

RENEWABLE ENERGY READINESS OF BULGARIAN FARMERS: EVIDENCE FROM THE ECOLOOP SURVEY AND IMPLICATIONS FOR NATIONAL POLICY

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Abstract

Bulgaria's National Energy and Climate Plan targets 34.1% renewable energy in gross final energy consumption by 2030, positioning rural areas and agricultural producers as key actors in the energy transition. This paper analyses the renewable energy readiness of Bulgarian farmers based on the ECOLOOP Horizon Europe project survey, applying the RES Readiness Index (RRI). The mean RRI score is 55.0/100. The Technical dimension records the lowest value (51.6), while the Social dimension shows the highest (56.9). Only 23.5% currently use RES, though 76.5% express interest. The main barrier is high initial investment cost (76%). Targeted advisory services, demonstration projects, and improved access to financial instruments could accelerate adoption.

Keywords: renewable energy adoption, energy communities, agricultural sustainability, energy readiness.

JEL: Q42, Q16, Q48.

Introduction

Bulgaria's National Energy and Climate Plan (NECP) for 2021-2030 sets a target of 34.1% renewable energy in gross final energy consumption by 2030, positioning rural areas and agricultural producers as key actors in the national energy transition [1, 2]. Agricultural holdings possess significant potential for decentralised renewable energy generation through solar, biomass, and biogas technologies. With over 80% of Bulgaria's territory classified as rural and a substantial portion of the workforce engaged in agriculture, the sector's participation in renewable energy deployment is essential for both environmental and economic development objectives.

Despite this strategic importance, empirical evidence on the preparedness of Bulgarian farmers to adopt renewable energy solutions (RES) and participate in energy communities remains limited. While national policy documents outline ambitious targets, there is insufficient understanding of the attitudes, knowledge levels, and practical barriers that farmers face at the operational level. The broader economic context of renewable energy integration in rural areas across the European Union (EU), including the four countries studied in the ECOLOOP project, has been examined by the author [9], providing a foundation for the present country-specific investigation.

The EU's Renewable Energy Directive (Directive (EU) 2018/2001, known as RED II) establishes a common framework for promoting energy from renewable sources and introduces the concept of renewable energy communities, explicitly recognising the role of citizens and local actors in the energy transition [3]. The transposition of this directive into national legislation remains an ongoing process in Bulgaria, where the NECP commits to establish-

ing comprehensive energy community legislation [1]. This creates both opportunities and uncertainties for potential rural participants who may lack clarity on the regulatory pathway.

This article analyses the renewable energy readiness of Bulgarian farmers based on a farmer survey conducted within the ECOLOOP Horizon Europe project (Grant Agreement No. 101118127). It applies the RES Readiness Index (RRI) to the Bulgarian subsample and examines the implications of the findings for national energy and agricultural policy. The objective is to provide evidence-based insights that can inform targeted interventions to accelerate renewable energy adoption in Bulgarian agriculture.

1. Literature Review

The literature on renewable energy adoption in agricultural contexts has expanded substantially in recent years, driven by EU climate targets and the recognition that rural areas hold significant untapped potential for distributed energy generation. Across European countries, research demonstrates that farmer adoption decisions are shaped by a complex mix of economic calculations, technical knowledge, social networks, and institutional support [4, 5]. These factors do not operate in isolation; rather, they form an interconnected system where deficiencies in one dimension can constrain progress in others.

Studies on energy transition in the agricultural sector consistently identify several common determinants of adoption: perceived economic viability, access to reliable information, trust in technology, and the availability of professional advisory services [6, 7]. The role of social capital and peer effects has been highlighted as particularly important in rural communities, where demonstration effects and

cooperative traditions can accelerate diffusion of new practices. Research on energy communities further emphasises that collective approaches to renewable energy can reduce individual risk and transaction costs while generating additional social benefits [5].

In the Bulgarian context, the agricultural sector has undergone significant structural transformation since EU accession in 2007, with increased exposure to Common Agricultural Policy (CAP) instruments and progressive integration into European value chains. However, energy modernisation has received comparatively less attention than production intensification and market integration. The country's NECP acknowledges this gap and commits to expanding grant programmes that can cover 50-70% of installation costs, establishing energy community legislation, investing EUR 500 million in rural grid modernisation by 2030, and delivering training programmes through the National Agricultural Advisory Service [1, 2]. The NECP also sets a target of at least 100 operational energy communities by 2030, with the majority expected to be in rural areas.

Composite indices for measuring readiness or adoption propensity have been applied in various energy transition contexts. Multi-dimensional frameworks that integrate economic, technical, and social indicators provide a more nuanced assessment than single-variable analyses [4, 8]. The RES Readiness Index applied in this study builds on this tradition, adapting it specifically to the agricultural and forestry sectors across multiple EU countries. Empirical studies specifically examining Bulgarian farmer readiness for renewable energy remain scarce, creating the research gap that this article seeks to address.

