Working paper

Analysis of the Critical Success Factors of Renewable Energy Communities in the EU: An Overview through Systematic Literature Review

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INTRODUCTION

Policy framework

GREEN NEW DEAL 2019

Strategy to make Europe **Climate - Neutral By 2050**. It defines the transition from fossil energy sources to **Renewable Energy Sources (RES)** as the primary approach to decarbonizing the European energy system. Considering that the **75%** of EU's greenhouse gas emissions come from energy production and use.

NEXT GENERATION EU 2021

At the **European level**, **€290 billion** has been allocated for green policies. The **Italian plan (PNRR)** has allocated **€23.7 billion** to increase the share of renewable energy.Of this, **€2.20 billion (M2.C2)** is earmarked for the implementation of **Renewable Energy Communities (RECs)**, primarily in municipalities with fewer than 5,000 inhabitants, typically located in rural areas

RED II 2021

It has established a **unified European definition of Renewable Energy Communities (RECs). "A coalition of users,"** the majority of which is owned by local members or shareholders, who have the right to produce, store, and/or distribute energy based on mutual needs to reduce costs and increase consumption efficiency

INTRODUCTION

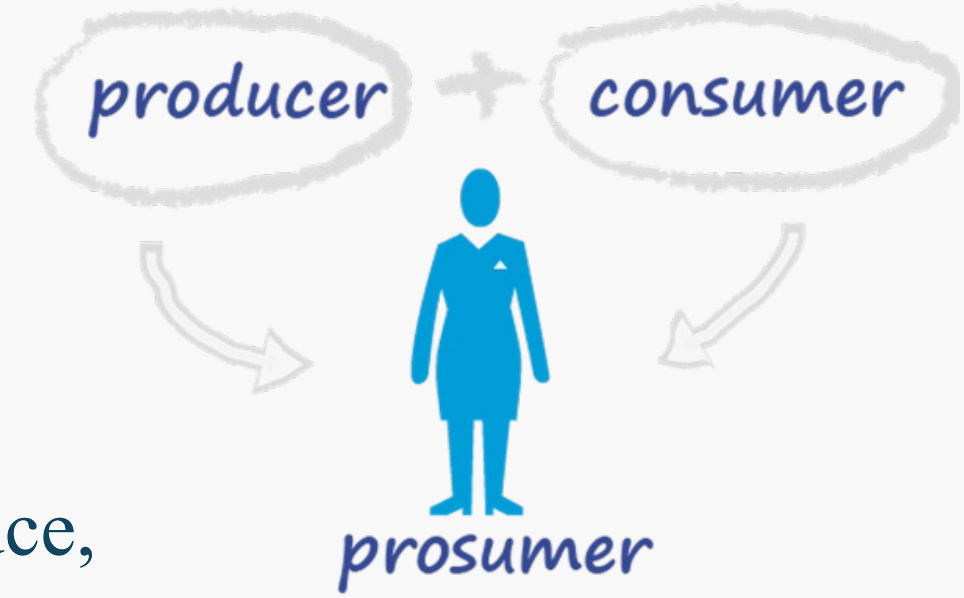
Basic Concepts

RENEWABLE ENERGY COMMUNITIES

This coalition of users, represent a new organization of energy distribution, seen as a "bottom-up" social innovation practice (Tricarico, 2015*)

PROSUMER

Users join together in the form of a business with the aim of managing a local energy system. In this way, the users become a **"prosumer"** as they both produce, store, and sell renewable energy (Iazzolino et al., 2022*)



***Tricarico, L. (2015)**. Energia come community asset e orizzonte di sviluppo per le imprese di comunità. Impresa Sociale, 5, 53-64.

***Hoicka, C.E., Lowitzsch, J, Brisbois, M. C., Kumar, A., Ramirez Camargo, L. (2021)**. Implementing a just renewable energy transition: Policy advice for transposing the new European rules for renewable energy communities, Energy Policy, 156, 112435

OBJECTIVES

PROVIDE AN OVERVIEW OF THE CRITICAL SUCCESS FACTORS OF EXISTING RECS IN EUROPE

HOW?

Through systematic literature review **(SLR)** using the **PRISMA*** model, as a diagram to represent the flow of information through the different phases of a systematic review

WHY?

Identify which replicable and scalable structure of REC best fits Italian rural areas, particularly those in inner regions. These areas are characterized by constant demographic decline and an aging population.

The results could provide additional information for both EU policymakers and local authorities and relevant stakeholders who need to address potential critical issues in implementing REC in inner areas.

***Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, C.D., Tetzlaff L., Akl, J.M., Brennan, E.A, Moher, S.E., (2021**). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. International journal of surgery, 88, 105906

METHODOLOGY

SYSTEMATIC LITERATURE REVIEW

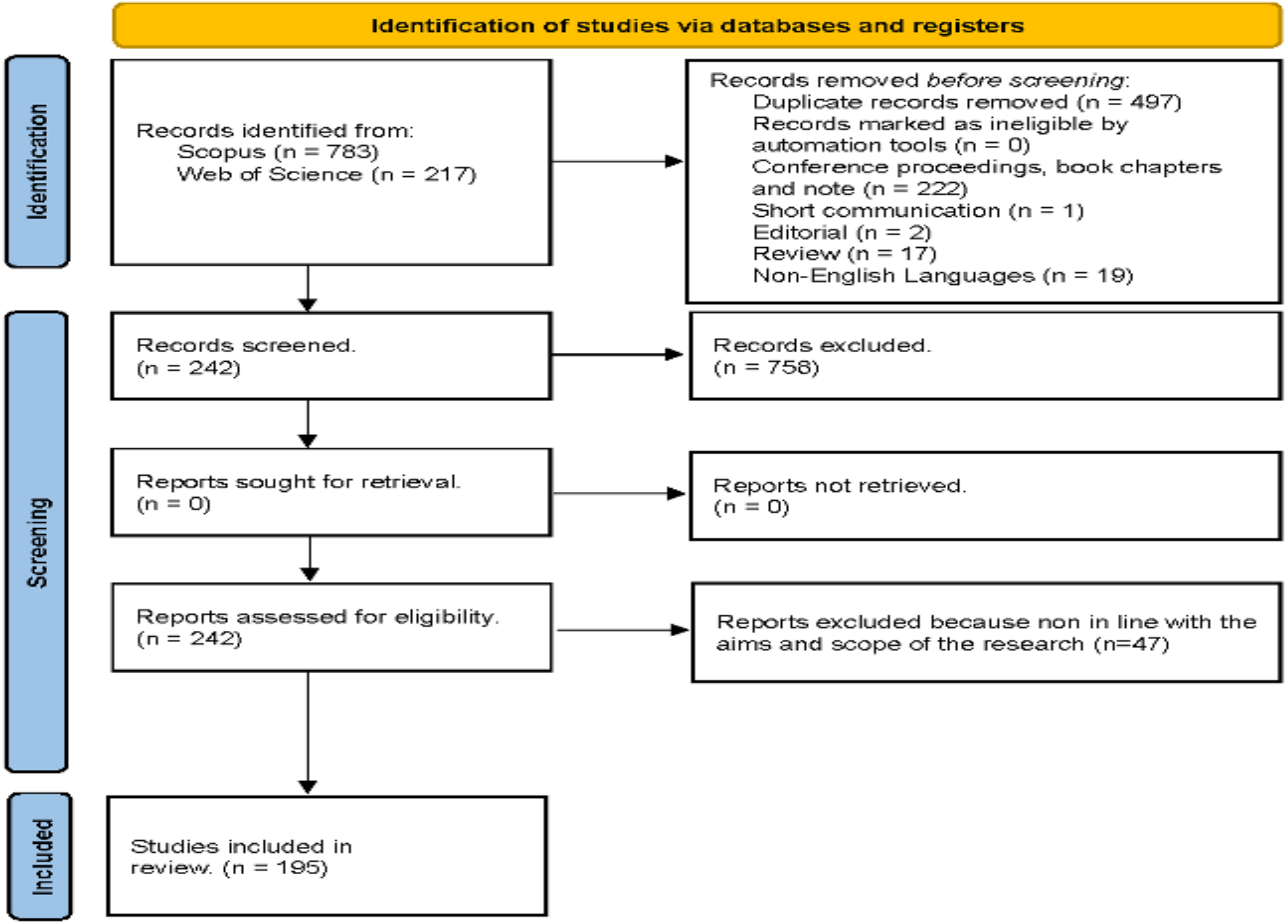
- **DATABASE: Scopus** (Elsevier index database); **Web of science** (Clarivate index database)
- **SELECTION CRYTERIA**: Peer-reviewed articles published until March 2024
- **KEYWORD USED: On Scopus**: "Renewable energy community", after connected with AND "features", AND "optimal", AND "factor", AND "success factor", AND "success", AND "prosumer", AND "rural areas", AND "citizens energy initiatives", AND "efficiency", AND "effectiveness".
  On Wos to expand the data package utilizing the search term "renewable energy communities"

The data resulting conducted across both databases, employing the **bibtex format**, were subsequently merged into a unified dataset using **R software** to mitigate the manual process errors

PRISMA DIAGRAM

(Preferred reporting items for systematic review and meta-analysis)

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

RESULTS

QUANTITATIVE RESULTS

DATASET BUILDING

1000 records identified for data analysis

The authors, following the selected criteria, excluded **758** studies due to various reasons.
Plus **47** studies not in line with the general objective

From these, **195** articles were selected for in-depth review

BIBLIOMETRIC ANALYSIS

Comprehensive bibliometric analysis using the **R package "bibliometrix"*** via the web interface "**biblioshiny**“

