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Multi-Level Governance and Industrial Engagement in Renewable Energy Communities. Pre-Regulatory Study from Lombardy

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Abstract

This study investigates the early-stage development of renewable energy communities in Italy, focusing on how small and medium-sized industries in the Lombardy region perceived and responded to communication efforts before the full implementation of new regulatory frameworks and economic incentives. The research is based on data collected through a targeted survey conducted among industrial firms. The analysis explores the roles played by national and regional institutions, as well as local public authorities such as municipalities, in shaping awareness and interest in renewable energy participation. A non-parametric statistical test was used to assess the influence of different governance levels on industrial engagement. Results indicate that local public authorities exert a significantly stronger influence on industrial perceptions and willingness to engage in renewable energy communities than higher-level institutions. This suggests that trust-based, locally driven communication strategies are more effective than top-down approaches. The findings highlight the need for coordinated, place-based governance strategies that reinforce the role of local actors in energy transition initiatives. Municipalities and similar authorities may serve as crucial intermediaries, translating national strategies into meaningful local action. By capturing perceptions before regulatory incentives were introduced, this study offers a unique and unbiased perspective on how industries naturally relate to different governance actors.

It contributes to the broader understanding of how communication and trust shape participation in sustainable energy systems.

Keywords: Local Public Authorities (LPA); Small and Medium-Sized Enterprises (SMI); Energy Transition; Low-Carbon Economy; trust

Introduction

The escalating environmental crisis has intensified the urgency of transitioning toward sustainable development, with the energy sector emerging as a key focal point. Shifting away from fossil fuel dependency to cleaner, renewable sources is not only desirable but essential. This energy transformation-defined by the principles of decarbonization, scale-up of renewables, and smart energy systems-has gained traction globally, both in policy frameworks and academic discourse, also driving concerns about energy security, and the broader socio-economic potential of renewable energy, the transition has become central to international agendas (Cheng et al. 2019; Bazilian et al, 2020). According to the International Renewable Energy Agency (IRENA), energy transition entails a broad restructuring of how energy is produced and consumed, prioritizing low-carbon, sustainable alternatives over traditional fossil fuels (IRENA, 2020), along with a profound rethinking of energy geopolitics worldwide (Strielkowski et al, 2021; Zhang et al, 2023).

This imperative has been further amplified by the geopolitical instability triggered by the Russia–Ukraine conflict. The resulting energy crisis of 2022 caused major disruptions in natural gas, coal, and electricity markets, as well as significant volatility in oil supply. In response, governments worldwide implemented emergency interventions while accelerating structural reforms to decrease reliance on fossil fuels. Major policy initiatives such as the U.S. Inflation Reduction Act, the EU's RePower EU and Fit for 55 packages, and Japan's Green Transformation (GX) strategy are all designed to hasten the deployment of clean energy. Simultaneously, countries like China and India have announced ambitious renewable targets, while global energy markets adjust to the reconfiguration of Russia–Europe energy flows (https://www.iea.org).

These developments align with the 2030 Agenda for Sustainable Development and the United Nations' Sustainable Development Goals (SDGs), which emphasize collaborative approaches to achieving sustainability (www.un.org). In the energy domain, this vision has translated into increased emphasis on decentralized models. The European Union, in 2019, introduced legislation promoting Renewable Energy Communities (REC) - localized initiatives that integrate citizens and organizations into energy production, storage, and demand response. These communities aim to

increase grid flexibility, stimulate local economic growth, and enhance long-term resilience (Strielkowski et al, 2021).

Italy presents a particularly relevant case. As one of the EU's most energy-import-dependent nations, relying on imports for over 77% of its energy consumption, especially in gas, oil, and coal, Italy has found itself under intense pressure to accelerate its energy independence (www.italyforclimate.org). Recent policy reforms have aimed to align national targets with EU directives, with REC positioned as a strategic component in achieving these objectives. However, several challenges persist, including administrative hurdles, limited access to financing, and low public awareness (Ahmed et al.2024; Esposito et al.2024).

