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Project Report

Energy and Digital Transitions for Energy Communities: Tools and Methodologies to Promote Digitalization in Italy

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Abstract: This paper presents an overall concept developed by ENEA (the Italian National Agency for New Technologies, Energy and Sustainable Economic Development) in the Italian framework of renewable energy communities (RECs). The proposed work is driven by the idea that RECs are part of a long-term vision aimed at achieving the broader concept of smart communities (SCs) through smart energy communities (SECs). SECs are, therefore, the evolution of RECs toward SCs, where ICT (information and communications technology) and digitalization play a pivotal role in fostering and boosting the energy transition and addressing societal challenge goals by 2050. In this scenario, the proposed approach is based on three dimensions, as follows: digital tools, use cases, and the observatory. Digital tools can be utilized at different stages of the creation of RECs, ranging from the design and engagement phase to evaluation, analysis, and the token economy. The second dimension refers to some selected different business cases that are used to test and demonstrate the proposed tools and provide support to specific RECs in the different phases of their creation. Lastly, the EC observatory was created by ENEA to provide necessary support to the market and stakeholders on different aspects, such as data management, economics, legal issues, communication, and regional governance.

Keywords: energy communities; digitalization; energy transition; Italian RECs; renewable energy; tools

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1. Introduction

In recent years, the energy transition has become a global priority, driven by the need to reduce greenhouse gas emissions and adopt more sustainable energy sources.

On 30 November 2016, the 'Clean Energy Package for all Europeans' initiated the revision of the so-called RED Directive (Directive (EC) 28/2009), in order to identify new instruments to support renewable energy and combat energy poverty. Following this communication, the Directive of the European Parliament and the Council 2018/2001/EU (Renewable Energy Directive Recast, referred to as RED II) identifies the regulatory framework for renewable energy communities as 'legal entities' with the following characteristics:

- 'Are based on open and voluntary participation, are autonomous, and are effectively controlled by shareholders or members who are located in the vicinity of the renewable energy production facilities owned and developed by the legal entity in question';
- 'Whose shareholders or members are natural people, SMEs, or local authorities, including municipal authorities';
- 'Whose main objective is to provide environmental, economic, or social benefits at the community level to their shareholders or members, or to the local areas in which they operate, rather than financial profits'.

In parallel, digitalization is transforming various sectors, offering innovative tools to optimize the use of resources, improve the efficiency of systems, and promote more participative and conscious management of energy resources.

Energy communities, defined as local groups sharing the production and consumption of renewable energy, represent a key model for the energy transition. However, their implementation and management require the support of advanced digital technologies, such as data sharing platforms, smart grids, and Internet of Things (IoT)-based monitoring systems.

In Italy, energy communities are gaining attention thanks to recent legislation that transposed RED II and defined the Italian regulatory framework. In particular, Article 31 of Legislative Decree No. 199 of 8 November 2021 has intervened to define the applicable regulation 'when fully implemented', identifying specific incentive mechanisms operating for self-consumption configurations and renewable energy sharing. However, the country is facing significant challenges, including infrastructure fragmentation, a lack of digital literacy, and the need to overcome administrative and bureaucratic barriers to REC creation.

In this context, this article aims to analyze tools and methodologies developed by ENEA that can foster the digitalization of RECs in Italy, contributing to their efficiency and sustainability.

1.1. Energy and Digital Transition

Energy transition refers to the transition from a fossil-based energy system to one based on renewable and sustainable sources. It includes the decarbonization of the energy sector and the adoption of innovative solutions to improve the efficiency and resilience of energy systems.

Digitalization, on the other hand, plays a key role in facilitating this transition by introducing technologies that enable the smart use of resources. Tools such as smart meters, IoT sensors, energy data management platforms, and applications based on artificial intelligence and blockchain improve energy management and promote greater end-user involvement.

In the context of energy communities, the synergy between energy and digital transition is essential to ensure fair, transparent, and efficient management of shared energy.

Moreover, digitalization not only supports the monitoring and distribution of energy, but in the proposed vision, all information technologies (big data, machine learning, digital twins, blockchain, etc.) are applied as enablers for the development of open, free, and interoperable solutions, as well as innovative business models, such as smart contracts, which facilitate peer-to-peer energy and service exchanges.

1.2. Widespread Self-Consumption Configurations in Italy

In Italy, the currently regulated and supported widespread self-consumption models are as follows:

- Renewable energy community:

This is a legal entity that aggregates several members and has at least one new renewable plant in its possession. The sharing of energy within the configuration generates environmental, economic, and social benefits. The perimeter of the configuration is defined as one of the HV/MV cabins; therefore, all the actors belonging to the same primary cabin can be part of an REC.

- Collective self-consumption group:

This is a group of individuals who are in the same building or apartment block and share the energy produced by at least one renewable plant in their availability, promoting optimized and conscious energy management.

- Individual self-consumer at a distance:

This is an individual who has several sites in his or her availability (at least one is a production site, and at least one is a consumption site). Renewable energy is shared virtually through the public distribution network.

The Italian regulatory framework is evolving rapidly, with specific incentive mechanisms in place for self-consumption configurations that enable the sharing of renewable energy, consisting of the following:

- A 20-year incentive tariff targeting the amount of 'shared' energy defined as the minimum between the energy withdrawn and fed into the grid by RESs from all connection points pertaining to the configuration;
- A non-repayable grant funded by REPower EU (through the National Recovery and Resilience Plan—NRRP) to partially cover (up to 40 per cent) the costs of building or upgrading renewable energy plants located in small municipalities. However, implementation challenges remain, such as the lack of technical expertise, access to finance, and difficulties in the integration of obsolete energy infrastructures.

These actions have a remarkable impact within the overall National Integrated Plan for Energy and Climate (NIPEC), which describes Italy's strategies and actions to achieve the Agenda 2030 and Fit-For-55 Package goals. In particular, in Italy, NIPEC sets an objective of 130.9 GW of renewable energy sources (RESs) by 2030. At present, RES-installed power is 73.5 GW; therefore, there is a 57.4 GW gap to be filled with new, additional RESs. In this scenario, the Italian government, with the previously described funding actions, aims to foster 5 GW of new RESs by 2027; therefore, RECs might cover about 9% of the newly requested RESs to achieve the national and European goals.

In this context, in order to achieve the described goals (5 GW of new RESs given by RECs), digitization has emerged as an enabling feature for solutions that facilitate data sharing, performance monitoring, and distributed energy management. In particular, the deployment of digital platforms for community coordination can accelerate the adoption of participatory models, ensure the long-term sustainability of initiatives, as well as serve as an enabler for future market actions.

2. Approach and Vision About Energy Communities

The Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) is a public body dedicated to research, technological innovation, and the provision of advanced services to enterprises, public administrations, and citizens in the sectors of energy, the environment, and sustainable economic development.

ENEA, through the "Tools and Services for Critical Infrastructures and Renewable Energy Communities" division, promotes the dissemination of energy communities and examines their implementation and operation through the provision of specific solutions, data analysis,

and the development of enabling paths and standards. ENEA supports institutions in defining the technical and technological aspects aimed at promoting and disseminating RECs [1], and promotes activities to facilitate the exchange of experiences and the transfer of good practices. The primary objective is to act as a technical–scientific advisor for the development of concrete REC initiatives in the territories (contextualization of the initiatives related to the prerogatives of the territory) and for the evaluation of their implementation process.

ENEA is also contributing to the creation of best practices of RECs in different regions and municipalities, by proposing to public administrations and territorial actors—at various capacities and levels—a governance model for the development of RECs that combines the aspects and needs of the energy and digital transitions with those of territorial development.

The proposed approach is based on pursuing the dual energy and digital transition toward smart energy communities (SECs), starting from RECs as an enabling factor for the development and implementation of "smart communities", whose primary goal involves the active participation of citizens and the development of local economies based on the sharing of goods and services (sharing economy), promoting deeper participation and expression in social transformation processes.

