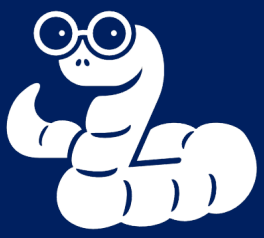

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Insights into Renewable Energy Communities in Poland: A PESTEL Framework Analysis and Expert Interviews

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Abstract

Renewable energy communities (RECs) are garnering significant interest and stimulating extensive discussions. However, they remain a marginal element of power systems in most countries, confined primarily to pilot projects and small-scale deployments. In Poland, this issue is even more pronounced, as RECs have not yet gained substantial public awareness. To explore why RECs are easier to discuss than to implement, we conducted in-depth interviews with a select group of experts. Utilizing PESTEL analysis to examine macro-environmental factors and investigate their interplay. Our study provides a diagnosis of the current situation and proposes a roadmap for the effective development of RECs.

Keywords: renewable energy community, experts, in-depth interviews, insights, PESTEL analysis

1. Introduction

Today, climate change stands as one of the most significant global challenges. An energy transition is essential to mitigate its negative and long-term effects, with renewable energy sources and energy efficiency playing crucial roles [1, 2]. Additionally, the recent geopolitical tensions in Eastern Europe have heightened the focus on energy security and affordability within EU countries. These nations are enhancing their energy independence through renewable energy technologies, including photovoltaics, wind turbines, and green hydrogen [3].

As one of the responses, the concept of the Renewable Energy Community (REC) came up, applying the latest digital technologies to unlock the potential of renewables and create an environmentally friendly ecosystem in which the community can produce, store, and consume energy locally [4, 5]. As a new entity, REC may alter existing electricity market models by transforming passive consumers into active prosumers [6–8]. Moreover, the REC concept has the potential to be not only innovative but more importantly, an impactful solution for society as a whole, not just individuals. Figure 1 summarizes the triggers for REC's development and shows the role of communities in the power system, society and economy. Although RECs have been examined from multiple angles, consumer approaches to RECs in Central and Eastern Europe remain understudied.

1.1. The specificity of Polish context

Despite extensive research on RECs in Western and Northern Europe [9–11] and beyond [12–14] Central and Eastern European perspectives, particularly in consumer approaches, remain less

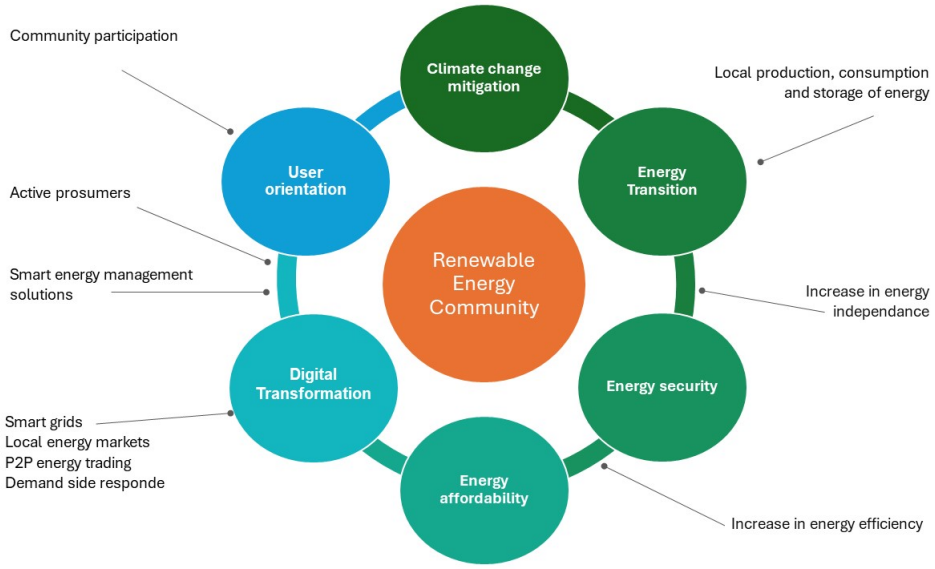

Figure 1: Triggers for creation of REC and its impact on the power system, society and economy

explored [15]. Differences in awareness, needs, and motivations for energy transition vary significantly across the EU [16]. The Polish perspective on the barriers, opportunities, and realistic pathways for REC development is especially interesting due to the specific circumstances of the country's political landscape and energy market dynamics. Poland showcases unique characteristics influenced by historical and recent events, including post-communist symbolic heritage, reactions to the European Union by its current government, and impacts from the Ukrainian conflict [17–20]. With the recent changes in the political scene, Poland is poised to launch a significant tranche of financing under the National Recovery Plan. This provides unique opportunities to fund numerous investments, including green initiatives such as RECs. At the same time, the discussion on RECs in Poland must consider the significant context of transformations in the energy market. Poland has experienced a remarkable surge in household photovoltaic (PV) installations in recent years, leading to significant market growth unmatched in Europe [21–23]. The country's PV market, driven by subsidies and innovative financing models like net-billing, saw an installation capacity exceeding 18 GW by the end of 2023 [24–26]. This surge has exposed the limitations of current methodologies for predicting energy system development and the nonlinear nature of its changes. From the perspective of REC development, the context of PV revolution offers valuable insights. It highlights the significant role of citizen initiatives in shaping the energy landscape, starkly contrasting with the top-down approaches seen in neighboring countries. Prosumer involvement is vital in REC success as an important factor in transforming user behaviour and enhancing electricity usage awareness [27]. Understanding barriers and motivations among these groups is crucial for shaping effective energy policies of the future.

1.2. Research strategy and study goals

The research strategy adopted in this article is based on in-depth interviews with experts from key stakeholder categories: policymakers, senior managers in the energy sector, researchers in

social and engineering sciences, and representatives from IT, innovation, and digital solutions. We chose expert interviews as the primary research method due to several reasons. First, the challenge of REC development is inherently interdisciplinary and complex, surpassing the conventional boundaries of specializations or professional roles. Second, the familiarity with RECs in Poland is still nascent, limited to small and medium enterprises and housing associations [15, 28]. The minimal scale of REC implementations in Poland means that this topic must be primarily approached from an expert perspective, as it is not yet represented in public awareness.

