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Sustainable energy transition and circular economy: The heterogeneity of potential investors in rural community renewable energy projects

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Abstract
Community renewable energy has been acknowledged as a necessary step in the transition toward a sustainable energy system. It can contribute to the achievement of energy autonomy by communities. In rural settings, it can be a driver of sustainable rural development. And it can be seen as a specific contribution to circular economy from the energy sector. The willingness to invest in community renewable energy has received some attention in previous research but needs further investigation at the local rural scale through quantitative approaches. Based on a survey in a small Galician village, this study contributes to the filling of this gap. The willingness to invest of its inhabitants is analyzed in relation to alternative financial, sociodemographic and sociopsychological features. Survey results show the heterogeneity of individual attitudes and concerns that condition the willingness to invest in rural community renewable energy and the different perceptions of risk and return related to these projects. Cluster analysis allows identifying four different investor profiles (skeptics, financial illiterate, enthusiasts, yield investors). These should be accounted for by project promoters and policymakers when designing incentives and strategies to foster community renewable energy in rural settings.

Keywords Circular economy · Community renewable energy · Rural development · Cluster analysis · Willingness to invest · Sustainable energy transition

1 Introduction

Rural areas across Europe face important challenges related to loss of population, economic relevance, and biodiversity (López-Iglesias et al., 2018; Simón et al., 2019). Some have also limited or difficult access to energy (Markantoni & Woolvin, 2013). Paradoxically, renewable energy (RE) is widely available in rural areas (Hain et al., 2005; Poggi et al., 2020) and has been acknowledged as the base of a sustainable rural development (SRD) (OECD, 2012; Sliz-Szkliniarz, 2013). However, this potential remains mostly

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unrealized (Clausen & Rudolph, 2020; ECA, 2018), since RE investments in rural areas have been traditionally promoted by big utilities through large-scale projects, letting the benefits run out of the rural economies (Okkonen & Lehtonen, 2016). The small-scale production of RE in rural places has been advocated as a necessary step to transition toward a sustainable energy system and reach a SRD (Marinakis et al., 2017; Paredes-Sánchez et al., 2018; Poggi et al., 2018). But small-scale RE projects entail high investment costs and long payback periods (Lowitzsch & Hanke, 2019; Polzin et al., 2015), demanding alternative business models (Lowitzsch & Hanke, 2019; Yildiz, 2014). Community renewable energy (CRE) proposes the active involvement of communities in the shared ownership and/or management of RE (Seyfang et al., 2013; van der Schoor & Scholtens, 2019; Walker & Devine-Wright, 2008). Involving rural stakeholders in the comprehensive management of their natural resources is a powerful strategy (Fatemi et al., 2021). It can foster social acceptance of RE (Shi et al., 2016; Yildiz et al., 2015) and let the benefits from the projects leak into the communities where they are placed (Clausen & Rudolph, 2020; Mignon & Rüdinger, 2016; Okkonen & Lehtonen, 2016).

CRE has been considered a form of grassroots innovation (Haggett & Aitken, 2015; Seyfang et al., 2013) and social entrepreneurship (Becker et al., 2017; Morrison et al., 2017). It represents a new form of governance in energy decision-making and management (Kunze & Becker, 2015; Lowitzsch & Hanke, 2019; van der Schoor et al., 2016) and can be considered a specific contribution to the circular economy (CE) from the energy sector (Finn et al., 2020). It can also be placed under the research strand of circular sustainable business models identified by Ferreira et al. (2022), although research on circular entrepreneurship is at an early phase and somewhat dispersed (Suchek et al., 2022). While the links between CE and digitalization have received great attention in previous literature (Ha & Thanh, 2022), the interrelation between CE and RE has been barely jointly approached in past research (Mutezo & Mulopo, 2021). In rural contexts, the possibility of achieving the energy autonomy of a whole territory or village ("bioenergy villages") is an especially interesting form of CRE (Dobigny, 2019; van der Schoor & Scholtens, 2015). To facilitate the design of strategies to promote these developments in rural areas, more research should explore how rural citizens perceive them, helping in the characterization of different investor profiles.

The willingness to participate (WTP) and willingness to invest (WTI) in CRE have received some attention in previous research, but need further investigation at the rural scale (Sliz-Szkliniarz, 2013; Süsser & Kannen, 2017). Some studies have explored these concepts in small rural communities through qualitative research, while, to the best of our knowledge, almost no studies are adopting a quantitative approach. Moreover, Valchovska and Watts (2016) acknowledge that "community-based rural enterprises have as yet received relatively limited attention in the academic literature, particularly those located within developed economies" (p.3). CRE can contribute to SRD both in developing (McKinley et al., 2019) and developed countries (van der Schoor & Scholtens, 2019), although the approaches differ (Aliloo & Dashti, 2021), with developing economies being more dependent on the support of NGOs (Forkuor & Korah, 2022). Among European countries, CRE initiatives have a long tradition in northern countries such as Germany or Austria, while southern countries such as Spain lag behind (Magnani et al., 2017), mainly due to an unfavorable regulatory framework (Capellán-Pérez et al., 2018). This is expected to change thanks to recent developments in the European and Spanish regulations (Campos et al., 2020; Frieden et al., 2019), supporting the opportunity of this study.

Through a survey in a small Spanish village, this study contributes to the filling of these gaps, analyzing the WTI of its inhabitants in a hypothetical bioenergy village project, and

its relation to alternative financial, sociodemographic and sociopsychological features. Cluster analysis allows identifying four investor profiles: CRE skeptics, financial illiterates, CRE enthusiasts, and yield investors. Only the financial illiterate cluster shows a clear negative WTI, while the other three clusters show a positive WTI, although with different sociodemographic and financial features mainly related to age, education, the amount to invest, perceived risk, and expected return and payback period. These different profiles could be accounted for by project promoters and policymakers when designing supporting policies and strategies to stimulate CRE in rural settings (Bauwens, 2016).

The rest of the paper is organized as follows: Through a literature review, the CRE concept is briefly defined and the main influencing factors of the WTI in CRE projects are presented. The next section explains the data and methods to conduct the quantitative analyses. Based on this research design results are presented, first through a descriptive analysis of the sample and the main survey results, and then showing the results of the cluster analysis. A discussion follows relating these results with previous literature. And, finally, the main conclusions are developed.

