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Harnessing citizen investment in community-based energy initiatives: A discrete choice experiment across ten European countries☆

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A B S T R A C T

In recent years, energy initiatives (such as energy cooperatives) have been expanding across European countries to meet the increasing demand for innovative solutions to renewable energy generation and distribution. However, research exploring citizens' acceptance of these new business models remains scarce, especially from the perspective of citizen investors. In this paper, we examine citizens' willingness to invest in energy projects through energy cooperatives and energy crowdfunding platforms. Using a discrete choice experiment with a sample of approximately 2000 EU citizens, we contribute to the growing literature on citizen investment in the energy sector by comparing citizens' stated engagement across ten European countries, many of which have not previously been examined in the literature. Our results provide evidence that citizens are willing to invest in renewable energy through energy cooperatives or crowdfunders. Investment returns and environmental benefits are important factors considered in making investment decisions, demonstrating both the financial and non-financial motivations of citizen renewable investors. The importance of several governance attributes, such as minimum amount of investment or the type of issuers in the case of civic crowdfunding, are also highlighted. Our findings also suggest the existence of a moderate level of preference heterogeneity regarding, e.g., carbon emission reductions, project location and minimum investment across different surveyed countries and different social groups (e.g., age, prior experience with energy initiatives) for both business models, which provides considerable implications for the generalisability of energy initiatives to different populations.

1. Introduction

In response to the growing threats from climate change and the potential of irreversible damage to ecosystems [1], the European Commission has set out a series of climate targets aimed at reducing greenhouse gas emissions, including investments in energy efficiency and renewable energy (RE). According to the new emissions reduction targets, the EU overall needs to achieve a 55% reduction in greenhouse gas emissions, a 38–40% increase in the share of renewables, and a 36–39% increase in energy efficiency compared with levels in 1990, followed by a more ambitious goal of reaching a climate-neutral economy by 2050 [2]. Renewable energy sources are key solutions to climate change, and a series of concrete policy mechanisms have been put in place across EU member states to increase renewable penetration in the power industry, yet a successful energy transition needs multidimensional cooperation instead of a standalone effort from the governments or energy industry.

Citizen empowerment, and in particular citizen investment, is emphasised by the European Green Deal for its contribution in assisting with the required increase in renewable generation in the EU. Renewable projects undertaken through energy initiatives, e.g., energy co-operatives and crowdfunding, have become increasingly popular in several countries in the EU and are considered essential in achieving energy decentralisation. These energy organisations empower European citizens to co-finance renewable generation, which has the potential to fill an investment gap [3]. Compared with RE provided by large private companies, social energy initiatives promote energy localisation and decentralisation, which subsequently enhances social cohesion and contributes to the local economy, for example, by creating green jobs [4]. Some community-based energy projects encourage a participatory

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approach and open communication, which increases transparency, and thus reduces regulation and search costs, as well as potentially reducing local opposition to RE projects [5,6]. These energy initiatives also contribute to the overall environmental agenda by increasing climate awareness and can help facilitate a just energy transition [7,8].

Two common collective solutions to finance renewable projects are energy cooperatives and energy crowdfunding platforms. Energy cooperatives are community-based energy organisations that provide citizens with the opportunity to invest in locally produced RE and energy-related services. Members of energy cooperatives are usually investors who collectively own the organisation, share the investment returns, and participate in the decision making of the cooperatives' important affairs, such as profit allocation and new investment plans [4]. Crowdfunding platforms are another innovative tool to raise funding for small or medium-scale renewable projects. They allow RE developers to raise money from a large number of investors, usually through an online portal, with a variety of financial participation options, including donation, lending, or buying equity/community shares. If funds are raised by lending or equity/community share, investors expect financial returns, however, donations are more socially oriented, and investors usually do not receive monetary returns. Lending is the most common funding method for energy crowdfunders in the EU, and the investment recipients are mostly small/medium private energy companies [9]. Unlike energy cooperatives, citizen lenders via crowdfunding are not entitled to ownership of the energy projects, and thus participation in the decision-making process of the invested projects is often less relevant.

Energy cooperatives and crowdfunded energy projects are more prevalent in North-Western Europe, such as in Germany and the UK due to long-established sense of community, various environmental movements, and relevant policy support, whilst they are less common but emerging in eastern and southern Europe [4,9,10–12]. In Western Europe, governments have established regulatory frameworks and implemented a set of policy measures aimed at facilitating the development of small energy initiatives (for example, the Renewable Energy Act in Germany). In some countries such as Spain, France and Italy where local governments play important roles in the development of RE, citizen participation is often achieved by investing in municipality-led energy projects (for example, through Public-Private Partnerships) [11]. Despite some signs suggesting a gradual development of energy initiatives in Eastern European countries such as Croatia, Czech Republic and Poland, energy generation is mostly centralised [13]. Croatia is relatively developed in energy initiatives among the post-socialist European countries due to the regulatory and financial support from the EU and United Nations [14]. In Poland, the government recently promoted a new concept - "energy clusters" - which is a civic law agreement between multiple actors (citizens, business entities, local municipalities, and research organisations) that focuses on energy generation, distribution and balancing [13], yet civic involvement in these energy projects is rather limited.

The existing literature on energy cooperatives or crowdfunders is predominantly focused on Western European countries (especially the German population). Most of these studies are qualitative analysis focusing on the barriers and potentials of energy initiatives in one or multiple countries in Europe [10,14,15–18,19–22]. Some quantitative studies investigated citizens' willingness to engage with energy niches and found that investment is mainly motivated by environmental as well as financial reasons, and the willingness-to-invest is associated with prior investment experience, transparency of the energy organisation and several socio-culture factors [23–28].

Some stated preference studies explored the views of the German population, with quantitative findings suggesting that citizens generally show an interest in investing in renewable projects through energy cooperatives or crowdfunding, and their investment or consumption choices are motivated by investment return and climate concerns [3,6,29–35]. Renewable projects operated by local energy cooperatives rather than national providers or private providers are preferred by consumers [31,35]. Some studies observe a "patriotic" preference for energy production, as individuals tend to support energy projects in the proximity of their region rather than foreign providers [6,29]. Individuals' attitudes towards several corporate features were also investigated, with respondents obtaining significant satisfaction when the chances of participating in cooperatives' decision making are provided and when the level of transparency is increased [6,32], but showing dissatisfaction with a long minimum duration – a lock-up period during which investors cannot redeem their investment [29].

Although the development and citizen acceptance of energy initiatives in Germany seem to be pronounced, little is known about citizens' views of these innovative business models in other European countries. Given that the development of RE, governmental support to energy initiatives and citizens' socio-cultural background varies greatly across European countries, it is less clear whether Germany's successful experience in promoting energy initiatives can be replicated in other European countries. The answer to this question is vital, as climate change mitigation should be a result of collective effort.

This study examines this key gap in the literature by conducting discrete choice experiments (DCEs) across a heterogeneous group of ten European countries (Croatia, France, Germany, Italy, Ireland, Poland, Portugal, Spain, Sweden and the UK), some of which have little to no development of energy cooperative and crowdfunding and also differ in terms of income levels and environmental concern. To our knowledge, this paper is the first to use cross-country surveys to unveil European citizens' intentions to invest in renewable projects through different engagement approaches, i.e., energy cooperatives and energy crowdfunding platforms. Our survey and experimental results show citizens' preferences for different characteristics of energy initiatives and the extent to which they are willing to make trade-offs between financial returns and non-financial benefits (such as carbon reduction) obtained from investing in these energy projects. We also compare preference estimates across surveyed countries to unveil the possible differences in willingness-to-engage. In addition, we explore preference heterogeneity based on observed individual characteristics.

2. Literature review

In this section, we present three strands of relevant literature. The first strand focuses on the investigation of citizens' attitudes towards RE in general. The second strand of studies explores the current development and barriers to energy initiatives in different European countries. The third strand attempts to understand experienced participants' motivations and the general public's attitudes towards these energy initiatives using surveys and/or experimental methods.