Our study objectives are shaped by two complementary perspectives. The first pertains to the previously described Polish context. Despite Poland being one of the largest countries in Europe, few studies have explored how its unique characteristics could influence the prospects for civic energy development in the upcoming years. The second perspective is broader: RECs have captivated significant interest and spurred debate for many years. Yet, in most countries, they remain peripheral within energy systems, mainly confined to pilot projects and limited-scale deployments. This scenario raises a challenging and potentially uncomfortable question: Why is it easier to discuss RECs than to implement them effectively? And what measures can be taken to alter this dynamic?

Consequently, the aim of our research is threefold:

1. to identify the factors that hinder and facilitate the development of RECs,
2. to examine their interrelationships, and
3. to devise a strategy for systemic changes that support the effective implementation of RECs in Poland.

1.3. PESTEL framework

The PESTEL framework represents an analytical tool that systematically evaluates macro-environmental factors affecting specific organizations or sectors. The acronym encompasses political, economic, social, technological, environmental, and legal dimensions. From a research standpoint, it also offers significant utility as it affords a comprehensive overview of the decision-making landscape and the dynamics at play.

In the specific context of energy transition processes, the PESTEL framework comprehensively analyses the crucial elements that shape energy policies and markets. It examines political influences, which include governmental interventions that affect market operations and performance through policies. Economic factors encompass both domestic and international macroeconomic variables. Social dimensions cover beliefs and attitudes. Technological aspects assess innovations such as automation, research and development, and the technological awareness of the industry and market. Environmental considerations relate to the ecological issues that influence industry and market dynamics, while legal aspects involve all the relevant regulations. The PESTEL analysis provides a clear structure while avoiding oversimplification and, as such, enables the integration of various actors' viewpoints. Beyond the advantage provided by a thorough diagnosis, this approach also significantly facilitates the planning of strategic changes and interventions, which we will utilize during the stage of in-depth analysis of the results.

The paper is organized as follows: after presenting the methods in Section 2, we analyze and discuss the results in Sections 3 and 4. The final conclusions and the future research avenues are provided in the end of Section 4.

2. Methods

2.1. Sample description

The professional backgrounds of the fifteen experts (E1-E14) interviewed are diverse and distinguished. This group includes two individuals who have served as ministers for digital affairs in the Polish government, a manager from one of the pioneering Urban RECs, and C-level executives across various segments of the utilities and energy sectors, including energy, heat, and water. It also features leading innovators from the IT and digital industries, alongside an environmental activist who co-leads one of Poland's largest educational programs on climate change. The participants span a range of scientific disciplines such as psychology, law, cultural studies, management, and electrical engineering. Notably, a significant portion of the group—five individuals—holds doctoral degrees. This carefully selected array of experts provided a comprehensive, in-depth, and contemporary perspective on the issue under study.

Below, the major information about the interviewed experts can be found:
E9: More than 10 years of experience in software development. Engaged in providing software for the energy clusters and virtual power plants, based on blockchain technology.
E10: Executive director for research and innovation in one of the largest Polish energy companies
E11: Long-time head of the distribution energy company and its R&D office. Expert in energy clusters, smart grids, and smart metering.
E12: associate professor in economics running research in on green economy, sustainability and energy transition, and energy citizenship.
E13: president of the energy cluster in Poland. Policy and Green Deal expert. Business development manager in the Lower Silesian Hydrogen Valley. Member of the Advisory Board of the National Chamber of Energy Clusters and the Institute of Autonomous Vehicles.

2.2. Data collection and analysis

Fourteen in-depth interviews with experts (13 IDIs, 1 dyad [1]) lasting between 50 and 75 minutes were conducted between May and June 2023. The interview structure closely matched the research questions presented above and focused on the following issues:

- Interviewee's field of expertise;
- Assessment of the REC concept (obtained before and after the presentation of a brief standardized description provided by the moderator);
- Visions of how RECs could function and by whom could be initiated and run;

[1] IDI - in-depth interview, dyad - in dyadic interviews, two participants interact in response to open-ended research questions

- Barriers and drivers related to the creation and operation of RECs in Poland.

The full interview questionnaire is available in Appendix 1.

In the second step, all the interviews were carefully transcribed and, in this form, submitted for the thematic analysis [29] facilitated by MAXQDA software [30]. The authors' team collaborated to create the first version of a two-level coding scheme designed to identify the key themes and their relevance to the research questions. Later, the tree and any coding ambiguities were iteratively refined as the coding process progressed. Finally, the empirical material was integrated, interpreted, and contextualized within a PESTEL framework.

3. Results

The material obtained during the interviews was organized using the PESTEL framework, with an additional division into opportunities, barriers, and key success factors for RECs as indicated by the interview participants. This descriptive layer of analysis (the results of which are presented in Table 1.) was further synthesized, revealing six main meta-themes, which are discussed in detail in the following sections. Each of these points represents a significant aspect of the macro-environment that determines the future of RECs in Poland. Since many expert statements took the form of recommendations, we present them as such in the following summary. Of course, this does not mean that we fully support all these proposals—the authors' stance on this matter is presented in the final section of the article. However, to maintain brevity, we will not reiterate this in each subsequent point.