In this development trajectory, strategic positioning involves providing digital tools for the start-up, promotion, and evaluation of RECs, leaving the management to market operators. The topic of energy is also addressed with a long-term vision through participation in international working groups that are outlining the energy model of positive energy districts. Positive energy districts (PEDs) are a relatively new concept aimed at promoting the main objectives of the Energy Union's strategy toward climate neutrality. They are based on an integrated, multi-sectoral approach to address Europe's most complex energy challenges, while targeting the more general goal of sustainability in urban areas. PEDs, therefore, combine energy efficiency, renewable energy production, and energy flexibility in urban and peri-urban settings, including both residential and tertiary buildings within their (virtual) perimeter.

PEDs promote a vision of energy districts that not only ensure energy neutrality in the short term but can also act as positive sources of energy in the long term. This change in perspective pushes city governance, multi-utility companies, and consumers to no longer consider only the specific logic of the building but to assume the logic of the district. The challenges posed by the PED model are many, and the interactions of several actors in the territory are crucial. RECs can serve as the trigger model for PEDs in territories because they support model consolidation and help in long-term implementation. In fact, RECs are based on a regulatory model defined at the EU level and transposed at the national level; PEDs are a necessity for large energy hubs, but their characteristics are evolving. Like energy communities, PEDs can provide some valuable answers to the climate, energy, and economic crises. Both models place particular attention on improving the quality of life by prioritizing inclusive approaches (to combat, for example, energy poverty) and supporting local economies. As highlighted by current projects [2–6], the PEDs model has ambitious goals and aims for long-term horizons by proposing new market opportunities [7] and sustainable energy for all. However, the inherent adaptability of the energy system is crucial because PEDs aim not only to achieve a net energy surplus on an annual basis but—together with RECs—also aim to relieve pressure on centralized energy networks. This is done by improving on-site load adjustment and self-consumption, using energy storage technologies and intelligent control systems to ensure energy flexibility.

In the area of RECs, activities are divided into three main aspects:

- Digital tools to support RECs;
- REC pilot cases;
- Observatory for energy communities.

3. Digital Tools for RECs

In the development trajectory toward smart energy communities described in Section 2, the first dimension is technological. ENEA proposes free solutions and tools (Figure 1) based on the following interoperability principles:

- A simulator for technical–economic feasibility analysis of REC configurations: RECON (renewable energy community economic simulator);
- A platform to support the energy management of one's own home: Smart SIM (SIMulator) and DHOMUS (data homes and users);
- A tool to support and address renewable energy generation for RECs in the national territory, the geoportal for RECs;
- A dashboard for evaluating and optimizing RECs by monitoring energy performance and a 'digital twin' of energy communities: CRUISE (CRUscotto Interattivo Smart Energy) and SIMUL;
- A service for smart energy communities for the reward of energy virtuosity through digital tokens and for the exchange of goods and services: a local token economy;
- A service for analyzing citizen sentiment on the topic of energy communities: ECListener (energy community listener);
- The PELL (public energy living lab) school platform for the census and energy monitoring of school buildings according to open and interoperable standards. This tool collects useful information for REC configurations that include schools.

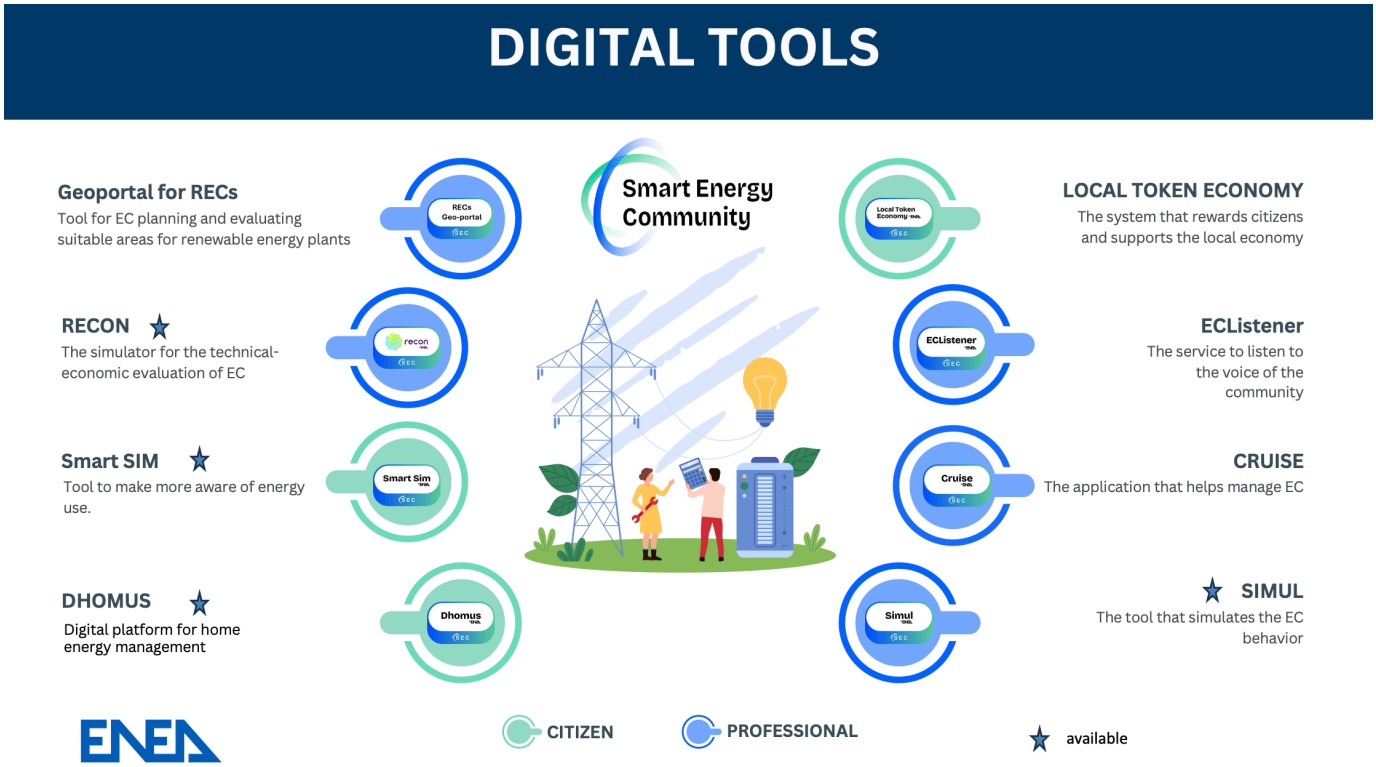


Figure 1. The digital tools for smart energy communities developed by ENEA are dedicated to citizens and professionals and can be used in the different phases of the life cycle of an REC.

3.1. Interoperability

For several years, ENEA has been working on aspects related to interoperability in the smart city domain.

"Interoperability" refers to the capability of two or more networks, systems, devices, applications, or components to exchange and readily use information securely and effectively, with little or no inconvenience to the user [8].

ENEA's achievements in this field are as follows:

- Definition of the smart city platform specification (SCPS) for the interoperability layer—a set of five specifications for interoperability in smart cities [8,9], inspired by the ebXML technical specification [10];
- Design and development of a smart city platform, based on SCPS—an ICT horizontal exchange platform that enables interoperable communication with various vertical solutions present in the city;
- Design and development of an identity provider (IDP) that allows centralized user authentication for various ENEA platforms, enabling users to perform a single login and navigate across different software solutions (single sign-on).

These results have also been applied to make various applications and tools related to interoperable energy communities. The IDP allows users to access the ENEA energy community web applications through a single login. Moreover, many of these energy community platforms can exchange data with each other using the urban dataset format defined in the SCPS specifications.

3.2. Pre-Feasibility Analysis Through Geoportal for RECs

The pre-feasibility analysis of RECs can be carried out through bottom-up and top-down approaches to evaluate solutions at the local or territorial level, respectively. Top-down modeling can mainly be used by public administrations and policymakers to verify the characteristics of a territory and to exploit certain clean technologies based on current and future energy demands. The proposed REC geoportal serves as both a technical and local governance tool for the planning and management of RECs in Italy, at both the national level (as a whole) and local level (at the municipal scale).

