poverty and increase environmental awareness among poor and vulnerable people. For this reason, these two actors joined the Fondazione Famiglia di Maria, another NGO that has been leading educational and social initiatives for many years in a marginalised area of a big Southern town (Naples). The energy community is supplied by a 53 kW photovoltaic system built on the roof of the Fondazione. It is capable of producing about 65,000 kWh/y of electricity, which is partly consumed by the structure itself and partly shared with the 40 families involved. The trusting bonds built among the inhabitants of this district through its social work encouraged and set up the starting group for creating the REC which, at the end of the process, will be composed of 40 families. The creation of the actor-network includes the families that will be members of the REC, but particularly the women of this area already involved in the activities led by Fondazione Famiglia di Maria. During the interviews, respondents emphasised the importance of the environmental impact and value derived from the use of renewable energies based on shared paths and the priority of this dimension over the economic one (saving money). The women more involved as actors of this network have attributed to the *non-human* actors, first of all the PV plant of 53 kW, the following meaning: the possibility of building a positive experience through an innovative way of using energy and their related technologies. In addition, the chance to represent their

social group in a different and more suitable perspective arised (*inter-essement*). After that, the next step is the *enrolment* which focuses on the attribution of roles to be played by each actor. Actually, this is rather the result of the process already done and of the negotiation defined so far. The link established between humans and non-humans is based on an educational perspective. As the interviews highlighted, we can derive that each actor accepted a specific role in this creating process of a REC, according to what is described in Table 2.

6. Discussion

In general terms, our analysis showed that the emergence of energy communities at a national level is characterised by the definition of alliances that revolve around the central role played by local authorities (especially Municipalities), although the role of other partner actors is also very important. This point is really interesting because we can argue a strong relation to geographical location. This significantly contributes to the construction and definition of networks that differ from each other precisely because of the different context conditions in which they arise and which also produce specific and localised needs. Nevertheless, this difference depends also on the resources (in terms of funds, knowledge and skills, material infrastructures, institutional support, cooperative/collaborative culture, etc.) available at local levels. As regards the North macro-area, we recorded a greater and more organised presence of actors linked to the world of technological research. For instance, the Polytechnic of Turin, also through its startup Energy4Com, is promoting and supporting the creation of different energy communities (one of them is our case study named Energy City Hall) between Piedmont and Friuli Venezia-Giulia within a vision that conveys them to the Italian Forum of Energy Communities (IFEC) promoted by the “Energy Center” of the Polytechnic. This position of current predominance of technical actors in the North certainly derives from decades of production of consolidated energy knowledge, systems and services. Therefore, these scientific-technological institutions and related market players are ready to play a leading role in the development of initiatives similar to those of the RECs. Furthermore, in the perspective of our analysis, this reality provides a highly technical imprint on the way of conceiving and implementing RECs on which, then, the dimension of sharing and the community perspective is grafted. The latter is normally linked to a relationship based on a very strong trust between the inhabitants and their local authorities, especially the mayor. This recognized leadership makes it possible to convince and involve the first citizens who can technically join the initiative (there is a bond of belonging to the same secondary transformation cabin imposed by the national law). Regarding the initiatives located in the Northern areas, we can claim that the technicians and the related energy companies play a crucial role in starting the process of setting up a REC and, at the same time, are the spokes-actor as well.

In more detail, the case study of *Energy City Hall* is characterised by three main features in relation to the *enrolment* phase.

- 1 As a whole actor-network, this case is based on a way of organising the relationships between public (municipality) and private actors (startups, companies, businesses) in order to foster local economic development and to provide services (not only energy services) to the local community;
- 2 The municipality is playing the role of promoter/facilitator among the other actants, above all the technicians and the inhabitants and businesses, but also an educational role in relation to energy consumption behaviours;
- 3 The local businesses are playing the role of drivers of the REC, at least in this starting phase, as a Professor and Engineer of the Polytechnic of Turin highlighted:

What is perhaps becoming the most important lever, not so much citizens but rather local businesses. That is, the REC creates a lot of work on the

territory. There is the digital dimension for the management of the REC, therefore the local ecosystem in which there are installers, SMEs, artisans, through what we have called the community operating group (GOC), but this means that it multiplies local job opportunities. On the one hand, the municipality informs and is also the guarantor of the process, but the private person who puts the photovoltaic on his roof deducts 50%, provided that he connects to the REC. He has incentives for 20 years and he gets these incentives only if he connects to the REC. So it is obvious that the GOC, that is, this group of local professionals is able to make such a choice, so in a certain sense a sort of cartel based on excellence is set up and this objectively makes the difference. In addition, citizens know who to contact because they talk to professionals from local companies they know each other [...]. This mechanism means that, paradoxically, the main drivers, at least in the start-up phase, are not so much the citizens, but the businesses (Interview with a Professor of the Polytechnic of Turin).

These features are very consistent with the socio and macro-economic conditions of the North. Indeed, the possibility of addressing many businesses, artisans, technicians in the area allowed the creation an actor-network strongly focused on the role of technologies and their related services. This kind of alliance created the conditions to increase the market opportunity and, at the same time, the chance to save money and make energy consumption more efficient for consumers. Trust in local authorities as well as their educational role in consumption behaviour are crucial positive factors for the obduracy of the alliance and for its further goals, which are oriented towards the replication and scaling up of this initiative by replicating similar starting conditions.

The mayors become testimonials, the mayors do not sell anything, so it is easier because obviously the private company more easily stimulates the retro thoughts “Who is behind? They just want to earn. Who are they?“, but here the promotion phase passes into the hands of local authorities (Interview with a Professor of the Polytechnic of Turin).

The bonus is given depending on self-consumption, so also from a social point of view, families and members who adhere to the REC should be re-educated, telling them to consume energy during the day, which is when we have maximum production. With ENEA and GSE we have seen how to equip members with an app to always see how much energy has been produced at every moment. Unlike how it was done before, which usually consumed more energy in the evening to spend less, now you have to re-educate people to consume it during the day, so the management of your life needs to be reviewed. Household appliances now come to meet us because, with the fact that some are connected to WI-FI and cell phones, you can program them. So citizens’ education on this thing is definitely important. We also signed a 5-year agreement with ENEA with regards to the idea of generating prizes coming out from the efficient usage of energy [...]. This app will go as far as to say that you have earned a token that gives you free access to the library for a month, rather than access to the gym. To exploit in this way the social appearance of education, people are pushed to consume energy only when it is necessary [...]. We are still working on this, but I believe we will get there at the end of the year. ENEA is also working on it and can have a strong value [...] within the REC. The public body, playing its role which is not for profit, can recognize these awards to consumer members, who consume energy efficiently, encouraging them to do better and better (Interview with the Mayor of Magliano Alpi).

It is evident that the spokesperson of this actor-network is the scientific and technical actor, the Polytechnic of Turin, with its startup and thanks to its infrastructures. But, as the ANT claims, all actants play an indispensable role within the network without which the stability or obduracy of the network could be compromised.

In the Southern areas, on the other hand, the technological dimension has in some cases considerable importance – as for the already mentioned “Comunità Energetica e Solidale” in Messina –, but it is more subordinate to the dimension of the construction of a strong community

bond. This is, by itself, of central importance in relation to the form the network takes on, thus composing itself and to the dynamics that underlie its action. Therefore, the role that each actor involved is assuming in this process of construction and mutual relationship differs in the two models (*Energy City Hall* and *CommON Light*), also giving to each REC actor-network as a whole a different physiognomy. In particular, it is precisely the alliance between humans and non-humans that takes on different characteristics between the two macro-areas. In the two case studies of Southern Italy, this alliance between technologies and humans acquires two relevant missions and social purposes.