While larger firms tend to manage the energy transition independently, thanks to their greater organizational capacity, small and medium-sized enterprises (SMEs**)**, particularly in the industrial sector, often lag due to limited resources and knowledge. In Lombardy, a region known for economic vitality and industrial leadership, studies have shown that firms are increasingly sensitive to environmental issues and are investing in energy-related strategies (www.unioncamerelombardia.it). A positive correlation has been found between company size and sustainability investment behavior, underscoring the need for targeted support measures to better engage SMI. Enabling them to access renewable energy solutions and transition more effectively will be critical to meeting broader climate goals.

Although the legislation acknowledges the role of the private sector-not only as consumers of clean energy, but also as co-investors and co-managers in community-based systems-the spread of Renewable Energy Communities (REC) in Lombardy remained limited until the end of January 2024, largely awaiting the publication of the final regulatory framework: the Implementing Decree on Renewable Energy Communities (RECs), issued by the Italian Ministry of the Environment and Energy Security (MASE) at the end of January 2024, marks a fundamental step toward promoting the establishment and development of energy communities and widespread self-consumption in Italy. The decree establishes rules and incentives, financial support and technical requirements: before its issue, the landscape of REC was multifaceted and supported actively by a system of communication by MLG, having a different impact on SMI.

MLG Multi-level Governance refers to the interaction and coordination of decision-making processes across different layers of authority, typically involving supranational, national, regional, and local institutions. Within this framework, power and responsibilities are not concentrated in a single level of government but are instead distributed and shared among various actors operating at different scales. MLG is particularly relevant in the context of the energy transition, where policy

design, regulatory enforcement, and operational implementation often involve multiple stakeholders with distinct but complementary roles. In the case of Renewable Energy Communities (REC), for instance, national and regional institutions tend to define strategic objectives and regulatory frameworks, while local authorities are crucial in translating those directives into practical initiatives by engaging directly with citizens, businesses, and civil society. This layered governance structure allows for both top-down alignment with policy goals and bottom-up responsiveness to local needs, making trust, communication, and institutional coordination key factors in the success of decentralized sustainability models.

Building on this context, this study investigates the role of Multi-level governance (MLG) in Lombardy's REC landscape, with a specific focus on the influence of Local Public Authorities (LPA) in fostering SMI participation.

The Lombardy region is located in the North of Italy and it is a leading industrial area, particularly rich in SMI. The regional Institution has actively pushed the development of REC. This includes offering financial incentives, technical support, and regulatory simplification (www.arpalombardia.it). The approach also involves partnerships with municipalities, local firms, and civil society actors; integrating REC planning with broader environmental and urban policy goals; and fostering knowledge sharing and community engagement (www.en.regione.lombardia.it). Awareness campaigns and educational programs are being implemented to encourage broader participation.

Building the conceptual framework for this study, we borrow and adapt the Multi-Level Governance (MLG) classification originally proposed by Hooghe and Marks (2003; 2010), which distinguishes between:

- Type I: Stable, general-purpose jurisdictions organized across nested territorial levels (e.g., the EU, nation-state, region, municipality);
- Type II: Task-specific, flexible governance arrangements that often cut across levels and functions (e.g., agencies, partnerships, or regulatory bodies).

We also match the Hooghe and Marks works with a complementary perspective, concerning the distribution of power across governance layers (Bache and Flinders, 2004). While they concentrate on Type I structures-describing national authorities as agenda-setters and legal standard-bearers, and regional institutions as mediators adapting strategic directives to territorial contexts-they also emphasize the interdependence of actors operating at different territorial scales, including sub-national governments and local municipalities. These municipalities are explicitly recognized as key subnational actors within systems of shared authority, particularly in EU

member states where local engagement is increasingly instrumental in policy implementation.