This tool provides support during the planning stage, prior to the analysis carried out by RECON (Section 3.3). The objective of this tool, which is under construction, is to support the creation of as many self-sufficient RECs as possible across the Italian territory, enabling them to exploit the resources available locally. The goal is to contribute to the energy self-sufficiency of the entire Italian territory.

This innovative tool facilitates the identification of optimal configurations of the energy system by selecting the renewable resources and technologies available locally and determining community membership based on the assigned input parameters. These parameters include electricity load profiles, energy prices, availability of renewable resources, technological characteristics, socioeconomic conditions, and the six types of territorial constraints identified as substantial for REC planning (technical, environmental, landscape, hydrogeological, economic, and governance) [11].

A multi-objective optimization framework is used to address energy, economic, environmental, and social priorities simultaneously. The geoportal incorporates features such as flexibility, scalability, and applicability to real-world territorial contexts, while providing decision support to regional planners and stakeholders. Scalability is achieved through the integration and management of spatial and temporal datasets at varying scales. Data are collected and analyzed at a municipal, provincial, regional, and national scale, using a georeferenced geographic information system (GIS), which guarantees efficiency and sustainability to the planning process [12].

To test the tool, which was created as a real web portal for use by all interested stakeholders, different scenarios were evaluated (Figure 2), including the maximum potential for renewable energy deployment using solar, wind and renewable energy (RE) technologies

from biomass, as well as an REC scenario that emphasizes the sharing of photovoltaic (PV) energy between sectors, residential prosumers, and consumers. The results indicate that the REC scenario with energy sharing achieves higher levels of self-consumption and self-sufficiency compared to isolated configurations. The first tests demonstrate the high potential of the tool, as the first analyzed scenarios revealed interesting data regarding the trajectories to be followed—both locally and nationally—for optimizing energy self-consumption as a function of energy self-sufficiency.

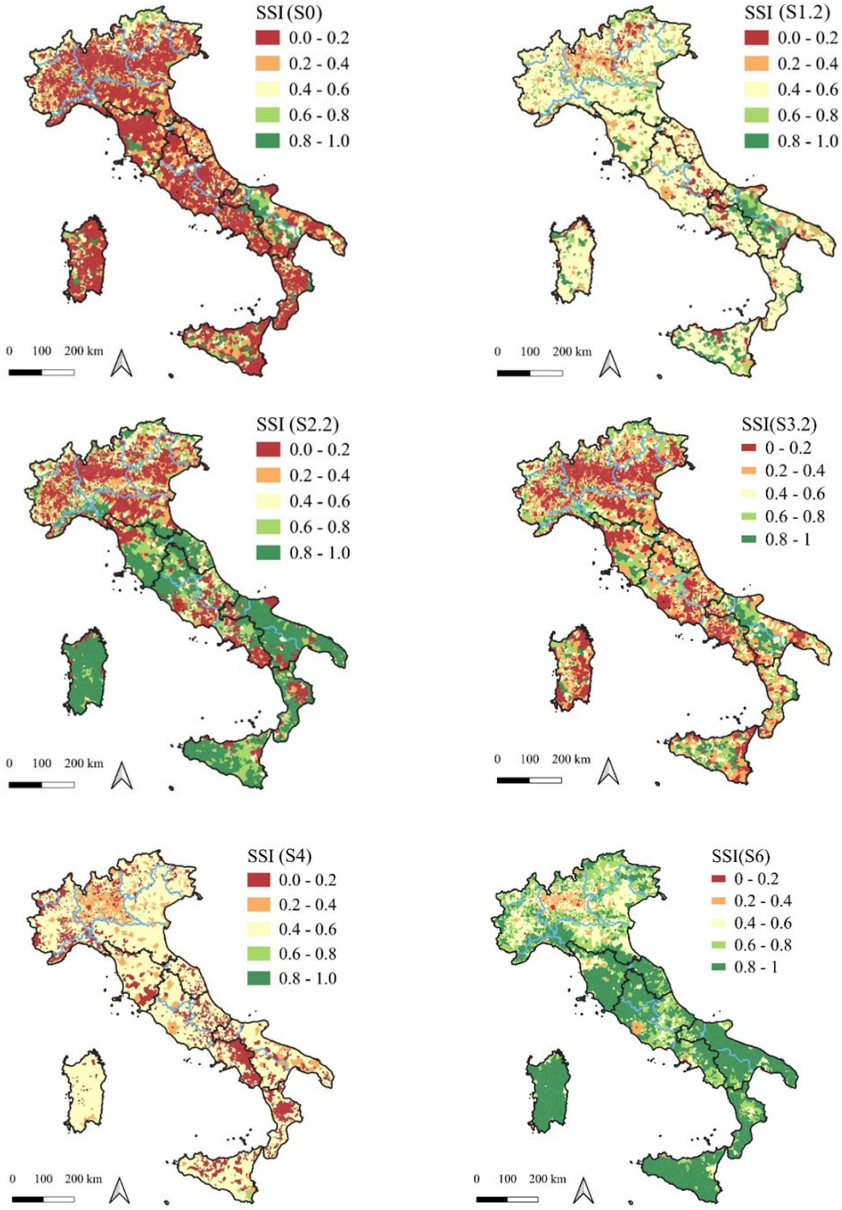


Figure 2. Comparison between different scenarios—in terms of SSI (self-sufficiency index) at the national level—evaluating the use of single RESs, their application within REC, and their integration. Current self-sufficiency of Italian municipalities (13%), with solar (39–42%), wind (26–28%), biomass 16–17%, REC 33–43%, and all RESs (71–73%). We observe very important variability across territories and greater potential in southern regions.

As an example, Ref. [13] presented a possible future development involving the aggregation of territories, which also favors large cities where high-density energy consumption prevails over the low availability of renewable energy.

3.3. RECON

RECON—a renewable energy community economic simulator—is a web application developed by ENEA, aimed at supporting preliminary energy, economic, and financial assessments for the creation of RECs or jointly acting renewables self-consumers (CSSs). RECON belongs to the ENEA Smart Energy Community platform and is available in Italian only; see Ref. [14].

Version 2.2.1 (the current version) has been updated to reflect the legislative and regulatory framework in force in Italy—Legislative Decree 199/2021 (which transposes the RED II Directive), the Integrated Code on Diffuse Self-Consumption (TIAD) issued by the National Energy Authority (ARERA), Ministerial Decree no. 414/2023, and the GSE 2024 operating rules.

RECON analyzes different types of users, i.e., consumers, prosumers, and producers. The configurations can, therefore, be composed of an arbitrary number of users of different types. It is possible to simulate different consumption profiles, e.g., residential, condominium, office, school, commercial, and industrial.

Regarding renewable energy production technologies, it is possible to evaluate photovoltaic systems with up to a couple of production units, wind, and hydroelectric systems.

The investment options for RES production plants include the operating lease, leasing, equity and/or debt, subsidies, and tax deductions. Subsidies included in the simulator are the NRPP contribution dedicated to diffusing self-consumption in small municipalities, any other subsidies under European Union programs, or capital grants not provided by the European Union.

RECON calculates the incentive for diffuse self-consumption based on the premium tariff defined by Ministerial Decree no. 414/2023 and the contribution associated with the valorization of self-consumed energy in accordance with TIAD. Moreover, RECON calculates the yield of RES production plants, onsite self-consumption, energy self-sufficiency, environmental benefits in terms of reduction in CO2 emissions, savings, revenue from energy sales, the incentive for shared energy, REC costs, discounted cash flows, and the main financial indicators (NPV, IRR, WACC, and payback time). Figure 3 shows a screenshot of a chart displaying cash flow by REC typology, available in RECON's Economic Results. It includes the incentive for diffuse self-consumption ("Tariffa premio"), the ARERA contribution ("Contributo ARERA"), revenues from electricity sold to the grid by RES plants owned by the REC ("Vendita energia"), the membership fee ("Quota associativa"), O&M and administrative costs of the REC ("Costi amministrativi e gestionali"), and the share of economic benefits generated by the REC and redistributed among REC members ("Redistribuzione") or reinvested in community services ("Reinvestimento in servizi"), along with their sum.