2. Methodology

The data analysed in this article were collected through the ECOLOOP multi-country farmer survey, conducted across Bulgaria, Estonia, Slovenia, and Spain at the end of 2025 and the beginning of 2026. The survey instrument comprised 48 questions organised into eight thematic sections: (A) respondent profile, (B) energy usage and costs, (C) renewable energy attitudes and barriers, (D) energy community awareness and interest, (E) information needs and trusted advisors, (F) economic factor importance, (G) investment intentions and timeline, and (H) follow-up willingness. The survey was administered through national partners in each country and translated into local languages to ensure comprehension and response quality.

The RES Readiness Index (RRI) is a composite index that evaluates the readiness of farmers and foresters to adopt renewable energy solutions. The index integrates three dimensions: 1) Economic, 2)

Technical, and 3) Social. Each of them is composed of multiple survey indicators normalised to a 0–100 scale. The detailed construction methodology, including indicator selection, weighting rationale, and normalisation procedures, is presented in a separate methodological article [10]. The RRI scores are categorised into four readiness segments: Ready (≥ 75), Preparing (50–74), Exploring (25–49), and Unaware (< 25). These thresholds were established to reflect meaningful differences in intervention requirements for each group.

In addition to the RRI, the study calculates an Energy Community Potential Index (ECPI) that assesses the propensity for participation in collective energy initiatives. The ECPI draws on energy community awareness, interest, preferred roles, and perceived peer interest, providing a complementary perspective on readiness for collaborative energy models.

The Bulgarian subsample consists of 17 respondents, predominantly farm owners and managers operating across diverse farm sizes and experience levels. While this subsample size is too small to support disaggregated statistical inference or multivariate analysis, it provides a valuable exploratory assessment of readiness patterns and identifies areas requiring further investigation. All findings are reported with appropriate qualification regarding the sample size, and the analysis focuses on descriptive patterns and qualitative interpretation rather than inferential statistics.

3. Results and Discussion

The Bulgarian respondents record a mean RRI score of 55.0 out of 100 ($SD=10.5$), indicating a moderate level of overall readiness for renewable energy adoption. This positions Bulgaria slightly below the four-country average of 58.7, with individual scores ranging from 38.1 to 76.5. The distribution suggests meaningful variation within the subsample, with no respondents falling in the Unaware segment but representation across the other three readiness categories.

Dimension analysis reveals an instructive pattern (Table 1). The Social dimension records the highest mean score (56.9), suggesting relatively strong openness to collaboration and community-based energy initiatives. This score exceeds the overall project average (52.5), indicating that Bulgarian respondents may possess comparatively stronger social capital and cooperative inclinations. The Economic dimension follows (56.0), reflecting moderate awareness of energy costs and some willingness to invest, though below the project average of 60.8. The Technical dimension is the weakest (51.6 vs. 62.2 overall), indicating limited familiarity with renewable energy technologies and implementation procedures. This represents the

widest gap between Bulgaria and the overall sample, highlighting technical knowledge as the most critical area for intervention.

Table 1. RRI Dimension Scores: Bulgaria vs. Overall

Dimension	BG Mean	Overall	BG Min	BG Max
Economic	56.0	60.8	26.6	76.3
Technical	51.6	62.2	16.7	84.7
Social	56.9	52.5	28.6	75.0
RRI (total)	55.0	58.7	38.1	76.5

Source: Author's calculations based on ECOLOOP survey data (n=17 for BG; N=112 overall).

The dimension ordering in Bulgaria differs from the overall project pattern, where the Economic dimension leads and the Social dimension is weakest. This suggests that Bulgarian farmers may be more socially receptive to collective energy initiatives than their counterparts in some other countries, but face greater challenges in technical preparedness and economic confidence. The wide range within the Technical dimension (16.7–84.7) further suggests substantial heterogeneity: some respondents possess considerable technical familiarity while others have very limited exposure to renewable energy technologies.

Segmentation analysis places the majority of Bulgarian respondents (58.8%) in the Preparing category, followed by Exploring (35.3%) and Ready (5.9%), with no respondents classified as Unaware (Table 2). Compared to the overall ECOLOOP sample, Bulgaria shows a markedly higher proportion in the Exploring segment (35.3% vs. 21.4%) and a lower share in the Preparing segment (58.8% vs. 73.2%). This indicates a slightly less advanced overall readiness profile, with over a third of Bulgarian respondents still in the early stages of engagement with renewable energy concepts.

