Energy Research & Social Science

Scales of solar energy: Exploring citizen satisfaction, interest, and values in a comparison of regions in Portugal and Spain

--Manuscript Draft--

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	Miguel Brito, Ph.D
	Guilherme Luz, Master
Abstract:	Solar energy installations are transforming urban and rural landscapes, with diverse socioeconomic and environmental impacts on local populations. Social acceptance of solar energy has been found to change depending on the scale of the installations. Yet, the conditions that lead citizens to become actively engaged in different solar energy "size" projects are still underexplored. Drawing on both social acceptance and energy citizenship literature, this study focuses on two case study regions in Southern Europe (i.e., Alentejo in Portugal and Andalusia in Spain), where a multi-scale solar expansion is advancing, with significant investments in large centralized solar photovoltaic systems (i.e., >50MWp). The aim of the article is to explore how citizens perceive the importance of the energy transition and gain further insight into the conditions that make citizens most satisfied with, and interested in, actively participating in the development of solar energy projects. The study draws on a representative survey (n=832) collected in the two study regions and includes a vignette experiment. Statistical data analysis supports an understanding of the relational nature of social acceptance, which is suggested to be also applicable to energy citizenship, across different scales of solar energy production, from large and centralized to small-scale decentralized installations. The conclusions offer new findings on the intersection of social acceptance and energy citizenship research, as well as insights into energy policies related to solar energy expansion, useful for other regions and countries with comparable geographies in the Mediterranean and Southern Europe.
Suggested Reviewers:	Christian Klöckner, PhD Professor, Norwegian University of Science and Technology Department of Psychology christian.knockner@ntnu.no Klockner has been working in social and energy research for several years and has coordinated quantitative survey studies. Therefore, his knowledge is very much within the scope of the article.
	Lanka Horstink, PhD Post-doc researcher, University of Lisbon Institute of Social Sciences lanka.horstink@ics.ulisboa.pt Lanka has published on social and energy issues including survey data. She would make a good reviewer given the scope of the article.
	Frances Fahy, PhD Professor, National University of Ireland Galway frances.fahy@nuigalway.ie Frances Fahy has developed extensive research in energy and social science, with a focus on geography studies, including qualitative and quantitative approaches. Her

	review would be highly relevant for this study
	Adina Dumitru, PhD Researcher, University of A Coruna adina.dumitru@udc.es Adina has participated in numerous research projects that focused on social and energy transition aspects. She has also used quantiative and survey methods, which is relevant for this study.
	Julia Blash, PhD Professor, VU University Amsterdam Institute for Environmental Studies julia.blasch@vu.nl Julia Blasch is developing research into the social aspects of the energy transition, including quantiative research, which is relevant for this article
	Doris Fuch, PhD Professor, University of Münster Doris.Fuchs@uni-muenster.de Doris is developing research on the political aspects of the energy transition, including aspects related to citizens' perceptions. She has also used quantitiative methods and would be a important reviewer for this article.
Opposed Reviewers:	
Response to Reviewers:	The response to reviewers is given in an uploaded file (response to reviewers) (pasted below also) Ref.: Ms. No. ERSS-D-22-01201R1 - Scales of solar energy: Exploring citizen satisfaction, interest, and values in a comparison of regions in Portugal and Spain Response to comments from the Editors and Reviewers: Dear Reviewer#1, Thank you very much for the new suggestions and feedback and for taking the time to carefully read our article (twice!). We were very happy to learn you find the new version has improved. Below we reply to each of the new comments and how they are integrated in this reviewed version. #Reviewer questionsResponse to reviewer P2: what is it meant by "green-on-green"? This refers to Rodis et al (ref. 37) and the sentences in page 2 were now rephrased to further clarified what is meant. The revised sentence reads: “Specifically, Roddis and colleagues [37] named “green-on-green tensions” (p.239) as those emerging when concerns for mitigating climate change clashed with concerns over wildlife preservation, leading to opposition to renewable energy projects.” (page 2) P4: "indicating that Alentejo's solar expansion is still catching up to Andalusia's." The idea that a region might be 'catching up' to another seems to imply the existence of a linear chronology in technological development. I would suggest removing this sentence. Good point. The sentence was now removed. P5-7: I suggest deleting "Section X" from the title of each subsection. We deleted ‘section’ from the heading titles. P8: Stratified sampling: please include a short explanation of this procedure in a footnote. Here, we have actually inserted this explanation as part of the text – see first paragraph of part 3.4 (page 8), in which the stratified sampling process is more clearly explained. P19: What is meant by the "ease" parameter? Ease of use? Easy to maintain? “ease” refers to being easy to implement. This is now explained in brackets on page 19. P20: I suggest replacing 'reactionary' by 'reactive'. We have now replaced reactionary to reactive, it does work better.

	P22, ref 1: repeated title. This repeated title has been deleted Thank you!

Dear Editor,

Thank you very much for this second round of feedback, we are very happy that our work has paid off. Concerning the list of items in your email, we have reviewed carefully the abstract and the whole document, the reference style used is in the journals' numeric style (which we downloaded to Zotero). We have also reviewed and improved all the tables and figures and made sure older versions of the documents were deleted when submitting the revised versions. The figure colours were also edited to ensure they are adequate for colour blind readers.

We have followed up and integrated all the suggestions from reviewers.

We are very happy with the way the article as improved and hope it can be published at your journal.

If the article is accepted, we would like to also publish a "data in brief" and/or publish our datasets in a public repository.

We looking forward to receiving additional feedback.

Our kind regards,

The authors

Ref.: Ms. No. ERSS-D-22-01201R1 **- Scales of solar energy: Exploring citizen satisfaction, interest, and values in a comparison of regions in Portugal and Spain**

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Scales of solar energy: Exploring citizen satisfaction, interest, and values in a comparison of regions in Portugal and Spain

Abstract

Solar energy installations are transforming urban and rural landscapes, with diverse socioeconomic and environmental impacts on local populations. Social acceptance of solar energy has been found to change depending on the scale of the installations. Yet, the conditions that lead citizens to become actively engaged in different solar energy "size" projects are still underexplored. Drawing on both social acceptance and energy citizenship literature, this study focuses on two case study regions in Southern Europe (i.e., Alentejo in Portugal and Andalusia in Spain), where a multi-scale solar expansion is advancing, with significant investments in large centralized solar photovoltaic systems (i.e., >50MWp). The aim of the article is to explore how citizens perceive the importance of the energy transition and gain further insight into the conditions that make citizens most satisfied with, and interested in, actively participating in the development of solar energy projects. The study draws on a representative survey (n=832) collected in the two study regions and includes a vignette experiment. Statistical data analysis supports an understanding of the relational nature of social acceptance, which is suggested to be also applicable to energy citizenship, across different scales of solar energy production, from large and centralized to small-scale decentralized installations. The conclusions offer new findings on the intersection of social acceptance and energy citizenship research, as well as insights into energy policies related to solar energy expansion, useful for other regions and countries with comparable geographies in the Mediterranean and Southern Europe.

Keywords: Spain, Portugal, solar energy systems, quantitative studies, energy citizenship, social acceptance, scale

Scales of solar energy: Exploring citizen satisfaction, interest, and values in a comparison of regions in Portugal and Spain

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Acknowledgements

The authors acknowledge and thank the participation of all survey respondents in this study.