Studies on consumer attitudes towards RE are abundant, with the evidence generally indicating that electricity buyers have shown increasing acceptance and awareness towards the use of RE [36–40]. Some stated preference studies find that citizens are willing to pay a higher electricity price to shift from electricity generated by conventional fuels (for example, oil or gas) to RE sources (such as solar, wind, hydropower, or a renewable mixture), and the willingness-to-pay (WTP) differs according to socio-demographic status [37–39], environmental attitudes [41–42], knowledge about RE and climate change [37–38], and confidence on whether RE projects will be widespread in the future [43]. Notably, several studies find that the levels of social trust and social norms have positive impacts on citizens' WTP, which emphasises the role of collective actions in supporting the uptake of RE [31,36,39].

A number of studies have conducted comparative analyses to investigate the history, current development and barriers of energy initiatives in one country or across multiple European countries, most of which are developed economies (e.g., UK and Germany) with relatively established legislation on energy communities, whilst little attention has been paid on Southern and Eastern Europe where innovative energy businesses are less developed and gains little support from the governments (10,14,15-18,19–22].

Several studies have investigated individual investment motivations to engage in socially innovative businesses using quantitative methods [23–28]. In the case of German, investment is typically motivated by both financial and non-financial reasons [26]. Bourcet and Bovari [27] surveyed both experienced and inexperienced energy crowdfunding platform users among the French population and observed significantly different attitudes towards RE, perceived investment risk and transparency of participated crowdfunding platforms. Social trust, social norms and institutional trust are positively correlated to investment intention [23–24]. In addition, socio-cultural factors, such as the level of strength among community members, energy autonomy and energy independence can also play significant roles [25,28].

A number of studies explore citizens' WTP for electricity produced by renewables or willingness-to-invest in renewable projects co-financed by citizens using DCEs (also called conjoint analysis in some consumer preference studies[1]) in which the German population is predominantly analysed [6,29–34]. In general, it is found that German individuals prefer increasing the share of electricity produced by RE and are in favour of solar rather than wind power [6,29]. Consumers are willing to pay a higher electricity price for the renewable projects operated by local energy cooperatives rather than national providers or private providers [27,35]. These studies also observe a "patriotic" preference for energy production, as individuals tend to support energy projects in the proximity of their region rather than foreign providers [6,29]. Individuals' attitudes towards several corporate features were also investigated, with respondents obtaining significant satisfaction when the chances of participating in cooperatives' decision making are provided and when the level of transparency is increased [6,32], but showing dissatisfaction with a long minimum duration – a lock-up period during which investors cannot redeem their investment [29].

Curtin et al. [34] investigated the Irish citizens' attitudes towards investing in energy initiatives and focused on risk-return trade-offs using conjoint analysis. The findings suggest a low willingness-to-invest and respondents are mostly motivated by financial incentives and are sensitive to the minimum holding period. Using a similar experimental setting with professional investors in Germany, results from Salm [33] indicate that whilst low-risk renewable projects are generally more attractive, institutional investors are more reluctant to invest in high-risk projects than incumbent utilities. In a more policy-oriented study, de Brauwer and Cohen [3] conducted a large-scale choice experiment across all EU countries to quantify the social potential of citizen-led energy projects in financing wind farm development. The results suggest that European citizens are willing to invest €176 billion, which is sufficient to achieve the 2030 climate target, i.e., the 32% RE share in final energy consumption.

Overall, research on citizens' investment intention in these social energy projects is still in its infancy. A key gap in the literature is that attention has been primarily focused on Western Europe (e.g., Germany and UK) where the sense of community has long been established, and energy initiatives, such as energy cooperatives and energy crowdfunding, are relatively known to their citizens, whilst few studies focus on other European countries where energy initiatives are less common but emerging. Another research gap is that only two existing DCE studies investigate citizens' preferences for characteristics of energy cooperatives, and no DCE study explicitly explores citizens' willingness to invest in energy projects through crowdfunding platforms. This paper overcomes these limitations by directly comparing these two business models within the same methodological approach. Furthermore, this is the first paper to explore and compare acceptance across such a diverse group of countries.

[1] See Louviere et al. (2010) for a discussion on theoretical differences between the two methods.

3. Methodology

3.1. Data collection and the survey

We implement a survey approach to investigate public attitudes towards RE and two common energy initiative business models, the Cooperative Model and Crowdfunder Model across ten EU countries. The survey includes a DCE component aimed at eliciting respondents' preferences for characteristics of energy projects operated by energy cooperatives or financed through crowdfunding, as well as several sections which examine citizens' general attitudes towards RE, energy initiatives and their socio-demographic status.

The survey was hosted on the online survey platform Qualtrics from June to October 2020 targeting the general public population (over 18 years old) in ten European countries. For each business model, we deliberately chose countries with varying levels of RE development and energy initiatives, which may imply divergent views by citizens on the acceptance of energy initiatives (see Table 1).[2]

For the Cooperative Model, citizens from the German, French, Spanish, Swedish, and Polish populations were surveyed, and for the Crowdfunder Model, data collection was conducted in Croatia, Italy, Ireland, Portugal, and the UK. In general, the choice of countries in each model is guided by our understanding of the development of energy initiatives in different countries in Europe. Our initial decision was informed by our collaborated energy initiative partners across Europe (Germany, France and Spain for the Cooperative Model, and Portugal, UK and Croatia for the Crowdfunder Model). They provided valuable information regarding the current energy policies and development of energy cooperatives or energy crowdfunding platforms in their home countries. Finally, Germany, France and Sweden were selected for the energy cooperative survey as the cooperative model is relatively established in these countries, whilst Spain and Poland were chosen as a contrast due to the underdevelopment of energy cooperatives. A number of well-known energy crowdfunding platforms exist in the UK and

Table 1
Number of community-based energy initiatives and share of renewable energy in surveyed European countries.

	No. of energy initiatives[a]	Renewable share (%)[b]	Business model examined in this paper[c]
Germany	1750	17.4	Cooperative
Sweden	200	56.4	Cooperative
France	70	17.2	Cooperative
Poland	34	12.2	Cooperative
Spain	33	18.4	Cooperative
UK	431	12.3	Crowdfunder
Italy	34	18.2	Crowdfunder
Portugal	–	30.6	Crowdfunder
Croatia	–	28.5	Crowdfunder
Ireland	–	12.0	Crowdfunder
EU-28 average	–	18.9	

Source: Data are extracted from Caramizaru and Uihlein [4] and Eurostat [44]. The data are indicative and the actual number of such energy organisations in each country could be larger.
[a] The approximate number of community-based energy initiatives.
[b] The share of RE in gross final energy consumption.
[c] The business model this study will focus on for each country.

[2] France is the largest nuclear power producer in the EU, which accounts for 52.1% of the EU total nuclear power in 2019 [45]. Renewable shares in France are just 17.2%, as shown in Table 1. However, Sweden only produces 8.6% of total EU nuclear power, yet renewable energy sources (especially hydro and wind) are the most common energy sources for this country. Poland has the lowest renewable share among the surveyed countries.

Portugal, such as Abundance and Goparity, whilst we are only aware of a limited number of small energy crowdfunders in Italy and Croatia.[3]

All surveys were translated to the languages of corresponding surveyed countries. We collaborated with a professional marketing company Coyne Research to secure a representative sample in each country, where quotas regarding age, gender and regions are set based on the national statistics of each surveyed country.[4] Respondents received an anonymous link through which they were directed to the survey. The sample contains 2008 valid respondents who completed the survey, with approximately 200 in each surveyed country. Euros were presented to respondents from the countries where Euro is the main currency. For countries where euro is not used (i.e., Poland, Sweden, UK), we presented the equivalent amount in their own countries' currency in the survey.

Comparisons of key statistics between the sample and general population for each country confirm the representativeness regarding age, gender, and region. However, our sample tends to be more educated and wealthier, which could partly result from the use of a web-based choice experiment where respondents need to have online access (See Table A.1 in Appendix A1 for details).