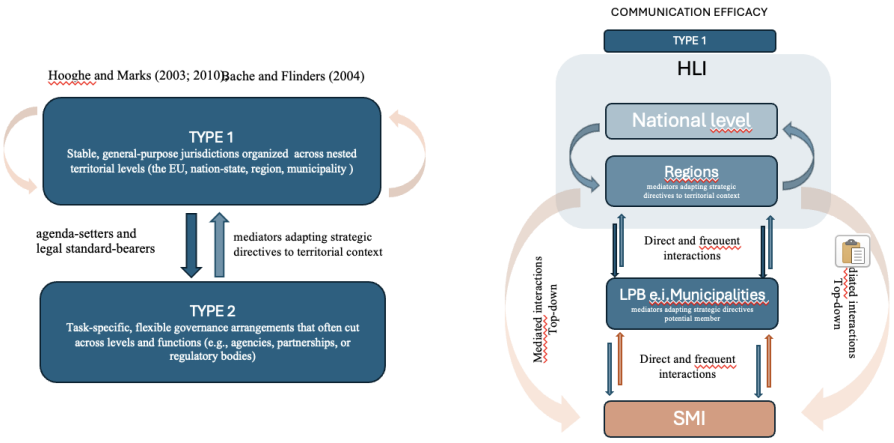


Figure 1: From MLG Models to the Communication Model to spread RECs interest among SMI

Figure 1 illustrates a conceptual model that bridges Multi-Level Governance (MLG) with the span of control and power, framing these dynamics within the context of communication efficacy in Renewable Energy Communities (RECs). Building on this concept and drawing on data collected through a structured survey, this study evaluates the readiness and willingness of small and medium-sized industries (SMIs) to participate in Renewable Energy Communities (RECs) prior to the formal establishment of the economic incentive framework (REC Decree 2024). Particular attention is given to the role of LPA.

The primary objective is to provide an initial classification of the varying impacts that different Multi-Level Governance (MLG) levels have on communication efficacy with SMIs. The study posits that LPA plays a pivotal role in shaping SMI perceptions and in lowering informational and institutional barriers, primarily due to their trusted, locally embedded communication infrastructures. As noted by Vecchi et al (2024, the analysis of REC potential needs to integrate socio-economic, environmental, and spatial evaluations; these kinds of assessments are facilitated by spatial proximity and familiarity with LPB

Methods

Given the regular and often personal interactions between SMI and LPA, there is a tendency for SMI to exhibit greater levels of trust toward these institutions than toward regional or national counterparts (Tillmar,

2009). Trust, in this context, is cultivated through consistent, positive interactions that reinforce perceptions of credibility and integrity. For many SMI, ongoing engagement with LPA enables more tailored communication, fosters mutual understanding, and strengthens alignment on priorities. In numerous cases, local familiarity, such as direct acquaintance with municipal officials, removes communicative barriers and enhances the flow of information, especially regarding emerging initiatives like Renewable Energy Communities (REC).

Although trust dynamics can vary by context, this study posits that LPA enjoys a more favorable position in building trust among SMI. Local institutions are not only geographically closer but also embedded in the same social and economic environments, allowing them to respond more directly to the operational realities faced by local businesses. By contrast, regional entities may appear more bureaucratic and disconnected from local concerns, potentially reducing their perceived responsiveness and relevance. As a result, SMI are often more inclined to engage openly and constructively with local governments than with regional authorities.

This greater receptivity is shaped by a combination of proximity, shared community identity, and repeated contact. Local authorities are viewed as stakeholders with a vested interest in the immediate environment and development of the SMI ecosystem. Consequently, their communication efforts are perceived as more pertinent and action-oriented. The reputational capital built through such close, ongoing relationships positions LPA as trusted intermediaries, capable of mobilizing SMI around new sustainability initiatives such as REC.

Moreover, SMI often maintains a strong ethical commitment to its local communities, which informs its approach to business performance and environmental responsibility (Longo et al. 2005). This embeddedness reinforces their sensitivity to sustainability-oriented programs, especially when these are framed and promoted by local actors. Local municipalities are thus increasingly seen as partners in advancing green transitions, while regional institutions may face challenges in generating similar levels of engagement due to less frequent interaction and limited personalization of outreach.

