

STUDY OF PILOT PROJECTS OF RENEWABLE ENERGY COMMUNITIES (RECs) IN THE EMILIA-ROMAGNA REGION, ITALY: ECONOMIC, TECHNICAL AND SOCIAL DIMENSIONS

Summary

The energy transition, as well as the independence of production and consumption of renewable energy communities (RECs), specifically applying photovoltaic technology, brings a relevant and challenging context for hybrid governance, involving various actors. The object of study is based on Renewable Energy Communities (RECs) focused on photovoltaic technology, which were analyzed using the multi-case study method, identifying the strengths and weaknesses summarized in the economic, technical, and social dimensions in 22 territories and 21 pilot projects in Italy, France, and Spain, within the context of the ENCOM-HUB project, funded by the European Union, between 2024 and 2025. The results presented are specific to RECs in the Emilia Romagna Region, Italy, raised in 2025 and can assist stakeholders in decision-making.

Keywords: Solar Energy, Governance, Renewable Energy Community, Sustainable

Field of application for the findings: Sustainable and Solar Energy Transition

Addressed audience: Researchers, Entrepreneurs, Governments, and Managers renewable energy community

1.Introduction

Renewable energy refers to energy obtained from natural resources that regenerate continuously on timescales compatible with human activity, such as solar radiation, wind, water, biomass, and geothermal heat. Compared to fossil fuels, these sources are characterized by a lower environmental impact and a significantly reduced intensity of greenhouse gas emissions (Panwar et al., 2011).

Among renewable energy sources, photovoltaic solar energy represents a technological alternative for generating electricity from solar radiation. Photovoltaic technology is based on the direct conversion of solar radiation into electricity through semiconductor cells, allowing applications on scales ranging from small residential systems to large centralized power plants (Maka et al., 2022).

Literature indicates that solar photovoltaic energy combines modularity, low operating costs, high scalability, and compatibility with distributed generation, with positive impacts in urban and rural contexts (Maka et al., 2022).

It is from these characteristics that the concept of energy communities emerges, understood as a form of collective organization of citizens, small businesses, and local authorities for active participation in the energy system through the generation, consumption, sharing, and management of energy (Magni, 2025). These initiatives are described as socio-technical innovations that combine decentralized energy infrastructure, participatory governance, and new business models oriented towards creating environmental, economic, and social benefits at the local level (Reis et al., 2021).

Energy communities are potentially relevant instruments for democratizing access to renewable energy, reducing costs for end consumers, and increasing social acceptance of technologies such as photovoltaics (Ahmed; Ali; D'Angola, 2024).

From a technological standpoint, the operational viability of photovoltaic energy communities is directly associated with the availability of enabling technologies, which comprise a chain of technical solutions from energy generation to management, allocation, and distribution processes. These technologies include, among others, smart metering systems, digital platforms for allocation and accounting of shared energy, Community Energy Management Systems (CEMS), and multi-user billing solutions (Reis et al., 2021; Bukar et al., 2023).

These technologies are considered critical for reducing transactional costs, ensuring transparency in benefit sharing, and enabling the integration of communities into the electricity market (Bukar et al., 2023). In

this context, the success of energy communities depends not only on the maturity of renewable technologies, such as photovoltaics, but above all on the design of energy policies that recognize, regulate, and encourage these collective arrangements (Reis et al., 2021; Ahmed; Ali; D'Angola, 2024). Regulatory frameworks, economic incentive mechanisms, and market rules act as structuring vectors for technological diffusion in energy communities, directly influencing both the adoption rate of community photovoltaic systems and the development of associated digital and management solutions (Barabino et al., 2023; Bukar et al., 2023).

2. Materials and methods

The method adopted was a survey applied to the leadership of the Renewable Energy Communities (RECs) of the Emilia-Romagna Region, Italy, during the event "Shared Horizons: From Today's RECs to Tomorrow's Communities," in December 2025. The questions raised the main strengths and weaknesses, using a Likert scale of 05 (five) points, in 3 dimensions: Economic, Technical, and Social. Thirteen responses were obtained from RECs, out of approximately 50 RECs present at the event. The economic dimension identified the main factors of the REC's economic viability, sources of resources, and efficiency of the business model; the technical dimension highlighted aspects of the members' technical skills; legal structure; and internal administrative processes; the social aspect was addressed from the perspective of governance, socioeconomic impacts on cities/territories, and the capacity to prospect new partners. It should be noted that the results presented are partial and the RECs are part of the ENCOM-HUB Project < <https://aessenergy.it/progetti/encom-hub-energy-community-hub/>> with several partners coordinated by Agency for Energy and Sustainable Development (AESS, acronym in Italian) and funded by the European Union. The project operates in 3 countries: Italy, France, and Spain, with a pilot project in Bulgaria, and the research will be expanded to the other countries where the project is active.

3. Results

This session presents the partial results collected from the Renewable Energy Communities (RECs) of the Emilia-Romagna Region, Italy, highlighting the main aspects in the economic, technical, and social dimensions.