Table 1: Chances, barriers and key factors from the perspective of Pestel analysis

Element	Chances	Barriers	Key-factors
Political	• National Reconstruction Plan	• Political instability • Political interest affects legislation changes • Business distrust of public funds • State-owned energy companies do not care about profit	• RECs as part of a larger whole, a permanent element of the electricity system • Efficient state, regulations, and electricity system
Economic	• Subsidies • Market and energy prices liberalization • Joint investments in REC infrastructure	• Potential social inequality • Potential costs of maintaining power backup • Lack of demand for REC • Need for investment in network infrastructure	• Economic viability of REC • Decentralization of the energy market • Lack of demand for REC • Participation of various stakeholder group

Continued on next page

Table 1: Chances, barriers and key factors from the perspective of Pestel analysis

Element	Chances	Barriers	Key-factors
Social	• Social and generational changes • Educational potential • Combating exclusion (compared to PV) • Appropriate communication	• Controversies around RES and ecology • Distrust • Individualism • The state is perceived as weak	• Functioning local community • Individual engagement • Local leaders • Pilot projects • Dialogue and trust between stakeholders • Enabling non-financial transactions in REC
Technological	• Energy transformation and partial decentralization of the Polish energy system • Need for local energy security • Availability and readiness of technologies for REC • Future development and affordability of energy storage technologies	• Negative impact on the stability of the centralized energy system • Incomprehensibility and complexity • Operational challenge for the energy sector	• Analysis of the technical feasibility • Local balancing of energy supply and demand • Diversification, adaptation of REC solutions to local conditions and community needs • Energy storage • High-quality digital solutions • Automation of REC • Data availability
Environmental	• Ecological awareness is increasing • Importance of transition to RES in the context of the increasing energy consumption and climate change mitigation	• Profitability more important than quality and eco-friendliness • Lack of understanding and interest in the energy system • Carbon footprint of production of electrical energy storage	• Climate education, awareness • Building civic responsibility • Communicating REC as one of the pro-environmental actions and supporting the energy transformation, but not the only one • RES not competing with biodiversity in remote fields
Legal	• Legislation as a force facilitating social and economic changes • Basing REC on the existing legal formula of cooperatives • Legal changes will occur provided there is political will and social pressure	• Legislative instability and complexity • National law not keeping up with changes required by the EU and technology • Lack of adequate legislative support for REC • Tension between the free market and the need for centralized regulations	• Shift in thinking about the importance of grassroots initiatives in legislation • Legal solutions supporting subsidies • Law as a guarantee of investment and energy citizen's security • Educating leaders for legal transformation

3.1. Political instability and its consequences

The issue that consistently emerged in the experts' statements was the insufficient stability of policies, including those in the energy sector. Respondents indicated that short-term interests often prevail over long-term goals and strategic thinking, which is essential for effectively introducing

systemic reforms in the energy sector. ”No one is in local government for 12 years because, after all, there are elections, it’s a carousel of positions, and the next person might have different interests because this one has a brother-in-law in charge of bicycle paths, and he will want bicycle paths, not RES” (E11).

Political actions have consequences on several levels. Firstly, political priorities and declarations are often driven by ideological or electoral logic rather than long-term interests: ”One cannot ignore that this is unstable and this strategy should be one of the most important national strategies. Actually, in my opinion, there is no more important issue today, and instead, there is a void. So, it’s hard to expect that cooperatives will settle in this void” (E14).

Secondly, on the legislative level, where instability leads to a lack of security (e.g., investment) and appropriate multi-year support programs (”Essentially, every few years people realize they live with their investments in a different world because they have a completely different level of execution, return, etc.”, E14). Conversely, certain legislative changes are introduced too slowly, such as adjusting regulations to EU requirements for the modern energy market, including legal frameworks for citizen energy (”This is recorded in directive RED-2, which we have not yet implemented, we have very big delays, and in directive RED-3, and as far as I know, the commission is probably already working on the fourth, so there’s no way we won’t do it”, E13).

Political and legislative issues create significant problems for businesses, leading to unfavorable conditions for public-private partnerships, large-scale infrastructure programs, and long-term initiatives dependent on public funds. ”Entering into a financial public-private partnership always involves some risk of control by various kinds of services, we know which ones come, which check, and exposure to certain inconveniences, to put it mildly, in running this business. ... We know from elsewhere and also from conversations with our partners that there are many such tenders announced by local governments, to which no business applies. That is, no business wants to come and be a service provider, which is for the public partner” (E4).

Finally, the excessive variability of political actions translates into social issues. Experts unanimously agree that a certain level of agency and civic engagement, as well as strong local communities, are essential for the emergence of RES cooperatives. While such communities may form as opposition to state inefficiency, current pro-ecological actions tend to be exclusive and led by individuals with high socioeconomic capital. For energy cooperatives to reduce energy exclusion and poverty, trust in local institutions and sufficient cooperation and security guaranteed by the state are crucial (”There’s also an aspect of a bit of mistrust, a bit of distrust in the legislation, a bit in the actions of the state and financial aid, but there’s also a bit of distrust among Poles in forming such communities because there’s fear about how my interests will be ensured, whether someone will not deceive me,” E12).

To fully harness the environmental potential of energy cooperatives, stronger regulatory actions by the state are necessary. The current growth of photovoltaics in rural Poland is not optimal for RES allocation. Changing this requires consistent state policies and their acceptance by business environments, which can only be achieved through greater mutual trust. Complex interdependencies between stakeholders are symptomatic of the problems considered, which will be discussed in the next section.

3.2. Energy market deregulation

The imperative for energy transformation lies in decentralizing the energy sector, with REC being a key component. As stated, "There is no energy transition without energy sector transformation. And energy sector transformation means decentralization of the system" (E11).

This transformation aligns with liberalizing the energy market, an approach deemed favorable. Decentralizing and liberalizing the market from centrally controlled prices could enhance economic viability. However, this shift necessitates thorough economic evaluation: "If such initiatives were economically viable, but it would have to be counted" (E13), "A super approach is also to liberalize this market, which is probably the opposite of what we see today. That is, no more centrally controlled prices and things like that because it's just not market-based" (E8).

The benefits of decentralization extend to various stakeholders, including the electrical grid and the state: "So the benefits are both for the electricity grid and the state" (E13). Nonetheless, the realization of REC hinges on decentralization processes within the energy sector, but political inclinations may not always favor this direction: "For now, it seems that they are moving toward a decidedly centralized approach" (E13). External pressures, such as EU directives like the Fit for 55 package, may force changes: "We have no choice not to do it" (E13).