In the case of *CommON Light*, the goal of the actor-network is to increase and disseminate consumption practices from renewable sources in line with a political and community path already underway for several years. The primary purpose of the alliance is therefore environmental. The role attributed to technologies is precisely to ensure this reduced environmental impact, while human allies play a role in acquiring awareness and knowledge in relation to cooperating with the technologies themselves. The main goal of the whole alliance, therefore, is educational in relation to consumption behaviours and lifestyles. But, it is different in comparison with the *Energy City Hall*, because in the case of Ferla this is the priority of action even without having yet thought in detail about the technologies (i.e., apps, smart meters) to be asked to perform the task of facilitating a more efficient use of energy. In fact, the only *technological actant* involved in this actor-network is a PV plant installed on the rooftop of a public building in the city centre.

In reality, the true meaning of REC is to ensure that people consume during the hours in which the plant is in production (Interview with a male lawyer of the University of Catania).

We started from an upstream choice, namely that of not distributing among the members, even compatible with the associative scheme we have chosen. But we chose the so-called ‘reserve’ to cover administrative costs and to achieve the various purposes of the association, which are many and wide. We have partly distributed a part of the incentive over all the components of the REC and the other part in proportion to the shared energy. So, to stimulate a virtuous behaviour in sharing energy and in focusing the consumption in the time slots. We have also destined another part of the incentive as a reserve, but giving priority to the use of this part for investments in plants or even for the entry of new producers. So we made this choice and they got advice precisely because we said upstream: ‘We are not here to look at how much you will have in return, whether 20/30/50 or 70 euros, but let’s look at the importance of this project’ and they trusted us [...]. We focused on the concept of community, that is, on the fact that this is a community experience (Interview with a female lawyer of the University of Catania).

This specific feature, focused on the educational meaning attributed to the alliance, is linked to the perception by the local authorities and the conception of the researchers involved of the need to create stronger community-based bonds.

In this case, we noticed two main actors: 1- the researchers in law from the University of Catania and 2- the Municipality (the Mayor). The lawyers played the role of first promoter and of supporting the setting up of the REC from the administrative and regulatory point of view. For instance, they followed the whole process of definition of administrative documents, the creation of the formal association among members, the definition of the rules for charges, distributing economic incentives, etc. Their action has been and is still oriented to support the growth of the community around this kind of socio-technical configuration and the sharing of energy production and consumption as a value for contributing to the energy transition.

The Mayor, instead, is the spokesman of the alliance. He motivates and involves the citizens, making the crucial choice of investing public funds in the plants, administrative services, communication and spreading knowledge (i.e., through a spot, public and selected calls and meetings, face-to-face interactions).

The idea of the Community of Ferla, I also believe the idea of the legislator, is to create greater awareness. On the one hand, we have this special ambition linked to courses that are formative for the community so that citizens can start to talk about which rate is applied by the distributor, for example, and what are the behaviours, including virtuous ones. The community process is a process that, in our opinion, concerns a change that is also strong [...]. We believe it can truly be an element of change from here over the next 10 years (Interview with the Mayor of Ferla).

This alliance is more oriented to a political and educational meaning of the REC, which corresponds to starting participatory processes concerning environmental and energy practices or issues rather than local economic growth or economic benefits derived from joining these kinds of initiatives. In other terms, the aim of *CommON Light* is precisely the achievement of energy citizenship [82–88]. In fact, although in drawing this alliance there are some lacks in relation to technological and economic aspects (i.e., cost-benefit analysis), the REC members (two households and two commercial activities) chose to face this challenge because they trust the local authority. This trusting relationship is, once again, the decisive social dynamic for creating a REC, as the Mayor pointed out:

With respect to the values and emotional elements they have attracted, trust comes to my mind. That is, this trust that has generated entrusting by the inhabitants. I believe that trust is always the element of values and therefore what created the emotion of saying: ‘Yes, I’ll do this and let’s see what happens’, and they have trusted thanks to this.

In the case of *Energy and Fair Community of East Naples*, the social meaning of the REC is even stronger and consistent with the socio-economic conditions of the macro-area and especially of the specific neighbourhood. In general terms, the meaning and aim attributed to the actor-network is the result of a negotiation among people, not necessarily members of the REC, but more generally the more engaged inhabitants of the district, and the practitioners of this initiative. This negotiation process generated the meaning of social redemption for the whole population of inhabitants in this area.