3.1 Economic Dimension

Initially, the main sources of funding for Renewable Energy Communities (RECs) in the Emilia-Romagna region of Italy were identified. In this respect, 77% stated that the resources originate from the public sector, highlighting a strong dependence on this source of funding for investments in RECs. (see Fig. 1)

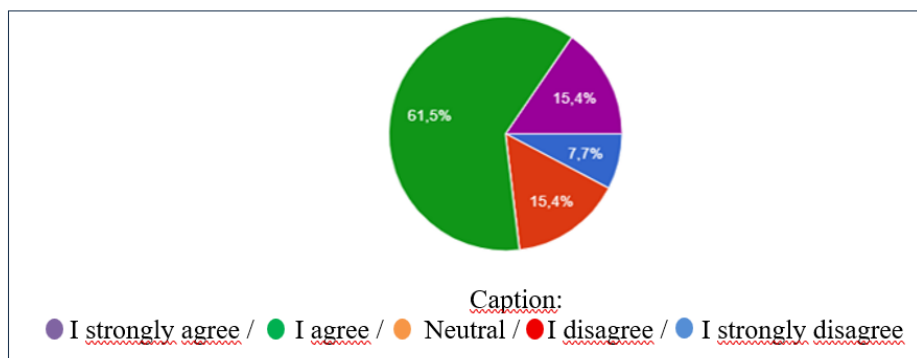


Fig. 1: Funding sources for REC investment

The investigation raised questions about the robustness of the RECs' business model in relation to their planned objectives, and 38.5% stated that their business models are robust in relation to their planned objectives. This scenario reflects the need for RECs to align their objectives with their business models. Volunteer labor is employed by 69.3% of the RECs studied. This highlights a strong dependence on volunteer labor, placing key business processes in a fragile position and possibly incurring the risk of fluctuations in the exclusive dedication of employees.

3.2 Technical Dimension

Among the RECs investigated, 38.5% stated that their members possess the necessary technical competence for their management and development. This reveals the need to develop managerial technical knowledge and skills so that the organization can be consolidated and achieve its main objectives efficiently. For 46.2% of the RECs, there is a dedicated platform for energy and financial management. This reveals a need for management and measurement technologies to generate parameters and indicators in order to obtain data and information for decision-making. Approximately 54% of the RECs have a strong dependence on external expertise in technical matters. This demonstrates the prospect of intensifying the technical qualification of REC members in order to reduce external technical dependence and develop internal capabilities.

3.3 Social Dimension

The governance model meets the operational and strategic needs of 61.6% of the Renewable Energy Communities (RECs), and 53.8% have a legal model formed by an association without legal personality, meaning that there is no formal registration of the constitutive acts. This suggests that most RECs need to formalize the processes of establishing the collective organization in order to have a governance model to provide robustness to the complexities and risks of the business model. 61.5% of the RECs believe that the business model they have developed does not generate socioeconomic benefits for the city or territory, such as job creation, income, etc.

4. Partial Considerations

Renewable Energy Communities (RECs) play a fundamental role in energy generation, especially in locations where energy availability is scarce/precarious, such as rural and mountainous areas. This work elucidates and discusses the main aspects of opportunities and challenges faced by RECs in the Emilia-Romagna region of Italy. The results suggest that the business model is dependent on public resources and volunteer labor, requiring technical improvement, and that there are quite modest socioeconomic impacts on the cities/territories where they are located. It should be noted that the results of this research are in the systematization phase, and the sample of RECs studied is being expanded to other countries in the ENCOM-HUB Project.

5. References

- Ahmed, S.; Ali, A.; D'Angola, A. A Review of Renewable Energy Communities: Concepts, Scope, Progress, Challenges, and Recommendations. *Sustainability* 2024, *16*, 1749. <https://doi.org/10.3390/su16051749>
- Barabino, B.; Porru, S.; Misso, R.; Coni, M. Renewable energy communities: Governance models, market integration and regulatory challenges. *Energy Policy*, Amsterdam, v. 181, p. 113734, 2023.
- Bukar, A. L.; Tan, C. W.; Lau, K. T.; Zaki, S. A. Peer-to-peer electricity trading: A systematic review of technologies, business models and regulatory frameworks. *Renewable and Sustainable Energy Reviews*, Amsterdam, v. 173, p. 113083, 2023.
- Magni, G. U. Economic incentives for renewable energy communities in Italy: Legal framework and implementation challenges. *Energy Policy*, Amsterdam, v. 189, p. 114102, 2025.
- Maka, A.O. and Alabid, J.M. (2022) Solar Energy Technology and Its Roles in Sustainable Development. *Clean Energy*, 6, 476-483. <https://doi.org/10.1093/ce/zkac023>
- Panwar, N.L.; Kaushik, S.C.; Kothari, Surendra. *Renewable and Sustainable Energy Reviews*, Elsevier, v.15, Issue 3, p.1513-1524, 2011. <https://doi.org/10.1016/j.rser.2010.11.037>
- Reis, I. F. G.; Gonçalves, A. B.; Costa, M. A.; Silva, F. R. Business models for energy communities: A review of key issues and trends. *Renewable and Sustainable Energy Reviews*, Amsterdam, v. 144, p. 110955, 2021.