Figure 1 Click here to access/download;Figure;Figure 1.png

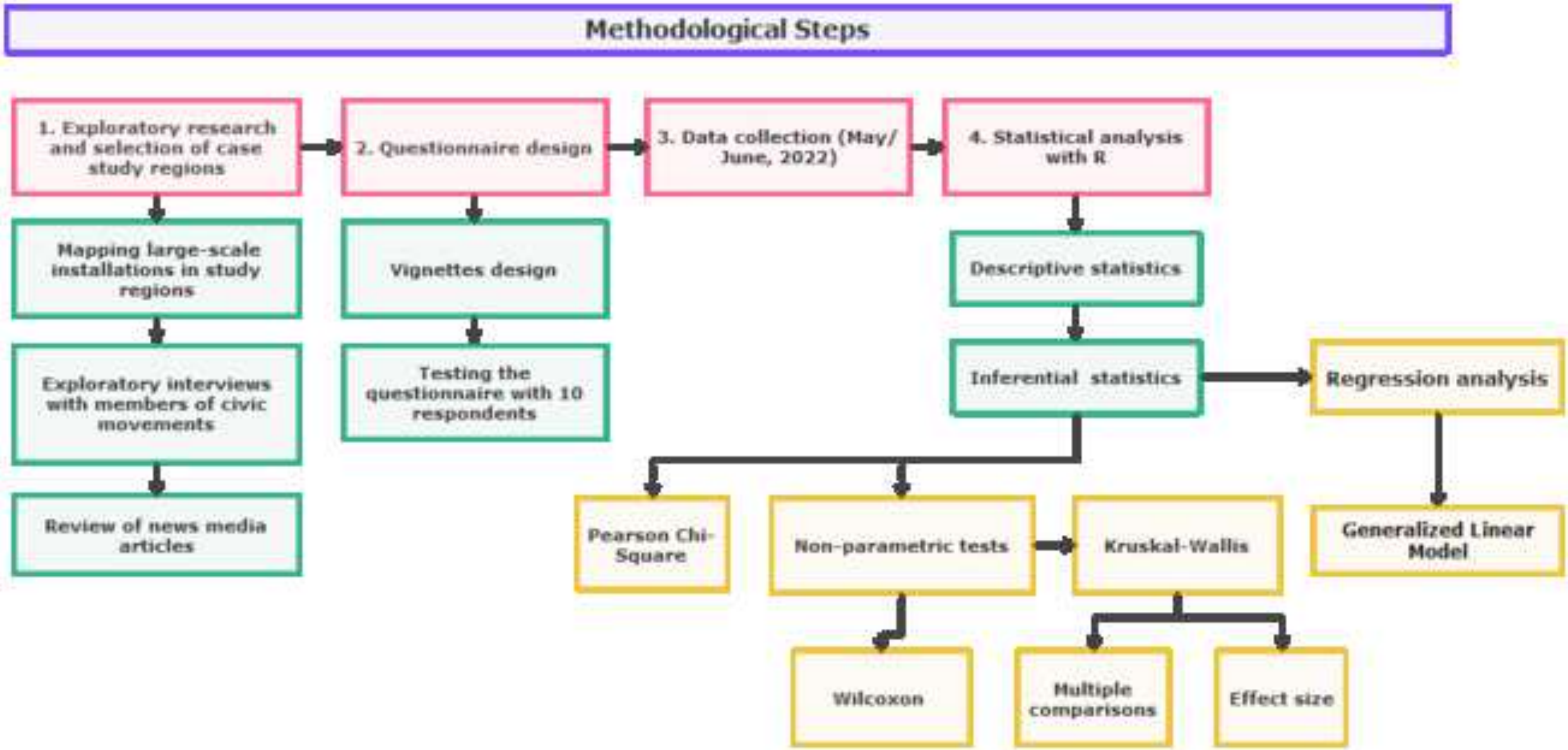


Figure 2

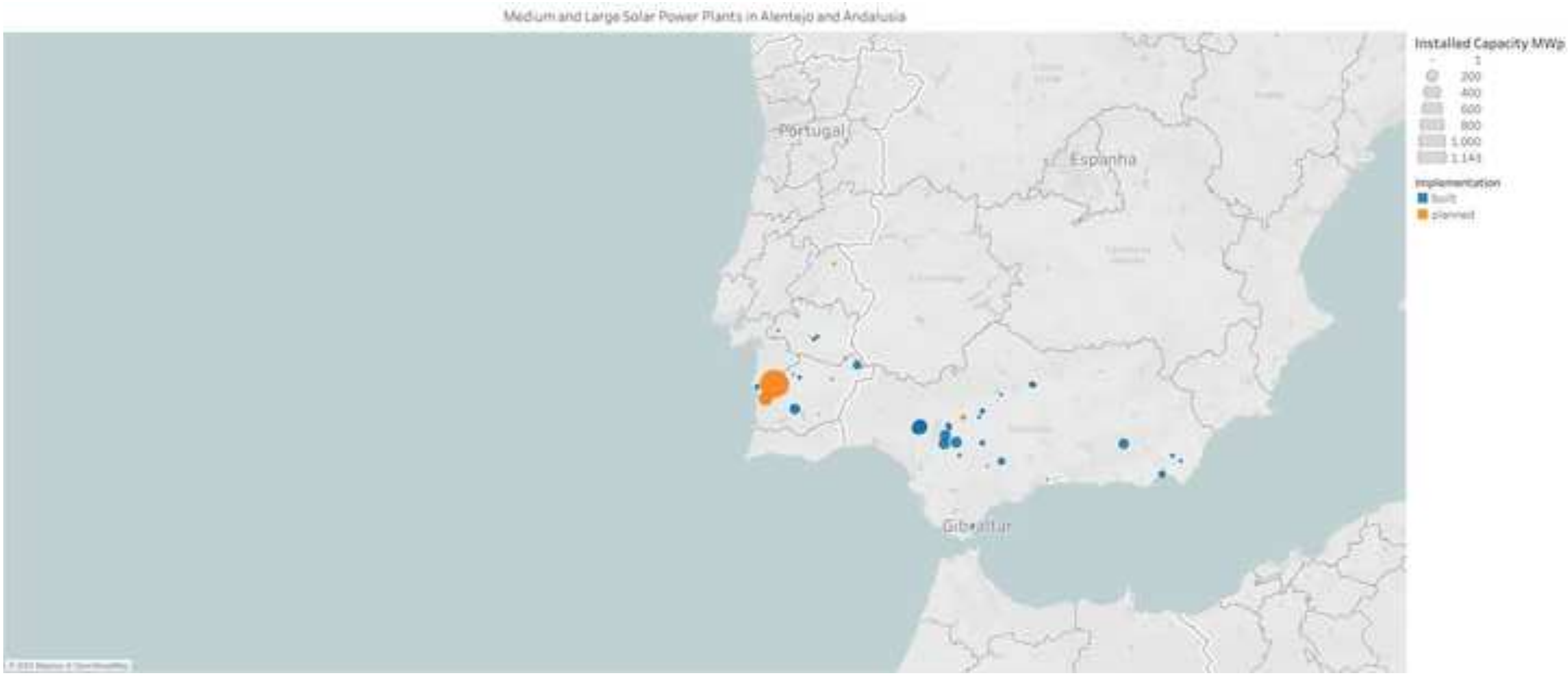

Medium and Large Solar Power Plants in Alentejo and Andalusia
Portugal
Espanha
Gibraltar
Installed Capacity MWp
1
200
400
600
800
1.000
1.141
Implementation
built
planned