The initial phase allows for the creation of descriptive bibliometric analysis and the development of matrices** by integrating all the paper selected using the PRISMA

QUALITATIVE RESULTS

TEXTUAL ANALYSIS

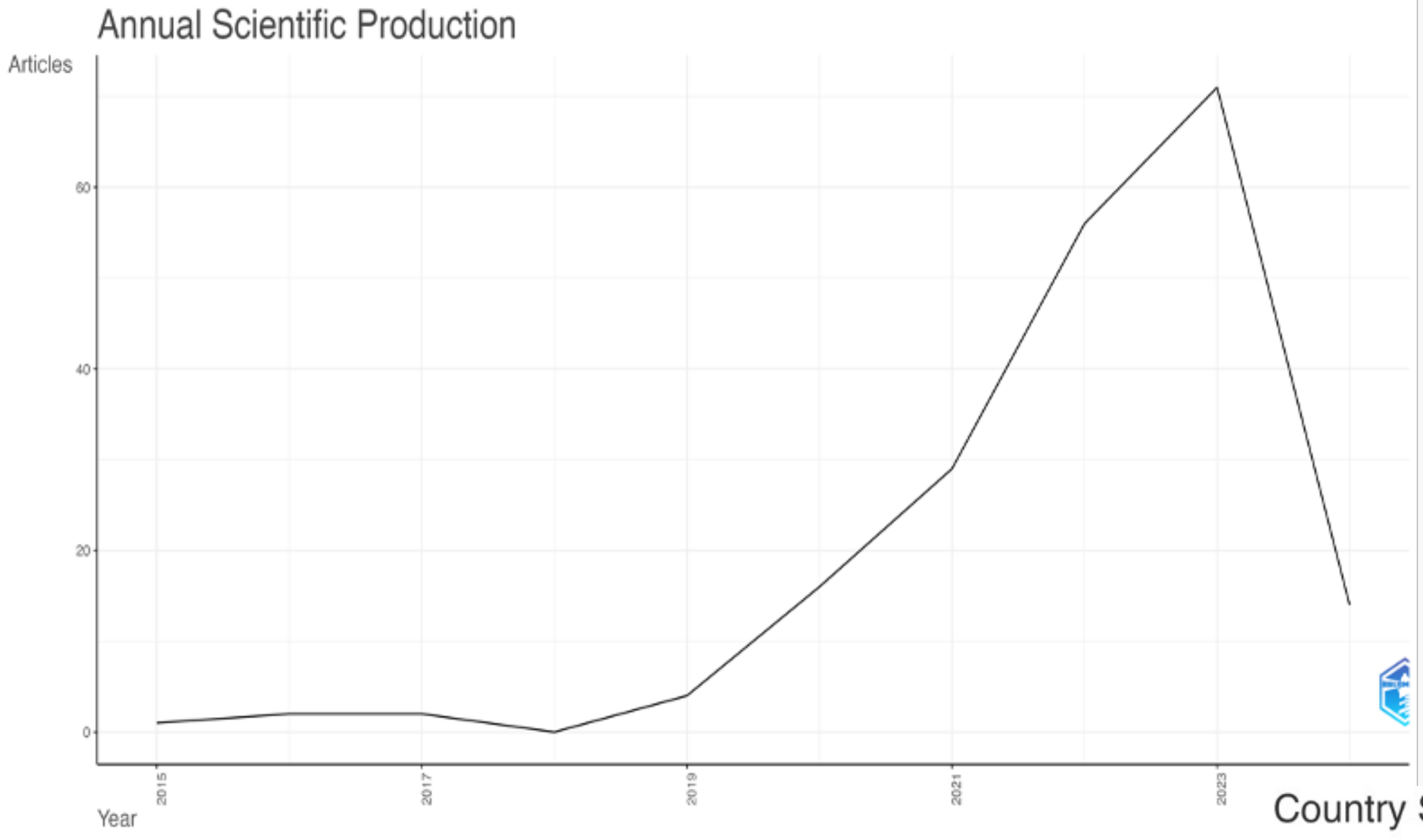
Full text analysis

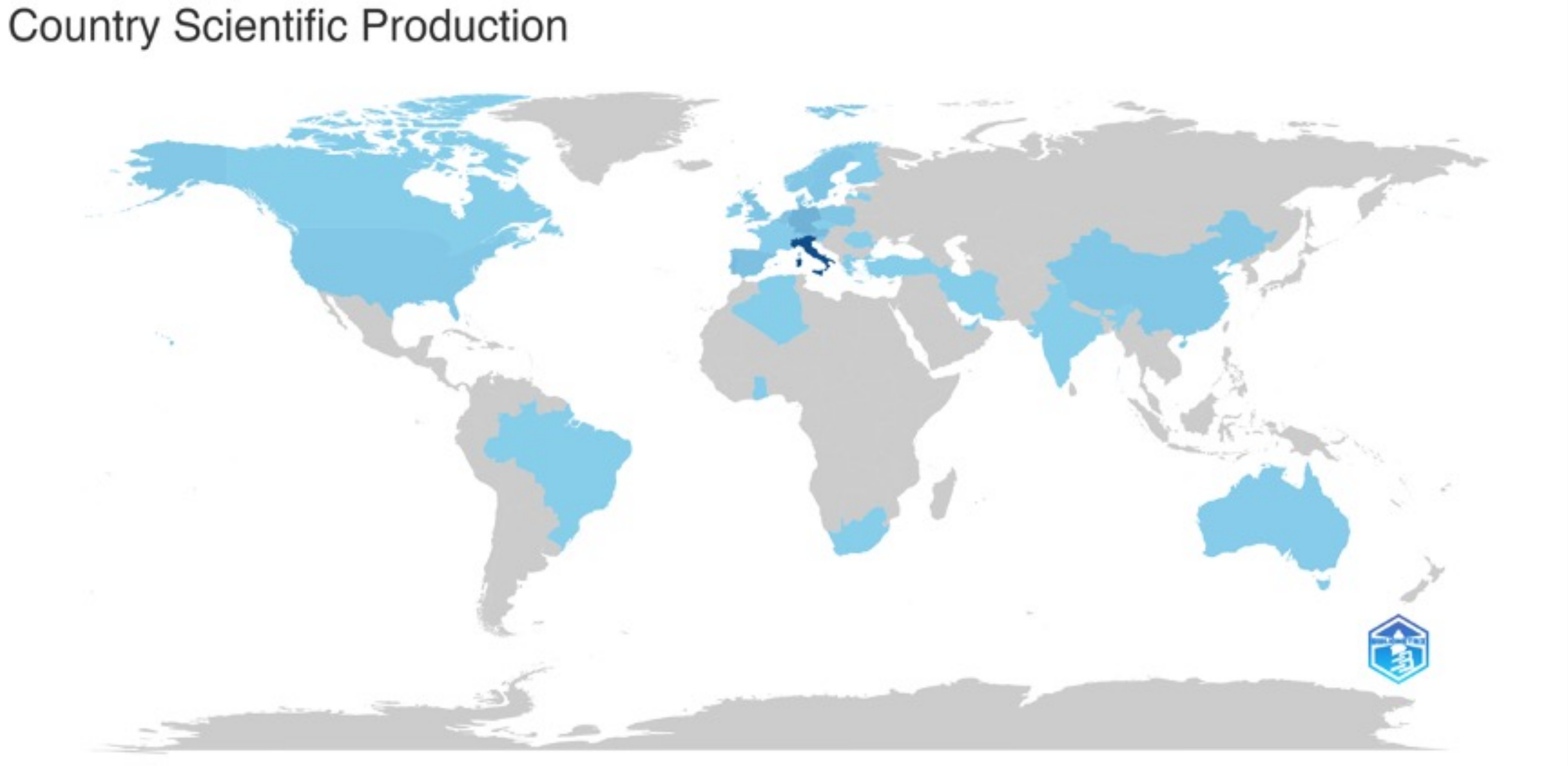
Identifying four main groups of critical factors essential for the success of RECs in Europe

***Aria, M., & Cuccurullo, C. (2017).** A brief introduction to bibliometrix. Journal of Informetrics, 11(4), 959-975

****Brescia, V. (2020).** Bibliometrix analisi: volontariato e community-based. European journal of volunteering and community-based projects, 1(1), 1-22.