Table 2. Readiness Segmentation: Bulgaria vs. Overall

Segment	Score	BG N	BG %	Overall %
Ready	≥75	1	5.9	4.5
Preparing	50–74	10	58.8	73.2
Exploring	25–49	6	35.3	21.4
Unaware	<25	0	0.0	0.9

Source: Author's calculations based on ECOLOOP survey data.

Current RES adoption among Bulgarian respondents stands at 23.5% (4 of 17), with the remaining 76.5% expressing interest in future adoption. This 53-percentage-point gap between interest and actual use represents a substantial implementation deficit that targeted policy interventions could address. The primary motivations cited by respondents are reducing energy costs (82.4%) and achieving energy independence (76.5%), both

strongly economic in character. Environmental responsibility and sustainability image improvements were each cited by 35.3% of respondents, while additional income potential was mentioned by 29.4%. Technology preferences are dominated by solar photovoltaics (88.2%), consistent with Bulgaria's high solar irradiation potential, followed by agri-PV systems (29.4%) and biomass (23.5%).

Barrier analysis reveals that high initial investment cost is the dominant obstacle, cited by 76.5% of Bulgarian respondents. This is considerably above the four-country average of 58.0%. Complex administrative procedures rank second (41.2%), while lack of information and grid connection issues each affect 23.5% of respondents. Insufficient financing options were cited by 17.6%, and uncertain return on investment by 11.8%. Notably, the investment barrier should be interpreted not solely as a financial constraint but also as an informational one. When farmers lack reliable data on actual costs, available subsidies, and expected returns, the perceived investment barrier is magnified beyond the objective financial gap. This interpretation is supported by the information needs analysis, where Bulgarian respondents rate their knowledge of available subsidies (3.88/5), payback periods (3.69/5), investment costs (3.59/5), and technical requirements (3.60/5) as areas requiring significant additional information.

The energy community dimension shows emerging potential. The mean ECPI for Bulgaria is 54.0, with the majority of assessable respondents classified as Moderate Potential (68.8%), alongside two respondents (12.5%) with High Potential and three (18.8%) with Low Potential. While formal awareness of energy communities as a defined concept remains limited, the relatively strong Social dimension score suggests that the cooperative traditions present in Bulgarian agriculture could provide a foundation for community energy initiatives, provided that adequate legislative frameworks and support structures are established in line with NECP commitments [1].

Regarding trusted advisory sources, Bulgarian respondents show the highest trust in independent consultants (29.4%), followed equally by government agencies and university/research institutions (17.6% each), with energy companies and other farmers each trusted by 11.8%. The absence of farmer associations from the trusted advisor list (0%) represents a notable gap, as peer-based knowledge networks are recognised internationally as effective channels for promoting agricultural innovation [5, 7]. Building the capacity of farmer organisations to serve as renewable energy knowledge intermediaries could therefore address an important structural weakness in the advisory landscape.

Findings and Recommendations

The evidence from the ECOLOOP survey points to several actionable policy recommendations for accelerating renewable energy adoption among Bulgarian farmers.

First, targeted advisory services addressing the identified information gaps should be prioritised. The NECP's provisions for training programmes through the National Agricultural Advisory Service should be operationalised with specific modules covering investment costs, subsidies, payback calculations, and administrative procedures [1]. Given that the Technical dimension records the lowest readiness score, technical literacy initiatives are particularly urgent. Advisory content should be practical and farm-specific, enabling individual farmers to assess the feasibility and economics of renewable energy installations on their particular holdings.

Second, demonstration projects in representative agricultural settings could address both the technical knowledge gap and the trust deficit. Seeing operational renewable energy systems in comparable farming conditions has been shown to accelerate adoption decisions [6, 7]. The ECOLOOP project's Bulgarian pilot site at Albena, which focuses on smart Agri-PV conversion and biogas production potential, provides one such demonstration opportunity. Expanding such demonstrations to additional regions and farm types would broaden their reach and relevance.

Third, improved access to financial instruments is essential. With 76.5% of respondents citing high initial investment as a barrier, expanding the coverage and accessibility of grant programmes that can cover 50-70% of installation costs, as outlined in the NECP, should be a priority [1, 2]. Complementary instruments such as guarantee funds, preferential green lending, and simplified application procedures could further reduce the financial threshold. Critically, financial support should be accompanied by transparent cost information, as the barrier analysis suggests that information deficits amplify the perceived financial obstacle.

Fourth, the potential for energy community formation should be cultivated through dedicated legislative and support measures. Bulgaria's commitment to establishing energy community legislation by 2025 should be accelerated, with specific provisions for agricultural cooperatives and rural communities [1]. The relatively strong Social dimension scores suggest a favourable attitudinal foundation for collective energy initiatives. Pilot energy communities in agricultural regions could test implementation modalities and generate practical experience.