The energy community was a social innovation that led local inhabitants to redemption, even if only in the narrative of that neighbourhood. So now, for example, the ladies lend themselves a lot to interviews. Until yesterday, they did it because the troupe of the national TV news went to take an interest in the shooting that had taken place. Instead, now the TVs with regards to this neighbourhood tell about the REC and these ladies lend themselves because they finally have a good thing to tell. Therefore, the ladies have been very dynamic on this path. Maybe because, with the President of the Foundation ‘Famiglia di Maria’, there is a trusting relationship and there is great participation in all phases and activities of the foundation [...]. The issue of redemption is very important to them (Interview with the President of Legambiente Campania).

From this perspective, we can talk about a narrative device which can be used to attribute this meaning in order to spread out a different image of the population inhabiting this area through the implementation of another technical device corresponding to the PV system and their connected technologies (smart meters, displays, platforms). Anyway, even before the installation of the system, the creation of a REC was perceived as an opportunity to build an alternative social identity for the local population in order to fight and moderate the social stigma over it. This reaction is really important also because nobody has provoked it. Indeed, at the beginning, the promoters (who are the representatives of the NGO and Legambiente) of this initiative had not even thought of conveying this meaning and value to the possible members and the whole population of the area. They rather expected from the inhabitants of the neighbourhood an interest more centred on the economic benefits (economic savings) derived from joining the REC. This seemed to them the greatest way for attracting people living in poor conditions. Instead, the sense of the REC was renegotiated starting from the desire and

interest shown by the people in the environmental impact of the REC in terms of overturning the social stigma associated with the population of this area. Moreover, as the interviews clearly showed, women are playing the most important role in spreading and explaining the sense and mechanisms of this initiative also in relation to the changes in consumption behaviours deriving from renewables.

This actor-network is aimed at developing a participatory process also through the educational path on environmental issues for young people led by Fondazione Famiglia di Maria and Legambiente, as well as for the REC members in relation to energy consumption, as the regional leader of Legambiente told:

We are going to start a path of environmental energy education, which we have called the “Education of boys and girls”, so under the roof of the foundation there are workshops from morning to evening, especially in summer. In winter, they [the social workers of the Fondazione Famiglia di Maria] accompany the children to school and pick them up and take them to the foundation which closes at 8 pm. So, with them, we have created this path which is called the “energy community of girls and boys” and the same thing with mothers. We are building a community that goes beyond the users of the foundation because it clearly depends on the secondary cabin, but it is the mothers of the foundation who are helping us to get to the homes of those who have been in the foundation maybe only once. So, this is a participatory path, because the mothers who were unable to participate, participate in the environmental education path and therefore we are making a path with them too [...]. REC members will pay their bills as they paid before, so the path against energy poverty is also educational on individual behaviour. This means that how to decrease your bill also depends on your behaviour.

We can claim that the spokes-actor corresponds to the Foundation which is leading the whole actor-network to achieve its goals. On the other hand, we noticed that in this case the local authority, which did not take part in the REC, played (at least partially) the role of barrier for the actor-network because regulatory conflicts with the regional legislation suspended the implementation of the REC.

We are stopped due to a bureaucratic quibble with the municipality that did not allow us to move forward: it is a hallucinatory thing. The bureaucratic hitch we are having is a mere nonsense. The municipality of Naples sent me a list of erroneous regulatory applications committed by us, but they did not know that the Region had already overcome them. I, who did everything in order, obviously stopped and asked the technicians, engineers and lawyers what we were doing, because they asked me to dismantle everything within 10 days. We have dismantled the regulatory applications of the municipality, one by one, under regional legislation. It has been about a year since we formed the REC (Interview with the President of Fondazione Famiglia di Maria).

This point is very interesting because it highlights once again the relevance of the role (positive or negative) played by local authorities and their involvement in this initial phase of creating RECs in Italy.