3.2. The discrete choice experiment

A DCE simulates real-life decision making by creating experimental scenarios where respondents are asked to make investment choices based on multiple characteristics of energy projects. This method has been widely applied to explore several frontier topics in energy economics, e.g., willingness to pay for energy-saving products or services [46–49], and individual preferences for energy labelling [50–51].

Following a number of warm-up questions which explored energy behaviours, respondents were directed to the DCE) section. There are two versions of the DCE, one for Cooperatives and one for Crowdfunders depending on the country of study (see Table 1). For the Cooperative DCE, respondents were presented with an explanation of the business model and were told that investors in cooperatives own a share of a renewable generation project and that they will receive a share of profits and vote on major decisions. For the Crowdfunder DCE, respondents were informed that some organisations (e.g., local councils) were raising funds to support the installation of renewable generation, and investors would receive regular interest over the terms of the projects.

In both cases, respondents were presented with eight choice sets and were asked to choose their preferred option from two hypothetical energy projects. A “choose neither” option is also provided for those who are not satisfied with either project for various reasons, e.g., no sufficient money to invest, distrust towards the renewable projects or energy organisations, or simply using heuristics to escape from hard choices [52–53]. Seven attributes (Table 2) were chosen based on the results from previous DCE studies on energy initiatives [6,29,31–32,34–35,54] and with input from several experts in the energy sector and employees of energy cooperatives or crowdfunding platforms (CEO/owner/project managers). After completing the choice tasks, respondents were asked several post-experimental questions about the choices they completed. The DCE section and business-model-specific questions in our survey are presented in Appendix B.

Table 2
Discrete choice experiment attributes and levels for the Cooperative Model and Crowdfunder Model.

Attributes	Levels				
Common Attributes:					
Annual Return	0%	2.5%	5%	7.5%	
Renewable Type	Solar	Wind			
CO2 Reduction (tonnes per year)	150	600	3000	6000	12,000
Land Cover (equivalent football pitches)	0.25	1	5	10	20
Location of the Project	Within local area	Within region	Within country	Outside country	
Additional Cooperative Attributes:					
Minimum Investment	€50	€100	€500	€1000	€5000
Minimum Duration (years)	None	1	2	5	
Level of Participation	None	Quarterly meetings	Annual meetings		
Additional Crowdfunder Attributes:					
Minimum Investment	€10	€50	€100	€500	€1000
Investment Duration (years)	1	5	10	20	25
Type of Issuer	Local council	Community organisation	Private company		

Source: Author's design.
Note: For the purpose of our experimental design, carbon reduction and land cover are treated as one attribute as these two factors are strongly correlated in practice, i.e., the capacity of carbon reduction is commensurate with project size.

Members who invest in energy cooperatives will receive financial returns from the premium of the renewable project they invested in. In our context, the rate of the return ranges from 0% to 7.5% to cover the expected economic return.[5] In terms of renewable technology, the projects are either solar or wind. We do not have a specific expectation regarding respondents' preferences for RE technologies, although previous research has shown a preference for solar.

One of the main environmental benefits of renewable projects is less CO_2 emissions compared with conventional energy resources. We describe the attribute as the volume of carbon reduction from the invested renewable projects, which ranges from 150 t, representing a micro-grid project (such as rooftop solar panels), to 12,000 t, representing a large-scale energy project (such as large wind farms/solar panels). To reflect the reality that the level of carbon reduction is commensurate with the size of the project, we also provide the information on project land cover, which is described using the number of football pitches due to expected heterogeneity in metrics across our sample countries. While carbon reduction and project size are presented separately in the choice cards, they are perfectly correlated by design and therefore considered as a single attribute in the experimental design

[3] The chosen procedure ensures that individuals in the different countries receive “realistic” scenarios (i.e., what is present and exists in the country). The downside is that we may fail to cover the countries in which energy cooperatives or crowdfunding businesses are currently not common, but potentially relevant in the future.

[4] Coyne Research used an online panel from Dynata - the world's largest first-party data and insights platform, with a reach that encompasses 60+ million consumers and business professionals globally. Dynata uses a number of approaches to collect and update information about panellists. Basic demographic information is collected at registration, followed by a verification message and a short survey to collect further information.

[5] A zero return is included in the design to reflect the situation where a project has not started to profit.

and data analysis.

Project proximity is considered as an attribute in some prior DCE studies [6,31,34]. The location of the project is associated with the information or search costs required to monitor the operation and management of the invested energy projects. Localised energy generation also retains economic benefits in the local area, for example, more green jobs can be created. We include four levels: within local area, within region, within country, and outside country, and expect that individual preference is positively correlated with project proximity given previous findings in the literature.

Minimum investment duration is included in both business models. However, for the Cooperative DCE, the amount varies from €50 to €5000, while for the Crowdfunder DCE, the level ranges from €10 to €1000 (based on feedback from business model management). Investment duration also differs by business models: from no minimum holding period to five years for Cooperatives and one to 25 years for Crowdfunders.

Democracy in energy cooperatives is often reflected by the one-member-one-vote principle in the decision-making process of co-operatives' important affairs, such as profit allocation and reinvestment decisions [4]. We investigate individuals' interests in the existence and frequency of participatory meetings which allow them to take part in such decision-making processes. Three levels are included: no meeting, quarterly meetings, and annual meetings. We expect that respondents prefer attending meetings, yet do not have a specific expectation regarding meeting frequency.

In the context of the Crowdfunder Model, the renewable projects can be crowdfunded by buying "climate bonds", and the issuer can be a local council, community organisation or private company. Following the results of several recent studies in which citizens generally prefer bonds to be issued by communities or local governments (e.g., local councils or municipalities) rather than private companies [29,34,35,54], we expect that local council and community organisation are preferred over private companies as issuers but have no clear expectation between the two.

Fig. 1a and b presents an example of a choice card for the Cooperative Model and Crowdfunder Model, respectively. The choice sets were constructed using a D-efficient fractional-factorial design in which 32 choice sets were grouped into four blocks using the routine *dcreate* in Stata 16.1 [55], and therefore each respondent faces eight choice cards.[6] We randomised the presentation of choice cards to individuals to minimize order effects.

4. Modelling framework

Typically, choice experiment data is modelled under the random utility framework [56], which can be summarised in Eq. (1):

$$\mathrm{U}_{ni} = \beta X_{ni} + \varepsilon_{ni} \tag{1}$$

where U_{ni} represents the utility received from choosing alternative i by individual n. X_{ni} is the attribute vector in alternative i which represents the observable component of the utility function to researchers, whilst the error term ε_{ni} represents a stochastic component following some known distributions. In a basic multinomial logit, the error term is assumed to be independently and identically distributed (IID) which implies homogeneous preferences across individuals. To allow for preference or "taste" heterogeneity, we use a mixed logit (MXL) model with utility function:

$$\mathrm{U}_{ni} = \beta_n X_{ni} + \varepsilon_{ni} = \alpha X_{ni} + \zeta_n X_{ni} + \varepsilon_{ni} \tag{2}$$

where β_n can be split to two components: α captures the mean of the individual preference for a certain attribute, and ζ_n captures the standard deviation around this mean [57]. The probability of choosing alternative i under MXL is shown in Eq. (3):

$$P_{ni} = \int \left(\frac{exp(\beta_n X_{ni})}{\sum_{i=1}^{I} exp(\beta_n X_{ni})} f(\beta) d\beta \tag{3}$$

where $f(\beta)$ is the density function of attribute coefficient β. The annual return attribute is assumed to be log-normally distributed, whilst all other attributes are assumed to be normally distributed. The maximum likelihood estimation method with simulation is used to estimate MXL based on 500 Modified Latin Hypercube Sampling draws using the *Apollo* package in R [58].