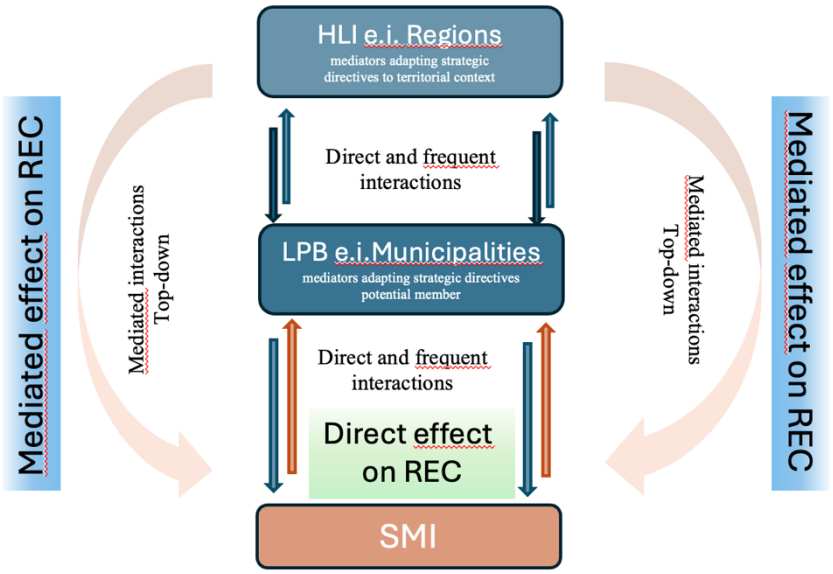


Figure 2. Hypothesis Framework: The Role of LPB and Trust in SMI Participation in REC

This study proposes the hypothesis that SMI exhibit a higher degree of trust in LPA compared to regional institutions, particularly when faced with novel or previously unexplored initiatives, such as the establishment of Renewable Energy Communities (REC) (see Figure 2). The hypothesis suggests that the familiarity and direct interactions typical of local governance environments can render local-level initiatives more compelling and actionable for SMI than those initiated at more distant administrative levels.

To examine this hypothesis, the research focuses on SMI operating in the Lombardy region, which stands as Italy's most industrialized area and one of the foremost economic engines within the European Union. With the highest density of manufacturing and artisanal enterprises in the country, Lombardy provides a strategically significant context for investigating the dynamics of institutional trust and engagement with sustainability initiatives. We consider the extensive legislation on REC issued between 2020 and 2022-including at the EU level (Clean Energy Package), nationally (Decreto Milleproroghe), and regionally (Regional Law 2/2022) (we define those Institutions as HLI in the introduction section) -and the substantial communication and financial efforts to promote REC development through information campaigns and support mechanisms. Also, we consider as given the shared regional engagement in Lombardy to raising awareness and

stimulating interest in REC, but we acknowledge the variability in engagement levels among LPA in the region.

Within this framework, the study is guided by two central research questions:

- RQ1: To what extent is the concept of Renewable Energy Communities (RECs) understood by Small and Medium-sized Industries (SMIs) in Lombardy?
- RQ2: Is there a measurable relationship between SMI awareness of RECs and the degree of commitment demonstrated by Local Public Authorities (LPA)?RQ2 also leads to a sub-question:
- RSQ1: Can we consider that SMI interest in RECs is directly and positively correlated with LPA commitment?

To generate original empirical data, this research was conducted in collaboration with Confapi Lombardia (hereafter, Confapi) a regional association representing small and medium-sized industrial enterprises. The decision to focus specifically on SMI was based on several considerations. Since the onset of the energy crisis in 2021, energy-related expenditures have emerged as a critical driver of the transition toward cleaner, more efficient energy systems. While larger firms often possess internal capabilities to autonomously manage their energy transitions, SMI face more pronounced informational and structural limitations-making them an especially relevant group for investigating the diffusion and reception of REC initiatives.

Preliminary qualitative discussions with communication officers from local Confapi branches highlighted marked differences in LPB engagement strategies across the region. These insights informed the selection of three target areas within Lombardy for the empirical study: the provinces of Varese**,** Brescia, and Lecco plus Sondrio. The provinces of Varese and Brescia were identified as having received minimal REC-related communication from their respective LPA. In contrast, Lecco and Sondrio-although administratively distinct-were treated as a unified area by Confapi and were noted for their proactive institutional engagement, including robust efforts to inform and involve SMI in REC development. This contrast offered a meaningful basis for exploring the influence of LPB activity on SMI awareness and responsiveness to energy community initiatives.