Figure 3

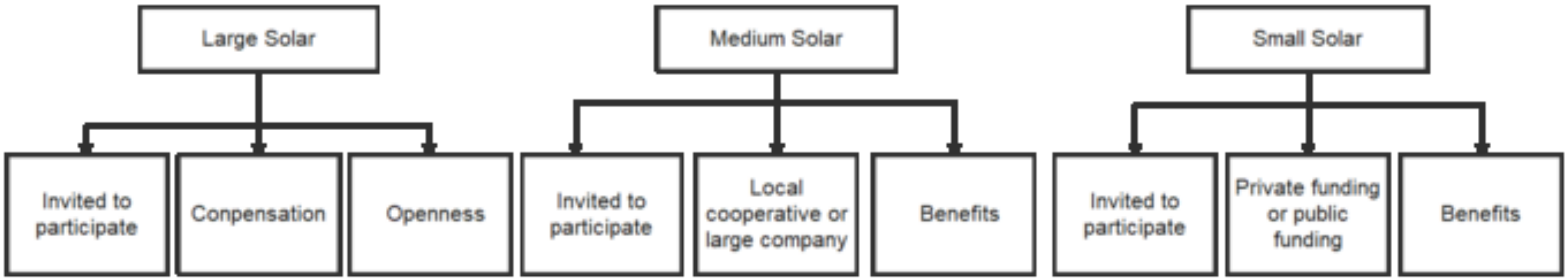

Large Solar
Medium Solar
Small Solar
Invited to participate
Conpensation
Openness
Invited to participate
Local cooperative or large company
Benefits
Invited to participate
Private funding or public funding
Benefits