To understand the trade-offs between monetary and non-monetary attributes, we use willingness-to-accept (WTA) to estimate to what extent individuals are willing to accept a reduction in annual return in order to obtain a more desirable feature of the invested renewable projects. The WTA can be approximated by the marginal rate of substitution between the annual return attribute and a non-monetary characteristic of co-owned or co-financed energy projects, which is presented in Eq. (4):

$$WTA_k = \frac{\beta^k}{\beta^c} \tag{4}$$

where β^k is the parameter for the non-monetary attribute k and β^c is that for the annual return.

To explore preference heterogeneity across different social groups, we interact the attributes with a number of selected individual characteristics reflecting respondents' socio-demographic status, general attitudes to climate change, general risk attitudes, prior experience of engaging with energy organisations, and attitudes towards the business models. The theoretical reasoning and expectation of the effects of these variables on preferences are stated below:

(a) The impact of climate change attitudes

Perceptions and attitudes towards climate change affect individuals" actual climate mitigation behaviour [59]. In our discrete choice experiment, CO2 emission reduction is the key environmental attribute, and we expect the level of preference for CO2 reduction varies between those with different opinions on climate change, with those who consider climate change as an emergency showing higher preference for carbon reduction.

(b) The impact of risk attitude

Risk preference generally plays an important role in investment decision making [60], and therefore we are interested in whether risk attitudes affect individuals' preferences for minimum investment amount and investment duration for green energy projects. In addition, we are interested the effect of risk attitude on preferences for local councils as bond issuers for the Crowdfunder Model. We expect that climate bonds issued by local councils are perceived as a safer option given the nature of authority, compared with those issued by private companies or community organisations.

(c) The impact of prior investment experience

We are interested in the effect of prior investment experience with energy initiatives on preferences for participatory meetings. This is motivated by evidence suggesting that previous investors/participants of energy organisations demonstrate distinct preferences compared with

[6] We are aware of several available options in experimental design, yet a D-efficient design is chosen in this study to maximise statistical efficiency for parameter identification. An alternative is an orthogonal design where correlation between parameters is minimised, yet a larger sample size is required for parameter identification compared with the D-efficient design. Overall, it is mainly a trade-off between statistical efficiency (e.g., D-efficient design) and statistical independency (e.g., orthogonal design).

a

	Project A	Project B
Annual Return	2.5 %	5 %
Type	Solar	Wind
Annual CO2 Reduction	3,000 tonnes	12,000 tonnes
Land Cover	5 football pitches	20 football pitches
Location	Within your region	Outside your country
Minimum Investment	€ 100	€ 500
Minimum Duration	5 years	2 years
Participation	Quarterly meetings	None

○ Project A
○ Project B
○ I would NOT choose either

b

	Project A	Project B
Annual Return	5 %	2.5 %
Type	Solar	Wind
Annual CO2 Reduction	600 tonnes	3,000 tonnes
Land Cover	1 football pitch	5 football pitches
Location	Within your country	Within your local area
Minimum Investment	£ 100	£ 500
Investment Duration	25 years	20 years
Issuer	Private company	Community organisation

○ Project A
○ Project B
○ I would NOT choose either

Fig. 1. a. Cooperative DCE choice card example. The panel on the left is the attribute vector representing characteristics of typical energy cooperatives. The two columns on the right list the attribute levels for each hypothetical energy project. Respondents were asked to choose either Project A or Project B, or simply choose to opt out if they like neither.
b. Crowdfunder DCE choice card example. The panel on the left is the attribute vector representing characteristics of typical crowdfunded energy projects. The two columns on the right list the attribute levels for each hypothetical energy project. Respondents were asked to choose either Project A or Project B, or simply choose to opt out if they like neither.

"freshers" [30,31]. We expect that prior investment experience in energy organisations helps individuals to gain a better understanding and thus leads to higher interests in future participation. In addition, we are interested in the effect of investment experience on preferences for minimum investment amount and duration, based on the expectation that financial literacy and familiarity with the process of financial investment affect one's perceived reasonableness of these investment requirements [61].

(d) The impact of trustworthiness of the energy organisations

Institutional trust plays an important role in a successful energy transition [62,63]. We expect that those who trust the carbon reduction claim from the energy organisation have a higher preference for carbon reduction due to increased certainty. We are also interested in the effect of trust towards the invested organisation on project proximity and expect that investors who express distrust towards the energy organisations are more willing to invest in localised energy projects for the reason of easy monitoring. For the Crowdfunder Model, green bonds issued by the local councils are commonly considered safer in terms of investment risk, yet we expect that those who trust the energy organisations will be more likely to accept bonds issued by community organisations or private companies.

(e) The impact of awareness of decision rights in energy cooperatives.

For the Cooperative Model, one of the main functions of participatory meetings is allowing members to exert their rights in the cooperative's main decision making [18,64]. Therefore, we expect that individuals who consider decision rights as important show a higher preference for the participatory meetings.

(f) The impact of socio-demographic status

For each of the interacted attributes, we also add socio-demographic interactions (i.e., age, education, income, and gender interactions) which serves a dual purpose: to explore preference heterogeneity across different socio-demographic groups and to ensure that the observed relationships mentioned above are not driven by socio-demographic effects (i.e., as control variables).

For the extended model with interaction terms, we assume all attributes are non-random, as the main purpose of this analysis is to examine the observed preference heterogeneity (captured by the interaction variables) instead of unobserved preference heterogeneity, which is captured by the spread of the attributes in Eq. (2). The modelling of preference heterogeneity is conducted using Stata 16.

5. Results

5.1. Descriptive statistics

Table 3 presents the summary statistics of key individual-level variables used in this study. For the country-level results, we observe that most respondents consider climate change as a serious issue and think that participation rights in energy cooperatives are moderately important in securing individual investment but have no prior experience in engaging with energy organisations. Cross-country differences are observed for some variables such as climate concern, trust towards the business models and prior participation experience. For example, climate concern varies from 61% in the German sample to 87% in the Portuguese sample. Croatian respondents have the least prior experience in participating in energy organisations, such as cooperative and crowdfunding platforms, whilst German and French individuals are the most experienced energy investors among all surveyed countries.

5.2. Estimation results

5.2.1. Preference estimation

Of the respondents who completed the survey, we exclude those who had no variation in their DCE answers, i.e., always chose Project A or Project B, which accounts for 2.7% (27 subjects) for the Cooperative sample and 1.9% (19 subjects) for the Crowdfunder sample.[7]

Table 4 presents the pooled results of the preference estimates for the Cooperative Model (pooled sample of Germany, France, Spain, Sweden and Poland) and Crowdfunder Model (pooled sample of Portugal, Ireland, UK, Croatia and Italy). In general, the negative and significant alternative specific constant in both business models (reference level is the opt-out option) suggests that respondents are willing to choose the proposed renewable projects i.e., "Project A" or "Project B", operated by energy cooperatives or co-financed through crowdfunding platforms, rather than choosing to opt out, which is an indication that the

[7] Such respondents, we expect, were likely rushing through the survey and not paying attention to the DCE details.

Table 3
Summary statistics of individual characteristic variables used in the choice modelling.