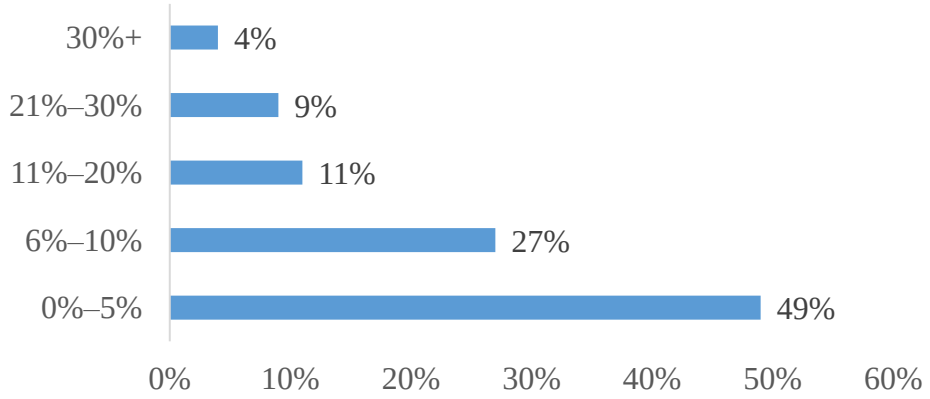
In January 2023, a structured survey was administered to small and medium-sized enterprises (SMI) affiliated with Confapi. The purpose was to assess, in the evolving local and regional policy contexts, their awareness, attitudes, and responses to Renewable Energy Communities (REC). The survey was conducted over a two-week period and yielded 450 responses. After eliminating incomplete and inconsistent submissions, a final dataset of 212 valid responses was retained for analysis.

The demographic profile of the sample revealed 48% operating in the metalworking sector**,** followed by 11% in rubber and plastics, and the remaining categories-including chemicals, food production, and textiles (accounting for less than 2% each). This distribution reflects the high industrial density of Lombardy, particularly in manufacturing and craft sectors.

Through an introduction question, respondents were asked to quantify the impact of energy costs on their revenue using a five-point scale. Results (Table 1) indicate that half of respondents reported minimal energy cost impact (0–5%), while only 4% indicated energy costs had a critical impact (over 30%). This helps understanding the cost-sensitivity of the respondents in a period of rising energy costs.

Respondents' answers distributions mainly in the low category means that the sample under exam is touched by the topic but it is not an emergency; thus answers concerning REC are not influenced by any personal urgency.

Table 1. Distribution of the impact of energy costs on sales

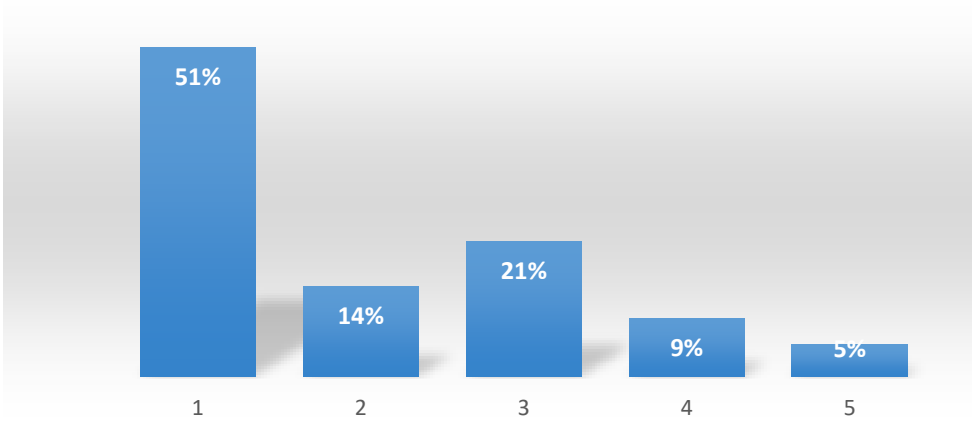


To answer RQ1, we generate two different questions, exploring awareness and attitudes towards REC. Awareness was assessed using a five-point semantic differential scale, from 1 (no awareness) to 5 (strong knowledge). Attitudinal responses were initially unstructured but were reorganized into five ordinal categories:

- 1 → "Not interested" or no response
- 2 → "Currently searching for basic information"
- 3 → "Currently searching for in-depth information"
- 4 → "Intending to participate in a REC"
- 5 → "Already involved in a REC"

This transformation allowed for consistent analysis of how awareness levels correlate with active engagement. Only 14% showed high or complete awareness (levels 4 and 5); over half of respondents (51%) indicated minimal or no knowledge of REC, while. The mean awareness score was 2.02, with a median of 1.0, reinforcing the conclusion that REC awareness remains low across the region.