The journey towards decentralization requires a shift in legislative frameworks. While the state may not readily adopt such changes, external influences and the deteriorating state of the electrical grid may necessitate action: "If someone does not force the Polish government...it will go down with an overwhelming resistance" (E13).

In conclusion, establishing REC requires a comprehensive energy system overhaul, including deregulation and fostering a market environment conducive to renewable energy initiatives. This requires overcoming political hurdles and fostering societal awareness of the benefits of decentralization.

3.3. Profitability of the proposed solution

REC solutions should guarantee economic incentives for individuals. People are interested in tangible benefits, such as savings from investing in renewable energy sources like photovoltaic panels and heat pumps, as well as peer-to-peer transactions (E3: "Some residents say: 'I would like to have the energy I use from the roof.' And this applies to my apartment. Then I sometimes have 5, 10, 15, 20 zloty a month relief. (...) And some people say: 'Well, wait a minute, let's do something that will multiply it for us because, after all, it's much more expensive to heat energy. Let's use our roof, for example, for photovoltaics, connect heat pumps to this photovoltaics, and let these heat pumps heat our hot water to some extent").

Economic benefits may also arise from subtracting various fees, such as distribution charges, from the energy bill, as communal energy systems might not incur the same level of network maintenance costs and taxes (E6: "energy within the community probably wouldn't be burdened with a series of distribution fees and para-taxes associated with the operation of the entire system").

The experts note, however, that large-scale development of RECs in Poland could potentially impact the stability of the centralized energy system, which must provide backup for RECs in case of power outages or insufficient power at the REC level. Maintaining power reserves is costly and could lead to higher energy prices for those not participating in RECs. As more RECs are established, fewer people will contribute to maintaining the centralized system, including the

less well-off and energy-excluded. To prevent such outcomes and energy injustice, appropriate regulations are essential [14].

A clear economic model for RECs is missing, stemming from inadequate education and communication about their purpose and benefits. The short-term perspective of both consumers and policymakers inhibits the realization of long-term benefits. Investment in energy systems is a long-term endeavor, but the focus tends to be on immediate gains and electoral cycles rather than sustained development (E11: "No one had an idea of the economic model really for this cluster. Which in my opinion is partly due to the former, which is the lack of vision, of education, of communicating what it should be to the public"). Additionally, many initiatives are created to secure funding rather than create added business value. Once funding is received, interest in operating the energy cluster wanes (E10: "In Poland, there is all the time such thinking that let's build a cluster, cooperatives, whatever, maybe we will be able to snatch some additional funding for it, or someone will reduce our distribution costs, or as if all the time we think about it from the perspective strictly related to obtaining some support, grants and so on, and not as a business venture").

Another fundamental problem is the lack of market interest from the demand side (E10: "But if there is no customer, it's as if you opened a store with some product that wouldn't sell. You can't keep it running like that indefinitely, keep the employees and the costs if there is no demand. I see the problem as being on the demand side, not the supply side").

3.4. Perspectives on the technical aspects

Key among the technical prerequisites for RECs is the importance of locally producing and consuming electricity, and balancing energy supply and demand locally. Energy sources should be located where the energy is consumed to enhance efficiency and local energy security. "In instances where the energy market becomes slightly destabilized in terms of power reserves, which could potentially be reduced, meaning either a drop in production or an increase in consumption, then I believe that an additional aspect for such RECs could indeed be ensuring security" (E8). This approach also avoids competing with biodiversity. "Renewable energy resources should be created close to places of consumption (...), for example, in industrial plants that use this energy, but also in entities such as cities, municipalities and (...) more often in cities and on roofs than, for example, in the field, where they compete with nature and biodiversity" (E2). The local nature of RECs also benefits energy-poor areas.

Due to the instability of RES, planning local energy storage within REC is prudent. Experts note that advancing energy storage technologies and reducing their costs could benefit RECs. "If there are no storage programs, producers will not want to develop their sources and truly compensate, balance, and connect to systems for such group balancing" (E9). Additionally, the development of electromobility and technologies like green hydrogen production could boost the popularity of energy communities. The choice of technology and energy sources for a REC should be tailored to the specific community's needs and capabilities, supported by an analysis of technical feasibility and investment profitability.

Effective implementation of REC in Poland also requires investments in electricity network infrastructure. "There is a fundamental problem related to the condition of the Polish distribution network, particularly the electrical one, which has recently become apparent when forced shutdowns of individual PV installations occurred" (E7). "The problem really is the preparation of the

network, because often operators, when they need electricity, prefer to purchase it from Germany where it is more attractive rather than actually developing the network structure, which is very expensive and requires investment" (E9). "However, if legislative changes were to occur, (...) we will have micro-operating companies that will deal with building such infrastructures. (...) Individual investors have formed one large group, pooled resources for a line, and built the line by establishing their own distribution company along with the grid connection point, so all of this at the level of medium and low voltages will essentially build itself" (E13).

Another essential condition for REC is the use of modern ICT technologies, which will facilitate local energy management and participant communication and increase the transparency of REC operations. Consumer applications should be high-quality and user-friendly. Data availability is an important aspect of the automation and digitization of REC operations. The ongoing CSIRE project (the Central Energy Market Information System) in Poland will standardize and enhance data accessibility, benefiting REC development. "In areas where such cluster initiatives already exist, our distribution reacts automatically, and everyone is provided with smart meters and equipped with such infrastructure. And CSIRE will also help because it will standardize, and it will be a bank of all information" (E10). Concurrently, educating the public about renewable energy sources and new ICT technologies is crucial to minimize barriers associated with modernity and the complexity of solutions RECs use.

3.5. Energy citizenship: education, awareness, and protection

The experts observe a widespread lack of understanding within the Polish population regarding the functioning of the energy system and the methods of energy billing, with the sources of energy origin being of little significance to the majority. Enhancing energy efficiency is considered crucial only at the municipal level and above.