	Energy Cooperative						Energy Crowdfunder					
	Pooled	Germany	France	Spain	Sweden	Poland	Pooled	Portugal	UK	Ireland	Croatia	Italy
Variables[a,c]	Mean (S.D.)											
Age	42.25	43.34	43.61	41.80	42.10	40.50	42.64	41.17	47.23	45.20	37.18	42.84
	(14.93)	(14.41)	(16.24)	(14.38)	(15.12)	(14.24)	(15.15)	(14.22)	(17.11)	(17.03)	(10.49)	(14.13)
Male	0.49	0.54	0.43	0.51	0.50	0.51	0.47	0.50	0.44	0.46	0.47	0.49
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Tertiary education	0.61	0.50	0.62	0.72	0.63	0.56	0.55	0.63	0.57	0.52	0.65	0.43
	(0.49)	(0.50)	(0.49)	(0.45)	(0.48)	(0.50)	(0.50)	(0.48)	(0.50)	(0.50)	(0.48)	(0.49)
Income (€)	31,556	42,445	34,417	32,120	31,930	17,304	29,745	24,077	37,744	39,733	17,336	31,213
	(26,994)	(34,576)	(28,393)	(23,668)	(23,112)	(15,539)	(24,721)	(20,816)	(28,370)	(28,656)	(13,688)	(22,112)
Climate Concern	0.72	0.61	0.74	0.80	0.67	0.78	0.76	0.87	0.65	0.75	0.76	0.74
	(0.44)	(0.49)	(0.44)	(0.40)	(0.47)	(0.42)	(0.43)	(0.33)	(0.48)	(0.43)	(0.42)	(0.44)
Trust	0.35	0.28	0.29	0.40	0.28	0.51	0.30	0.43	0.23	0.32	0.28	0.25
	(0.48)	(0.45)	(0.45)	(0.49)	(0.45)	(0.50)	(0.46)	(0.49)	(0.42)	(0.47)	(0.45)	(0.43)
Active Participation[b]	0.48	0.44	0.53	0.53	0.33	0.59	n.a	n.a	n.a	n.a	n.a	n.a
	(0.50)	(0.50)	(0.50)	(0.50)	(0.47)	(0.49)						
Energy experience	0.16	0.18	0.22	0.16	0.15	0.09	0.11	0.10	0.13	0.11	0.08	0.15
	(0.36)	(0.38)	(0.41)	(0.36)	(0.36)	(0.28)	(0.32)	(0.30)	(0.34)	(0.31)	(0.28)	(0.35)
Risk averse	0.67	0.74	0.66	0.61	0.63	0.72	0.69	0.62	0.80	0.69	0.66	0.72
	(0.47)	(0.44)	(0.48)	(0.49)	(0.48)	(0.45)	(0.46)	(0.49)	(0.40)	(0.46)	(0.47)	(0.45)

[a] Age is the actual age; Male is the percentage of male respondents; Income is the self-reported income level; Tertiary education is a dummy variable representing whether the respondents have completed tertiary education. Climate Change is a dummy variable representing self-perceived seriousness of climate change (=1 if respondents chose "very serious" or extremely serious" on a 5-point Likert-scale question), and equals to 0 otherwise; Trust is a dummy variable representing self-perceived trustworthiness of the carbon reduction claim by the energy organisations, which equals to 1 if respondents stated "4″ or "5″ on a 5-point Likert scale question (from 1 = "don't trust at all" to 5 = "fully trust"), and equals to 0 otherwise; Active Participation a dummy variable representing respondents' perception of the importance of actively participating in cooperatives' main decisions in securing their investment in energy cooperatives (=1 if respondents chose "very important" or "extremely important" on a 5-point Likert-scale question, and = 0 otherwise); Energy Experience is a dummy variable representing self-reported prior experience in participating in energy organisations (e.g., energy cooperatives); Risk Averse is a dummy variable representing individual risk attitude elicited using a general survey question.

[b] Active participation is only relevant for the Cooperative Model and thus measured only in the Cooperative survey.

[c] Those who chose "prefer not to answer" were excluded from analysis, which only account for a small proportion.

innovative business approaches are appealing to respondents. This is consistent with findings from Rommel et al. [35] (using a sample of about 2000 German respondents) that electricity provided by co-operatives is preferred over private by energy consumers.

As for the attribute effects (parameter means), we observe highly significant effects for the annual return attribute in both business models in the expected direction, and the resulting mean estimates of this (lognormally distributed) attribute suggest that respondents prefer higher financial return. Individuals also prefer solar rather than wind technology for renewable projects. We find that individuals for the Cooperative sample prefer higher levels of carbon reduction (with larger land cover), yet the utility gain is not commensurate with the amount of carbon reduction (the increase of land size) – diminishing marginal utility is observed when the level of carbon reduction (project size) increases. A similar pattern is witnessed for individuals in the crowd-funding scenarios, except that they do not show a higher preference for 600 t of carbon reduction (project size equivalent to a football pitch) compared with 150 t of carbon reduction (project size equivalent to 1/4 football pitch).

We observe that respondents do not show preferences for a within-region or within-country project compared with a local project, yet they oppose building renewable projects outside their countries, which is consistent with Kalkbrenner et al. [31] using a sample of 953 German respondents, implying that citizens hold a "patriotic" attitude towards energy generation. We find that respondents in both business models dislike a higher amount of minimum investment. For the Cooperative Model, respondents dislike a 5-year lock-in period as an investment requirement but are indifferent to a short duration (1 year or 2 years), compared with no minimum duration requirement. A similar pattern is observed for the Crowdfunder Model where a longer investment duration is assumed. We find that individuals are insensitive to a medium-term 5-year or 10-year contract compared with a short-term contract (1-year), yet oppose a long-term contract (20 years or 25 years).

For the participation attribute, which is a unique feature of energy cooperatives, respondents do not obtain significant utility from the presence of meetings organised by energy cooperatives with opportunities to be involved in the decision making of cooperatives' important affairs. For the Crowdfunder Model, the results show that respondents do not demonstrate significant differential preferences between community organisations and local councils as issuers of climate bonds, but dislike lending to a private company.

Tables 5a and 5b show the country-specific results, in which cross-country differences in preference estimates are observed for several attributes. First, solar is preferred over wind projects only for Spain, Sweden, Portugal, Ireland and the UK; respondents in other surveyed countries are indifferent between the two renewable technologies. Second, there are distinctive patterns across different countries in terms of the carbon reduction and project size attribute. Preference estimates for the Spanish respondents increase monotonically, implying that a higher level of carbon reduction (larger project size) is always preferred, whilst respondents from the other four countries generally do not show higher preferences for increased levels of carbon reduction (larger project size). The cross-country differences are also observed for the Crowdfunder Model, where the pattern of preference estimates for the Croatian and Italian respondents is monotonic, whilst individuals from the other three surveyed countries are not. Thirdly, German, Swedish and UK respondents are not against building energy projects outside their countries, whilst survey participants in most other countries oppose this scenario. Fourth, we find that individuals' attitudes towards investment requirements are moderately different across countries. For example, individuals from Portugal and Italy are indifferent to a 20-year and a 25-year investment contract, yet those from the other countries are opposed to a lengthy agreement such as this. Lastly, although respondents from all other countries are not particularly interested in

Table 4
Result from the mixed logit model for the pooled cooperative sample and crowdfunder sample.

Variables	Cooperative		Crowdfunder	
	Mean	SD [d]	Mean	SD [d]
Constant	−2.315*** (0.111)	***	−3.405	***
Annual return [a]	0.279*** (0.029)	***	0.200*** (0.015)	***
Wind project	−0.328*** (0.048)	***	−0.186*** (0.044)	***
600 t (1 fp)	0.247*** (0.069)		0.013 (0.071)	***
3000 t (5 fp)	0.249*** (0.074)	***	0.222*** (0.064)	
6000 t (10 fp)	0.321*** (0.07)	***	0.153* (0.08)	
12,000 t (20 fp)	0.490*** (0.082)	***	0.402*** (0.08)	***
Within region	0.062 (0.06)		0.059 (0.061)	*
Within country	0.082 (0.062)		0.003 (0.057)	
Outside country	−0.447*** (0.067)	***	−0.394*** (0.067)	***
Additional Attributes for the Cooperative Model				
Minimum investment [c]	−0.202*** (0.019)			
Minimum term (1 year)	−0.018 (0.058)			
Minimum term (2 years)	0.082 (0.058)			
Minimum term (5 years)	−0.19*** (0.062)	*		
Quarterly meetings	0.036 (0.053)			
Annual meetings	0.027 (0.049)	***		
Additional Attributes for the Crowdfunder Model				
Minimum investment [b]			−0.479*** (0.067)	***
Minimum term (5 years)			0.063 (0.065)	***
Minimum term (10 years)			0.068 (0.069)	
Minimum term (20 years)			−0.285*** (0.067)	*
Minimum term (25 years)			−0.293*** (0.073)	***
Community organisation			−0.078 (0.047)	**
Private company			−0.186*** (0.05)	***
Model statistics				
BIC	13,476		13,056	
Log-likelihood	−6594		−6376	
No. respondents[e]	991		971	
No. of countries	5		5	

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
[a] Annual return is log-normally distributed.
[b] "t" here means tonnes and "fp" means football pitch(es).
[c] Minimum investment is treated as linear and rescaled by 0.001.
[d] Estimated parameters for the standard deviations are abbreviated and represented by stars of significance levels due to limited space. Full results are presented in Table A.2 in the appendix.
[e] The model estimation excluded those who constantly chose "Project A" or "Project B" throughout the experiment.

participating in annual meetings organised by energy cooperatives, Spanish respondents value those meetings. For the Crowdfunder Model, we observe that UK, Croatian and Italian respondents do not distinguish between private companies or local councils as climate bond issuers, but local councils are significantly more preferred by those from the other two countries.