Figure 4

Click here to access/download;Figure;Figure 4.png

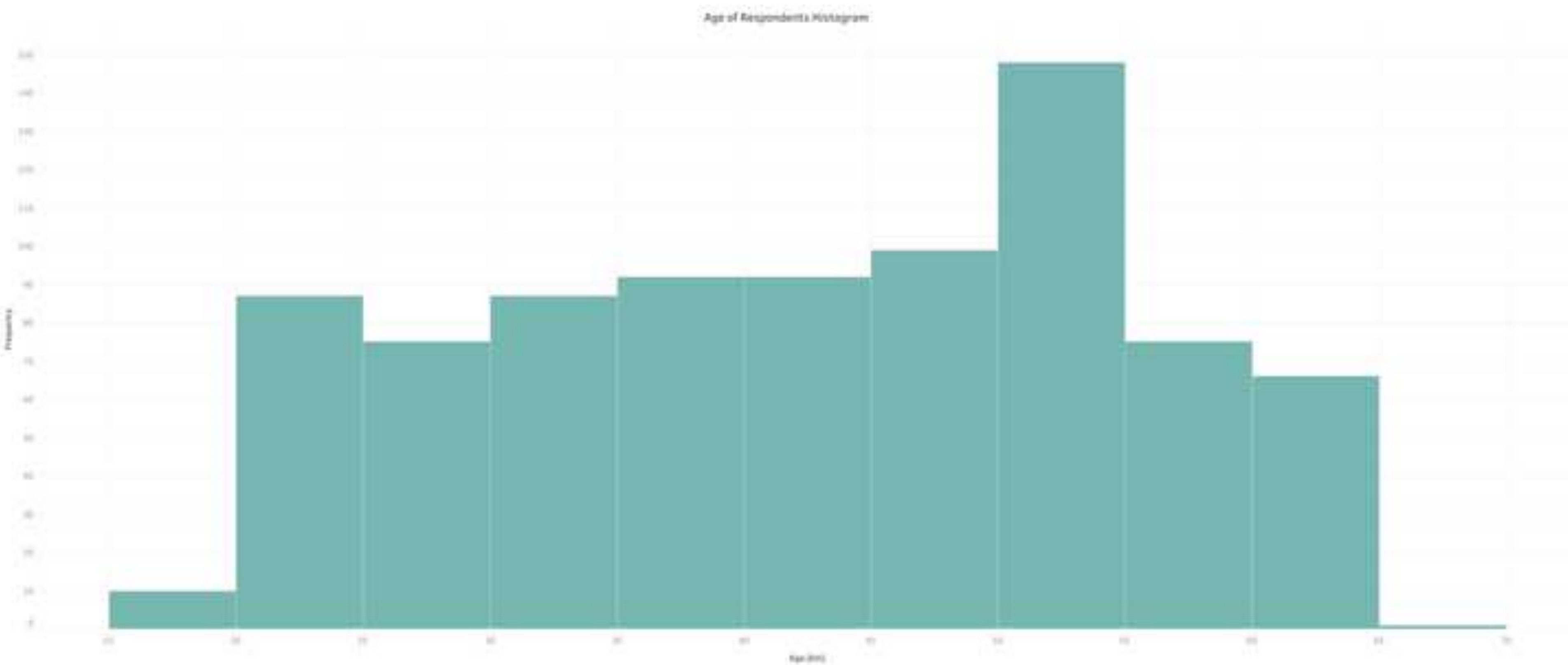


Figure 5

Click here to access/download;Figure;Figure 5.jpeg

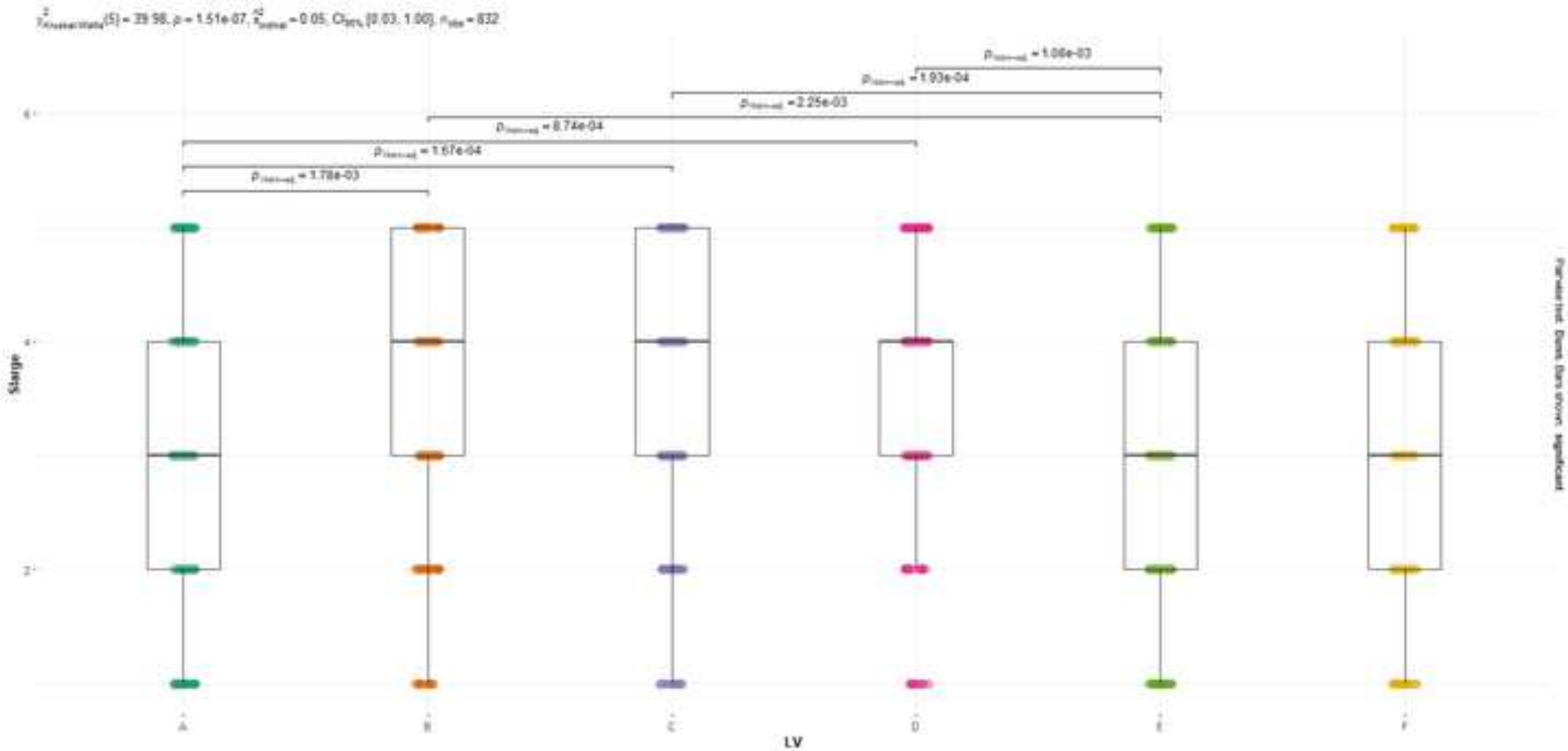


Figure 6 Click here to access/download;Figure;Figure 6.jpeg

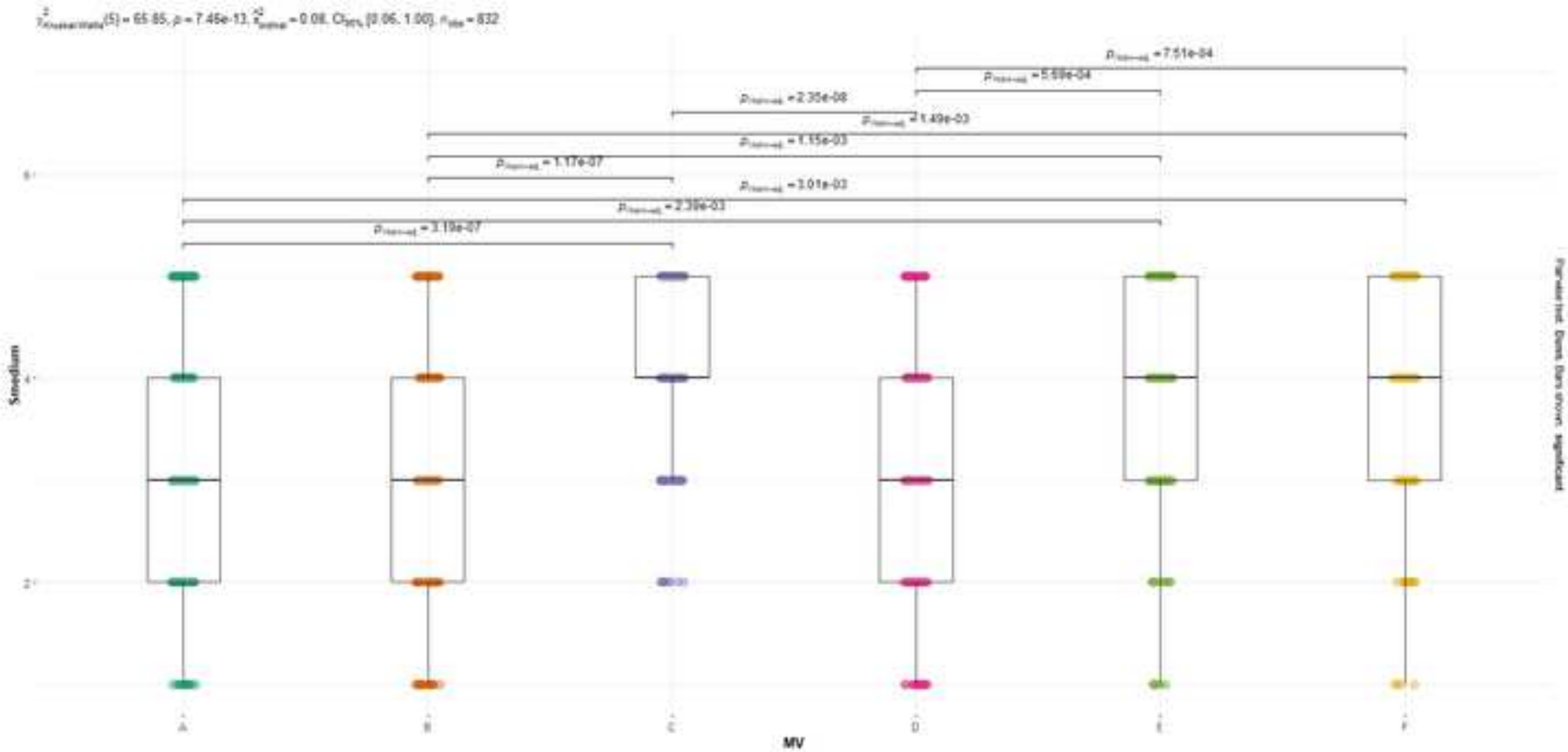


Figure 7

Click here to access/download;Figure;Figure 7.jpeg