Models and algorithms included in RECON were first validated individually against real cases or commercial simulators. Specifically, the data used to validate the hydropower models refer to small turbines installed in Northern Italy, and the deviation from real data in the yearly energy calculation was below 10%. The model for the wind power plant was compared with TRNSYS simulations, obtaining results that were very close (less than 1%). Regarding PV, RECON calculates the production of PV plants by means of application programming interfaces (APIs) available in the PVGIS tool developed by the EC JRC Institute. RECON was then validated through various case studies on RECs and CSSs, based on real production and consumption data, and by comparing the results with those generated by the ROSE Designer PRO simulator developed by Maps SpA. The analyzed case study includes a variable number of consumers and prosumers, different types of end customers (residential, commercial, schools, offices, SMEs, etc.), reference locations (northern, central, southern Italy), and varying numbers and sizes of production plants.

By comparing the results obtained with RECON and ROSE, differences in aggregated consumption were negligible (less than 1%), while the differences in total PV production were generally less than 5%, which reflected the calculated energy fed into the grid, the energy shared, and the economic results. On average, the deviation in the calculated premium tariff for diffuse self-consumption was generally less than 15%, with a peak of 44% recorded in the only case where the PV production calculated by ROSE exceeded the 22% obtained by RECON.

With RECON, ENEA aims to support national and local authorities, as well as stakeholders, in making conscious and informed choices aimed at creating RECs and CSSs, while promoting the involvement of citizens in the energy transition and their active participation in the energy market according to European Union rules. At present, RECON has been used in more than 4000 potential projects.

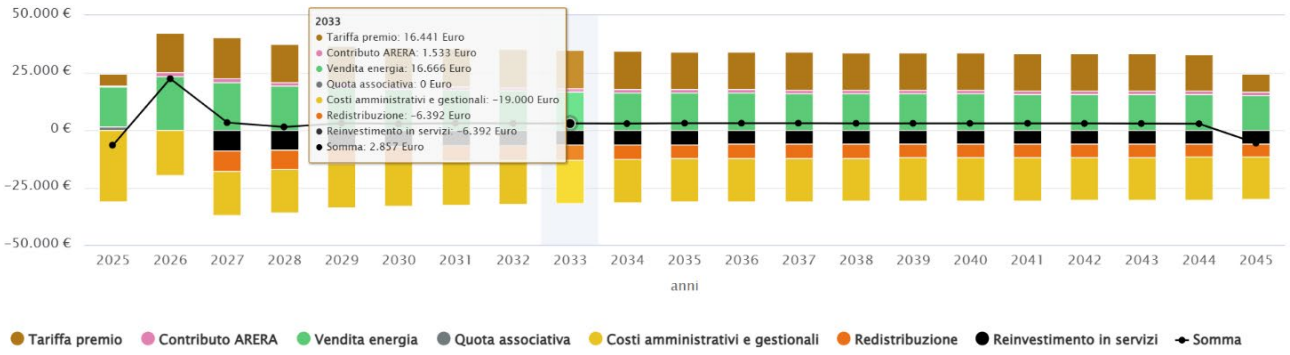


Figure 3. Screenshot of a chart with cash flow by typology of the REC, available in RECON's economic results.

3.4. Smart SIM and DHOMUS

Smart SIM and DHOMUS are two digital web tools dedicated to citizens to improve energy awareness and the engagement of end users.

Smart SIM is freely accessible online [15]; it requires the completion of a simple questionnaire about one's home and consumption habits. In exchange, the tool allows users to self-assess the consumption, costs, and environmental impacts (Figure 4). In addition, the user receives personalized suggestions to help them understand how to save energy and costs, e.g., simulating different efficiency interventions to choose from or highlighting the possible presence of better rates for energy supply. This tool can share information on the type of user with other digital tools, which is useful during the engagement phase and for collecting user memberships in the creation of an energy community. At present, over 2000 Smart SIM cards have been filled out by residential users, forming the basis for statistical analyses and the identification of KPIs representative of the properties.

Access to the DHOMUS platform is reserved for users equipped with IoT devices for energy monitoring, capable of sharing data according to standard and interoperable data formats. DHOMUS allows users to view, in real-time, on a dedicated dashboard (Figure 5), the monitored data (for example, the energy produced, fed into the grid, and self-consumed), but also receive personalized feedback based on the analysis of the data acquired thanks to algorithms developed specifically for the disaggregation of consumption, benchmarking, and analysis of consumption profiles. Furthermore, comparative analyses of the performance of individual users are carried out to encourage a virtuous and flexible use of energy, especially within energy communities, to maximize the self-consumption of shared energy.



Figure 4. Smart SIM. Feedback for citizens—breakdown of general primary energy consumption by end use (appliances, cooling, heating); breakdown of primary energy consumption by energy carrier, cost, and environmental impact; comparison and benchmarking of the user's electricity and gas consumption with similar users.



Figure 5. DHOMUS. User dashboard that displays the power and energy withdrawn, produced, and fed into the grid. The user can choose different time aggregations, i.e., real-time or aggregated. The consumed and self-consumed energy is calculated by the platform, as it is not supplied by the measuring instruments.

In the experiment conducted with about ten families without photovoltaic systems, an average annual saving of 8% on electricity consumption was found, thanks to the active involvement of end users [15], while in another group of families, following the installation of 0.35 kWp micro-photovoltaic systems, an average saving of 20% of energy taken from the grid was found, with an average self-sufficiency of 14% [16].

3.5. SIMUL and CRUISE

SIMUL and CRUISE are tools that support the novel management and planning of energy systems based on RECs and guided by data-driven approaches (Figure 6).

SIMUL is a computational tool designed to model RECs based on actual data, such as the consumption and production curves of the members, weather data, the characteristics of the renewable energy production, and the electricity storage plants included within the community. It defines a digital twin of RECs that accurately represents the community's energy characteristics and provides relevant KPIs to evaluate potential improvements and developments of the community over time. The tool enables the evaluation of different REC configurations (e.g., the inclusion of new production plants or the electrification of consumption) and, therefore, provides support for technical and management decision-making. CRUISE is a dashboard used to manage and visualize real-time data from energy communities. It aims to be an interactive web application to stimulate REC members and boost virtuous energy actions. This dashboard can be configured according to the needs of the user; it is able to deal with multiple communities, exchange data with energy meters, and interact with a simulation backend, like SIMUL, to show different community indicators. The monitoring requirements are defined by the community manager, based on the kind of community (e.g., the typology or the dimension), the available data, the useful KPIs (self-consumption, self-sufficiency, shared energy, etc.), and the need to group members by consumption levels or by more advanced techniques, like clustering methods.

The application and validation of these tools have been carried out using real datasets and various case studies related to collective self-consumption (located in Scandiano, Emilia-Romagna Region, Italy) and RECs in Lignano Sabbiadoro, Friuli Venezia Giulia Region, Italy [17].

Moreover, the performance of the tools has been analyzed and compared with similar, although less precise, tools that are currently available.

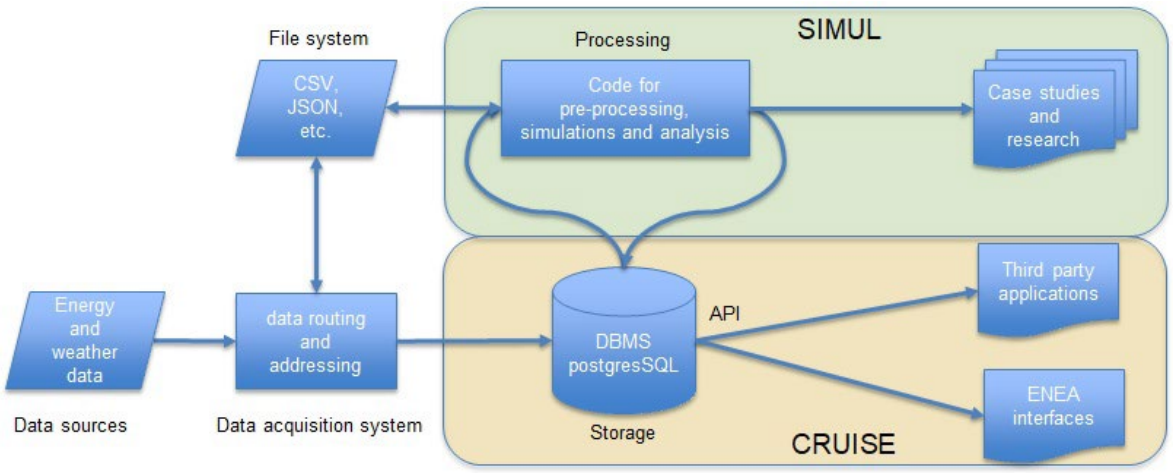


Figure 6. Data flow chart of SIMUL and CRUISE tools, consisting of a data acquisition section (left of the chart) and the two tools (right of the chart) equipped with interfaces to interact, cooperate, and produce output.