QUANTITATIVE RESULTS





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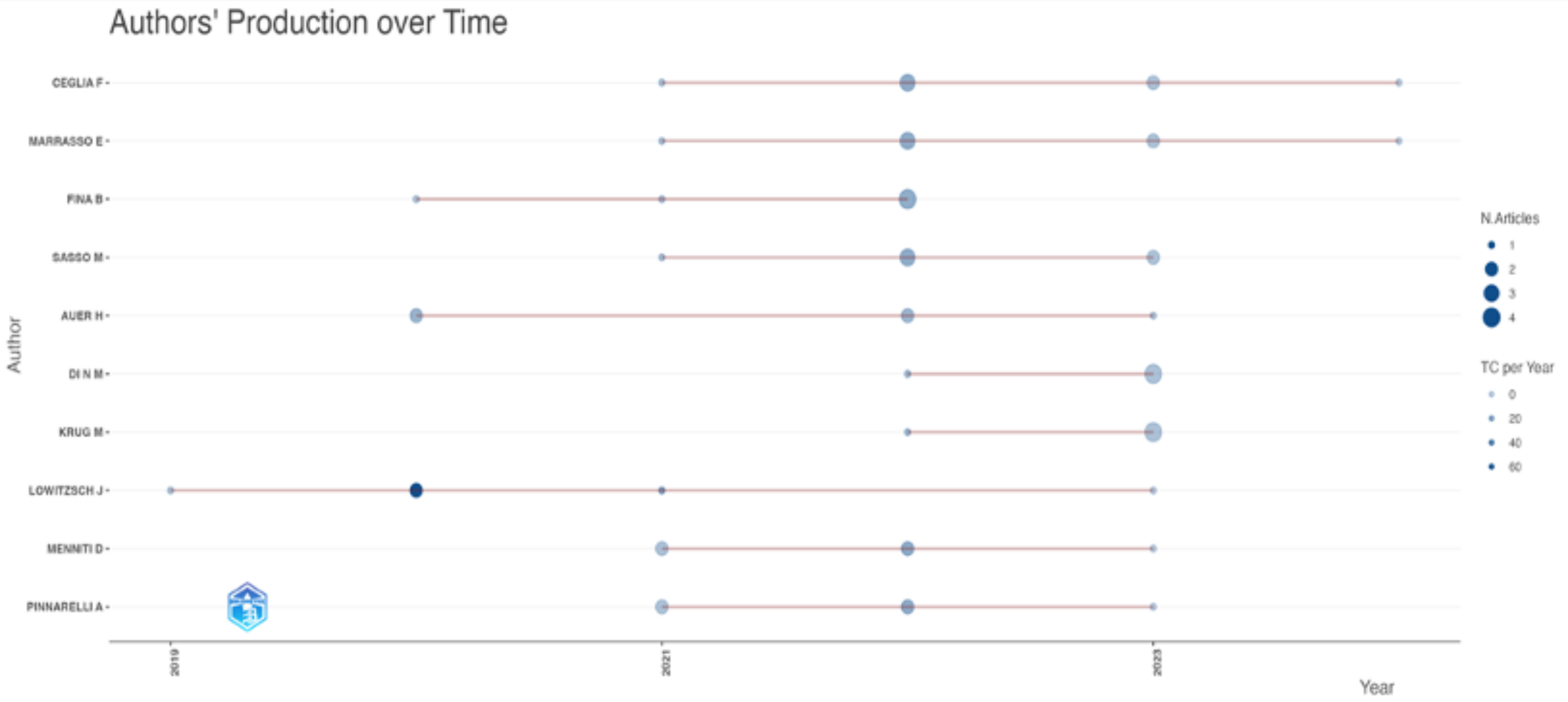