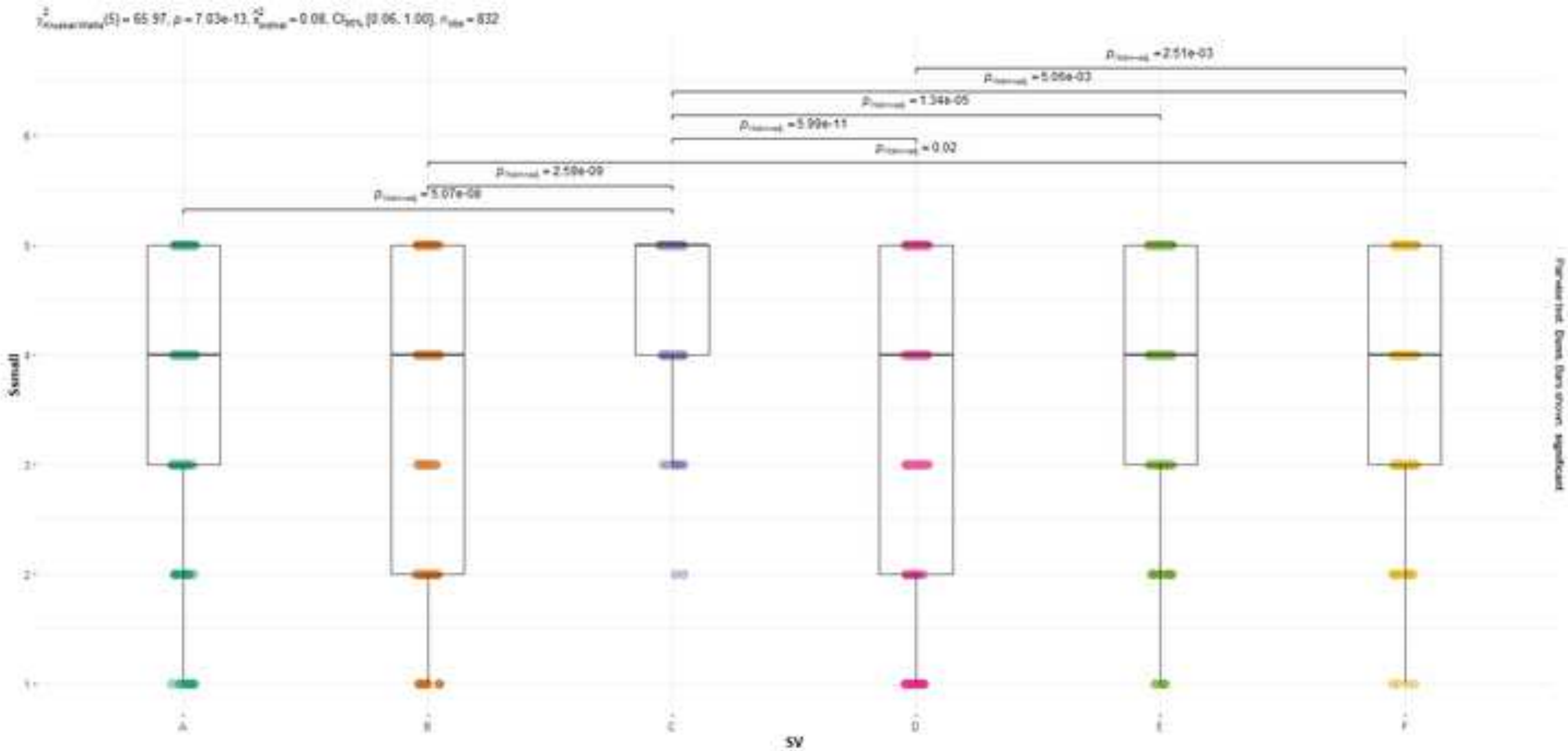


Figure 8

Click here to access/download;Figure;Figure 8V2.jpg

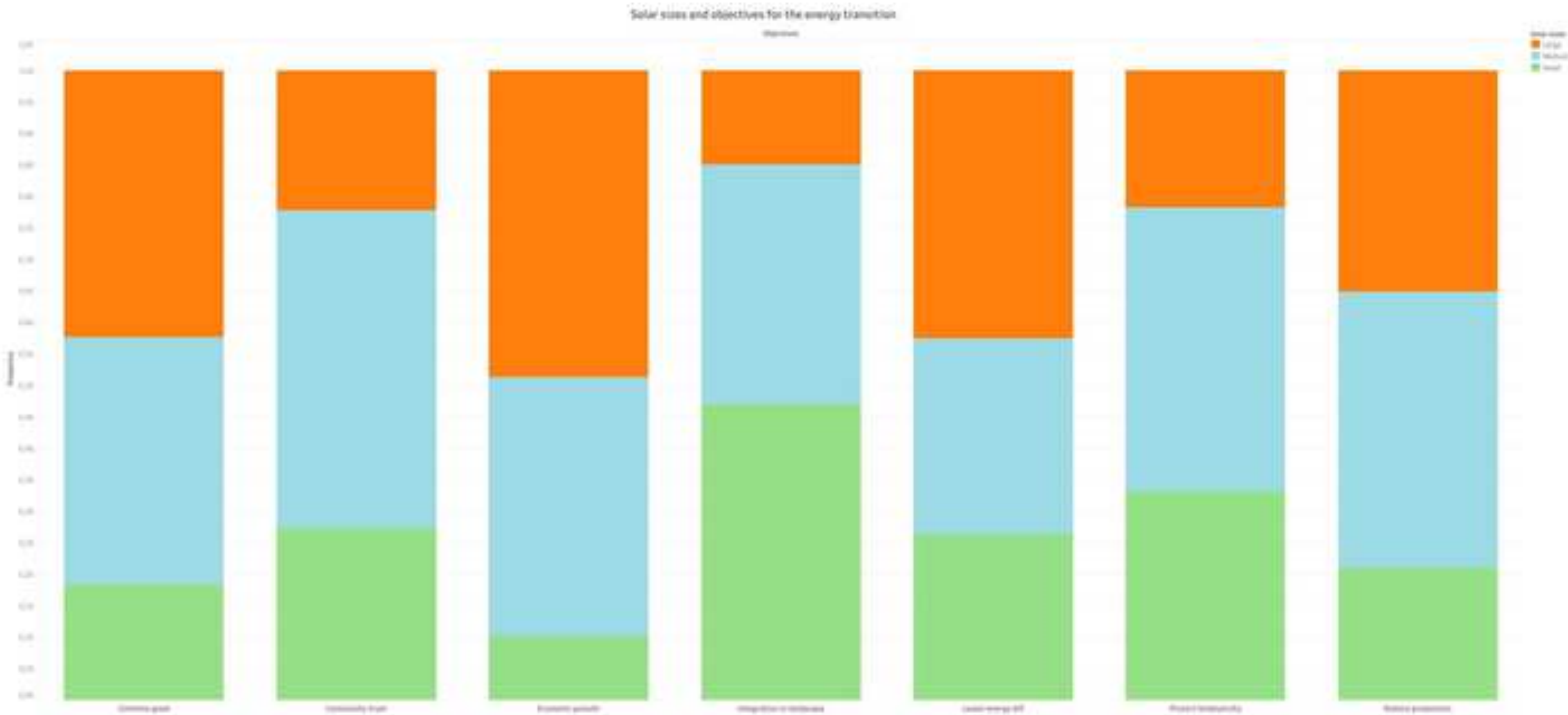
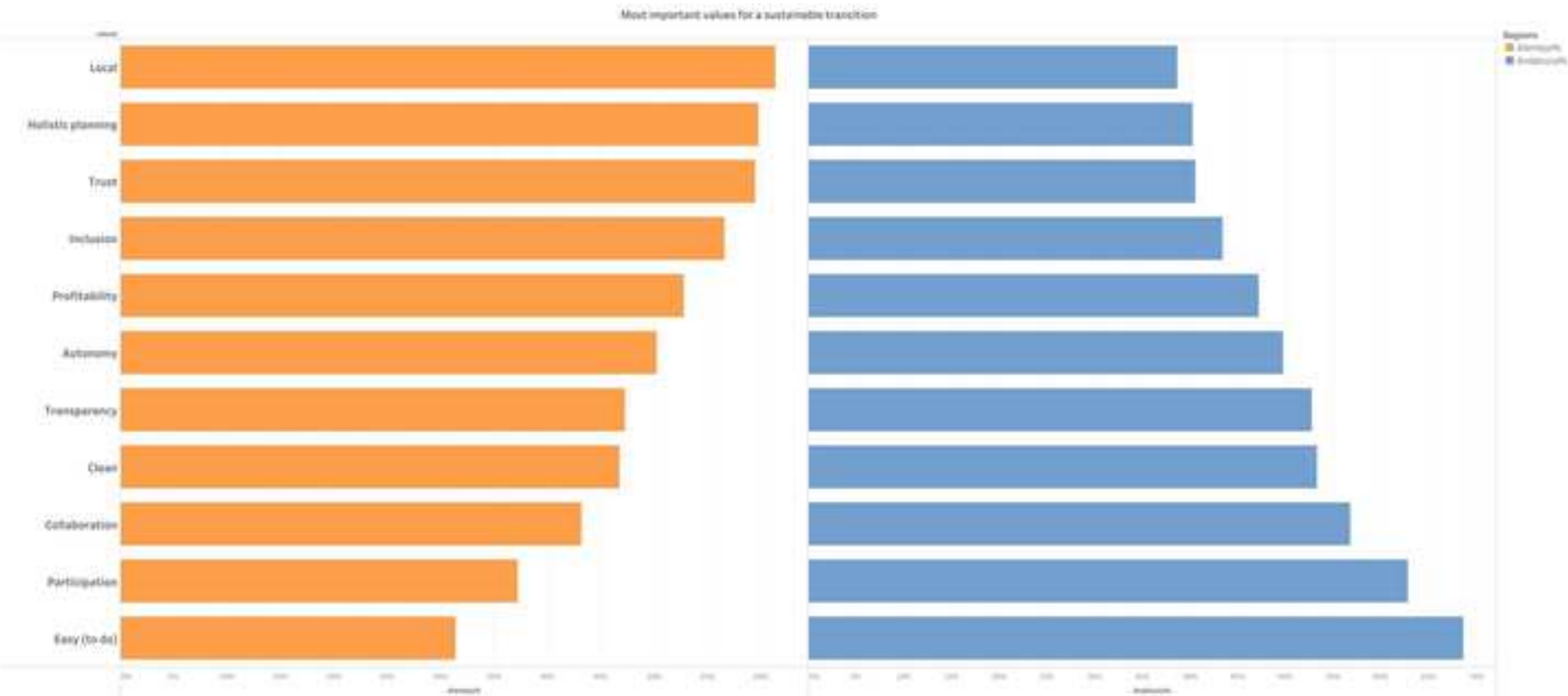


Figure 9

Click here to access/download;Figure;Figure 9V2.jpg



Vignette example (underlined parts correspond to the factors that varied between the vignettes).