Figure 3. REC awareness at a regional level



The visual analysis of the frequency distribution revealed a sharp decline in respondent numbers as awareness increased (Figure 3). This skewed distribution highlights a clear knowledge gap among SMI, underscoring the need for more effective communication and training on REC-related opportunities.

To deepen the analysis, awareness scores were correlated with attitudinal categories.

Table 2. Attitude towards REC

Awareness level **Attitude towards REC**	***%***	**1**	**2**	**3**	**4**	**5**
Not interested	34%	42%	13%	28%	33%	29%
Searching for basic information	50%	54%	81%	48%	11%	14%
Searching for in-depth information	8%	2%	6%	16%	33%	0%
Try to build/join an REC	4%	2%	0%	4%	11%	29%
Actively involved	4%	0%	0%	3%	7%	25%
Total	100%	51%	14%	21%	9%	5%

A correlation coefficient of 0.34 was found between awareness levels and attitude, indicating a moderate positive correlation: SMI with higher awareness of REC are more likely to express interest or participate in such

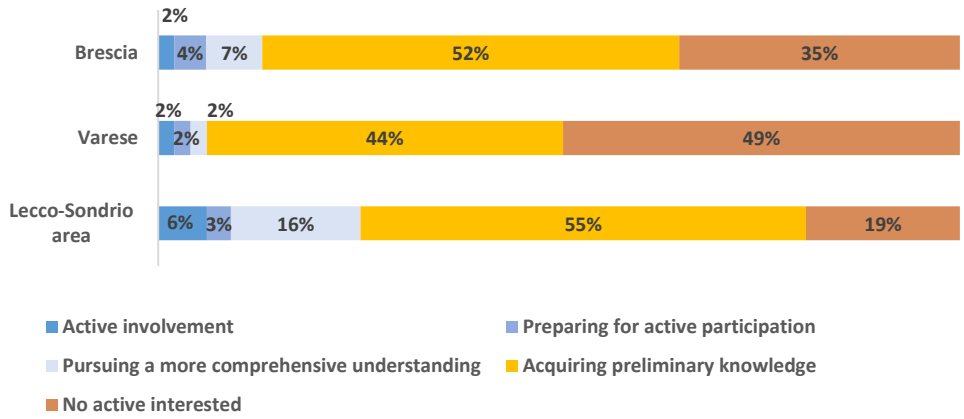
initiatives. The relationship between awareness and the economic impact of energy costs was also tested by recoding the cost impact variable to a five-point ordinal scale. The resulting correlation ($r \approx 0.023$) was statistically weak, suggesting that awareness and attitudes toward REC are not strongly influenced by rising energy costs alone.

Table 3. REC awareness levels by province/area

AREA Scale	Lecco-Sondrio	Varese	Brescia
1	31%	57%	60%
2	21%	9%	16%
3	26%	22%	16%
4	17%	7%	4%
5	5%	5%	5%
TOT	100%	100%	100%

To address RQ2, responses from the Lecco-Sondrio area (high LPB engagement) were compared to those from Varese and Brescia (limited LPB engagement) using a Mann–Whitney U test. This non-parametric test is appropriate for comparing ordinal data that may not follow a normal distribution. Statistical analysis produced a p-value < 0.05 for both awareness and attitude comparisons, suggesting a significant difference between the Lecco-Sondrio cluster and the other two provinces.

Figure 4. Comparative Analysis of SMI Engagement with REC by Area



This supports the hypothesis that more intensive and trust-based communication from LPA can positively influence SMI awareness and engagement with REC-related initiatives.