Experts observe a widespread lack of understanding within the Polish population regarding the energy system's functioning and energy billing methods, with the energy sources being of little significance to most people. Enhancing energy efficiency is considered crucial only at the municipal level and above.

Public awareness in Poland remains low on climate and environmental issues, although it is rising among the younger generation. Recently, the importance of emissions and understanding the impact of conventional energy on greenhouse gas emissions has been increasing. Politically and within public campaigns, it is articulated that consumers bear the cost of CO2 emissions not only environmentally but also financially. Despite these changes, ongoing education is needed, with social consciousness needing to address not only potential solutions but also the existence of problems like smog. Simplified and effective educational methods are essential, as individuals cannot engage with issues they do not comprehend. Consequently, experts advocate that RECs should fulfil an educational role and foster awareness of ecology and renewable energy, framed within civic and human responsibility. RECs can drive behavioral changes across social groups, focusing on environmental care, rational resource management, and effective self-consumption of energy: "The moment we realize that energy is a commodity of special value nowadays, individual responsibility arises, which causes us as a group or individually, to want to manage this energy, but it is only possible when discussions focus on savings and efficiency" (E1).

Generational change is expected to facilitate energy transformation and grassroots initiatives. Currently, an outdated mindset about social economics prevails in Poland, characterized by low participation. However, the younger generation understands the concept of a sharing economy. Until recently, "the majority of Poles believed that 'authority is that good that provides something' "(E1), but there has been a shift towards responsibility and grassroots social initiatives. The development of individual PV investments reflects Poles' desire to take the initiative in energy matters, though not all social groups can afford PV installations due to economic and technical reasons.

RECs should be grassroots initiatives, emerging directly from residents to ensure ownership and participation in developing the best solutions for their context. Engaging local communities, which should be cohesive, self-organizing, and motivated to act collectively, is vital. RECs can be anchored in existing local communities, such as schools, urban food cooperatives, or rural women's groups. Decentralizing energy management fosters community spirit, civic engagement, and the creation of local enterprises and jobs, making RECs excellent for local community development. However, implementing the REC concept requires the emergence of a civic society and the cultivation of appropriate pro-social attitudes.

Several respondents envision the development of energy citizenship as a future direction, ensuring citizens' rights to energy, fair energy transformation, and empowering them as market participants. "Energy citizenship implies that the state creates favorable conditions for citizens - a citizen can join an energy community or another organization, can independently realize their projects, but must have privileged or at least equal conditions, which the market alone cannot provide. In this sense, the state must assume an active role in equipping citizens with the appropriate tools" (E12). Appropriate legal frameworks are necessary, as legislative solutions can either facilitate or hinder community-building actions. Despite the pivotal role of legislative changes, experts note that they can often be secondary to the social pressure generated by leaders and generational changes.

3.6. Dialogue between REC stakeholders and the need for leadership

REC, as a solution supporting energy transition, should consider the interests of various beneficiaries, including investors and energy consumers. While household involvement in energy management is crucial, it is essential to ensure that this citizen-centric focus does not overshadow the contributions of other participants in shaping the future of the energy sector. Including groups from various sectors, such as manufacturing enterprises, municipal administrations, and agricultural practitioners, is vital. The modern social economy "is built by engaging various entities, creating communities" (E1).

To align the needs and capabilities of different stakeholders, dialogue is essential. An agreement among stakeholders, particularly between the investor, market regulator, transmission and distribution network operator, and electricity producers and consumers, is necessary.

Experts highlight the challenge of distrust in Polish society and a preference for individualistic efforts, such as installing PV panels independently, over collective actions. Cooperation is often linked with conflict and democratic procedures' burdens. Effective leaders trusted by the local community are crucial for overcoming these barriers. Local authorities, whether from villages, cities, municipalities, or counties, can play a significant role. The identity of the leader is

secondary—"whether it is a women's rural association, a parish, a local entrepreneur, or a volunteer fire brigade. What matters is the real impact on the local community" (E1). Implementing legal reforms requires education for leaders at both central and local government levels. Being an ambassador for such initiatives and acting as a mediator is challenging and time-consuming. REC projects will need time for the community to adapt and undergo a mental shift. Successful initial projects managed by competent leaders can create a snowball effect, increasing interest in implementing RECs in Poland.

4. Discussion and conclusions

The PESTEL analysis based on expert opinions offered a multifaceted view of challenges, though it might, to some extent, artificially separate the individual components of the phenomenon being examined. Viewing the outcomes more broadly, the first thing to stand out is the vast web of interdependencies and feedback loops within the system being analyzed, which are crucial for the feasibility of establishing RECs. The most important key-factors are interrelated, meaning that the fulfillment of most of them parallel is needed, to enable smooth market deployment of RECs, see Figure 2.

Może tu obrazek z tym interrelationships. Pokazujemy, że wychodzimy poza sam opis, to co nam podali na tacy eksperci. My widzimy big picture, który wykracza poza indywiualne partykularne doświadczenia. To jest to wyzwanie - zobaczyć całość. My porzadkujemy to po pierwsze pokazujac - w formie tych vicious cycles - zależności utrudniajace ruszenie z miejsca + pokazujemy happy path.