2 Literature review

One of the more applied frameworks for the analysis of CRE distinguishes between a process dimension (by whom) and an outcome dimension (for whom), thus focusing on the relevant issues of who promotes, owns and/or controls the project and who benefits from it (Walker & Devine-Wright, 2008). Based on this approach, a general definition of CRE relates it to RE developments with a high degree of community involvement in their ownership and/or management and/or benefits (Bauwens, 2016; Seyfang et al., 2013). The active involvement of individuals can show different forms and degrees, from volunteering in the planning and development of the projects to committing financial resources to them (Klein & Coffey, 2016; Koirala et al., 2016; Rogers et al., 2008). A relevant distinction is made in the academic literature between communities of interest (COIs) and communities of place (COPs) (Walker, 2008). The last are often seen as the ideal form of CRE since they are assumed to be run by locals and bring collective benefits into the local community (Walker et al., 2022). They have been also identified as communities of practice (CoPs) (Campbell et al., 2016). Bioenergy villages are an outstanding example of place-based communities aimed at achieving energy autonomy objectives (Roesler & Hassler, 2019; Ugalde et al., 2016; von Bock & Polach et al., 2015).

Local communities can promote their own development getting involved in the management of different services (social and sports centers, recreational areas, schools, transport, tourism, etc.) (Meijer, 2018). CRE initiatives represent another outstanding example. The analysis of this type of initiatives could be placed in the broader context of CoPs (Pattinson & Preece, 2014) and do-it-yourself (DIY) laboratories (Arndt et al., 2021). These approaches put the focus on who are the agents than can promote change and have been argued to be useful in rural societies in terms of empowerment and welfare creation (Wulandhari et al., 2021). Community initiatives can also be linked to "New Work" practices such as coworking that have been related to the creation of an organizational sustainability identity that can be particularly important in CRE projects in rural settings (Bouncken et al., 2022, 2023). This shared identity can be seen as a distinctive feature of CRE initiatives, with this distinctiveness acting as a source of legitimacy (Taeuscher et al., 2018). CRE projects also demand management competencies (Herbes et al., 2021),

sustainability dynamic capabilities (Tiberius et al., 2021), leader mentorship and self-development (Schiavone & Borzillo, 2014), and supporting ecosystems (Vernay & Sebi, 2020). These human and social capital factors are relevant issues in the management of CRE and could also have an influence on the WTI of potential CRE investors.

Following Klein and Coffey (2016), to orient the analysis of the WTI in CRE, three main sets of theories are considered: utility and rational choice theories to deal with financial issues (risk, return, and payback period); the theory of planned behavior to account for the influence of concerns, attitudes, and personal characteristics; and the information deficit model to account for the limited knowledge about energy and financial issues of the general population. Combining these theoretical frameworks, the decision to invest in CRE has been addressed in previous literature by various studies, fundamentally qualitative and based on semi or unstructured interviews, and from an ex-post (Dóci & Gotchev, 2016; Dóci & Vasileiadou, 2015; von Bock & Polach et al., 2015; Yang et al., 2021) or ex-ante (Rogers et al., 2008) perspective. Studies based on quantitative techniques are scarcer (Fleiß et al., 2017). Among them, we can also distinguish between studies about CRE projects already in operation (Bauwens, 2016; Bauwens & Devine-Wright, 2018; Braito et al., 2017; Fleiß et al., 2017) and those that analyze, from an ex-ante perspective, the WTI or WTP in hypothetical CRE projects (Broughel & Hampl, 2018; Conradie et al., 2021; Kalkbrenner & Roosen, 2016; Koirala et al., 2018; Salm, 2018; Salm et al., 2016).

These previous studies have highlighted the heterogeneity of motivations and sociodemographic and sociopsychological factors among investors with geographic links (Bauwens, 2016). Nevertheless, quantitative studies specifically focused on communities of place in a rural setting are almost non-existing. To the best of our knowledge, the more outstanding exceptions are Reise et al. (2012) and Proudlove et al. (2020). Reise et al. (2012) perform a quantitative analysis of different financial aspects related to farmers' decision to invest in biogas plants, confirming the influence of capital costs and perceived risk and the minor relevance of non-monetary issues. Proudlove et al. (2020) analyze the WTI in a CRE initiative in Australia and find that the potential for the project to generate community benefits is the strongest predictor of the WTI, while beliefs related to personal financial gain, environmental concern, impacts on landscape and local flora and fauna, were less influential and reliable predictors.

There are many financial aspects of CRE projects that could influence the WTI of rural citizens. The WTI can be influenced by economic motives linked to energy cost savings and returns on investment (Bauwens, 2016; Rommel et al., 2018). According to traditional financial theory, perceived risk is, together with expected return, one of the main parameters of any investment decision (Markowitz, 1991). Broughel and Hampl (2018) analyze risk and return and the long-term nature of the investment as potential barriers to CRE, assuming that these projects can yield low returns on investments, involve long payback periods and entail a high risk level. According to Dóci and Gotchev (2016), CRE promoters tend to be more risk averse, have lower expectations for profit and require more initial support.

Regarding perceived risk in CRE projects, although it has been acknowledged that they are less risky in terms of planning than their commercial counterparts (Haggett & Aitken, 2015), due to community involvement and participation in decision-making and/or ownership (Shi et al., 2016; Warren & McFadyen, 2010), the small scale of the installations, high capital costs, and long payback periods hinder the funding possibilities (Lowitzsch & Hanke, 2019; Polzin et al., 2015; Yildiz, 2014). Other disadvantages are the reduced economies of scale, higher transaction costs (due to the large number of people involved) and the limited possibility of diversifying risks across several projects

(Schreuer & Weismeier-Sammer, 2010). The lack of financial infrastructure, knowledge and interactions, and supportive regulatory frameworks are also significant barriers (Mignon & Rüdinger, 2016).

Regarding expected return, CRE initiatives embrace both the exploitation of natural resources and the entrepreneurial orientation and environmental sustainability orientation of their promoters and members, which have been signaled as drivers of financial performance (Dias et al., 2021). Entwistle et al. (2014) highlight that raising capital from the community can reduce the overall cost of capital and boost the financial return to shareowners. CRE projects sometimes offer a fixed return to investors (Braito et al., 2017; Fleiß et al., 2017) that can range 4–6% or 6–8% depending on their legal form (Entwistle et al., 2014), although average returns at 3% seem more realistic at present (Braito et al., 2017; Fleiß et al., 2017; Ugalde et al., 2016).

Apart from the expected return, other economic drivers, such as reducing energy costs, can also be important antecedent conditions of the decision to invest in CRE (Dóci & Vasileiadou, 2015), and can be related to the required payback for the investment (how many years will take to recover the investment with the energy cost savings derived from the CRE project). Koirala et al. (2018) find that potential CRE investors expect to recover their investment within 10 years. Similar (Paredes-Sánchez et al., 2018) or even shorter (Vendoti et al., 2021) payback periods have been confirmed by technoeconomic analyses.