3.6. Local Token Economy

The local token economy (LTE) tool is an innovative web-based platform designed to develop advanced models for the management of local resources. The heart of the system is represented by an integrated marketplace that exploits frontier technologies, such as blockchain, to create a digital ecosystem that combines environmental, economic, and social sustainability [18,19]. This tool is designed to support local communities, public bodies, and territorial networks in the development of circular economy models, promoting the resilience and sustainable growth of territories.

On a technological level, the LTE tool combines the following:

User-friendly front-end environment: This is an interactive platform that allows users to easily access the marketplace and track the exchanges of goods and services (Figure 7).

Energy algorithms: The integration of advanced algorithms that convert the efficient use of the energy resources of REC members into digital tokens, promoting more efficient management.

Blockchain technology: This is used to ensure the security, reliability, and transparency of transactions, as well as to manage digital tokens.

The LTE tool aims to strengthen local economies and the "Community" factor [20], promoting the exchange of goods and services, and facilitating direct transactions between citizens and various stakeholders within a community through a token economy. Goals of the LTE tool include encouraging sustainable practices, such as reuse, participation in community services, supporting communities in energy efficiency, and reducing waste.

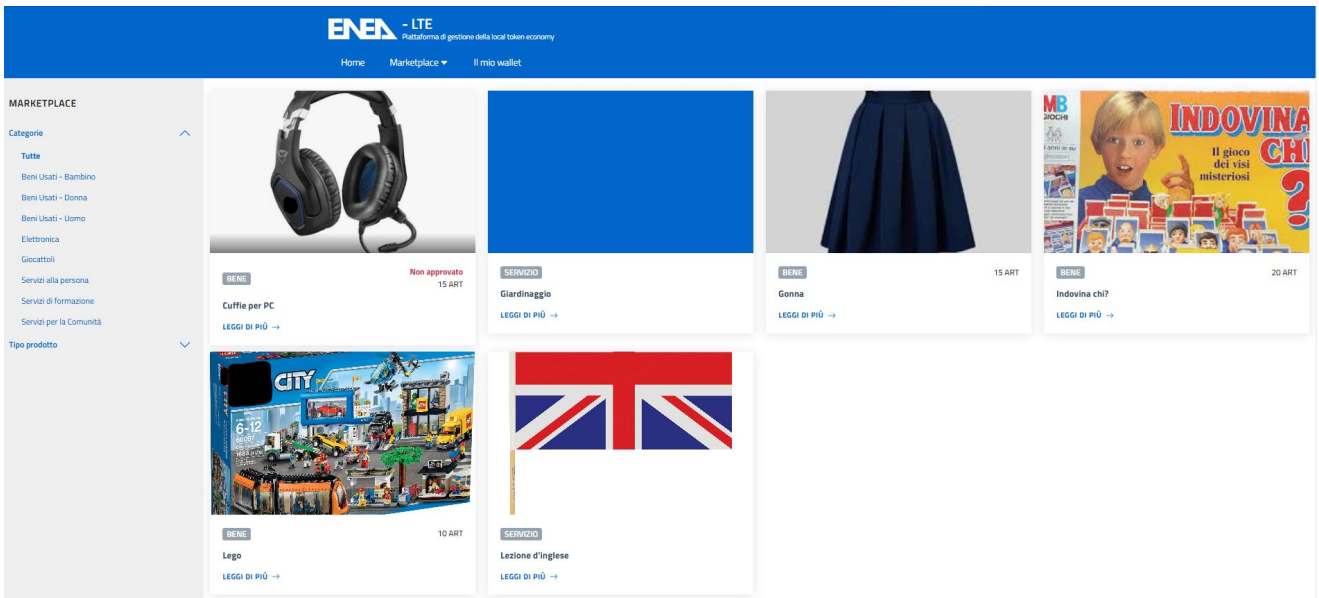


Figure 7. LTE user dashboard with goods and services available on the marketplace (approved and in pending status). The figure is related to goods and services added from an Italian Energy Community in the testing phase; they include: headphones ("Cuffie per PC"), gardening ("Giardinaggio"), skirt ("Gonna"), games ("Indovina chi?" and "Lego"), English lessons ("lezione d'inglese").

Local tokens, created and managed on the blockchain, represent the main means of fostering the circular economy within the community. These tokens, in addition to serving as an exchange tool, are distributed according to reward algorithms that use consumers' energy data in order to maximize collective self-consumption and energy sharing. Smart contracts automate the process, allowing virtuous behaviors to be directly rewarded. The blockchain, a private Ethereum-based testing environment called ENEA-Network, is the

heart of the LTE system and is a crucial component of the LTE tool due to its intrinsic characteristics, as follows:

- Traceability: Every transaction is recorded transparently and immutably, creating a reliable and accessible ledger.
- Security: Data and exchanges are protected by strong encryption, minimizing the risks of fraud or manipulation.
- Decentralization: Distributed management eliminates the need for a central authority, increasing system resilience.

Tokens can be used to reward sustainable behaviors such as reducing energy consumption, participating in separate waste collection, or using sustainable mobility options; to facilitate local exchanges by enabling the purchase of goods and services within the community without the need for official currency; and to manage local incentive programs, creating virtuous economic cycles that strengthen the social and economic fabric of the territory. The tool promotes practices that reduce environmental impact, involves all members of the community to create a sense of belonging and shared responsibility, and introduces advanced digital tools to facilitate economic interactions.

The tool is in the post-production monitoring phase and is being tested with a pilot REC to gather input from end users, helping to identify usability issues or bugs that were not caught during laboratory testing.

3.7. ECListener

ECListener (energy community listener) aims to capture the information provided spontaneously from ordinary users and professional journalists on social networks and in the most accredited newspapers. ECListener is part of a larger project that aims to observe in an automated way what citizens spontaneously post on the network, discussing all essential services. In its specific version, ECListener focuses on news reports in the mainstream media. The monitoring of these systems, combined with the acquisition of information on the energy community's social platform, enables an assessment of the users' appreciation of the services provided by the energy community and, more generally, of the appreciation of essential services related to the use of electricity.

ECListener is a work in progress and is concerned with finding information provided by users and journalists on malfunctions of all infrastructures, not only energy infrastructures. For this reason, it is not possible to automatically use information already available from previous campaigns, but the algorithms used have to be adapted to spontaneous statements and articles about the 'energy community'. The service will select news items relevant to the project's demo community and user acceptance, and possible malfunctions will be evaluated. ECListener campaigns on 'energy community' began in July 2020; around 23,000 web news articles have been analyzed and categorized. The web crawling campaigns stored around 8000 items, resulting from the application of relevance filters and categorization procedures. These procedures are continuously improved as new keywords/key phrases are discovered in newspapers and social media. ECListener has a web interface that allows end users to see the results of the web crawling process. ECListener analyzes end-user engagement through ad hoc web and social crawling campaigns focused on specific energy communities, as well as analyzes the LTE logs.

3.8. Public Energy Living Lab

The public energy living lab (PELL), developed by ENEA, improves public infrastructure management by utilizing digital technologies and big data. PELL began by focusing on public lighting systems and now serves as a national information asset that delivers both fixed infrastructure data and live energy information.