Finally, alignment with CAP eco-schemes could create integrated incentives for renewable energy adoption alongside agricultural modernisation. Coordinating renewable energy support with agricultural investment measures would enable farmers to pursue energy and production objectives simultaneously, reducing the perceived opportunity cost of energy investments and leveraging the administrative channels that farmers already navigate.

Conclusion

This article has presented the first empirical assessment of renewable energy readiness among Bulgarian farmers, drawing on survey data from the ECOLOOP Horizon Europe project. The findings reveal a moderate level of overall readiness (mean RRI=55.0/100), characterised by relatively stronger social openness to collaboration but weaker technical preparedness compared to the four-country average. A substantial gap exists between stated interest in renewable energy (76.5%) and actual adoption (23.5%), suggesting that targeted interventions could unlock significant untapped potential.

The practical significance of these findings lies in their capacity to inform evidence-based policy design. The evidence suggests that financial barriers, while dominant in farmer perceptions, are fundamentally intertwined with informational deficits. Policy responses that combine financial support with structured knowledge transfer and professional advisory services are likely to prove more effective than purely financial instruments. The relatively strong social readiness scores point to energy communities as a promising institutional vehicle for organising collective action, provided that the necessary legislative framework is established.

This study has several limitations that should guide the interpretation of results. The Bulgarian subsample of 17 respondents provides exploratory insights rather than statistically generalisable conclusions. The cross-sectional survey design captures readiness at a single point in time and cannot track how attitudes and behaviours evolve as the policy environment develops. Future research should expand the sample to enable regional and sector-specific disaggregation within Bulgaria, and longitudinal monitoring would provide insights into how readiness translates into actual adoption behaviour over time.

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References

1. Национален план за енергетика и климат на Република България 2021–2030. Министерство на енергетиката. София. 2024.
2. Bulgarian Ministry of Energy. *Bulgaria's Final Updated National Energy and Climate Plan 2021–2030*. Sofia. 2025.
3. Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources. Official Journal of the European Union. L 328. 21.12.2018. pp. 82–209.
4. Klöckner, C. A comprehensive model of the psychology of environmental behaviour – A meta-analysis. *Global Environmental Change*. 23(5). 2013. 1028–1038.
5. Lowitzsch, J., Hoicka, C., van Tulder, F. Renewable energy communities under the 2019 European Clean Energy Package – Governance model for the energy clusters of the future? *Renewable and Sustainable Energy Reviews*. 122. 109489. 2020.
6. Michelsen, C., Madlener, R. Homeowners' preferences for adopting innovative residential heating systems: A discrete choice analysis for Germany. *Energy Economics*. 34(5). 2012. 1271–1283.
7. Reise, C., Musshoff, O., Granoszewski, K., Spiller, A. Which factors influence the expansion of bioenergy? An empirical study of the investment behaviours of German farmers. *Ecological Economics*. 73. 2012. 133–141.
8. Solangi, Y., Tan, Q., Mirjat, N., Ali, S. Evaluating the strategies for sustainable energy planning in Pakistan: An integrated SWOT-AHP and Fuzzy-TOPSIS approach. *Journal of Cleaner Production*. 236. 117655. 2019.
9. Stoyanov, K. Unlocking the Economic Potential of Renewable Energy in Rural and Agricultural Sectors. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*. 25(1). 2025.
10. Stoyanov, K. Assessing Farmers' and Foresters' Readiness for Renewable Energy Adoption and Energy Community Participation. (forthcoming).

ГОТОВНОСТ НА БЪЛГАРСКИТЕ СТОПАНСТВА ЗА ВНЕДРЯВАНЕ НА ВЪЗОбновяема ЕНЕРГИЯ: ДОКАЗАТЕЛСТВА ОТ ПРОУЧВАНЕТО ПО ПРОЕКТ ЕСОLOOP И ОТРАЖЕНИЯ ВЪРХУ НАЦИОНАЛНИТЕ ПОЛИТИКИ

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Резюме

Националният план за енергетика и климат на България цели делът от ВЕИ да бъде 34,1% до 2030 г. Прилагайки Индекс за готовност за внедряване на ВЕИ (RRI), чрез проучване сред българските фермери, тази статия разглежда трите му различни измерения – икономическо, техническо (най-ниско от трите) и социално (най-високо от трите). Целенасочени консултантски услуги, демонстрационни проекти и подобрен достъп до финансиране биха могли да разгърнат потенциала на селските райони по отношение на ВЕИ.

Ключови думи: внедряване на възобновяема енергия, енергийни общности, устойчивост на земеделието, енергийна готовност.