Perceptions and attitudes toward environmental problems are also relevant influencing factors to consider in the analysis of individual and community action (Bom et al., 2022). Among the non-financial motives driving the WTI or WTP in CRE, previous literature has paid attention to environmental concerns (Bauwens, 2016; Bauwens & Eyre, 2017; Boon & Dieperink, 2014; Braito et al., 2017; Dóci & Vasileiadou, 2015; Kalkbrenner & Roosen, 2016), attitudes toward RE (Bauwens & Devine-Wright, 2018; Broughel & Hampl, 2018), and, to a lower extent, concern for energy-related issues (Bauwens, 2016; Fleiß et al., 2017; Koirala et al., 2018). As long as RE involve positive and negative economic, social, and environmental impacts (D'Souza & Yiridoe, 2014; Fergen & Jacquet, 2016; Savvakis et al., 2022; Süsser & Kannen, 2017), favorable attitudes toward RE (Bauwens & Devine-Wright, 2018; Broughel & Hampl, 2018) and environmental awareness (Bauwens & Eyre, 2017; Boon & Dieperink, 2014; Kalkbrenner & Roosen, 2016) can positively influence WTI in CRE.

The links between WTI/WTP and personal characteristics have also been extensively analyzed in previous research (Li et al., 2013). Higher education and income levels are found to positively relate to a higher WTI (Broughel & Hampl, 2018; Koirala et al., 2018; Salm et al., 2016). Regarding gender, most studies find that males predominate among current (Fleiß et al., 2017; Fraune, 2015) or potential (Broughel & Hampl, 2018) investors, despite some works pointing at the finding of lower environmental concern among the male population (Dhenge et al., 2022). Finally, previous literature supports that older people are more likely to engage in CRE (Fleiß et al., 2017).

Given the great variety of influencing factors of the WTI in CRE projects, and the absence of a specific focus on rural areas in previous research, this study adopts an exploratory approach to investigate whether the main features of potential CRE investors revealed by previous literature are also present in rural settings. Figure 1 specifies the factors considered in this study. Previous studies have also paid attention to social capital factors such as place attachment, trust, and social norms (López-Cabarcos et al., 2020; Romero-Castro et al., 2021) that have not been considered here.

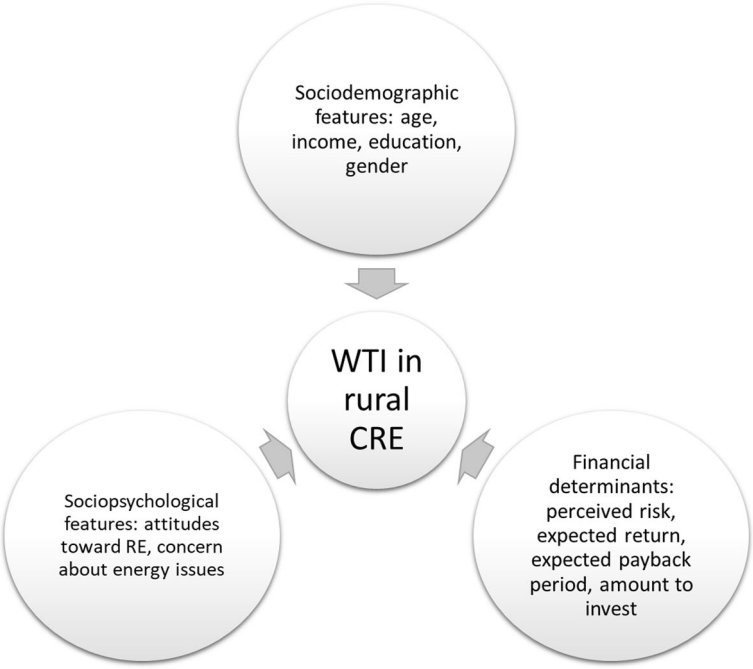

Fig. 1 Factors influencing WTI in rural CRE projects

3 Data and methods

3.1 Case study area

The scarce development of CRE initiatives in Spain and its great RE availability make its rural municipalities interesting areas to study. Galicia is one of the Spanish Autonomous Communities with the greatest RE potential and installed capacity (Montoya et al., 2014), but RE exploitation in its rural areas has been mainly driven by investments from dominant utilities that have reaped the benefits with scarce or no positive effect on local economies (Simón et al., 2019). The municipality of Baltar, in the Galician province of Ourense, with a surface area of 9399 km^2 bordering Portugal (see Fig. 2), is a peripheral mountainous area that has experienced a sharp population decline in the last decades (968 inhabitants in the 2020 census) and possesses a high RE potential. It is involved in the exploitation of various RE sources (Serra de Larouco wind park and biomass heating network in municipal buildings) and has shown sensitivity to issues related to energy and climate change as a signatory in 2016 of the European Covenant of Mayors for Climate and Energy.

3.2 Data collection

Data were collected from December 2018 to January 2019 through a survey in the village of Baltar (242 inhabitants, 136 male and 106 female). The sampling procedure intended to survey a single person over 18 years of age in regularly occupied properties in the indicated

Fig. 2 Baltar's geographical location, Ourense Province

period, avoiding the inclusion of properties only occupied during vacation periods. With the help of a local social agent, a total of 88 households with these conditions were identified. A hand-delivered questionnaire was addressed to each household, including 20 items to assess concerns and attitudes about energy and RE issues, sociodemographic features, and the financial conditions of the WTI in a hypothetical bioenergy village project. 66 responses were retrieved, representing a response rate of 27.27% of the total census population of 242 inhabitants, and 75% of the population contacted. This response rate is above similar studies not focused on a single locality (10.8% in Bauwens, 2016), and only slightly below equivalent studies such as Rogers et al. (2008), which achieved a response rate of 83%. After revision, the final sample consists of 62 respondents.

A total of 11 items, shown in Table 1, were devoted to exploring general concerns about energy issues (NRG codes, 5 items) and attitudes toward RE (RE codes, 6 items). Concerns about energy issues were approached through five questions: the first one to assess the general interest in energy issues (Janhunen et al., 2014), two items to analyze environmentally driven concerns related to climate change (Bauwens, 2016) and the preservation and conservation of the natural environment (own formulation), and other two items to analyze economic-driven concerns related to the current evolution of energy prices or the lack of transparency and information on energy prices (Bauwens, 2016). These were assessed on a Likert-type scale from 1 (very low) to 5 (very high).