PELL provides a centralized management platform for municipalities to modernize old and expensive public lighting infrastructures. Lighting companies operated with isolated datasets, blocking the creation of a unified national perspective.

PELL establishes unified data collection standards and functions as part of the main public procurement tender conditions, which mandate energy contractors to upload pre-/post-renovation information and provide real-time monitoring of public infrastructures as school buildings.

Through PELL, municipalities and energy communities gain the ability to assess both static and dynamic KPIs to compare different infrastructures and oversee systems using interactive dashboards. The initiative has attracted multiple municipalities and stakeholders such as ESCOs, utilities, universities, and public institutions. The application of the PELL framework to schools is in an advanced phase, enabling the acquisition of data from thousands of public schools throughout the national territory. Thus, REC configurations that include schools as prosumers can receive a boost from the PELL application.

The validation of the PELL approach is demonstrated through its application in the public lighting domain. The PELL IP platform currently collects data from about 300 municipalities throughout the Italian territory, amounting to over 15,000 PODs (points of delivery) and 635,000 light spots. The data enable the provision of insightful information on both local and central administrations.

In particular, the dashboard section offers multiple widgets showing key information and KPIs, such as a geomap showing the actual detailed lighting plants of each municipality (Figure 8) or a benchmarking tool (Figure 9) for comparing performance across different municipalities.

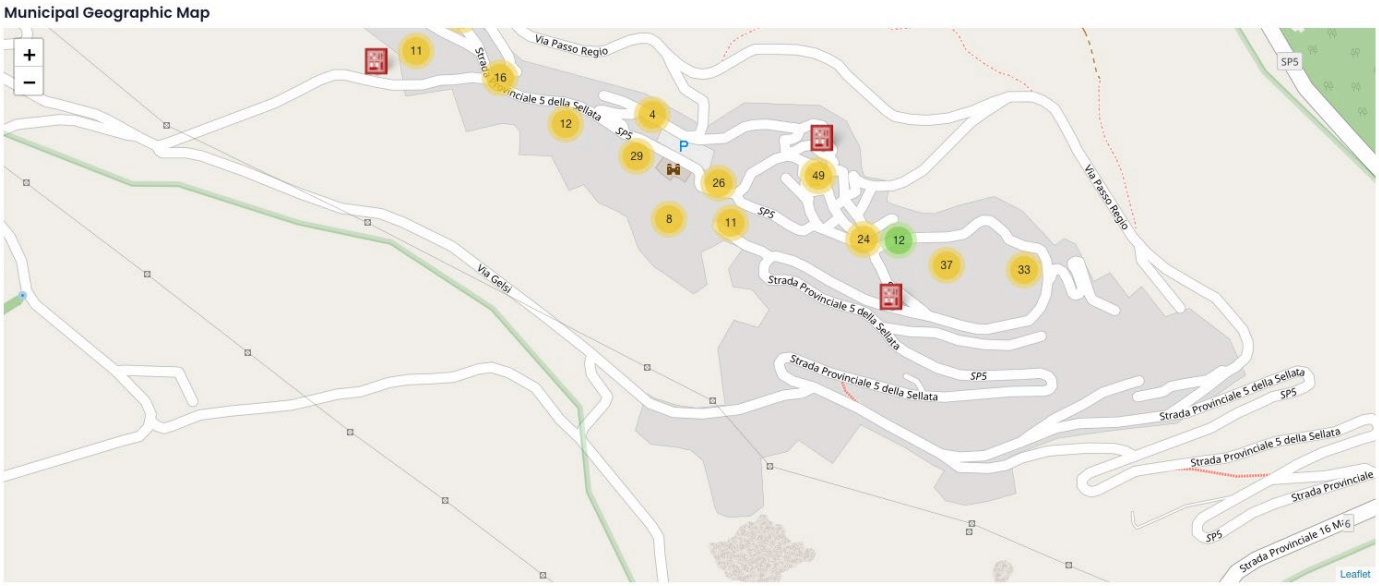


Figure 8. PELL: Geomap representing an actual lighting plant of an Italian municipality, detailing every single light spot (in yellow circles the number of light spots, in green circle the number of PODs and in red icon the electrical panels).

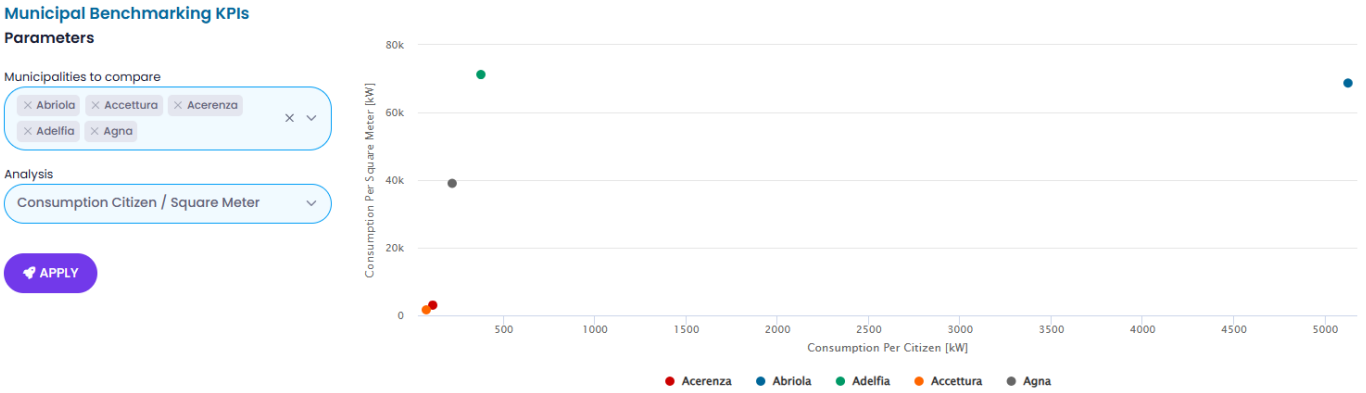


Figure 9. PELL: Benchmarking tool that compares consumption, normalized by the number of citizens and square meters, across 5 municipalities.

4. Use Cases

The second dimension of the roadmap to "smart energy communities" relates to demo pilots; here, we report three different use cases that have interesting specific features that can be seen as models to be replicated in similar scenarios.

The first one refers to a PA-driven initiative in a highly densely populated area; the second one involves a wide-area REC (covering 23 municipalities) driven by a public multi-utility, and the third describes a private-driven scenario in a touristic area.

4.1. PA-Driven Scenario in a Highly Densely Populated Area

The Pilot Project with the city of Portici stems from a collaboration agreement aimed at supporting the municipality in creating an REC through the use of tools developed by ENEA. This project is of particular interest as it is driven by the public sector, thus configuring itself as a PA-driven REC, where the public administration plays a key role in promoting local energy sustainability.

The city of Portici covers a relatively small area of about 4.5 square kilometers; it is an Italian municipality located in the Metropolitan City of Naples, in the Campania Region. With a population of 51,817 inhabitants, Portici is the second most densely populated city in Italy. This characteristic significantly impacts energy consumption and presents specific challenges related to managing energy demand and supply. Portici is also characterized by a rich historical and architectural heritage, with numerous prestigious buildings owned by public authorities. This context offers significant opportunities for the development of an REC, as it allows for the active involvement of public structures in the energy transition process. The main challenge of this use case is its application in a high-density residential area (about 12,000 inhabitants/km^2), with constraints related to historical and architectural heritage.

The study, which started in 2024 and is currently ongoing, began with a detailed mapping of the consumption of 25 users, all connected to the public administration, with a total annual consumption of approximately 778 MWh. Of the 25 users, quarter-hourly consumption curves for the year 2023 were available for 17. In the REC configuration, eight of them were classified as "consumers" while nine were "prosumers", referring to consumers who are also energy producers, both real and simulated. This first use case involves the installation of 16 photovoltaic systems, with peak power estimated using an analysis model based on photovoltaic productivity and solar irradiation data. According to forecasts, these systems will be able to generate approximately 1.1 GWh of energy per year.