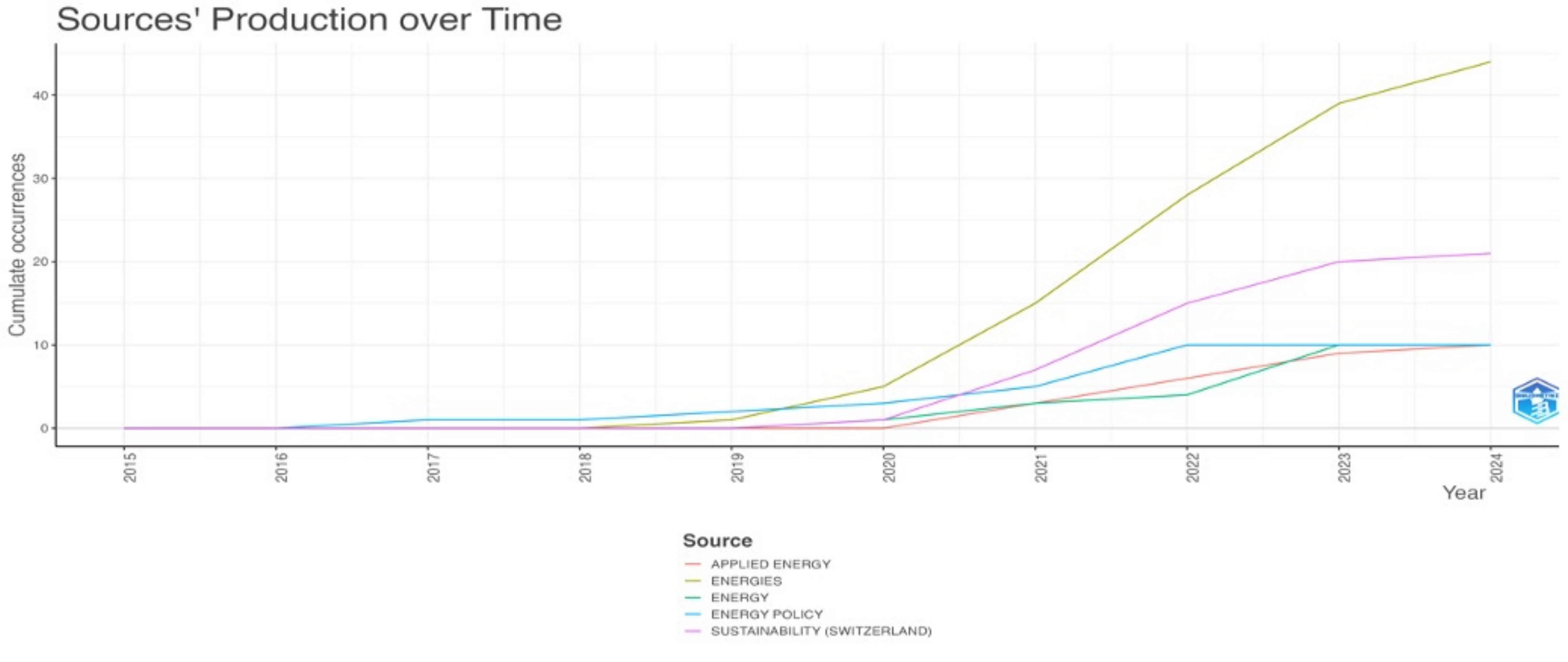

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