Attitudes toward RE were measured through 6 questions, divided into two blocks. The first is related to environmentally driven attitudes: RE contribute to the fight against climate change (Süsser & Kannen, 2017); RE allows the production of cleaner and healthier energy (own formulation); I am worried about the possible negative impacts of RE on the environment (D'Souza & Yiridoe, 2014; Fergen & Jacquet, 2016). The second block is related to economic-driven attitudes: RE is more expensive than non-renewable (Moula

Table 1 Items on energy concerns and RE attitudes

Code	Item	Source
NRG_GEN_1	My degree of interest in energy-related issues	Janhunen et al. (2014)
NRG_ENV_CONCR_2	My degree of concern about climate change is	Bauwens (2016)
NRG_ENV_CONCR_3	My degree of concern for the preservation and conservation of the natural environment is	Own formulation
NRG_ECO_CONCR_4	My degree of concern about the current and future evolution of energy prices (electricity, fuels, etc.) is	Bauwens (2016)
NRG_ECO_CONCR_5	My degree of concern about the limited transparency and information concerning how energy prices are determined is	Bauwens (2016)
RE_ENV_ATTD_6	REs contribute to the fight against climate change	Süsser and Kannen (2017)
RE_ENV_ATTD_7	REs are cleaner and healthier energy production technologies	Own formulation
RE_ENV_ATTD_8	I am concerned about the possible negative impacts of RE on the environment (impacts on the landscape, biodiversity, health…)	D'Souza and Yiridoe (2014); Fergen and Jacquet (2016)
RE_ECO_ATTD_9	RE technologies are more expensive than non-renewable ones	Moula et al. (2013)
RE_ECO_ATTD_10	The use of RE allows us to reduce the costs of electricity and fuel for heating	Fergen and Jacquet (2016); Moula et al. (2013)
RE_ECO_ATTD_11	REs provide economic benefits (higher incomes, job creation…) to the areas where they are installed	Groth and Vogt (2014)

et al., 2013); RE use allows reduction of energy costs (Fergen & Jacquet, 2016; Moula et al., 2013); RE provides economic benefits in the area where they are installed (Groth & Vogt, 2014). These items were also presented with a Likert-type scale from 1 (strongly disagree) to 5 (strongly agree).

Gender, age, household monthly income and education were chosen as sociodemographic variables. Five- or six-point interval scales were used to measure age (1—18–30, 2—30–40, 3—40–50, 4—50–60, 5—60–70, 6- 70 years and older), income (1—Less than 900€, 2—900–1300€, 3—1300–1500€, 4—1500–2000€, 5—More than 2000€) and education (1—No studies, 2—Primary education, 3—Secondary education, 4—High school or FPI, 5—FPII, 6—University education).

The financial conditioning factors considered were the expected return, expected payback period, perceived risk, and amount to invest (ATI). Respondents were asked what annual return they would consider appropriate for investing in a CRE project (1—Less than 1%, 2—1%–2%, 3—2%–3%, 4—3%–4%, 5—4%–5%, 6—More than 5%), in what period they think they should recover the investment through energy cost savings (1—1–3, 2—3–6, 3—6–9, 4—9–12, 5—more than 12 years) and whether they think that developing a CRE project in their village entails a high level of risk (measured through a 5-point Likert scale from highly disagree to highly agree). ATI was measured through an interval scale with six alternatives: 1—Nothing, 2—Up to 500€, 3—500–1000€, 4—1000–1500€, 5—1500–3000€, 6—More than 3000€.

Previous literature has sometimes approached the WTI concept rather loosely as equivalent to the more outstanding and researched WTP concept (Memon et al., 2020). There are soft but relevant semantic differences between these and other related concepts such as willingness to change, willingness to purchase or willingness to participate, conditioned by the context of the analysis and influenced by different behavioral aspects. To allow a clear specification of the WTI concept adopted in this study, respondents were asked to assess whether they would financially contribute (invest money) in a CRE project that would turn Baltar into a bioenergy village (Kalkbrenner & Roosen, 2016; Rogers et al., 2008), using a Likert-type scale between 1 (not invest) and 6 (very high WTI).

3.3 Method

After a preliminary statistical descriptive analysis that allows obtaining an initial assessment of the profile of potential investors and non-investors, a two-step cluster analysis is performed. Cluster analysis aims to group observations based on some multivariate profile. The method ensures the highest homogeneity within and maximal heterogeneity between the clusters (Broughel & Hampl, 2018; López Cabarcos et al., 2006) and can be used with categorical variables present in our dataset (Kaufmann & Rousseeuw, 2005). This method has been widely used in bibliometric studies (Kraus et al., 2022) and economic research, such as the analysis of entrepreneurship (López Cabarcos et al., 2006), bioenergy policy approaches (Broughel & Hampl, 2018), sustainable energy development (Marti & Puertas, 2022) or sustainable mobility (Medina-Molina and Tienda, 2022).

The items described above produced a total of 20 possible cluster inputs. However, the number of variables that can be used in a cluster analysis depends on the sample size, being recommended a minimal sample size of 2^k, where k represents the number of variables (Sanders et al., 2019). It was decided that six variables could be used in the cluster analysis: the four sociodemographic variables (gender, age, education level, and net monthly household

Table 2 Sample characteristic

Variables	Sample ($N=62$) frequency	
	Absolut	(%)
Gender		
Female	36	58.06
Male	26	41.94
Age		
18–30 years	9	14.52
30–40 years	7	11.29
40–50 years	14	22.58
50–60 years	10	16.13
60–70 years	8	12.90
70 years and older	14	22.58
Education		
No studies	5	8.06
Primary education	23	37.10
Secondary education	9	14.52
High school or FPI	9	14.52
FPII	9	14.52
University education	7	11.29
Average monthly net household income (in EURO)		
Less than 900	19	30.65
900–1300	22	35.48
1300–1500	9	14.52
1500–2000	8	12.90
More than 2000	4	6.45

income), concern for the preservation and conservation of the natural environment (NRG_ENV_CONCR_3), and WTI in a CRE project.

Cluster analysis was done using R Studio software, version 1.1.463. First, a hierarchical method was applied (in this case Ward's Method) to know the number of clusters that can be formed with the data matrix and select the initial centroid. The solution resulting from the hierarchical method was taken as the starting point for a non-hierarchical K-means cluster analysis, which helps to adjust or make more precise the constitution of the clusters obtained by applying the hierarchical method (Aldás & Uriel, 2017; López Cabarcos et al., 2006; Picón Prado et al., 2005).

To investigate inter-cluster differences, independent t tests (Anova) were dismissed since they do not fit categorical outcomes (Jaeger, 2008), so Chi-squared tests were conducted with the null hypothesis: "Cluster membership is not associated with sociodemographic variables, environmental concern or WTI in a CRE project."