Out of the sixteen planned systems:

- Eight will be dedicated to the total sale of the energy produced to the electricity grid.
- Eight will be used for direct self-consumption, associating them with specific consumption users.

The analysis conducted so far has enabled the definition of the key parameters of the REC, including the following:

- Energy shared among participants;
- Direct self-consumption;
- Self-consumption and energy self-sufficiency rates.
- These parameters form the basis for technical and economic evaluations aimed at ensuring the project's sustainability. The use case, which started in 2024, is under development, and lessons learnt are not available yet. Currently, the initial results are being analyzed by the Municipality of Portici, with the objective of defining the next steps for the concrete implementation of the REC. This includes both strategic planning and the actual realization of the plants, which will need to be properly located and sized to ensure maximum benefit to the community.

4.2. Wide-Area REC Project Led by a Public Multi-Utility

Since 2022, Garda Uno S.p.A. (a public multi-utility) and its member municipalities have undertaken the process of creating RECs in the territories of the western side of Garda Lake and "Bassa Bresciana" (Bresciana lowland). The ambitious goal is to actively participate in the energy transition and develop a large-area project dedicated to increasing the capacity from renewable sources, increasing energy self-sufficiency, and making public buildings more efficient.

The municipalities are the referents and promoters of the RECs, with technical support from Garda Uno, which aims to foster a virtuous and sustainable pathway that delivers important social benefits to the local territory. The goal is to actively involve citizens and other final users to increase their awareness of efficient energy production and consumption.

Around 23 small municipalities (with less than 5000 inhabitants) are involved in the project, with around 1.1 MW of photovoltaic systems planned for submission under the National Recovery and Resilience Plan call dedicated to energy communities in small municipalities. Moreover, 17 municipalities with more than 5000 inhabitants have joined the project, with a PV potential higher than 10 MW on public buildings. Most of the municipalities are currently defining the regulation. In this phase, in addition to the administrative and design aspects of the systems, Garda Uno is deeply involved in communicating and testing ICT monitoring platforms and implementing other technological solutions.

During the development of the project, several challenges were encountered. First, this pioneering project aims to promote the electrification of consumption through the decentralization of generation and local energy balancing strategies. This requires significant efforts in communication and outreach, as the involvement of local citizens and businesses is essential. It is important to raise consumer awareness about their energy needs and possible actions to improve efficiency and to adapt energy habits based on the availability of energy produced in the RECs. Smart meters and digital platforms were identified as enabling technologies for users' engagement. Moreover, compliance with the new national regulatory framework caused delays and required several adjustments in response to its evolution. These challenges suggest moving ahead with determination but also with caution, guided by a robust medium to long-term vision. By involving many municipalities with different sizes and characteristics, and considering the complexity of setting up RECs, a key lesson learnt was to simplify operations by defining a clear and replicable REC model, and to adopt it in all the configurations involved.

Garda Uno demonstrated its interest in the RECs from the first transient transposition of the REDII Directive in Italy, by signing a collaboration agreement with ENEA in February 2022; within this context, it collaborated in the development and validation of numerical models dedicated to collective self-consumption.

4.3. Private-Driven Scenario in a Touristic Area

The REC in Lignano Sabbiadoro is a complex use case involving 88 members (with a total of 27 photovoltaic systems), ranging from residential users to hotels, restaurants, beach resorts, and services, such as offices, warehouses, schools, etc. The specific features of this use case concern its geographical location (beach tourism area in the northeast of Italy), the coverage of all types of members (61 consumers, 16 prosumers, and 11 producers), and the inclusion of detailed consumption data (48 datasets of electricity load profiles based on accurate measurements recorded at 15 min intervals).

The total rated power of installed photovoltaic systems is about 920 kWp, and the production profiles are simulated using actual hourly average data on solar irradiation, outdoor temperature, and wind speed. Only one user (out of 88) has a battery energy storage system (BESS) with a capacity of 70 kWh.

The SIMUL tool was applied in this use case to evaluate its functionality, and specifically, an innovative parametrization scheme of KPIs' dependence on the production/consumption ratio of the REC. This approach also extends the concept of a net-zero energy building (NZEB) to that of a net-zero energy community (NZEC), where total annual energy production equals total annual consumption. The application of this methodology has enabled the evaluation of various REC configurations and the influence of seasonal and daily effects on them [17].

Using data related to the year 2022, this REC can produce approximately 1.2 GWh/year of electricity, which covers about half of its total demand of 2.3 GWh/year. More than 76% of the electricity produced is self-consumed, i.e., used locally, either in the form of direct physical self-consumption, which is about 19% of the total energy produced, or virtual shared energy (exchanged among members via the electricity grid), which amounts to 57% of the energy produced. In this way, the self-sufficiency rate of this community, i.e., the electricity demand met by local production, is about 40%.

As a result, shared energy plays a significant role within RECs, both in supporting local self-consumption and in promoting it. It can also serve as a source of income for the REC when incentives are in place, as in Italy. However, the REC model becomes less advantageous when the amount of shared energy among members is low. This typically occurs when many members feed energy into the grid and withdraw it at the same time as others. Exchange profiles should be thoroughly considered during the configuration phase of any REC, as well as periodically throughout its development.

5. EC Observatory

The third dimension of the roadmap to "smart energy communities" refers to the governance of a common REC development model.

The observatory, dedicated to assessing the status and development pathways of energy communities at the national level, along with identifying critical issues that may hinder their diffusion and participation, aims at:

- Establishing a platform for dialogue and exchange among stakeholders directly and indirectly involved in REC processes;
- Identifying issues in REC diffusion based on actual experiences;
- Supporting institutions in defining enabling policies to foster the growth of energy communities;

- Comparing available market technologies and identifying new enabling and/or higher-performing solutions, with a particular focus on data acquisition and management;
- Exploring new technological, regulatory, financial, economic, and social scenarios and perspectives;
- Promoting the ethical principles of the RECs process and fostering local capacity building.

At present, the observatory for energy communities consists of a network of more than 100 public and private entities directly and indirectly engaged in the promotion, development, management, and assessment of energy communities. These include institutions, associations, research bodies, universities, public administration, energy sector companies, ESCOs, ICT firms specialized in data management platforms, experts in regulatory, legal, and administrative frameworks, and other key stakeholders.

Given the cross-sectoral and multidisciplinary nature of the topics addressed by the network of participants, the activities have been divided into five key areas, each covered within a dedicated working group, as follows:

- Regulatory, administrative, legal, and governance aspects;
- Economic and financial aspects;
- Data acquisition and management;
- Public awareness and communication;
- Regional policies.

Over the past two years, the working groups have engaged in regular discussions (including joint sessions), closely following regulatory and implementation developments. These exchanges have enhanced understanding and awareness among the participants. Additionally, they have facilitated the formalization of perspectives from various stakeholders and the proposal of solutions to key emerging challenges.

In particular, the following outcomes have been identified as highly strategic and impactful, laying the groundwork for more effective and scalable development of energy communities:

- Comprehensive conceptual mapping of the various legal structures available under Italian law for establishing an REC, providing stakeholders with clear guidance on the most suitable governance models;
- Innovative financial instruments to support the critical startup phase of RECs, particularly those based on community-owned energy installations (shared ownership), ensuring greater financial viability and accessibility;
- Development and testing of interoperable communication standards for real-time monitoring devices and community management platforms, fostering integration, data exchange, and operational efficiency;
- Structured benchmarking of the regional initiatives and best practices aimed at strengthening the effectiveness of local policies. By comparing real-world experiences, this effort enables more informed decision-making and policy alignment across different territories.

By bringing together different experiences and perspectives, the observatory has actively contributed to the dissemination of the cultural model embodied by energy communities, fostering a shared understanding of their principles and potential. This has been achieved through the organization and participation in numerous outreach initiatives, including workshops, conferences, podcasts, articles, interviews, and more. Two public events are organized annually to present the activities and results of the observatory, targeting stakeholders involved in the REC process. During these events, interaction among speakers and with the audience is promoted by means of round tables and Q&A sessions.