As already mentioned, existing literature on the Italian context – with a few exceptions – focused mainly on technical and/or normative issues. Some studies addressed social issues. In particular, our approach has some similarities with the work of Bonifazi et al. [20], where the analysis was carried out at the local level, considering three case studies placed in two Italian regions (Apulia and Lombardy). Based on a multilevel perspective, they concluded that regional energy transition policy frameworks influence REC-building strategies, demonstrating the interdependency between context and agency. Some methodological similarities can be found also with the use of relational STS, based on ANT and used in a recent paper [27] where, however, the process analysed is more focused on the emergent participatory practices and models in relation to the Italian energy communities. Furthermore, other papers focused on selected case studies and some of them are included in our analysis as well, but the aim of our contribution and, consistently, of the theoretical and methodological approach are

strongly different. Indeed, we did not concentrate our study on the assessment of the energy, environmental, and socio-economic impacts of the RECs [22], neither on the perspective of niche-studies [23], or more strictly on the organisational dimensions of RECs based on clustering classification [28]. Rather, our contribution stands in a complementary position with respect to the existing literature, showing the complexity of the specific conditions of territories as well as individual RECs models in establishing themselves as socio-technical configurations capable of strengthening their network and then acting effectively and with long-term potential.

In summary, our findings differ from previous literature on Italian RECS, mainly for the adoption of the actor-network theory and the emphasis on socio-technical dynamics that we consider crucial for the development and uptake of RECs.

7. Conclusions

The research carried out showed that, at least in Italy in this starting phase of creating energy communities, the contexts are very important because they affect the way of meeting actors in actor-networks related to RECs. Indeed, their features depend also on the local conditions and resources available as well as on the needs and values promoted by practitioners or spokes-actors and all this is consistent with the social milieu.

The socio-economic gap between the two Italian macro-areas (see Section 2) did not translate, at least for the present, into a substantial difference in terms of distribution of RECs (12 in the North, and 11 in the South of Italy). Therefore, our analysis partially puts into question the common belief of a successful and prevailing concentration of RECs initiatives in the Northern area. Nevertheless, we also evidenced some differences between the RECs present in the two macro-areas. In particular, the initiatives set up in the North are characterised by greater dimensions, and a more effective presence of companies and/or universities and research institutes. On the contrary, as a consequence of the socio-economic context, in the South there is a prevalence of initiatives related to energy poverty issues and promoted by non-governmental organisations (NGOs).

Due to these general considerations, we can highlight four main findings from our analysis.

- 1 The three case studies we have selected look at three different actor-networks or, in other terms, three different ways of organising actants, meanings and goals of RECs. To sum up, the *Energy City Hall* (located in Piedmont) has a meaning and aim related to local economic development, while *Common Light* (Sicily) and *Energy and Fair Community of East Naples* (Campania) have a political, educational and social meaning. The first one is more linked to environmental and community policies, whereas the second one prioritises the fight against energy poverty, injustice and social stigma.
- 2 A common feature is the presence of trusting relationships between the population and the spokes-actors or the other main actors, especially local authorities. More generally, as the analysis of the current Italian situation suggests, local authorities often play the role of facilitator in creating an actor-network with technologies. They are facilitators from an economic and administrative point of view because they fund the plants, manage platforms, devices, etc., but also all the required bureaucratic procedures. This is an important node because, as the case of Naples showed, when a local authority does not directly support or is interested in supporting the REC it could even be a barrier.
- 3 The local context is also important in relation to the participatory models implemented. About this issue, our three case studies showed three different levels and ways of participation by citizens/consumers in RECs. *Energy City Hall* seems more linked to technologies and platforms focusing on the role of *non-human* actors. *Common Light* takes more attention to the involvement and direct

participation by citizens in setting up a community and sharing their knowledge and needs before than energy. In the case of Naples, the participatory process has already been promoted by the NGO in the neighbourhood, so that some more motivated women are actively participating in spreading the initiative, defining a bottom-up model of participation.

- 4 The replicability of the “model” is an issue at least in two cases: *Energy City Hall* and *Energy and Fair Community of East Naples*. In one case, the possibility of replicating the model is pursued in order to create a network of networks for local economic development. While, in the second case, the effort is oriented to identify the main strategy for fighting against energy poverty and injustice and promote more efficient and conscious changes in energy consumption behaviours.