Segmentation analysis is conducted to further explore observed preference heterogeneity across socio-demographic groups and groups with different attitudes and prior experience towards energy cooperatives. The key results of the analysis are presented in Table A.4a and Table A.4b in the appendix for the Cooperative Model and Crowdfunder Model, respectively. We notice the existence of preference heterogeneity for several attributes across socio-demographic groups and report the key findings here:

- Males and those with higher income are more likely to be interested in economic returns for the Cooperative Model, yet this is not observed for the Crowdfunder sample. Females have higher preferences for community organisations over local councils as climate bond issuers.
- Older respondents seem to dislike higher levels of carbon reduction (or bigger projects with more land cover) and, in the case of energy crowdfunding, long investment contracts. Age is also a predictor for individual preference for the project location, with older respondents being more willing to retain the energy projects in their local areas rather than elsewhere.
- As for the attitudinal variables, those who consider climate change as a serious issue unsurprisingly prefer a higher level of carbon reduction.
- Risk-averse individuals dislike higher annual returns and prefer local councils rather than community organisations as bond issuers for the Crowdfunder Model.
- Those with prior experience in participating in energy organisations are less averse to higher minimum investment requirements for projects under cooperative governance, but this is not observed for the Crowdfunder Model. In addition, the correlation between prior experience and preference for participatory meetings is not observed.
- Organisational trust explains preference heterogeneity for several attributes for both business models. For example, those who trust the organisations' carbon reduction claims show a higher preference for carbon reduction and are more tolerant for the projects to be built in non-local areas (i.e., within or outside the country). For the Crowdfunder Model, trust positively influences the acceptance of community organisations or private companies as green bond issuers compared with local councils.

5.2.2. *Willingness-to-accept estimation*

To summarise this section, we quantify to what extent individuals are willing to sacrifice financial returns (willingness-to-accept (WTA)) for non-financial attribute improvements. The results in Fig. 2 suggest that respondents place high values on CO_2 reduction (land size), solar technology, and express a high willingness to avoid projects being built outside their countries for the Cooperative Model. For example, respondents would be willing to sacrifice 1.7 percentage points (PPs) of annual return for projects with carbon reductions of 12,000 t instead of 500 t (and a corresponding increase in project size from a quarter football pitch to 20 football pitches equivalent). Furthermore, individuals would need to be compensated 1.1 PPs for wind projects (relative to solar).

For the Crowdfunder Model, we observe similar patterns for the attributes that are common between the two business models, except that the minimum amount of investment is valued as more important for (0.7 PPs vs 2.4 PPs). In terms of the term-money trade-off, individuals would sacrifice as much as 1.4 PPs in order to avoid a long-term contract (e.g., 20 years). Respondents are willing to forgo a 0.9 PPs for climate bonds

Table 5a
Country-specific results of the mixed logit models (Cooperative Model).

Variables	Germany		France		Spain		Sweden		Poland	
	Mean	SD [d]	Mean	SD [d]	Mean	SD [d]	Mean	SD [d]	Mean	SD [d]
Constant	−1.446***	***	−1.214***	***	−1.214***	***	−2.260***	***	−3.047***	***
	(0.370)		(0.364)		(0.364)		(0.369)		(0.382)	
Annual return [a]	0.349***	***	0.352**		0.300***		0.214***		0.324*	
	(0.053)		(0.144)		(0.115)		(0.048)		(0.193)	
Wind project	−0.383***	***	−0.437***	***	−0.184	***	−0.185*	***	−0.537***	***
	(0.115)		(0.115)		(0.114)		(0.111)		(0.127)	
600 t (1 fp) [b]	0.189		0.379**		0.240		−0.059		0.603***	
	(0.162)		(0.173)		(0.171)		(0.156)		(0.182)	
3000 t (5 fp) [b]	0.074	*	0.268	***	0.513***	***	−0.107		0.574***	
	(0.175)		(0.199)		(0.193)		(0.168)		(0.183)	
6000 t (10 fp) [b]	0.202	**	0.313*	***	0.783***	***	0.035	***	0.366**	***
	(0.168)		(0.182)		(0.172)		(0.162)		(0.175)	
12,000 t (20 fp) [b]	0.135	**	0.561***	***	0.953***	***	0.275	***	0.662***	***
	(0.187)		(0.200)		(0.208)		(0.189)		(0.211)	
Within region	0.090		0.145	*	0.077	*	0.236*		−0.200	
	(0.145)		(0.156)		(0.152)		(0.138)		(0.144)	
Within country	−0.02		0.216		0.145		0.247*		−0.041	
	(0.149)		(0.157)		(0.162)		(0.148)		(0.147)	
Outside country	−0.277*	**	−0.485***	***	−0.710***	***	−0.236	***	−0.736***	***
	(0.154)		(0.169)		(0.179)		(0.153)		(0.169)	
Minimum amount [c]	−0.228***	***	−0.189***	***	−0.258***	***	−0.269***	***	−0.174***	***
	(0.046)		(0.045)		(0.059)		(0.051)		(0.042)	
Minimum term (1 year)	−0.216		0.040		0.193		−0.177		0.121	*
	(0.140)		(0.144)		(0.147)		(0.130)		(0.141)	
Minimum term (2 years)	0.124		0.152		0.223		−0.046		0.082	
	(0.140)		(0.152)		(0.146)		(0.132)		(0.139)	
Minimum term (5 years)	−0.396***		−0.257	**	−0.063	**	−0.310**		−0.013	*
	(0.147)		(0.165)		(0.150)		(0.143)		(0.154)	
Quarterly meetings	−0.019		−0.059		0.197		0.058		−0.025	
	(0.126)		(0.131)		(0.132)		(0.122)		(0.128)	
Annual meetings	−0.113	**	−0.211	***	0.343***	***	0.026	**	0.101	***
	(0.119)		(0.129)		(0.124)		(0.112)		(0.122)	
Model statistics										
BIC	2799		2910		2708		3003		2732	
Log-likelihood	−1282		−1337		−1236		−1383		−1248	
No. respondents	192		199		196		205		199	

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
[a] Annual return is log-normally distributed.
[b] "t" here means tonnes and "fp" means football pitch(es).
[c] Minimum investment is treated as linear and rescaled by 0.001.
[d] Estimated parameters for the standard deviations are abbreviated and represented by stars of significance levels due to limited space. Full results are presented in Table A.3a in the appendix.

issued by local councils instead of private companies.

6. Discussion and conclusions

Given the climate emergency and its potentially catastrophic effects on human health and on the global economy, a fundamental energy transition is urgently needed and can only be achieved through multi-dimensional participation, including from citizens. Energy projects crowdfunded or co-owned by citizens are increasingly popular in some European countries with the aim of scaling up renewable energy production. Unlike large and private energy providers, energy initiatives reflect a bottom-up business model and emphasise the power of citizens in achieving climate neutrality. Although a few studies have investigated EU citizens' attitudes towards how renewable projects are organised, the investigation is predominantly focused on the German population. Given that the development of RE and energy initiatives varies greatly across European countries, it is less clear whether Germany's successful experience in promoting community-based energy initiatives can be replicated in other European countries.