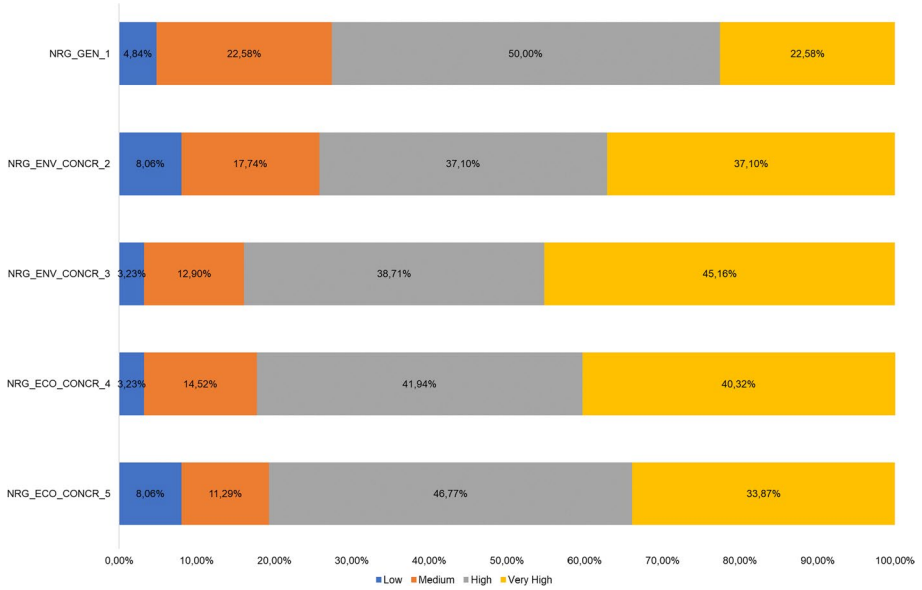

Fig. 3 Concern about energy issues

4 Results

4.1 Descriptive statistics

Table 2 gives an overview of the sample characteristics. 58.06% of the respondents are women and 41.94% are men, mainly in the range of 40–50 years (22.58%), followed by people about 70 years and older (22.58%). Most respondents show a low education level (37.1% with primary education). The average monthly net household income is between 900 and 1300€ for 35.48% of respondents and less than 900€ for 30.65%.

Regarding concerns about energy issues and attitudes toward RE (Fig. 3), most respondents have a high interest in energy-related issues (50.00%) a high or very high preoccupation with climate change (37.10%), and a very high interest (45.16%) on the preservation and conservation of the natural environment, as well as for the evolution of energy prices (41.94%) and the limited transparency and information concerning how energy prices are determined (46.77%). It should also be noted that any "very low" responses were recorded, suggesting that, in general, people are highly concerned about energy issues.

Regarding environmentally driven attitudes toward RE (Fig. 4), 42.11% agree or strongly agree with the statement that REs contribute to the fight against climate change, and 45.45% consider that REs are cleaner and healthier. 61.78% show a medium agreement level with the statement about being concerned about potential negative impacts of RE. As for economic-driven attitudes, 40% and 20% show, respectively, a low or medium degree of agreement with the assumption that RE is more expensive than non-renewable, and most respondents show a high or very high degree of agreement that RE

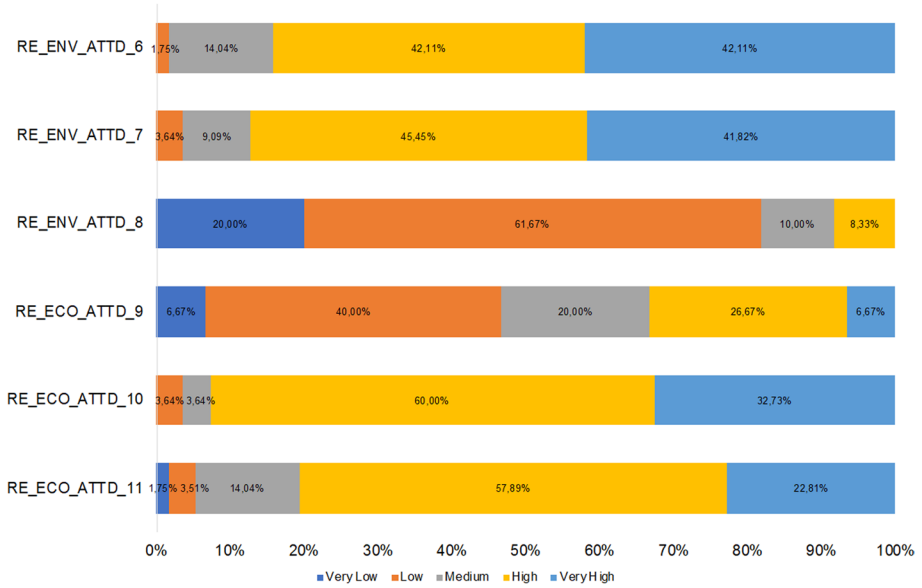

Fig. 4 Attitude toward RE

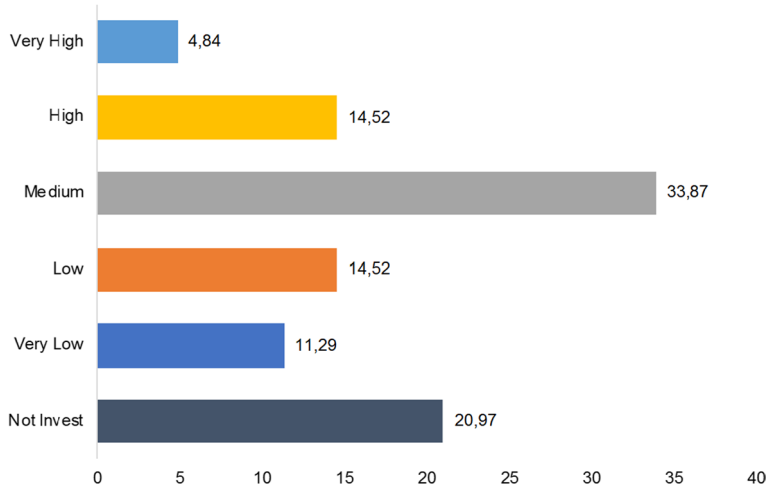

Fig. 5 WTI in CRE projects

can reduce the cost of electricity and fuel for heating and produce economic benefits in the areas where it is installed.

Regarding the WTI in a hypothetical project to configure a bioenergy village (Fig. 5), 20.97% would not invest, 25.81% show a very low or low WTI, 33.87% show a medium WTI, and 19.36% a high or very high WTI.

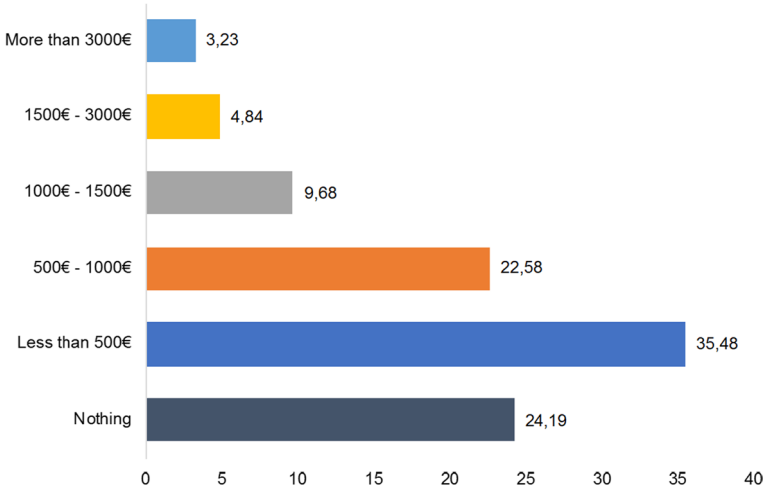

Fig. 6 ATI in CRE projects

Table 3 Pearson Chi-squared test for independence between cluster membership and characteristics of investors and non-investors in CRE projects

Variable	Value of Pearson's Chi-squared statistic	
AGE	66.28	**
GENDER	NS	
EDU	51.818	**
INCOME	61.076	**
WTI	45.232	**
NRG_ENV_CONCR_3	17.28	*

**Chi-squared test significant at the 0.01 level

*Chi-squared test significant at the 0.05 level

Regarding the ATI (Fig. 6), 24.19% of respondents would invest nothing and a 35.48% less than 500€, so an overall low amount predominates. 22.58% would devote between 500 and 1000€ and only 17.75% would invest more than 1000€.