"As you pass by a rural area near you, you see the new installation of solar panels, seemingly covering several kilometres. You know that the local community was <u>invited to participate</u> in the planning process of the solar park, which has been funded by a large utility company. Those who live nearby the installation <u>have not received</u> any sort of compensation for the impacts of the new installation on their livelihoods. The plans and land lease contracts were <u>not openly</u> shared with the community."
1. Would you be satisfied with a such a project? (Choose below the option that is most applicable to you) (1) Not satisfied, (2) poorly satisfied, (3) somewhat satisfied, (4) satisfied, (5) very satisfied.
2. If the possibility was presented to you, would you be interested in participating in such a project? (Choose below the option that is most applicable to you) (1) Not interested, (2) poorly interested, (3) somewhat interested, (4) interested, (5) very interested

Table 2

Vignette factors for each type of solar installation and sample size

Codes	**Large-scale solar installations**	**Sample size**
A1	invited to participate, no compensation, no openness	133
B1	invited to participate, compensation, no openness	127
C1	invited to participate, no compensation, openness	144
D1	not invited to participate, compensation, openness	142
E1	not invited to participate, no compensation, openness	164
F1	not invited to participate, compensation, no openness	122
Codes	**Vignettes for medium scale solar installations**	
A2	invited to participate, local cooperative, no benefit	148
B2	invited to participate, large company, no benefit	131
C2	invited to participate, large company, benefits	151
D2	not invited to participate, local cooperative, no benefit	144
E2	not invited to participate, local cooperative, benefits	124
F2	not invited to participate, large company, benefits	134
Codes	**Vignettes for small-scale solar installations**	
A3	invited to participate, private funding, no benefit	129
B3	invited to participate, public funding, no benefit	146
C3	invited to participate, private funding, benefits	132
D3	not invited to participate, public funding, no benefit	140
E3	not invited to participate, private funding, benefits	130
F3	not invited to participate, public funding, benefits	155

Stratified sampling design

Regions	Andalusia	Alentejo
Total	400	400
Male	194	196
Female	206	204
18-24	54	44
25-34	71	88
35-44	100	100
45-54	97	92
55-64	78	76

Frequency of responses on relation of respondents with energy industries

Energy Industry	**Works or is close to person who works in:**	
Fossil fuels	15	2%
Renewable energy	29	3%
Nuclear energy	5	1%
Not applicable	766	92%
Other	17	2%

Frequency of type of technology respondents would regularly see, hear or smell

Regularly see, hear or smell:	Frequency
Hydroelectric dam	28%
Wind turbines	30%
Coal station	8%
Solar Park (large)	39%
High tension cables	52%
Small scale solar	56%
Biomass treatment plant	8%
None	22%
Other	1%

Descriptive statistics of three variables on the importance of the transition

Regions	**Descriptive statistics**					
	T.1 Importance of the energy transition					
	Mean	Standard Deviation	Skewness	Kurtosis	Median	n
Alentejo	4.4	0.73	-1.570692	3.191331	5	411
Andalusia	4.2	0.97	-1.244209	1.077716	5	421
	T.2 Important that renewable energy systems ensure compatibility with the natural environment and biodiversity (i.e., they do not harm natural habitats)					
	Mean	Standard Deviation	Skewness	Kurtosis	Median	n
Alentejo	4.4	0.73	-1.653047	3.242947	**5**	411
Andalusia	4.2	0.97	-1.206453	1.274457	**4**	421
	T.3 Importance that renewable energy systems benefit more vulnerable citizens					
	Mean	Standard Deviation	Skewness	Kurtosis	Median	n
Alentejo	4.4	0.73	-1.627195	3.1237731	**5**	411
Andalusia	4.2	0.90	-1.137980	0.9635106	**4**	421

Pearson's correlation coefficient matrix for variables T1, T2 and T3

Questions	T2	T3	T1
T2	1.0000000	0.7368718	0.6713527
T3	0.7368718	1.0000000	0.8080352
T1	0.6713527	0.8080352	1.0000000

Results of the GML 1.1, 1.2 and 1.3

GLM 1.1 Large Solar and Degree of Satisfaction				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values** (*indicate statistically significance)
Vignette A1 (intercept)	2.37887	0.43869	5.423	**0.0000000587 *** **
Vignette B1	1.33541	0.39979	3.340	**0.000837 *** **
Vignette C1	1.27800	0.38258	3.341	**0.000836 *** **
Vignette D1	1.39078	0.39593	3.513	**0.000444 *** **
Vignette E1	0.05381	0.28703	0.187	0.851293
Vignette F1	0.44997	0.33330	1.350	0.177011
Gender (male)	0.07032	0.22250	0.316	0.751960
Age Group [T.25 to 34]	-0.69981	0.46038	-1.520	0.128490
Age Group [T.35 to 44]	-1.11021	0.42972	-2.584	**0.009778 ** **
Age Group [T.45 to 54]	-0.42684	0.43989	-0.970	0.331890
Age Group [T.55 to 64]	-1.16279	0.45331	-2.565	**0.010314 * **
Region (Andalusia)	-0.79283	0.21572	-3.675	**0.000238 *** **
GLM 1.2 Medium Solar and Degree of Satisfaction				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values**
Vignette A2 (intercept)	3.00756	0.57154	5.262	**0.000000142 *** **
Vignette B2	-0.52813	0.38035	-1.389	0.164982
Vignette C2	17.27600	849.60183	0.020	0.983777
Vignette D2	-0.13548	0.38047	-0.356	0.721789
Vignette E2	1.04347	0.54105	1.929	0.053779
Vignette F2	1.14097	0.58397	1.954	0.050724
Gender (male)	0.69401	0.31386	2.211	**0.027023 * **
Age Group [T.25 to 34]	-0.22882	0.54398	-0.421	0.674017
Age Group [T.35 to 44]	-0.16684	0.54312	-0.307	0.758708
Age Group [T.45 to 54]	-0.05189	0.53520	-0.097	0.922767
Age Group [T.55 to 64]	-1.03192	0.54708	-1.886	0.059265
Region (Andalusia)	-1.20594	0.32015	-3.767	**0.000165 *** **
GLM 1.3 Small Solar and Degree of Satisfaction				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values**
Vignette A3 (intercept)	3.52692	0.62620	5.632	**0.0000000178 *** **
Vignette B3	0.36663	0.43537	0.842	0.39973
Vignette C3	17.39661	899.02154	0.019	0.98456
Vignette D3	-0.68770	0.37486	-1.835	0.06658
Vignette E3	0.83304	0.51662	1.612	0.10686
Vignette F3	1.59679	0.58960	2.708	**0.00676 ** **
Gender (male)	0.43798	0.31372	1.396	0.16269
Age Group [T.25 to 34]	-0.04778	0.62786	-0.076	0.93934
Age Group [T.35 to 44]	-0.48896	0.59384	-0.823	0.41029
Age Group [T.45 to 54]	-0.78627	0.55133	-1.426	0.15383
Age Group [T.55 to 64]	-1.50983	0.57755	-2.614	**0.00894 ** **
Region (Andalusia)	-1.38051	0.32766	-4.213	**0.0000251727 *** **