We expand the investigation of citizens' attitudes towards energy initiatives to multiple European countries and explore their preferences for characteristics of energy projects operated by cooperatives or crowdfunded by citizen investment using discrete choice experiments. Our pooled results indicate that EU citizens are willing to invest in renewable projects through crowdfunding platforms or operated by energy cooperatives, and the investment intentions are motivated by both financial returns and environmental concerns. Whilst direct comparisons are challenging due to differences in methodologies and sample sizes, the results presented here vary from those conducted among the German population. For example, we do not find significant preferences for project proximity, if it is built within one's country, whilst Sagebiel et al. [6] (with a sample of 287 German respondents) and Salm et al. [29] (with a sample of 1041 German respondents) found a significant preference for local-level, compared with national-level energy generation. For the Cooperative Model, our results suggest that individuals are overall less interested in the participatory opportunities provided by energy cooperatives, yet this is contradictory to the findings in Sagebiel et al. [6] and Knoefel et al. [32] (with a sample of 1858 German respondents) in which respondents from the general public value the opportunity to participate in the decision making of community-based energy cooperatives. In addition, our country-level results suggest the existence of a moderate-level cross-country heterogeneity in individuals' preferences for several characteristics of energy initiatives for example, the level of carbon reduction and project size, investment requirements, and open participation (for the Cooperative Model) and type of bond issuers (for the Crowdfunder Model). These results imply that citizens'

Table 5b
Country-specific results of the mixed logit models (Crowdfunder Model).

Variables	Portugal		UK		Ireland		Croatia		Italy	
	Mean	SD [d]	Mean	SD [d]	Mean	SD [d]	Mean	SD [d]	Mean	SD [d]
Constant	−5.049***	***	−1.749***	***	−2.578***	***	−4.776***	***	−3.159***	***
	(1.060)		(0.416)		(0.445)		(0.661)		(0.440)	
Annual return [a]	0.380***	**	0.240***	**	0.189***	*	0.143***	***	0.171***	***
	(0.073)		(0.043)		(0.052)		(0.022)		(0.030)	
Wind project	−0.245*	***	−0.105	***	0.056	***	−0.432***	***	−0.342***	***
	(0.135)		(0.125)		(0.095)		(0.094)		(0.107)	
600 t (1 fp) [b]	0.137	***	−0.092	***	0.053	**	−0.048		0.035	**
	(0.215)		(0.201)		(0.165)		(0.147)		(0.162)	
3000 t (5 fp) [b]	0.113		−0.043		0.510***		0.285**		0.228	
	(0.183)		(0.176)		(0.148)		(0.141)		(0.142)	
6000 t (10 fp) [b]	0.095		−0.187		0.141		0.373**	**	0.247	
	(0.231)		(0.219)		(0.188)		(0.180)		(0.180)	
12,000 t (20 fp) [b]	0.455**	***	0.092	***	0.553***	***	0.548***	***	0.414**	***
	(0.231)		(0.229)		(0.188)		(0.177)		(0.176)	
Within region	0.225		0.062		0.000		0.046	***	−0.001	
	(0.17)		(0.177)		(0.136)		(0.139)		(0.139)	
Within country	0.207		−0.134		−0.011		−0.069		0.029	
	(0.162)		(0.169)		(0.132)		(0.123)		(0.129)	
Outside country	−0.689***	***	−0.169		−0.274**		−0.638***	***	−0.401***	*
	(0.212)		(0.184)		(0.138)		(0.151)		(0.148)	
Minimum investment [c]	−0.782***	**	−1.011***	***	−0.073	**	−0.401***		−0.678***	*
	(0.208)		(0.226)		(0.144)		(0.139)		(0.153)	
Minimum term	0.028		0.062		0.314**		−0.004	**	−0.025	
(5 years)	(0.183)		(0.181)		(0.143)		(0.143)		(0.143)	
Minimum term	0.501**	**	0.070	***	−0.039	**	0.009		−0.017	
(10 years)	(0.203)		(0.194)		(0.163)		(0.151)		(0.154)	
Minimum term	0.070		−0.602***	***	−0.422***		−0.398***	*	−0.291*	*
(20 years)	(0.183)		(0.203)		(0.158)		(0.154)		(0.152)	
Minimum term	−0.100	***	−0.683***	***	−0.350**	**	−0.267*		−0.312*	***
(25 years)	(0.223)		(0.222)		(0.167)		(0.154)		(0.167)	
Community organisation	−0.120		0.040		−0.229*	**	−0.020		−0.065	**
	(0.136)		(0.133)		(0.121)		(0.104)		(0.111)	
Private company	−0.347**	***	−0.127	***	−0.412***	***	−0.154		−0.070	
	(0.152)		(0.148)		(0.13)		(0.103)		(0.107)	
Model statistics										
BIC	2556		2763		2845		2776		2810	
Log-likelihood	−1153		−1257		−1297		−1262		−1280	
No. respondents	196		187		194		201		193	

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
[a] Annual return is log-normally distributed.
[b] "t" here means tonnes and "fp" means football pitch(es).
[c] Minimum investment is treated as linear and rescaled by 0.001.
[d] Estimated parameters for the standard deviations are abbreviated and represented by stars of significance levels due to limited space. Full results are presented in Table A.3b in the appendix.

views towards energy initiatives in one country might not be externally valid in all European countries, and research should be conducted on a case-by-case basis. However, we acknowledge that caution needs to be taken regarding the interpretation of our results, as our sample size is relatively small at the country level.

Open participation is a distinctive feature of energy cooperatives, but our DCE findings suggest that it is generally not valued by respondents. Several studies find that customers in small cooperatives are more participative, whilst individuals in large cooperatives, such as Greenpeace Energy, are less involved [26,66]. Business operation in large cooperatives is mostly managed by professional managers, which is arguably more efficient from a corporate perspective, yet the decision-making process is less likely to reflect direct democracy, as advocated in energy cooperatives [26]. Some personal reasons such as lack of time can also contribute to the reluctance to participate [67]. Limited engagement (either due to citizens' low willingness to attend or inaccessibility to cooperatives' services) deviate from the participatory characteristic of community-based RE and provide inadequate social benefits, making it merely a financial investment. In our scenario description, the opportunity to influence the decision making of the invested cooperative is substantiated, and we find that respondents who consider decision making as an important component to secure investment are more likely to state that they would participate in meetings organised by energy cooperatives. Although the dimension of democratic control is included in our experiment, an interesting avenue for future research is to explicitly state other individual and social benefits of open participation, for example, opportunities to participate in educational and communicative activities, round tables and seminars on residential energy use, and assemblies for collective action on climate change.

For both the Cooperative Model and Crowdfunder Model, we find that individuals generally prefer more CO_2 reduction from renewable projects, yet the marginal utility obtained from a higher level of carbon reduction is decreasing. Recall that the amount of carbon reduction is proportional to the land size of the project in our context, and therefore one possible explanation could be that large-scale energy projects (with the ability to reduce a large amount of carbon emission) contradict the notion of decentralised energy provision committed by energy initiatives (especially true for grassroots companies), making the governing body of the projects less distinctive from large private generators. Second, as the one-member-one-vote approach is commonly applied in energy cooperatives, the presence of the large number of owners dilutes