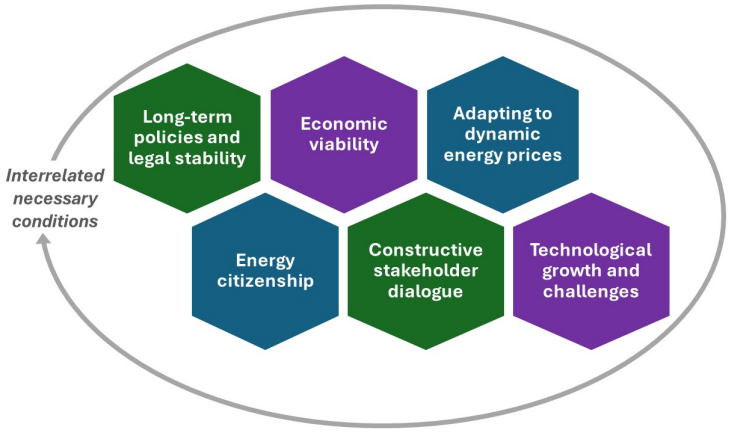

Figure 2: Feedback loops between key-factors for REC's deployment

4.1. Vicious circles ...

The first negative feedback loops impacting REC development might be identified within legislative, economic, and political realms, see Figures 3 and 4. Interviews have highlighted that the formation of energy cooperatives is not prioritized, either socially or by influential interest groups. The REC topic engages a specific audience, including progressive activists, environmentalists, and

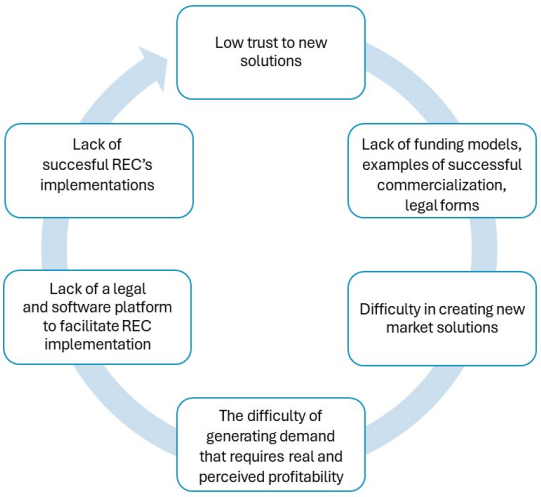

Figure 3: A vicious circle between legislation, economics and politics

individuals keen on energy system reform, leaving RECs without strong advocacy. This absence of representation leads to their low political importance, hindering necessary legislative adjustments. For instance, regulations that might support co-financing for REC investments or promote their establishment in urban areas are lacking. The deficit in suitable legislative infrastructure results in insufficient financing mechanisms and, consequently, a general hesitancy to undertake financial risks. Launching investments becomes challenging amidst legislative uncertainty and ambiguous investment returns. The unlikelihood of clear advantages, be they economic or political, ensures that this issue does not gain significant traction among interest groups that influence political agendas, thereby perpetuating the cycle of inaction.

A comparable adverse feedback loop emerges when analyzing the issue from a straightforward observation: in Poland, virtually no operational REC solutions exist, and the few that do are largely unrecognized by the public. This obscurity renders RECs as innovative or experimental endeavors, naturally fostering significant skepticism. The perception of REC creation as both innovative and pioneering, partly due to the absence of established financing models, successful commercialization instances, and proven legal frameworks, was echoed in numerous respondent accounts of administrative, economic, and social barriers to REC formation and support.

From a market perspective, RECs face high entry barriers, with potential consumers unaware of their potential benefits. Demand from prospective end-users hinges on recognising tangible, measurable, and personal gains from such investments. Without supportive financial and economic structures to ease community-based REC formation, the prospects of change in their social perception remain slim.

Ultimately, it appears valid to argue that the successful establishment of RECs cannot proceed without initiating a dialogue that involves all crucial stakeholder groups, such as government bodies, potential REC members, businesses, and energy system managers at various levels, see Figure 5. Regrettably, setting up such a collaborative platform is both time-consuming and resource-intensive, with significant uncertainties involved. Competitive alternatives in the renewable energy field, which have been established for some time without invoking these concerns, present a

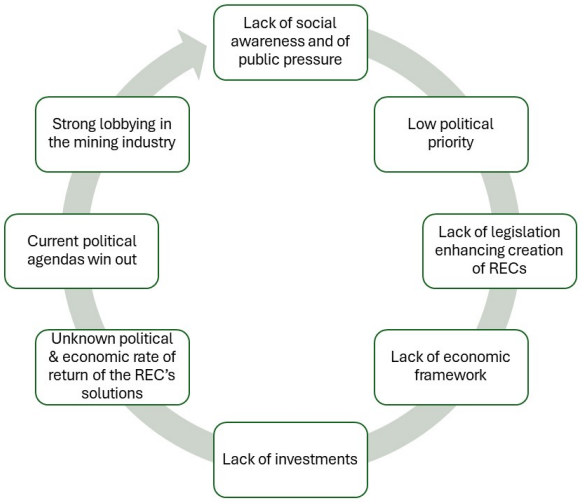

Figure 4: A vicious circle of the need for cooperation versus the widening of social inequalities

markedly lower opportunity cost. For instance, individual, prosumer-based photovoltaic energy, which has not yet reached its developmental peak according to forecasts, may soon experience a resurgence due to the growing adoption of electric vehicles and energy storage solutions. Initially, those with the financial capability to invest benefit from these changes. Regrettably, this approach to the renewable energy transition exacerbates rather than mitigates disparities in energy access. Meanwhile, individuals facing escalating energy poverty lack adequate representation and a clear articulation of their interests. The ethos of social solidarity and mutual advantage, foundational to the REC model, is overshadowed by market-driven imperatives in a landscape of insufficient regulatory oversight.

The above-described - exemplary, but illustrative - adverse feedback loops clearly show why the issue of REC implementation is so complex. Looking at this problem from the perspective of Necessary Condition Analysis, it can be said that RECs can only exist in a very limited segment of the multidimensional space analyzed within the PESTEL approach. Figure 6 delineates the ideal scenario for the proliferation of RECs in Poland, commencing with an increased awareness fostered through grassroots initiatives, educational endeavors, and the engagement of local leaders. Favorable conditions are facilitated by the support of EU directives, national legislative reforms, political stability, and the decentralization of the energy system. The provision of funding, establishment of stable regulations, and the affordability of energy production and storage technologies enhance economic viability and support the formation of REC management entities. Ensuring energy justice, ICT readiness, and the completion of the Central Energy Market Information System project further support these conditions. Subsequently, successful pilot projects and effective communication strategies create a snowball effect, culminating in a significant expansion of REC projects across Poland.