Table 9

Click here to access/download;Table (Editable version);Table 9.docx

Results of the GML 2.1, 2.2 and 2.3

GLM 2.1 Large Solar and Degree of Interest				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values** (*indicate statistically significance)
Vignette A1 (intercept)	1.52687	0.40632	3.758	**0.000171 *** **
Vignette B1	1.02269	0.40900	2.500	**0.012402 ***
Vignette C1	1.65837	0.47824	3.468	**0.000525 *** **
Vignette D1	0.79036	0.37468	2.109	**0.034906 ***
Vignette E1	0.30153	0.32347	0.932	0.351237
Vignette F1	0.73588	0.38509	1.911	0.056012
Gender (male)	-0.15703	0.24530	-0.640	0.522078
Age Group [T.25 to 34]	-0.31696	0.42505	-0.746	0.455839
Age Group [T.35 to 44]	-0.13716	0.41373	-0.332	0.740258
Age Group [T.45 to 54]	0.53615	0.43718	1.226	0.220046
Age Group [T.55 to 64]	-0.15671	0.43912	-0.357	0.721177
Region (Andalusia)	0.09617	0.23088	0.417	0.677025
GLM 2.2 Medium Solar and Degree of Interest				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values**
Vignette A2 (intercept)	3.4106	0.6094	5.597	**0.0000000219 *** **
Vignette B2	-0.8236	0.4081	-2.018	**0.04355 ***
Vignette C2	1.0060	0.6002	1.676	0.09375
Vignette D2	-0.3177	0.4214	- 0.754	0.45087
Vignette E2	0.6344	0.5591	1.135	0.25654
Vignette F2	0.5952	0.5598	1.063	0.28766
Gender (male)	0.6032	0.3073	1.963	**0.04964 ***
Age Group [T.25 to 34]	-0.5619	0.5618	-1.000	0.31721
Age Group [T.35 to 44]	-0.6324	0.5516	- 1.146	0.25159
Age Group [T.45 to 54]	-0.3427	0.5530	-0.620	0.53540
Age Group [T.55 to 64]	-0.7514	0.5909	-1.272	0.20354
Region (Andalusia)	-0.9906	0.3063	-3.234	**0.00122 ****
GLM 2.3 Small Solar and Degree of Interest				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values**
Vignette A3 (intercept)	3.43891	0.63781	5.392	**0.0000000698 *** **
Vignette B3	-0.02221	0.48122	-0.046	0.96318
Vignette C3	16.92916	919.77656	0.018	0.98532
Vignette D3	-0.73067	0.43157	-1.693	0.09045
Vignette E3	0.38498	0.54725	0.703	0.48176
Vignette F3	0.50322	0.52303	0.962	0.33599
Gender (male)	0.35276	0.32237	1.094	0.27384
Age Group [T.25 to 34]	-0.60544	0.56968	-1.063	0.28789
Age Group [T.35 to 44]	-0.27095	0.59313	-0.457	0.64780
Age Group [T.45 to 54]	-0.34077	0.56056	-0.608	0.54325
Age Group [T.55 to 64]	-0.73618	0.59432	-1.239	0.21546
Region (Andalusia)	-0.93868	0.32322	-2.904	**0.00368 ****

Frequency of Values for Alentejo, Andalusia and in total

Values	Alentejo%	Andaluzia%	Total %
Local	61%	39%	**9%**
Participation	37%	63%	**15%**
Collaboration	43%	57%	**15%**
Inclusion	57%	43%	**16%**
Holistic planning	60%	40%	**17%**
Easy (to do)	31%	69%	**18%**
Autonomy	50%	50%	**25%**
Trust	59%	41%	**26%**
Clean	47%	53%	**42%**
Transparency	47%	53%	**48%**
Profitability	53%	47%	**54%**

Supplementary Materials

Table S1 News media sources consulted during exploratory research

Article name (translated)	Media (Publication, TV channel) and country	Reference
"Movement *Juntos pelo Cercal* launches crowdfunding to fight solar power central"	*Observador* (Online Newspaper/national) Portugal	(Suspiro, 2021)
"Cercal's population against solar power central in Alentejo"	*Correio da Manhã/CM+* (TV channel/national) Portugal	(*CM+*, 2021)
"Running towards the sun: new projects for solar parks quadruplicate current annual production"	*Expresso* (Online Newspaper/national) Portugal	(*PRADO*, 2020)
"Solar power centrals will have to compensate municipalities with self-consumption installations."	*Público* (Online Newspaper/national) Portugal	(Brito, 2021)
"Cleanwatts bets 20 million in energy communities"	*Jornal de Negócios* (Online Newspaper/national) Portugal	(*Mar*, 2021)
"The largest solar power central of the world in Alentejo"	*Portal Energia* (online newspaper/national) Portugal	(Reis, 2016)
"Floating solar power station of Alqueva is ready to start"	*Reuters* – republished by *Público* (Online Newspaper/national) Portugal	(Reuters, 2022)
"Portugal: €1B solar plant project in Santiago do Cacém generates protest"	*Macau News Agency*, by *Lusa* (Online publication/international) International	(Lusa, 2021)
"Protesters over massive solar energy parks"	*SUR in English* (Online publication/national) Spain	(Hawkins, 2021)
"Anti-renewables protesters from rural Spain descend on Madrid"	*Renewables Now* (online news portal/national) Spain	(Djunisic, 2021)
"Solar wars: Protests against massive 900 hectare 'environmentally friendly' power plant in southern Spain"	*The Olive Press* (online news/regional) Spain	(Rueda, 2021)
"Protestors battle against massive solar farms threatening to destroy most beautiful countryside in Spain's Andalusia"	*The Olive Press* (online news/regional) Spain	(Govan, 2021)

Table S2 Factorial design

Vignette numbers (3 factors, 8 levels, 1 degree of freedom)	**A**	**B**	**C**	**Factor effect**
1	+1	-1	-1	A
2	+1	+1	-1	AB
3	+1	-1	+1	AC
4	1	1	1	ABC
5	-1	+1	+1	BC
6	-1	-1	+1	C
7	-1	+1	-1	B
8	-1	-1	-1	CBA

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Declaration of interests

☒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.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Scales of solar energy: Exploring citizen satisfaction, interest, and values in a comparison of regions in Portugal and Spain

Inês Campos, Miguel Brito and Guilherme Luz

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1. Introduction

The energy transition requires new energy geographies, and the participation of citizens across regions and countries [1]. While energy cooperatives, based on citizens' collective investments in small to medium-scale solar energy projects flourish across Europe, new discussions emerge on the sustainability of large-scale solar installations [2,3]. Large centralized solar installations are fostering a debate on the social acceptability (SA) of new solar landscapes [4,5], as they may compete with other land uses and have negative impacts on local activities, such as rural tourism [3,6]. Furthermore, research is still lacking on how energy citizenship (EC), or the active involvement of citizens as protagonists in new energy systems [7], is developing in the context of different solar geographies, derived from both centralized and decentralized systems [8].

Thus, the expansion of new renewable energy geographies, requires insights from both SA and EC perspectives [8,9]. Informed by these two interrelated research fields, this article aims to shed light into citizens' acceptance and participation in multiscale solar projects. The overall goal is to explore how citizens perceive the urgency of the energy transition and gain further insight into the conditions that make citizens most satisfied with and interested in participating in ~~the development of~~ different ~~scales of~~ solar energy projects– from large installations to small and medium-scale production.

To address this goal, the study focuses on two Southern European regions - Alentejo (Portugal) and Andalusia (Spain) - and draws on a representative survey (n=832). There has been an expansion of large-scale solar energy projects in the past decade in the two regions [10,11]. These regions have witnessed a boom in decentralized solar energy production supported by national legislation and by incentives for the growth of 'prosumers' - i.e., self-consumers of small-scale energy from renewable sources, at the individual and/or collective level [12,13], including energy communities and cooperative investments [14,15], often led by citizens' investments [16,17]. Wind energy is less suitable for these regions, particularly in their in-land and rural areas.