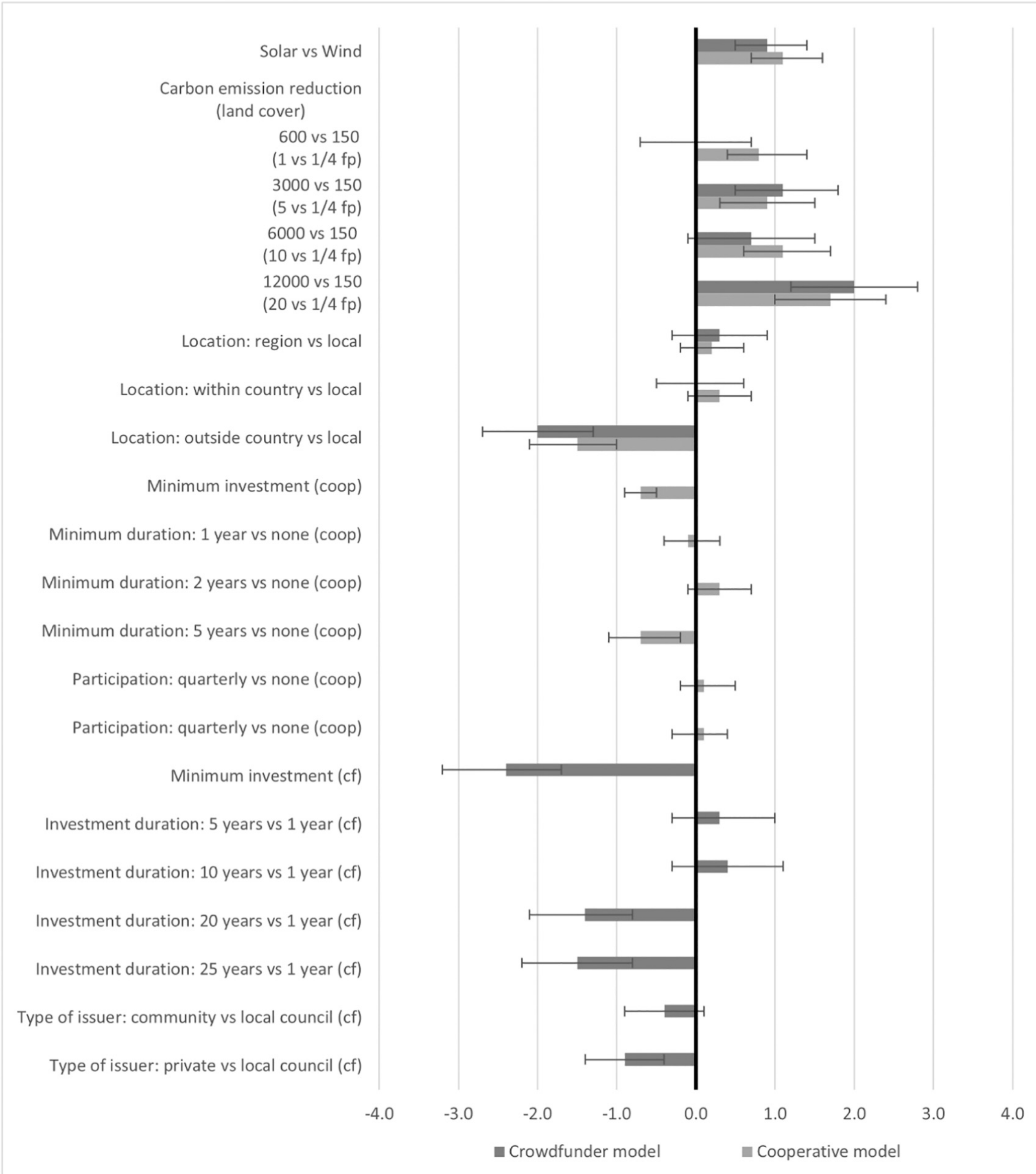

Fig. 2. Mean WTA values for the Cooperative and Crowdfunder sample. The panel on the left represents the characteristics of a typical energy cooperative or a crowdfunded project. The bar represents the extent to which a level is preferred over the reference level of the attribute. The larger the bars on the positive domain (on the negative domain), the more respondents value (dislike) the alternative level relative to the reference level.
Note: "fp" refers to football pitch; "coop" refers to attributes for the Cooperative Model and "cf" refers to attributes for the Crowdfunder Model. All the WTA estimates are presented in percentage of annual return. 95% confidence is calculated using Krinsky and Robb [65]'s approach.

the decision rights of each individual, driving organisations' decision-making process to be less democratic [6]. In addition, individuals may devalue large wind projects for the potential adverse effects they can perceive, such as, deterioration of biodiversity and visual impacts [68]. Lastly, the concave utility function may simply be a result of scope insensitivity, a common finding in environmental studies using stated preference methods [69–71]. Despite the realistic assumption of a combined effect of project size and its corresponding capacity in carbon reduction in our study, future research could disentangle the effect of project size from the combined effect by applying a split-sample design with individuals in the new sample being presented with a carbon-reduction-only or project-size-only choice cards.

Like all quantitative studies using stated preference methods, our study is not exempt from hypothetical bias [72,73], implying that citizens may behave differently when it comes to investing in energy initiatives in real life. For example, individuals may perceive financial returns as more important compared with other attributes, resulting in lower willingness-to-trade with non-financial attributes in making real investment decisions. A cheap talk protocol has been included in our DCE scenario to remind respondents about their budget constraints with the aim of mitigating hypothetical bias [74]. To identify whether the hypothetical-real gap exists, one direction is to conduct a real-life DCE in which respondents are asked to put real money in the development of energy projects (see Michaud et al. [75] and Moser et al. [76] for examples from environmental and agricultural studies). Our sample is skewed towards more educated and wealthy people, which has also been found in other DCE studies [77,78]. One of the explanations is that this is a web-based DCE, and therefore respondents from the online panel need to be able to get access to the internet. Another possibility is respondents with a higher level of education are more interested in topics related to RE. One approach to reach more populations is to include a question asking respondents' general interests in investing in energy communities in a census or national survey. We also acknowledge the limited statistical power of our analysis at the country level due to the relatively low sample size. Low statistical power results in high Type II error, and hence lead to false detection of non-existent effects. Underpowered studies in social science are not uncommon. Ioannidis et al. [79] assessed 159 meta-analyses of empirical economics studies and found that in some areas, over 90% of the studies are identified as lack of statistical power. Although a thorough discussion of statistical power is beyond the scope of this study, systematic review and meta-analysis should be encouraged in social science subjects (as it has been done in medical science) to improve the credibility of their statistical inference.

In conclusion, the findings illustrated in this paper reiterate the potential of upscaling renewable provision through socially innovative business models in Europe. The results indicate that respondents are generally interested in investing in crowdfunded or co-owned renewable projects. In terms of the attributes, individuals show preferences for financial return, solar projects (rather than wind projects) and carbon emissions reduction, whilst having negative preferences for projects being built outside their countries and stringent investment requirements (such as minimum investment amount and minimum investment duration). We also find that these preferences are heterogeneous across different socio-demographic groups, those with different social attitudes and those in different surveyed countries. From a policy perspective, preference and willingness-to-trade estimates obtained from our quantitative analysis can be used to identify attributes that are important to potential investors, and therefore guide incumbent energy operators to improve their energy products and services and provide recommendations for future energy initiatives. For example, avoiding a high minimum investment amount and a long investment duration. Our results from segmentation analysis allow us to identify preference heterogeneity across different social groups (including age and environmental attitudes), and thus assist energy organisations to effectively target social groups for renewable investment and environmental awareness campaigns.

Data availability

The data that support the findings of this study are openly available in ResearchGate through the following DOI links:

Data

Cooperative DCE data: 10.13140/RG.2.2.11823.46245

Crowdfunder DCE data: 10.13140/RG.2.2.25245.23526

Codes

Table 4 (Cooperative Model) and Table 5a: 10.13140/RG.2.2.35311.56480

Table 4 (Crowdfunder Model) and Table 5b: code 10.13140/RG.2.2.10984.60161

Fig. 2 (codes for WTP estimation for the Cooperative Model): 10.13140/RG.2.2.24406.37442

Fig. 2 (codes for WTP estimation for the Crowdfunder Model): 10.13140/RG.2.2.17695.48808

Table A.4a: 10.13140/RG.2.2.17977.29284

Due to the requirements of our ethical approval, we are only able to share the discrete choice experiment data.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.erss.2022.102552.

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