In addition, the main results of the observatory are collected in an annual report that will be published online on the ENEA Smart Energy Community's new website. Moreover, outcomes of the working groups—above all, the one focused on regional policies comprising delegates from regions, municipalities, and regional energy agencies—may provide an actual contribution to the definition and implementation of replicable local policies for the diffusion and monitoring of energy communities.

6. Discussion

The work described here triggered some remarks that go beyond the specific project and that can be useful also for other countries.

Firstly, the final national transposition of the European RED II concerning RECs, along with the described funding scheme, has been particularly complicated, as certain parts of the overall approach contrasted with the EU laws, particularly those related to "State Aid" regulations.

Secondly, the operational implementation rules, due to the complex scheme of the national law, were not very easy, and updates were quite frequent. As a result of this, local public officers and private company administrations were not able to carry out REC projects, and a considerable effort to train them had to be made.

Thirdly, from a scientific and technical point of view, the main issue we tackled was that of the availability of suitable quality and the amount of data to carry out economic analysis, simulations, and optimization. Therefore, the availability of proper energy metering systems, or bills, is something that has to be carefully considered when dealing with RECs and SECs.

Finally, the paradigm shift introduced by RECs and SECs—such as distributed energy production, energy sharing, prosumer participation, self-consumption, individual vs. collective benefits, as well as social and environmental impacts rather than financial ones—is something that needs a 'cultural transition' among citizens, public authorities, and companies. This shift represents the main challenge to be addressed in the coming years in order to engage people and stakeholders as active players in the required energy transition.

7. Conclusions

The large-scale adoption of energy communities requires the synergistic integration of digitalization, favorable regulations, and active citizen involvement. In particular, the evolution toward smart energy communities represents a crucial step in this process, integrating advanced digital tools with new governance models to optimize energy use and foster local economic and social sustainability. The data collected and stakeholder mobilization in the Italian scenario, based on the three pillars of the ENEA model, are pivotal elements in this direction. Also, the positive energy district (PED) concept emerges as a long-term solution to achieve energy self-sufficiency, improve urban resilience, and create surplus energy for local communities to reach the goals and ambitions of the Green Deal. ENEA's approach aims to achieve the broader concept of smart communities through smart energy communities and, therefore, it provides innovative and interoperable solutions, facilitating collective self-consumption and contributing to the national energy transition. The future of energy communities and PEDs will depend on the ability to overcome administrative barriers, improve access to financing, sustainable business models, and a cultural paradigm shift. SECs can be a way to cope with these and trigger a wider societal spin.

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References

1. Massa, G.; Pizzuti, S.; Meloni, C.; D'Agosta, G.; Caldera, M.; Romano, S.; Branchetti, S. ENEA's Approach and Technologies for the Development of Smart Energy Communities in Italy. *J. Sustain. Energy* **2024**, *3*, 224–233. [CrossRef]
2. Zhang, X.; Penaka, S.R.; Giriraj, S.; Sánchez, M.N.; Civiero, P.; Vandevyvere, H. Characterizing Positive Energy District (PED) through a Preliminary Review of 60 Existing Projects in Europe. *Buildings* **2021**, *11*, 318. [CrossRef]
3. Bossi, S.; Gollner, C.; Theierling, S. Towards 100 Positive Energy Districts in Europe: Preliminary Data Analysis of 61 European Cases. *Energies* **2020**, *13*, 6083. [CrossRef]
4. Alpagut, B.; Sanz Montalvillo, C.; Vélez Jaramillo, J.F.; Hernandez Iñarra, P.; Brouwer, J.; Hirvonen-Kantola, S.; Kosunen, H.; Martinez, N.H.; Ahokangas, P.; Rinne, S.; et al. Methodology and Guidelines for PED Design. MAKING-CITY Project 2020. Available online: https://makingcity.eu/wp-content/uploads/2021/12/MakingCity_D4_1_Methodology_and_Guidelines_for_PED_design_final.pdf (accessed on 14 February 2025).
5. Kalms, A.; Cornago, I.; Ezquer, M.; Diaz de Garayo, S.; Arias, A.; Torre, L.; San Emeterio, D.; Irulegui, M.O.; Bouchotrouch, F.; De Groote, M. "oPEN Lab" project as an underpin innovation for Positive Energy District solutions in Pamplona. *J. Phys.* **2023**, *2600*, 082029. [CrossRef]
6. PED-ID Project. Available online: https://jpi-urbaneurope.eu/project/ped-id/ (accessed on 14 February 2025).
7. Ala-Juusela, M.; Tuerk, A. Business models for rolling out Positive Energy Buildings. *IOP Conf. Ser. Earth Environ. Sci.* **2022**, *1122*, 012060. [CrossRef]
8. Locke, G.; Gallagher, P.D. *NIST Special Publication 1108—NIST Framework and Roadmap for Smart Grid Interoperability Standards; Release 1.0. NIST*; National Institute of Standards and Technology: Gaithersburg, MA, USA, 2010.
9. UN/CEFACT OASIS. *ebXML Technical Architecture Specification; Version 1.0.4*; OASIS Open: Woburn, MA, USA, 2001. Available online: http://www.ebxml.org/specs/ebTA.pdf (accessed on 14 February 2025).
10. Brutti, A.; De Sabbata, P.; Frascella, A.; Gessa, N.; Ianniello, R.; Novelli, C.; Pizzuti, S.; Ponti, G. Smart City Platform Specification: A Modular Approach to Achieve Interoperability in Smart Cities. In *The Internet of Things for Smart Urban Ecosystems*; Cicirelli, F., Guerrieri, A., Mastroianni, C., Spezzano, G., Vinci, A., Eds.; Springer International Publishing: Berlin/Heidelberg, Germany, 2019; pp. 25–50. Available online: https://www.springer.com/us/book/9783319965499 (accessed on 14 February 2025)ISBN 978-3-319-96549. [CrossRef]
11. Mutani, G.; Morando, V.; Zhou, X.; Tayefinasrabad, M.; Tundo, A. An Italian Geoportal for Renewable Energy Communities. *J. Sustain. Energy* **2024**, *3*, 244–264. [CrossRef]
12. Mutani, G.; Alehasin, M.; Usta, Y.; Fiermonte, F.; Mariano, A. Statistical building energy model from data collection, place-based assessment to sustainable scenarios for the city of Milan. *Sustainability* **2023**, *15*, 14921. [CrossRef]
13. Mutani, G.; Morando, V.; Zhou, X.; Tayefinasrabad, M.; Montazeri, A. Strumenti e metodi GIS-based per la pianificazione energetica a scala territoriale delle CER. *Electr. Syst. Res. Rep.* 2024, *in press*.
14. Available online: https://recon.smartenergycommunity.enea.it/ (accessed on 14 February 2025).
15. Available online: https://www.smarthome.enea.it/smartsim/ (accessed on 14 February 2025).
16. Lauro, F.; Romano, S.; Botticelli, M. Monitoring the impact of micro-photovoltaic production on a real residential case study. *J. Phys. Conf. Ser.* **2024**, *2893*, 012049. [CrossRef]
17. Petrovich, C.; Branchetti, S.; D'Agosta, G. Parametrization of self-consumption and self-sufficiency in Renewable Energy Communities: A case study application. *Energ. Ecol. Environ.* **2025**, 1–28. [CrossRef]
18. Basile, D.; D'Adamo, I.; Goretti, V.; Rosa, P. Digitalizing Circular Economy through Blockchains: The Blockchain Circular Economy Index. *J. Ind. Prod. Eng.* **2023**, *40*, 233–245. [CrossRef]

19. Lavoie, E.; Tschudin, C. Local crypto-tokens for local economics. In Proceedings of the 3rd International Workshop on Distributed Infrastructure for the Common Good, DICG '22, Quebec City, QC, Canada, 7 November 2022; p. 22. Available online: https://dicg-workshop.github.io/2022/papers/lavoie.pdf (accessed on 14 February 2025).
20. Viano, C.; Avanzo, S.; Cerutti, M.; Cordero, A.; Schifanella, C.; Boella, G. Blockchain tools for socio-economic interactions in local communities. *Policy Soc.* **2022**, *41*, 373–385. [CrossRef]

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