Finally, the ANT approach adopted in this research allowed us to highlight the obstacles encountered by the promoters of the three REC cases in building each heterogeneous network. This means that they had to face some common barriers and some specific obstacles due to the local context, as the reported extracts from the interviews showed.

Regarding common barriers, the respondents reported: bureaucracy, lack of trust in the market, lack of awareness, technical and formal restrictions based on the interim act on RECs. Concerning the latter one, two issues came up in particular.

- the obligation to connect to the secondary processing substation, which reduces the spatial perimeter of possible members of the energy community;
- the prohibition for associations to be part of a REC.

These considerations were valid when we carried out our analysis (October 2021) whose objective was to trace a narrative, based on the actor network theory, of the phenomenon of Italian RECs in its initial stage. However, as already mentioned, based on the new upcoming Italian regulatory framework [74] these restrictions will be removed.

Regarding the specific obstacles, however, we can focus on the two

cases located in Southern Italy. This is because they have to deal with a poorer environment, both from an economic and infrastructural point of view, as shown also in the first part of the paper and as underlined by the interviewees.

Moreover, these hindering conditions are also specific characteristics of urban neighbourhoods where the two RECs will arise. Actually, they are also the crucial reasons that motivated the setting up of the two initiatives, such as educational and energy poverty and the fight against them. All this could compromise the obduracy of the actor-networks and provoke some betrayals [89].

Limitations and possible future developments of this study can be summarised as follows. As already mentioned, the major limitation is the non-representativeness of the three case studies investigated. While an on-site verification of our findings based on the Actor-Network Theory, or the application of other theoretical approaches, could be the subject of further work.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRedit authorship contribution statement

Monica Musolino: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Gaetano Maggio:** Conceptualization, Writing – original draft, Writing – review & editing. **Erika D’Aleo:** Conceptualization, Investigation, Writing – original draft. **Agatino Nicita:** Conceptualization, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table 3
List of the Italian RECs (until January 2023). In bold, the three case studies.

#	Name of the REC	Town	Region	Number of people involved	Players	Partnerships	Current status	BU/TD	Technologies	Funds
1	GECO (Green Energy COmmunity)	Pilastro-Roveri district (Bologna)	Emilia-Romagna	The development area includes: a residential zone of 7500 inhabitants, of which 1400 live in social housing (ACER), a commercial zone hosting an agri-food park and two shopping centres, and an industrial zone comprising the agri-food centre of Bologna-CAAB	- Emilia Romagna Region - Municipality of Bologna - Agenzia locale di Sviluppo Pilastro Distretto Nord Est - Centro Commerciale Pilastro - ACER Bologna - Centro Agroalimentare di Bologna-CAAB	- Fondazione FICO - Bastelli HTS S.r.l. - Nute Partecipazioni S.p.A. - ZR Experience - FRI -Fashion Research Institute - AESS - University of Bologna - ENEA	Under implementation	Top down	14 MW PV plant, storage system and 50 kW biogas plant	European funds
2	Condominio “Green”	Scandiano (Reggio Emilia)	Emilia-Romagna	48 apartments (20 private; 28 managed by the Municipality of Scandiano)	- Municipality of Scandiano - ACER Reggio Emilia - ART-ER S.c.p.a.	- ENEA - University of Bologna - ENEL X	Under implementation	Top down	PV plants	Private funds
3	Comunità di Energia Rinnovabile (CER)	San Daniele del Friuli (Udine)	Friuli-Venezia Giulia	Municipality of San Daniele, Primary school of San Daniele	- Municipality of San Daniele del Friuli	- Polytechnic of Turin	Implemented	Top down	54.40 kW PV plants	Regional funds

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Table 3 (continued)