4.2. Limitations and future work

The present study, while making a reasonable choice of methodology given the complexity of the studied problem, is not without its inherent limitations. One notable constraint arises from

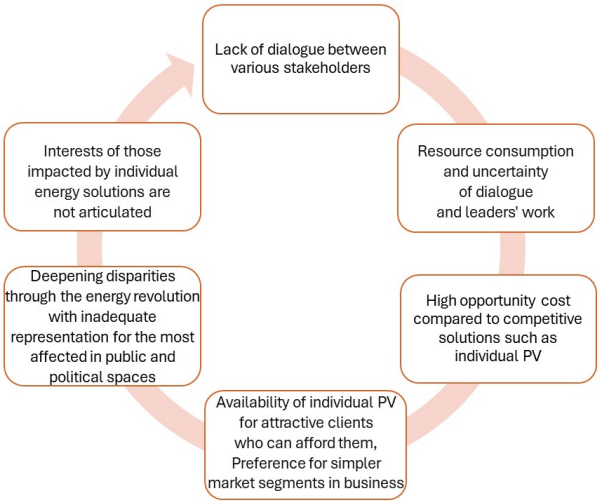

Figure 5: A vicious circle of the need for cooperation versus the widening of social inequalities

the limited sample size employed in our analysis. While this sample size was deemed appropriate given the intricacies of the research question, it remains a potential limitation in terms of generalizability. Another noteworthy aspect is the need for quantitative verification, a concern that is already acknowledged within our project framework. Incorporating robust quantitative methods will enhance the reliability and validity of our findings.

Furthermore, the dynamics of the current situation in Poland introduce additional challenges and potential limitations. The political turmoil and geopolitical instability, particularly the situation in Ukraine, co-determine the context in which our study unfolds. These external factors may introduce fluctuations and uncertainties that could impact the accuracy and applicability of our results. Recognizing this, future research should consider incorporating real-time data and adjusting methodologies to account for the dynamic nature of the geopolitical landscape in the region.

In the future, it is imperative to address these limitations and strive for a more comprehensive understanding of the subject matter. Expanding the sample size, implementing rigorous quantitative measures, and adapting research strategies to accommodate the ever-changing geopolitical climate will contribute to the robustness and relevance of our findings. Additionally, exploring avenues for collaboration with experts in political science and international relations could provide valuable insights into the broader contextual factors influencing the dynamics under investigation.

Acknowledgments

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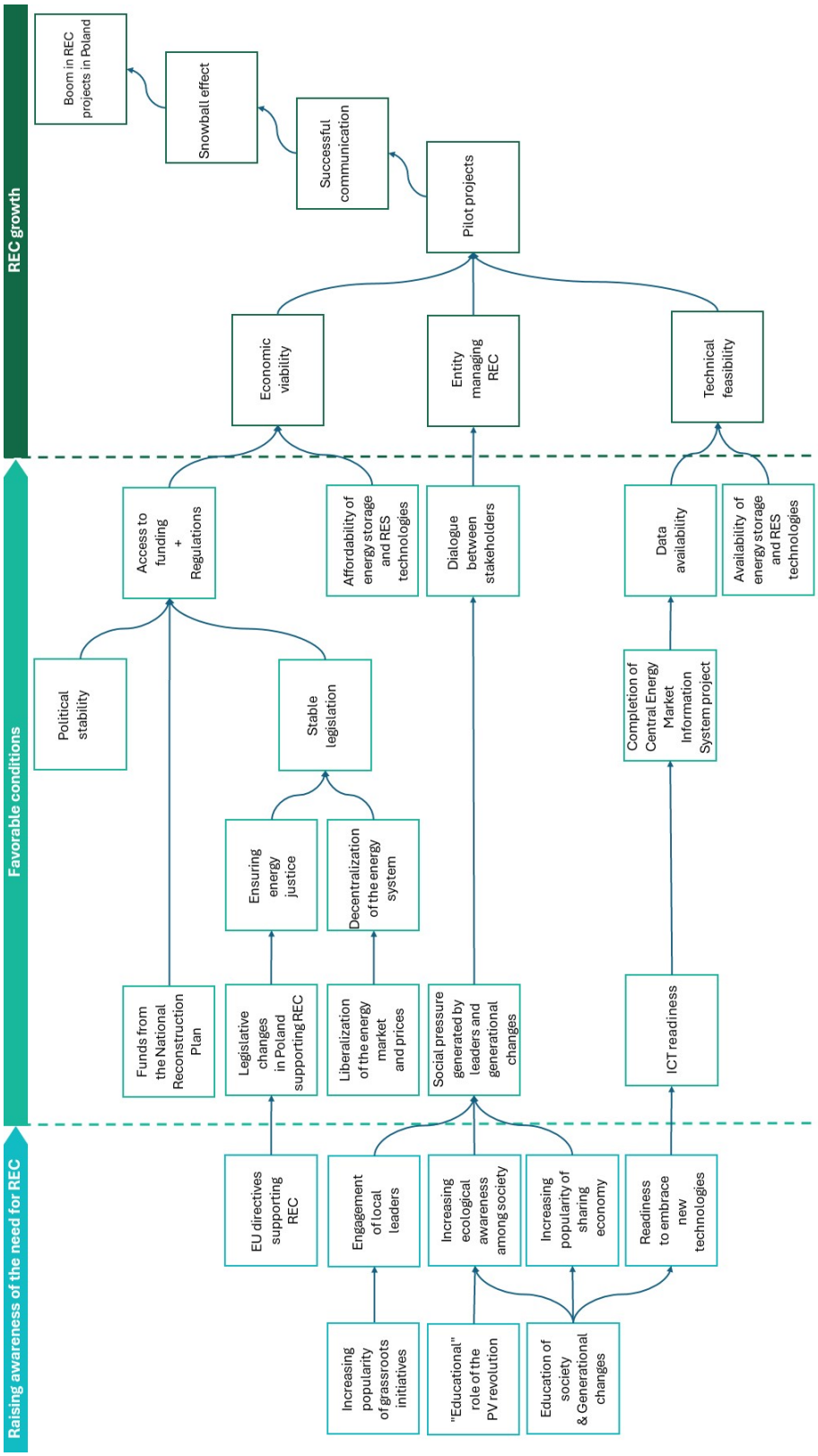

Figure 6: Ideal scenario for the growth of RECs in Poland

5. Appendix

5.1. Experts' bios

5.2. Interview Script

In the following, we present the interview script that was used while conducting the interviews with the partcipants of the survey.