4.2 Cluster analysis

Cluster analysis allowed us to identify four clusters with different inter-cluster and similar intra-cluster sociodemographic features, environmental concerns and WTI in the CRE project. Chi-squared tests confirmed that clusters differ in terms of sociodemographic characteristics (age, education, income), concern for the preservation and conservation of the natural environment and the WTI in a CRE project. Table 3 *reports the cases where the null hypothesis was rejected, with only GENDER showing a not significant Chi-squared statistic.* Table 4 shows the responses of the members of each cluster on the six items considered for their configuration, and reports on the ATI and the perceptions regarding financial issues (expected return, expected payback and perceived risk), allowing a deeper understanding of the different investor and non-investor profiles.

Table 4 Characteristics of investors and non-investors in a CRE project in Baltar

Variable	Question and coding	Cluster 1 ($N=15$) (%)	Cluster 2 ($N=11$) (%)	Cluster 3 ($N=20$) (%)	Cluster 4 ($N=16$) (%)
		24.19	17.74%	32.26%	25.81%
Gender	0 = Male	33.33	27.27%	40.00%	62.50%
	1 = Female	66.67	72.72%	60.00%	37.50%
Age*	1 = 18–30 years	60.00	0.00%	0.00%	0.00%
	2 = 30–40 years	26.67	0.00%	0.00%	18.75%
	3 = 40–50 years	6.67	9.09	15.00	56.25
	4 = 50–60 years	0.00	27.27	20.00	18.75
	5 = 60–70 years	6.67	18.18	20.00	6.25
	6 = 70 years and older	0.00	45.45	45.00	0.00
Education*	1 = No studies	0.00	27.27	10.00	0.00
	2 = Primary education	0.00	63.64	70.00	12.50
	3 = Secondary education	13.33	0.00	20.00	18.75
	4 = High School o FPI	20.00	9.09	0.00	31.25
	5 = FPII	33.00	0.00	0.00	25.00
	6 = University education	33.33	0.00	0.00	12.50
Average monthly net household income*	1 = Less than 900€	60.00	18.18	40.00	0.00
	2 = 900€ and 1300€	33.33	81.82	40.00	0.00
	3 = 1300€ and 1500€	6.67	0.00	20.00	25.00
	4 = 1500€ and 2000€	0.00	0.00	0.00	50.00
	5 = More than 2000€	0.00	0.00	0.00	25.00
NRG_CONCR_3*	My degree of concern for the preservation and conservation of the natural environment is:				
	1 = Very low	0.00	0.00	0.00	0.00
	2 = Low	0.00	9.09	5.00	0.00
	3 = Medium	6.67	18.18	25.00	0.00
	4 = High	46.67	27.27	50.00	25.00
	5 = Very High	46.67	45.45	20.00	75.00
WTI*	How high is your willingness to contribute financially and invest money in a CRE project?				
	1 = Not invest	6.67	81.82	0.00	18.75
	2 = Very Low	20.00	18.18	0.00	12.50
	3 = Low	20.00	0.00	20.00	12.50
	4 = Medium	46.67	0.00	45.00	31.25
	5 = High	6.67	0.00	30.00	12.50
	6 = Very High	0.00	0.00	5.00	12.50
ATI	What amount would you be willing to invest?				
	1 = Nothing	6.67	81.82	10.00	18.75
	2 = Less than 500€	80.00	9.09	35.00	12.50
	3 = 500€–1000€	6.67	9.09	25.00	43.75
	4 = 1000€–1500€	0.00	0.00	25.00	6.25
	5 = 1500€–3000€	0.00	0.00	0.00	18.75
	6 = More than 3000€	6.67	0.00	5.00	0.00

Table 4 (continued)

Variable	Question and coding	Cluster 1 ($N=15$) (%)	Cluster 2 ($N=11$) (%)	Cluster 3 ($N=20$) (%)	Cluster 4 ($N=16$) (%)
		24.19	17.74%	32.26%	25.81%
PAYB	If you invest in CRE project for your use then what should be the payback period?				
	1 = Between 1 and 3 years	0.00	27.27	40.00	25.00
	2 = Between 3 and 6 years	53.33	9.09	45.00	50.00
	3 = Between 6 and 9 years	33.33	0.00	10.00	6.25
	4 = Between 9 and 12 years	0.00	0.00	0.00	0.00
	5 = More than 12 years	0.00	0.00	0.00	0.00
	6 = Do not know	13.33	63.64	5.00	18.75
EXRET	What annual return would you consider appropriate for investing in a CRE project?				
	1 = Less than 1%	26.67	0.00%	5.00	18.75
	2 = Between 1 and 2%	40.00	0.00	35.00	18.75
	3 = Between 2 and 3%	13.33	27.27	30.00	12.50
	4 = Between 3 and 4%	0.00	9.09	20.00	6.25
	5 = Between 4 and 5%	6.67	0.00	0.00	0.00
	6 = More than 5%	0.00	0.00	5.00	25.00
	7 = Do not know	13.33	63.64	5.00	18.75
PERSK	Once the cooperative is established, I believe the risk of project failure would be				
	1 = Very Low	0.00	0.00	0.00	0.00
	2 = Low	20.00	18.18	35.00	12.50
	3 = Medium	53.33	0.00	40.00	68.75
	4 = High	13.33	27.27	20.00	0.00
	5 = Very High	6.67	0.00	5.00	6.25
	6 = Do not know	6.67	54.55	0.00	12.50

*Significant Pearson Chi-squared statistic that rejects the null hypothesis of no difference between clusters

The first cluster (15 observations) represents 24.19% of the sample and is mainly female (66.67%), between the ages of 18 and 30 years old (60%), with high education, either FPII or university (both with a 33.33%) and with income less than 900€ (60.00%). This cluster has a high or very high concern for the preservation of the environment (46.67% respectively), and a medium WTI in a CRE project (46.67%). Studying this group of potential investors more closely, they would be willing to contribute less than 500€ (80.00%) and hope to recover this investment in a period of between 3 and 6 years (53.33%), although 33.33% would settle for a 6–9-year payback. They consider the risk of failure to be medium (53.33%) and would mostly settle for an expected return between 1 and 2% (40.00%). Considering these features, this cluster is labeled as "CRE sceptics," since, although showing a medium WTI, the ATIs and expected returns and payback periods are modest, while the perceived risk is medium.