#	Name of the REC	Town	Region	Number of people involved	Players	Partnerships	Current status	BU/TD	Technologies	Funds
4	Collinare del Friuli Monticello Green Hill	Monticello Brianza (Lecco)	Lombardy	The area includes about 4000 inhabitants. The members of the energy community are 12 private users	- Friuli-Venezia Giulia Region (funding body) - Energy Saving Management Consultants S.p.A.	- Comunità Collinare del Friuli NO	Implemented	Top down	10 kW PV plants	Private funds
5	Comunità Energetica Alpina di Tirano	Tirano, and Sernio (Sondrio)	Lombardy	1200 families	- Municipalities of Tirano and Sernio - Teleriscaldamento Cogenerazione Valtellina Valchiavenna Valcamonica (TCVVV S.p.A.) - Reti Valtellina Valchiavenna (ReVV S.r.l.)	NO	Under implementation	Top down	Cogenerative district heating by biomass (20 MW), PV plants	Unspecified
6	Comunità Energetica “Solisca”	Turano Lodigiano (Lodi)	Lombardy	Small village of about 1600 inhabitants. The energy community consists of 9 households – soon to rise to 23–1 parish, and 9 municipal utilities	- Municipality of Turano Lodigiano - Sorgenia S.p.A.	NO	Implemented	Top down	47 kW PV plants on the covered areas of the sports field and of the gym	Private funds
7	Comunità Energetica del Pinerolese	Cantalupa, Frossasco, Roletto, San Pietro Val Lemina, Scalenghe, and Vigone (Turin)	Piedmont	Unspecified	- Municipality of Scalenghe - ACEA Pinerolese Industriale - Consorzio Pinerolo Energia	- Polytechnic of Turin	Under implementation	Top down	450 kW hydroelectric plant, biogas plant, PV plants	Public, private, and equity crowdfunding
8	Comunità Energetica Rinnovabile “Energy City Hall”	Magliano Alpi (Cuneo)	Piedmont	2184 inhabitants of the small rural municipality of Magliano Alpi	- Municipality of Magliano Alpi - Energy Center Lab of Polytechnic of Turin	- Polytechnic of Milan - University of Bologna - University of Trento - University of Modena-Reggio Emilia - University of Udine	Implemented	Top down	20 kW PV panels on the roof of the town hall	Public and private funds
9	Comunità Energetica “Nuove Energie Alpine”	Municipalities of the Maira and Grana valleys (Cuneo)	Piedmont	22 municipalities (about 40,000 inhabitants)	- Associazione “Comunità Energetica Valli Maira e Grana” (promoter) - Municipalities of the Maira and Grana valleys - Azienda Cuneese dell’Acqua S.p.A.	Enerbrain S.r.l. (technical support)	Under implementation in 3 municipalities (Busca, Villar San Costanzo, Pradleves)	Top down	Hydroelectric plant, PV and biomass	Public and private funds
10	Comunità Energetica della Valle Susa (CEVS)	Valle Susa (Turin)	Piedmont	Unspecified	- Unione Montana Valle Susa - Unione Montana Alta Valle Susa - Consorzio forestale Alta Val di Susa - ACSEL S.p.A. - Cooperativa forestale La Foresta - Replant (startup)	NO	Under implementation	Top down	2 MW PV plants, 7 MW biomass plant, solar heating	Public and private funds
11	Comunità Energetica Primiero-Vanoi	Canal San Bovo, Imer, Mezzano, Primiero San Martino di Castrozza, and Sagron Mis (Trento)	Trentino-Alto Adige	The number of members of the energy community is 100	- Municipal Services Consortium Company S.p.A. (ACSM)	NO	Under implementation	Top down	90 MW hydroelectric plant, 2 district heating plants fired by wood biomass, 1 MW PV plants	Public funds

(continued on next page)

Table 3 (continued)