I. Introduction to the principles and purpose of the interview; Introduction to the interview facilitator

II. Introduction of the interviewee (5 min)

- Could you tell me a little about yourself and your household?
- What do you do for a living? Do you work from home or drive to work?
- What is the composition of your home? Do you live alone or with your family?

III. Home and electricity (20 min)

1. Could you describe your house or flat?
    - What sources of heat and air conditioning do you use in your home?
    - Do you use appliances such as heat pumps, photovoltaics, energy storage?
2. Block of questions for prosumers
    - Can you tell us something about how you became a photovoltaic user? (When? What is the capacity of your PV?
    - What was the decision-making process like? (Who did you talk to? Who did you advise?
    - What convinced you? What were your motivations?)
    - What was the process of selecting a contractor like?
    - What were the sources of knowledge/advice in this process?
    - Were you influenced in any way by people close to you or neighbors?
    - What expectations did you have from setting up the installation (financial and other)?
    - How do you evaluate this decision now? Have these expectations been met?
    - Does the energy from RES cover your energy needs?
    - What happens to excess energy that is not used for your own needs?
    - Would you make the same decision to invest in an installation again? Would you change anything?

3. Block of questions for non-prosumers

   - Are you planning or have you planned to set up photovoltaics?
   - What do you think? What are the arguments for and against?
   - What has convinced you? What could convince you?
   - What are your sources of knowledge on the subject?
   - When do you plan to set up the installation?
   - What expectations do you have/have of the installation (financial and otherwise)? How would you like it to work?
   - Do you think RES energy will cover your energy needs?
   - What will happen to this excess energy that is not used for your own needs?

4. Block of questions for all participants

   - What do your electricity bills look like? Can you give examples of values?
   - On what do these values depend? What do they consist of?
   - How much is your electricity consumption and/or production usually?
   - Do/how do you try to reduce electricity costs (e.g. by reducing consumption)?
   - How does the use of PV compare financially? What would change if you set it up - what do you think? Or what has changed since you had it? How do you know this? What is the billing process for the energy produced?

IV. Renewable energy communities (20 min)
Now I would like to talk about a topic that is new - it is a solution that does not actually exist in Poland yet but will probably appear in the future. What do you associate the phrase ”energy community” with?

1. Questions **before reading** the REC description

   - What do you think it could be?
   - Who participates in something like this?
   - What might it be? And how does it work?
   - Even if you don’t know, what associations do you have here?

   Now I would like to show you a short description showing what energy communities are. I will be curious to hear your opinions [shown].

2. Questions **after reading** the REC description

- What do you think of this solution? Is there anything that puzzles you or surprises you?
- How do you think it could become popular? Why? What advantages might it have?
- And what might make it difficult to do such a thing? Why? What could be the problems here? Difficulties? What disadvantages might it have?
- If such a solution appeared in your area, would you be interested? Why? Under what conditions?
- Would you have specific financial expectations about your participation? What would be important to you? When would you consider it worthwhile for you?
- If there were an opportunity to donate additional unused electricity free of charge, would you be prepared to do so? To whom? To whom would they sell energy at the 'normal' price? To whom would they sell energy at a 'promotional' price?
- And what do you think about the possibility of transferring energy to, e.g. neighbors for some additional benefits, products or services? What / what would be interesting here?
- How do you imagine who could create such communities? Does it fit with local authorities or local government? Or energy distributors? Perhaps photovoltaic companies?
- Would it make any difference to your decisions on who forms such a community?
- Do you think that the state should regulate and support the development of energy communities? Why yes/no? In what way? What would be important here?
- If such communities had already emerged, where would you look for information on this topic? Who would be reliable to you as a source of information? In what form? What could be done to better inform people that such a thing has appeared?

3. Questions about the names There are possible different translations of the English term used to describe this solution. In Polish, names such as energy community, energy cooperative, and energy cluster are used.
   - What do you think about them?
   - What associations do they evoke?
   - Does any name appeal to you more? Why?

V. Thanks and closing (5 min)

- Do you have any more points to add/add?
- If you had to write 3 pieces of advice for someone who wants to introduce such a solution and wants it to be successful, what would they be of all the things we have talked about?
- Thank you for participating in the survey.

5.3. Description of REC

The REC (Renewable Energy Community) concept aims to:

- increase energy efficiency through the consumption of electricity, as close as possible to where it is produced,
- increasing the production of energy from renewable sources,
- involving households in conscious electricity management.

REC can be implemented under one or a combination of the following options:

1. part of the energy produced from renewable sources (e.g. solar PV) within a household can be transferred to another household, a public organisation or a private organisation. Transactions take place within agreed administrative boundaries (e.g. neighborhood, village, city, county), with or without pre-agreed benefits - depending on the arrangements.
2. Households can use a shared installation for local production and / or storage of renewable electricity for their own consumption. Examples of installations: photovoltaic farm, wind farm, hydrogen energy production installation, energy storage.
3. To a predetermined extent and at a predetermined time, a household's electricity consumption (e.g. electric heating, air conditioning) can be regulated remotely by a management entity. This is done in return for a pre-agreed benefit.

In each case, a device will be installed in the household to measure the consumption and (if applicable) the production of electricity. All activities such as energy sales/purchases or remote consumption management will be recorded electronically. Each household will have access to a mobile app where it will find information about its energy production and consumption, as well as transactions between it and other REC participants. All transactions related to energy exchange/management are carried out from within this app.

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