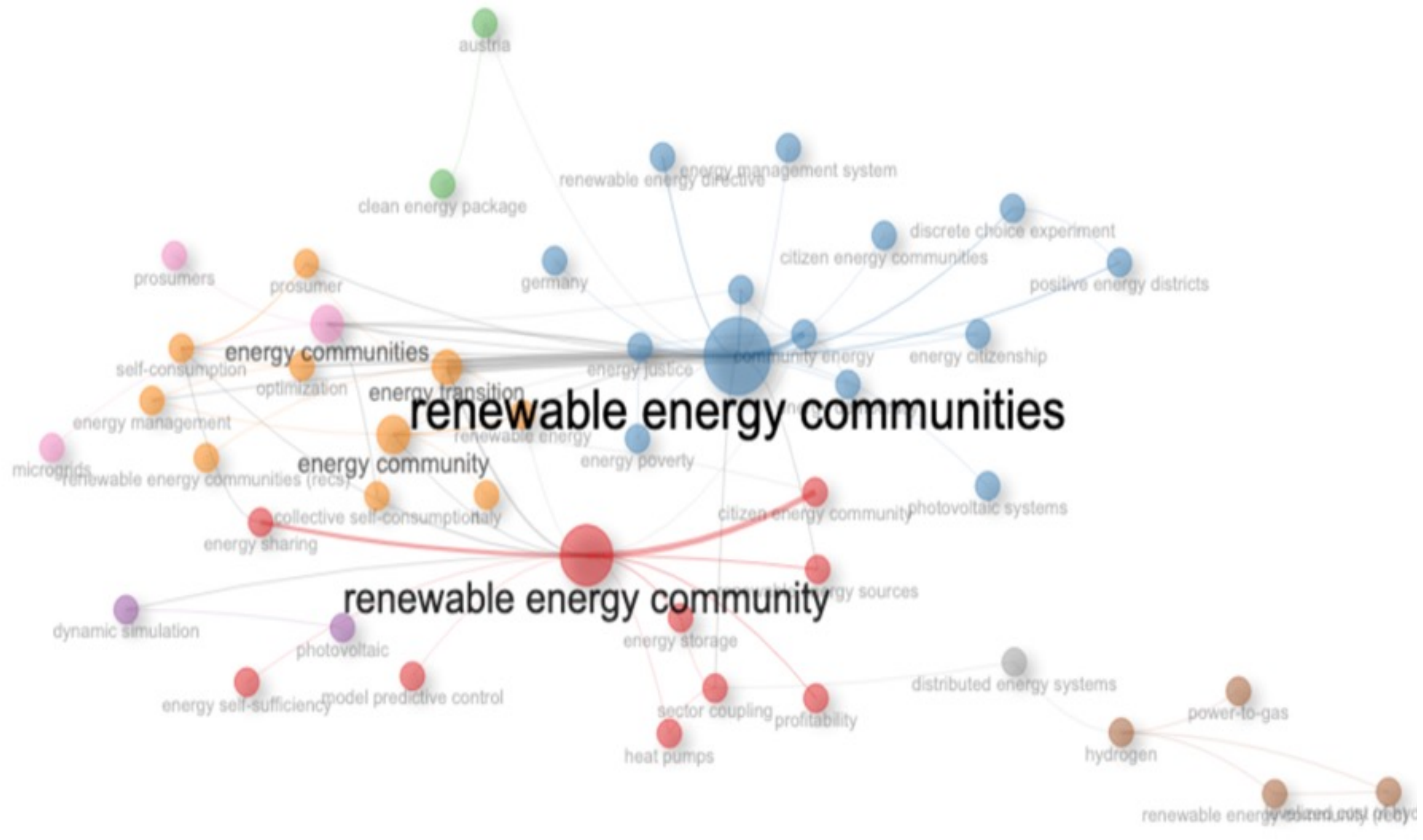
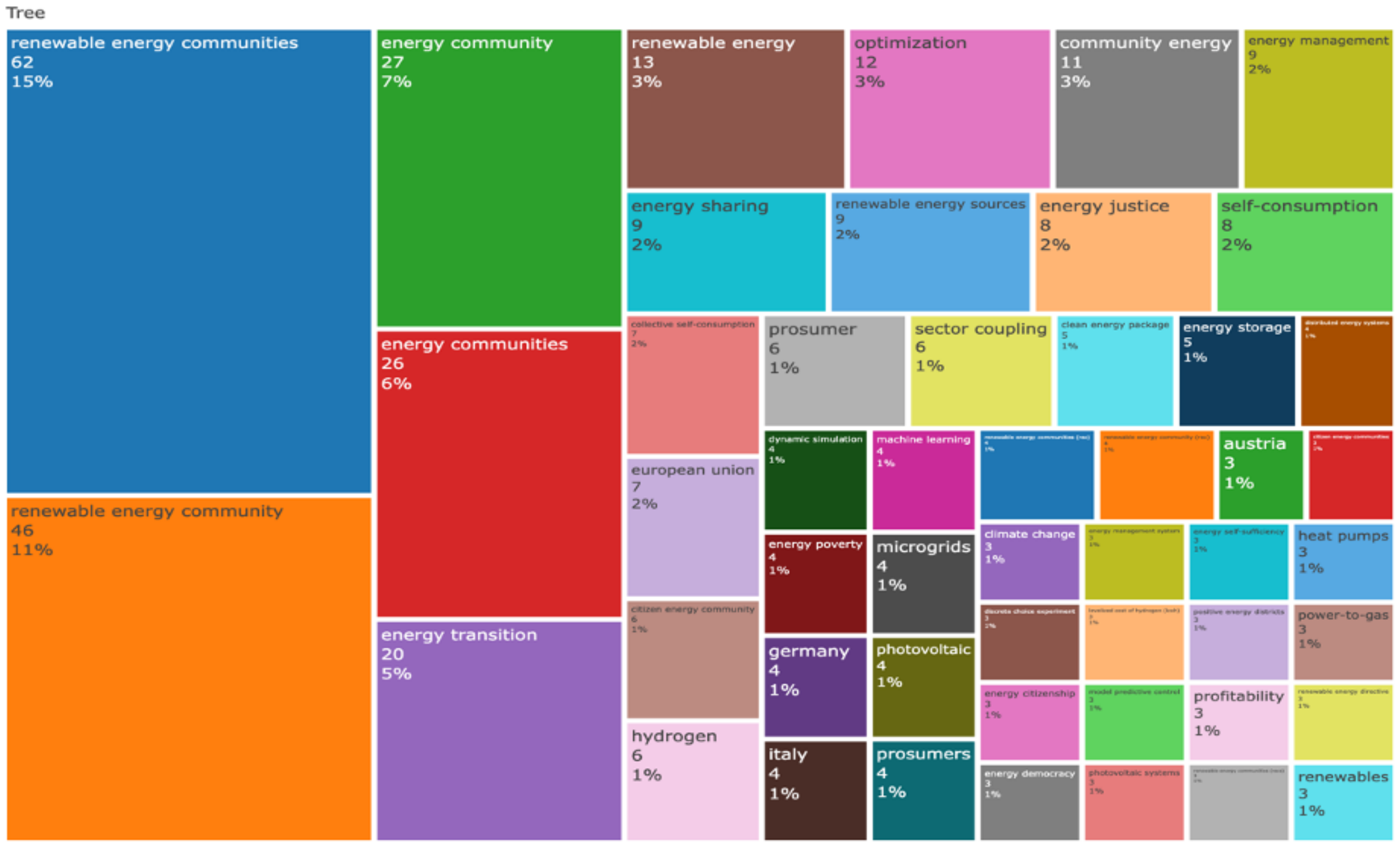
QUANTITATIVE RESULTS