Results

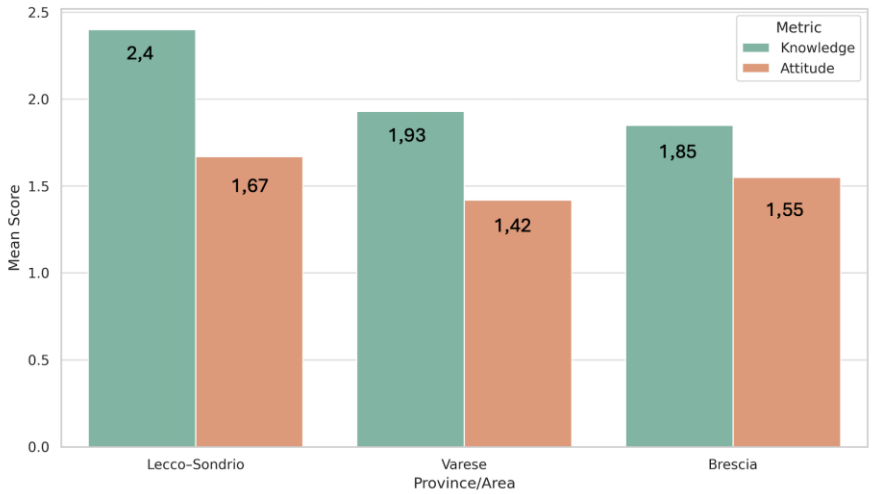
The analysis performed using the Mann–Whitney U test to compare REC knowledge levels between the Lecco–Sondrio area and the other

provinces reveals a statistically significant difference in awareness. The mean awareness score in the Lecco–Sondrio area stands at 2.40, surpassing the mean scores of 1.93 for Varese and 1.85 for Brescia (see Figure 2-3).

The p-value of 0.0045, which falls below the conventional 0.05 threshold, indicates that the observed variance is unlikely due to random chance. These outcomes provide empirical support for the hypothesis that active local engagement by LPA correlates with higher awareness of REC initiatives. In areas where LPA have assumed a prominent role in disseminating information and supporting REC-related actions-such as Lecco–Sondrio-SMI demonstrate a greater understanding of the topic than those in areas primarily influenced by regional-level communication efforts.

In contrast, when comparing attitudinal differences toward REC across the same regions using the same statistical test, the p-value of 0.0836 does not indicate statistical significance.

Figure 5. Mean Knowledge and Attitude Levels Toward REC by Area



Although the mean attitude score is shown in Figure 5n Lecco–Sondrio (1.67) is slightly higher than in Varese (1.42) and Brescia (1.55), this variation is not sufficient to confirm a definitive impact of local engagement on attitude formation. While a positive trend is observable, giving insightful suggestions to be investigated, it probably lacks the statistical strength required for generalization.

Table 4. P-value

P-value	Knowledge level	Attitude level
Lecco-Sondrio area vs. the other provinces	0.0045	0.0836

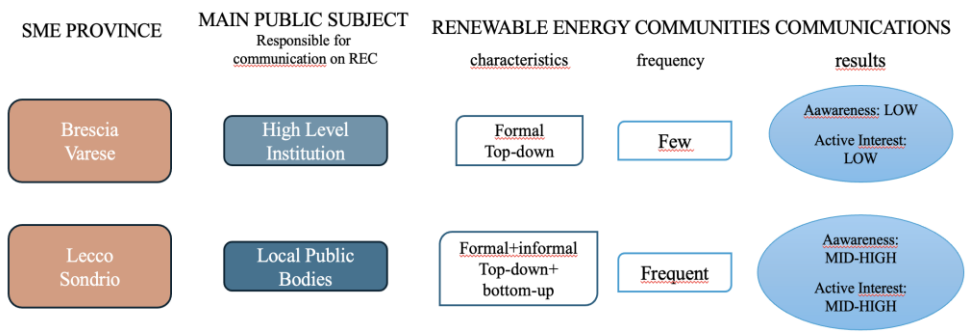
The results clearly indicate that the involvement of local institutions has a statistically significant positive effect on REC awareness among SMI.