#	Name of the REC	Town	Region	Number of people involved	Players	Partnerships	Current status	BU/TD	Technologies	Funds
12	Energia Agricola a km 0	Municipalities of Veneto Region	Veneto	514 firms already involved (owners of renewable energy plants able to produce and exchange energy, and consumers)	- ForGreen S.p.A. - Coldiretti Veneto - Coldiretti Puglia	NO	Under implementation	Top down	PV plants	Private funds
13	CERossini	Montelabbate (Pesaro and Urbino)	Marche	The area includes: 7000 inhabitants. The members of the energy community are: - School institute "G. Rossini" (prosumer) - 6 residential inhabitants and 3 commercial activities (consumers)	- Municipality of Montelabbate	NO	Implemented	Top down	15 kW PV plants	Public funds
14	Comunità Energetica Rinnovabile di Biccari	Biccari (Foggia)	Apulia	About 70 families	- Municipality of Biccari	- ARCA Capitanata (regional agency for public housing) - èNOSTRA	Under implementation	Top down	PV plants	Public
15	Comunità Energetica di Roseto Valfortore	Roseto Valfortore (Foggia)	Apulia	The area includes: 1066 inhabitants. The number of members of the energy community is 30	- Municipality of Roseto Valfortore - Friendly Power S.r.l.	- Creta Energie Speciali S.r.l. (spin-off enterprise from the University of Calabria)	Implemented	Top down	Installation of smart meters and nanogrids	Public funds
16	Comunità Energetica Rinnovabile e Solidale "Critaro"	San Nicola da Crissa (Vibo Valentia)	Calabria	The area includes: 1253 inhabitants. - Municipality of San Nicola da Crissa (prosumer) - 15 families (30 families when fully operational)	- Municipality of San Nicola da Crissa	- 3E Environment Energy Economy S.r.l.	Implemented	Top down	66.8 kW PV plants	- Private funds with a tax deduction of 50% of the "Building renovation bonus" - Fifteen-year fixed-rate bank loan
17	Comunità Energetica e Solidale di Napoli Est	San Giovanni a Teduccio (Naples)	Campania	40 families in the neighbourhood of San Giovanni a Teduccio, and the Fondazione Famiglia di Maria	- Fondazione Famiglia di Maria - 3E S.r.l. (for the realisation of the plant) - Legambiente	- Fondazione con il Sud	Implemented	Bottom up	53 kW PV panels on the roof of the Fondazione Famiglia di Maria	Private funds
18	AMARES	Ripalimosani (Campobasso)	Molise	Number of members: 3	- Amaranto's group	- Società Cooperativa "A. RE.S." A.r.l. - "Amaranto Software Factory S.r.l." (Amaranto's group) - Society "Energia Prima Services S.r.l." (Amaranto's group)	Implemented	Bottom up	37.15 kW PV plant	European funds
19	Comunità Energetica di Borutta	Borutta (Sassari)	Sardinia	Mountain town of 254 inhabitants	- Municipality of Borutta	NO	Under implementation	Top down	PV plants in the city centre (town hall, sport facilities, schools, museum, street lighting, etc.)	Unspecified
20	Comunità Energetica di Ussaramanna	Ussaramanna (Medio Campidano)	Sardinia	61 members including some commercial activities (petrol station "Onnis Ombretta & C. Plant", a	- Municipality of Ussaramanna	- Ènostra (technical support)	Implemented	Top down	71 kW PV plant	Public funds

(continued on next page)

Table 3 (continued)

#	Name of the REC	Town	Region	Number of people involved	Players	Partnerships	Current status	BU/TD	Technologies	Funds
21	Comunità Energetica Biddanoa E' Forru	Villanovaforru (Medio Campidano)	Sardinia	34 members including 1 commercial activity (Funtana Noa hotel)	- Municipality of Villanovaforru	- Énostra (technical support)	Implemented	Top down	44.3 kW PV plant	Public funds
22	CommON Light	Ferla (Syracuse)	Sicily	Municipality of Ferla, 5 citizens and a company	- University of Catania - ENEA	NO	Implemented	Top down	20 kW PV system	European Regional Development Funds (PO FESR Sicily 2014–2020)
23	Comunità Energetica e Solidale di Fondo Saccà	Messina	Sicily	6 inhabitants	- Fondazione di Comunità di Messina	- Fondazione con il Sud	Implemented	Bottom-up	PV plants	Public funds
24	Comunità Energetica Agricola di Ragusa	Ragusa	Sicily	Several farms of about 60 ha	- Municipality of Ragusa - MACS S.r.l.	NO	Under implementation	Top down	200 kW PV system	Public (regional) and private funds

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