The second cluster (11 observations) represents 17.74% of the sample. Members are mainly female (72.72%), more than 70 years old (45.45%), with primary education (63.64%) and with net monthly incomes between 900 and 1300€ (81.82%). Similar to the first cluster, this second cluster shows a very high concern for the preservation and conservation of the natural environment

(45.45%), but the majority in this cluster would not invest in a CRE project (81.82%). The most outstanding result is that this cluster shows a big concentration of "I do not know" responses in relation to the items analyzing the financial features of the investment (expected return, expected payback and perceived risk). Thus, it is labeled as the "financial illiterates" cluster.

The largest number of observations (20) is concentrated in the third cluster, representing 32.26% of the sample. Like clusters 1 and 2, it is mainly made up of women (60.00%), mainly older than 70 years (45.00%), with primary education (70.00%) and net monthly incomes less than 900€ and between 900 and 1300€ (both with a 40.00%). It also shows a high concern for the preservation and conservation of the natural environment (50.00%), and a medium-to-very-high WTI in a CRE project (80.00%), making it the cluster concentrating the biggest portion of potential investors. 35% of this cluster's members would be willing to contribute less than 500€, while 50% would contribute between 500 and 1500€. Short payback periods predominate, with 40% of members hoping to recover this investment in a period between 1 and 3 years (45.00%). Compared to cluster 1 of CRE skeptics, this third cluster shows higher expected returns (25% would demand more than 3%) and a similar perception of risk, so it is labeled as the "CRE enthusiasts" cluster.

The last cluster (16 observations) represents 25.81% of the sample. Members are mostly men (62.5%), between 40 and 50 years old (56.25%), with a high school or FPI education (31.25%) and net monthly incomes between 1500€ and 2000€ (50.00%). This cluster shows the highest concern for issues related to the conservation and preservation of the natural environment and a medium-to-very-high WTI in a CRE project (31.25% show a medium WTI, with an additional 25% showing a high and very high WTI). Although 18.75% would not devote any investment to the CRE project, this cluster shows the highest ATI, since 43.75% would be willing to contribute between 500 and 1000€, 6.25% between 1000 and 1500€ and 18.85% between 1500 and 3000€. Expected payback is mainly concentrated around the ranges of 1–3 years (25%) and 3–6 years (50.00%), similar to cluster 3, and a low to medium risk perception predominates. However, this cluster shows a big proportion (25%) demanding an expected return greater than 5%, justifying the label of "yield investors" (Salm et al., 2016) for this cluster.

5 Discussion

To acquire a better knowledge of the profile of potential investors and non-investors in a hypothetical CRE project in a rural setting, a survey was conducted in a small Galician village to explore the WTI of its inhabitants. Through cluster analysis, four groups of investors and non-investors have been identified. The configuration of clusters 1 (CRE skeptics), 3 (CRE enthusiasts) and 4 (yield investors) confirm the heterogeneous profiles of potential CRE investors (Bauwens, 2016). Their main common features are a high concern about the environment and the willingness to contribute with small to modest investment amounts (< 1500€). The characteristics of the "CRE sceptics" cluster coincide with those of previous studies that indicate that adopters of RE technologies tend to be younger, more educated, and trust RE as a complementary activity to agricultural or other ones, not requiring high returns (Holstead et al., 2017), with a medium perception of risk, and aiming to devote small amounts (weighted average of 450€[1]). In this segment, the higher expected payback period is found, with an average value of 5.9 years, in line with the results of Vendoti

[1] Calculated considering in the ATI variable the midpoint of each response range (2—0–500€, 3—500–1,000€, 4—1,000–1500€, 5—1,500€-3,000€) the exact point of the two extreme options (1—Nothing, 6—More than 3,000€.), and the corresponding response percentages in each cluster.

et al.'s (2021) technoeconomic analysis. The "CRE enthusiasts" cluster is mainly made up of older women with low education but medium income, showing the highest WTI but in the form of medium amounts (weighted average of 738€), associated with a medium perceived risk and expected return, and a shorter expected payback period. The "yield investors" cluster stands out for being mainly made up of men, of working age and with a higher purchasing power than the previous clusters. This group shows a very high WTI in CRE, with the higher amounts (weighted average of 860€), associated with a medium perceived risk but a shorter expected payback period and a higher expected return (25% more than 5%). This demand for higher profitability in a shorter period is, nevertheless, also compatible with the highest concern for the environment, as found in previous studies such as Salm et al. (2016), confirming that both gain (such as obtaining a financial return or decreasing energy costs) and normative (such as protecting the environment or combating climate change) considerations influence the WTI of rural inhabitants (Dóci & Vasileiadou, 2015).

Previous literature has traditionally linked COPs with a focus on non-financial motives and COIs with a focus on financial gains (Fleiß et al., 2017; Kunze & Becker, 2015; Salm et al., 2016). Although this study's results do not allow to formalize clear differences between investors interested in financial gains or other non-financial motives, contrasting the CRE skeptics and CRE enthusiast clusters with the yield investors one reveals that among potential investors financial gains could be considered a secondary driver, since CRE skeptics and CRE enthusiasts show low-to-moderate expected returns despite a medium perceived risk. Nevertheless, the fact that both potential investors (CRE skeptics, CRE enthusiasts and yield investors) and non-investors (financial illiterate) show high concerns about environmental issues, confirms results from previous studies in rural contexts (Proudlove et al., 2020; Reise et al., 2012) pointing out the minor relevance of non-monetary issues as influencing factors of the WTI in CRE.

Anyway, the existence of this shared concern about environmental issues supports the relevance of an organizational sustainability identity (Bouncken et al., 2022) in rural CRE projects since they entail economic, social, and environmental objectives. This shared identity is more easily achievable in COPs than in COIs, where place attachment has proved to be an important influence on local responses to CRE developments (Kalkbrenner & Roosen, 2016; van Veelen & Haggett, 2017). Merging COPs and CoPs approaches can facilitate specific knowledge creation and sharing processes (Bouncken et al., 2023) and sustainability dynamic capabilities (Tiberius et al., 2021) necessary for the success of CRE projects in rural settings. Moreover, although COPs and COIs are assumed to pursue different objectives in distinct ways, recent literature recommends a hybrid approach, encouraging COPs to involve COIs to upscale CRE projects and make more significant progress toward climate change mitigation (Walker et al., 2022). Thus, in rural areas, CRE projects will be launched as COPs/CoPs, and then could consider getting non-local members also involved, retaining the ability to democratically decide which COIs join their project.