However, the same cannot be concluded for SMI attitudes, which appear less directly influenced by LPB activity.

The findings of the analysis point to a general knowledge deficit among Lombard SMI regarding Renewable Energy Communities. A considerable portion of respondents assessed their understanding as either minimal or nonexistent, aligning with earlier survey insights that emphasized widespread informational gaps. Nevertheless, a moderate positive correlation (≈ 0.34) between awareness and attitude levels suggests a meaningful relationship: as SMI knowledge of REC improves, so does their openness and willingness to engage. This association underscores the importance of targeted educational and outreach initiatives designed to enhance SMI familiarity with the benefits and functioning of REC. To leverage this potential, it may be necessary to reassess current communication strategies, particularly those implemented at the regional level. Findings from the Lecco–Sondrio area provide a compelling case for the strategic role of LPA, such as municipalities. Their proximity to SMI, combined with more frequent and personalized interaction, appears to generate higher levels of trust, an essential factor in overcoming skepticism and inertia, especially when introducing novel sustainability models like REC. While the Lecco–Sondrio area demonstrates a clear advantage in terms of SMI knowledge, this did not translate into a statistically significant difference in attitudes compared to Varese and Brescia. This may suggest that awareness alone is not always sufficient to shift perceptions or behaviors, particularly when structural, economic, or organizational barriers remain unaddressed.

Those results, as in Figure 6, reinforce the idea that local commitment from LPA contributes meaningfully to awareness building but that further support mechanisms, such as training, incentives, or collaborative platforms, may be necessary to transform awareness into proactive participation in energy communities.

Figure 6. Research findings



Conclusions

This study has addressed the growing relevance of Renewable Energy Communities (REC) within the broader framework of Italy's commitment to sustainable, low-carbon energy transitions. Grounded in empirical evidence from a regional survey, the analysis focused on three economically and industrially comparable areas of Lombardy-Lecco–Sondrio, Brescia, and Varese-chosen for their differing levels of engagement with REC-related initiatives.

The findings reveal that LPA plays a crucial role in shaping awareness and perceptions of REC among SMI. In particular, the Lecco–Sondrio area, characterized by more proactive LPB engagement and direct communication efforts, exhibited significantly higher levels of REC awareness than the other provinces, where promotional activities were primarily conducted at the regional level. This suggests that localized, trust-based communication mechanisms are more effective in reaching SMI than top-down, region-wide campaigns.

The comparative analysis indicates a clear association between the proximity of information sources and SMI knowledge levels. When communication originates from local institutions-entities with which SMI often have frequent and informal interactions-awareness tends to be higher. Moreover, a moderate correlation was observed between awareness and attitude: SMI with greater understanding of REC concepts are more likely to display proactive interest, such as seeking further information or considering participation in a community energy initiative.

These insights highlight the strategic role of LPA as catalysts for REC development. Strengthening the involvement of local authorities in sustainability communication, therefore, appears critical. To enhance the effectiveness of REC outreach, regional institutions should consider reallocating or increasing resources to support LPA, offering training, case-based learning, implementation toolkits, and other practical materials designed to empower local actors and improve dissemination. Such efforts could bridge existing gaps between legislation and implementation by fostering clearer and more actionable communication pathways.

As Lombardy stands among the most industrialized regions in Europe, the outcomes of this study contribute to broader discussions on territorial governance and decentralized energy policy implementation. Although the current analysis focused on three provinces, future research could expand the sample to validate findings across other territories and industrial clusters. Additionally, it would be valuable to investigate the internal capacity of LPA, particularly their own understanding of REC frameworks, to assess whether this mediates their ability to effectively promote awareness among local firms.

Ultimately, while increased awareness is a necessary step, it may not be sufficient to drive widespread participation in REC initiatives. To translate knowledge into concrete action, policymakers and local actors may need to develop more comprehensive engagement strategies, combining awareness campaigns with incentives, technical support, and collaborative platforms that facilitate SMI inclusion. In this regard, the Lecco–Sondrio example offers a compelling case for how localized leadership can influence progress toward collective energy transformation

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Conflict of Interest: The authors reported no conflict of interest.

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Data Availability: All data are included in the content of the paper.
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