CO-OCCURENCY KEYWORDS

THREE WORDS MAP



QUALITATIVE RESULTS

THE AUTHORS IDENTIFIED FOUR MAIN GROUPS OF CRITICAL FACTORS ESSENTIAL FOR THE SUCCESS OF RECs IN EUROPE

They are as follows:
i) community involvement at various levels;
ii) the importance of conducting ex-ante evaluations, simulations, and design in projecting RECs
iii) the enabling technologies used;
iv) the support of policymakers and the regulatory framework.

Other minor components have been identified, but they refer to factors considered innate to the nature of energy communities

Main Succesfull Factors	Number Of Articles
Local communities	52
Ex-ante evaluation, design and simulation	52
Technologies	42
Political support	38
Total	184
Others minor factor (not considered)	11
Total	195

LOCAL COMMUNITIES

COMMUNITY ENGAGEMENT AS A KEY DRIVE

Community engagement is essential for the development of RECs, fostering a more democratic and inclusive energy transition. This engagement is propelled by both the use-value (direct economic benefits) and non-use value (environmental and social benefits) of RECs

LOCAL TIES AND SOCIAL CAPITAL

Strong social ties and community engagement are critical to the success of RECs. Local engagement is shaped by individuals' connections to their environment and their interactions within it, fostering a robust sense of place and community

IMPORTANCE OF FORMAL STRUCTURES

Formalized structures and clear pathways for collaboration are crucial to avoiding misunderstandings and ensuring effective community engagement. While informal configurations can foster creativity, they may lead to discontent without clear rules

SOCIAL IDENTIFICATION AND TRUST

Social identification with the community and trust among members are vital for participation in RECs. Close relationships and strong social capital enhance cooperation and community collaboration

ROLE OF LOCAL CO-OWNERSHIP

Local co-ownership enhances public acceptance of decentralized energy infrastructure and encourages participation

EX-ANTE EVALUATION, DESIGN AND SIMULATION

PLANNING AND EVALUATION

Effective establishment and management ofRECs demand meticulous planning and thorough evaluation. Success hinges on a holistic approach that integrates simulations, strategic design, and ex-ante evaluations

PHASES OF DEVELOPMENT

The development of Renewable RECs generally encompasses three key phases: design, creation, and ongoing management. For effective project management, a planning method rooted in the Plan-Do-Check-Act process could be recommended

TOOLS AND DATA INTEGRATION

The implementation of RECs begins with a preliminary evaluation during the design phase, utilizing various methods and software tools. Standardizing data management is crucial to accelerate REC development and support informed decision-making

ECONOMIC CONSIDERATIONS

The economic effectiveness of RECs is influenced by tariff structures and necessary infrastructure investments. Including energy tariffs in optimization models is essential to maximize Net Present Value and support decision-making.

MULTIDISCIPLINARY APPROACH

It is essential to adopt a holistic approach during the planning phases of RECs.

TECHNOLOGIES

TECHNOLOGICAL INTEGRATION

Advanced technologies play a pivotal role in enhancing the efficiency, flexibility, and sustainability of RECs. Effective RECs typically incorporate a blend of 'green' and 'grey' technologies, such as photovoltaic roofs, to optimize both environmental impact and energy performance. This integration maximizes the overall benefits of RECs, ensuring robust and sustainable energy solutions

ENERGY MANAGEMENT TECHNIQUES

Reinforcement Learning (RL) enhances energy management within RECs by adapting to complex market patterns and optimizing energy use. Additionally, advanced programming methods that integrate conic projection with linear programming improve both operational efficiency and user privacy in REC management

DIGITAL AND SMART TECHNOLOGIES

Digital platforms and smart technologies, including smart meters and energy storage systems (ESS), streamline REC operations and boost public engagement. Community Management (ECM) platforms enhance communication, monitoring, and control, significantly improving REC efficiency

MACHINE LEARNING AND DEEP LEARNING

Machine learning models enhance REC management by predicting electricity consumption and optimizing energy storage. Deep learning frameworks, such as Long Short-Term Memory (LSTM) networks, provide personalized management strategies and reward mechanisms, promoting sustainable energy behaviors and improving overall efficiency.

POLITICAL SUPPORT

Active involvement from institutions and public actors is crucial for the success of RECs. Support mechanisms such as tax incentives, subsidies, and favorable regulations play a key role in attracting stakeholders and creating a conducive environment for REC development and sustainability

REGULATORY FRAMEWORK

The regulation of Renewable Energy Communities (RECs) is currently fragmented and varies significantly among European countries due to differing implementations of European Directives. Countries such as Germany and Austria are making necessary adjustments, while Italy is transitioning from a centralized to a more decentralized energy model

POLICY OBJECTIVES

Effective support for RECs requires interdependent goals, including expanding RECs, providing public financing, ensuring policy legitimacy, and supporting entrepreneurs. RECs enhance legitimacy through co-ownership and local involvement, which boosts social acceptance and equity.

LEGISLATIVE CHALLENGES

Ensuring fair access to electricity conditions is crucial; legislation must avoid restricting participation based on grid types. Additionally, the often-un-defined legal nature of cooperatives poses challenges for their integration into REC mode

LOCAL ADAPTATION

Efficient policy support must consider local needs and conditions, striking a balance between standardized and tailored legislative measures

CONCLUSION

This study has shown that scholars have shown an increasing interest in the **REC's topic**, especially in the last three years and by the Italian researchers, in line with the evolution of the EU regulations, and that they have mainly recognized four critical successful factors.

These are:

i) the role of the local communities as "starter" of REC establishment;
ii) the ex-ante REC evaluation, simulation, and plan;
iii) the technological factor to facilitate the plant management; and
iv) the political support to define better rules, benefits, and the administrative procedures

Nevertheless, these results could represent a preliminary source of information both for the EU policy makers, and for the local authorities of the rural areas who must face with the possible critical issues in the RECs' implementation

Thank you

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