The results do not clarify much about the conclusions reached in previous studies showing that investment in RE and CRE is more likely among men than among women (Broughel & Hampl, 2018; Fraune, 2015). Gender is not significant in this study, in line with Dhenge et al.'s (2022) conclusion that gender attitudes toward environmental protection are simultaneously influenced by other personal characteristics and by exogenous factors. Anyway, it is remarkable that the "CRE sceptics" and "CRE enthusiasts" clusters, with a bigger concentration of women, show a lower expected return than the "yield investors" cluster, mainly made up of men. Also noteworthy is the evidence that men seem to have a lower aversion to risk than women because, in the face of the same perception of medium risk of the project, men would be willing to invest higher amounts. Strikingly, they would also demand a higher return,

while, according to traditional financial theory, the demand for higher profitability should be associated with the perception of higher risk. These considerations point to the interest of delving deeper into the analysis of the financial aspects related to the WTI from a bounded rationality perspective (Romero-Castro et al., 2021).

Although both the "CRE sceptics" and "CRE enthusiasts" clusters are mainly made up of women, they show different sociodemographic and financial features. Note that the difference made between skeptics and enthusiasts in this study is mainly related to the financial determinants of the WTI. CRE skeptics show lower expected returns and ATIs, while CRE enthusiasts demand higher returns and are willing to devote higher ATIs. This approach differs from Broughel and Hampl (2018), who also identify two segments of skeptics and enthusiasts in relation to wind energy, but based on people's willingness to accept wind energy installations near their communities.

Regarding sociodemographic features, CRE enthusiasts reflect the common image of the rural world in developed countries, mainly characterized as an elderly female population with a low educational level. Quite strikingly, the "financial illiterates" cluster, which concentrates the non-investor profiles, shows the same age range, gender, and educational level as the CRE enthusiasts' segment. The great differences found in their WTI reveal that the financial literacy of the population can be a determining factor of the WTI (Brent & Ward, 2018). The financial illiterate cluster also shows a bigger concentration of high or very high perceived risk.

Results show that potential investors would be willing to contribute small investment amounts. Project promoters can account for this by designing CRE projects to make them suitable for investing incremental amounts, while policymakers should encourage the creation of investment platforms by removing regulatory obstacles to their operation. Information and knowledge about climate change can also help in raising concern and awareness and promoting environmental (investing in CRE in this case) behaviors, as confirmed by Yilmaz and Can (2020).

Perceived risk is also an important conditioning factor. Results have shown that those not willing to invest concentrate the bigger proportion of the perceptions of a high or very high risk in the project. Both project promoters and policymakers should address this issue, trying to create a supportive and stable policy and financial framework, provide managerial support in the form of knowledge and interactions, and improve the financial literacy of the population, to reduce CRE perceived risk (Hicks & Ison, 2011; Mignon & Rüdinger, 2016). Resorting to CoPs and DIY laboratories (Arndt et al., 2021; Pattinson & Preece, 2014) can be a valuable strategy and contribute to the spread of CRE among rural areas. As Wulandhari et al. (2021) point out, governments should consider group social learning as an alternative method of the innovation system for rural communities.

6 Conclusions

This study builds on the idea that CRE projects in rural settings, and more specifically bioenergy villages, can be understood as expressions of the CE principles supporting the energy transition (Finn et al., 2020; Mutezo & Mulopo, 2021), and an important instrument for SRD, because of their contribution to the recirculation and distribution of benefits from RE (Slee, 2015). The study has tried to enlarge the scarce literature that applies quantitative approaches to the analysis of CRE in rural areas. The characterization of the profiles of potential investors in CRE projects, delving into the reasons for their positive or negative predisposition, can help project promoters and policymakers to better design

the instruments to promote the expansion of rural CRE and the involvement of communities, accounting for the different motivations of investors in communities of place and communities of interest (Bauwens & Devine-Wright, 2018). Our results reveal that both gain (expected return) and normative (environmental concern) considerations drive the WTI in CRE, with some clusters showing greater importance of the one or the other. This questions uniform policy approaches and demands tailor-made incentives to address the different motivations of potential investors (Dóci & Vasileiadou, 2015; Wirth, 2014). Treating them as a homogenous group can slow down the energy transition (Dóci & Gotchev, 2016), either because an unattractive investment environment is created or because the wrong RE investments are incentivized (Salm et al., 2016). Finally, and accounting for the financial illiterate cluster, where cases not willing to invest and with higher "don't know" responses regarding financial features are concentrated, we highlight the importance of improving the financial education of the population to facilitate decision-making related to the development of CRE in rural areas.

The main limitations of this study are related to the case study design, the WTI concept and the survey instrument. First, it must be acknowledged that in the analysis of specific cases the possibility of generalizing the results is limited (Mahzouni, 2019). But this limitation is partially addressed with the main motivation of the paper, which is to signal the heterogeneity and diversity of potential investors. The categorization of CRE investors might to some extent be case-dependent. Regarding the WTI concept and the survey approach, previous research has referred to the value-action gap (Heaslip et al., 2016) and the fact that the stated WTI could not be representative of actual behavior or "intention-behavior" gap (Broughel & Hampl, 2018). We acknowledge that the items related to the financial implications of the WTI in a rural CRE initiative could result rather abstract for survey respondents and that more concrete information about the risk and return of the hypothetical CRE project could have been helpful to offer a more realistic setting (Kalkbrenner & Roosen, 2016). We have to note also that the use of a different set of variables to conduct the cluster analysis could have yielded a different set of clusters (Broughel & Hampl, 2018).

More future research dealing with the association between CE and RE would be welcome. Moving beyond the analysis of the WTI of potential investors in CRE, the analysis of the entrepreneurial ecosystems that should support CRE initiatives under a circular economy approach (i.e., integral management of biomass resources) would be particularly interesting (Ferreira and Dabic, 2022). The sharing economy concept could also be a relevant one in this context (Dabbous & Tarhini, 2021). Future research should try to work on larger samples and in different locations, facilitating the application of other research methods such as logit or probit models (especially interesting when categorical or ordinal variables based on Likert scales or similar are involved), mediation analysis, structural equations or panel data analysis. Further analyses could focus on the already mentioned need of deepening into the study of the financial features of CRE investments under a bounded rationality perspective and explore the relationship between risk, technology and ownership form. In this sense, specific business models seem to be related to concrete technologies and the scale of projects, and relying on a diversified set of technologies in a CRE project could contribute to risk reduction (Dóci & Gotchev, 2016). Another relevant strand of research around rural CRE could focus on the investigation of the entrepreneurial traits of potential investors (Huarng & Yu, 2021), their sustainability dynamic capabilities (Tiberius et al., 2021) and managerial competencies (Herbes et al., 2021), the application of the technology acceptance model to the analysis of their behavioral intentions (Huang & Chueh, 2021), or the consideration of the influence of social innovation ecosystems (Audretsch et al., 2022).

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Data availability The datasets generated and analyzed during the current study are not publicly available due to their sensitive nature but are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript, and there is no financial interest to report.

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