Alentejo region is likely to host the biggest solar energy installations in Portugal, at least in two locations. One example is the project planned for Cercal village, consisting of five photovoltaic installations in adjacent areas, with a total installed capacity of 275 MWp, expected to produce about 596 GWh/year and cover 137,05 hectares of farmland. A group of circa ~~250~~200 residents and local entrepreneurs has been opposed to the project, creating a civic movement to prevent its implementation. Four participants of this movement were interviewed at an exploratory stage of this study. Their reasons for opposing the project related to the perceived impacts on local social, economic, and environmental sustainability, while they considered small and medium-scale installations to be sustainable alternative solutions. Interviewees mentioned that Andalusia was facing similar challenges, leading the authors to investigate this region.

In Southern Spain, Andalusia has also been the focus of a surge in solar energy investments, sparking debates regarding the sustainability of massive solar installations for over a decade [10]. In Malaga, newspapers reported local protests in 2021-22 backed by the slogan "Renewables yes, but not this way!" [18]. Protests delayed the approval of dozens of large-scale photovoltaic projects proposed across the region. According to news media, the major causes for concern have been the possible negative environmental impacts of these power plants on agricultural lands, as well as their impact on local rural tourism activities. In Castellar de la Frontera (Andalusia), communities have also been concerned with the impact of large-scale solar farms on ecologically protected regions [19].

Both regions are vulnerable to climate change impacts, mainly due to increased temperatures, more frequent heat waves and a reduction in precipitation [20,21]. These regions offer a setting to investigate SA and EC in the context of a multi-scale solar expansion, while gathering insights relevant for other regions and countries in South Europe [22].

To systematize the analysis of citizens' preferences in relation to different solar scales, three "sizes" were identified based on the two countries' regulatory frameworks [23], and on their prevailing solar energy production models [24,25]. The small size refers to installed capacities of up to 1000 kWp. This type of installation may be as small as a rooftop solar in households and/or may be implemented by an energy community, where its members collectively pay for the solar panels and, through an internal agreement, share, self-consume and/or sell the energy produced. Relevant regulatory frameworks are the DL15/2022 that comprises specific legislation for self-consumption and energy communities in Portugal and the RD-L 244/2019 for self-consumption in Spain. The medium size refers to solar projects with an installed capacity of between 1 and 50 MWp. Medium-size installations can fall under the energy community concept, ~~although~~or they ~~are more likely to~~can be owned by an industry player. They can~~ be~~ also take the form of "agrivoltaic", enabling the joint development of farming activities and energy production [26]. The reason for the 50 MWp threshold relates to Portuguese and Spanish legislations, which consider that only installations larger than 50 MWp require an Environmental Impact Assessment. Finally, within a centralized distribution configuration, the large size refers to projects with an installed capacity of above 50 MWp, which may include storage facilities, the development of high voltage transmission lines and floating solar photovoltaic projects. Relevant regulatory frameworks in Spain are the RD-L 6/2022, and in Portugal the DL30-A/2022.

In what follows, we outline the theoretical background for this study, followed by the methodological approach and data analysis methods, and then present the results of the survey in ~~section~~part 4. The findings are discussed in relation to current literature on SA and EC in ~~section~~part 5, and key implications for future research are summarized in the conclusion.

2. Background

~~Social~~Studies of social acceptance (SA) [27–29] and energy citizenship (EC) [7,30] ~~studies~~ are strongly interrelated and offer a theoretical background for this study.

The concept of SA of renewable energy technologies (i.e. RET) developed by Wustenhagen and colleagues [31], has been largely informed by empirical findings on case studies of wind energy acceptance, while solar energy, by comparison, was thought to be broadly accepted. SA considers three dimensions, namely socio-political, community and market acceptance [29] and therefore, assumes a multi-stakeholder perspective [32]. Participation is considered a key factor for higher acceptance of new energy projects [33,34]. More recently, SA has developed into a 'critical approach', increasingly concerned with the (in)justice aspects of RET, including ~~distributional~~distributive, procedural and recognition justice~~ aspects~~, and understanding SA as being "socially embedded and co-constructed" [35] (p.2). Within this critical approach, research of large-scale wind installations found that (monetary or in-kind) compensation for any negative impacts of projects is important for local communities [29]. Also, research into large-scale solar energy projects concluded these~~ projects~~ foster concerns at the community level [36,37], although the same type of project continues to enjoy a high acceptance from a policy and top-down perspective [38], as well as market acceptance [26].

Community acceptance of large-scale solar installations is framed by key issues such as "green-on-green, scale, place attachment, policy, process and justice"(from highlights: [37]). Specifically, Roddis and colleagues [37] named "green-on-green tensions" (p.239) as those emerging when concerns for mitigating climate change clashed with concerns over wildlife preservation, leading to opposition to renewable energy projects. For instance, in their study there were concerns with the extent to which large-scale solar projects required using land in spaces previously untouched, thus competing with alternative land uses (e.g., for agriculture, biodiversity preservation and/or rural tourism activities), while the need for decarbonizing the energy system was also recognized. In this context, citizens ~~have~~ highlighted a lack of political attention to alternative solutions for producing solar energy (e.g., such as the proliferation of small and medium scale installations using pre-existing infrastructure). Thus, acceptance of RET has been characterised as having a "relational nature" [37], meaning that community acceptance of a particular project is informed by broader policy views on e.g. local development, land management and diverse local, regional and even international governance issues.

~~To investigate a 'green on green' dimension~~Thus, this article considers interrelations between citizens' attribution of importance to the energy transition and their opinions on the importance of an energy transition that creates synergies with environmental protection and preservation, to which we broadly refer to as being "compatible with the natural environment and biodiversity". Furthermore, issues related to procedural and ~~distributed~~distributive justice were integrated by questioning how citizens' satisfaction with energy projects changed according to whether citizens are invited to participate, and ~~when installations offer compensation~~ to whether those impacted by projects are offered compensation and/or projects benefit more vulnerable communities.

Next to SA, the EC concept proposed by Devine-Wright [7], addresses people as active participants, democratically engaged in sustainable energy transitions. Citizens are participating in the energy transition by engaging politically and taking part in various types of collective energy-related projects as users, consumers, prosumers, supporters, and/or protesters [30]. Although EC refers to both individual and collective action, a recent review concluded that research has been strongly focussed on communities and democratic participation in energy-related decisions, with a particular emphasis on decentralized systems, and with less focus on centralized and large-scale systems [8]. From an EC perspective, citizens shift from passive to active actors in the energy transition, through participation in energy investments, consumption choices, and in supporting or protesting in view of effective policies for advancing the energy transition [39]. However, it is not always clear how EC can be combined with inclusivity and justice goals, particularly when participation implies direct investments from citizens, and does not account for broader socioeconomic inequalities [39,40].

Specifically, how citizens can be active participants in centralized systems, such as large-scale solar energy systems, has received little attention in EC literature [8]. By contrast, EC is mainly addressed in the context of studies of prosumers, or citizens involved in social innovations, and/or social movements, including protest movements in the scope of energy policies [41]. Finally, while the concept is increasingly a research focus, there is still little evidence of how citizens who are not involved in any type of energy project, can exert and/or are willing to exert their (energy) citizenship rights. Indeed, while EC assumes active behavioural changes at the individual level, there has been less focus on citizens' rights when confronted with new energy projects in which they are not invited to participate [39]. To enable a focus on 'citizens', this study opted for a representative survey to learn how citizens feel about potential energy projects.

3. Methodology

The methodology started with an exploratory and qualitative approach, leading to the selection of the case study regions, and proceeded with a quantitative study, based on an online survey, which contained a vignette experiment [42,43]. Strict ethical procedures and requirements were followed, providing all research participants with informed consent, and following internal ethical guidelines approved by the ethical committee of the Faculty of Sciences of the University of Lisbon. Data collection was fully anonymous, and no personal data was collected.

Figure 1 is a flowchart of the different methodological steps undertaken and described in the following paragraphs.

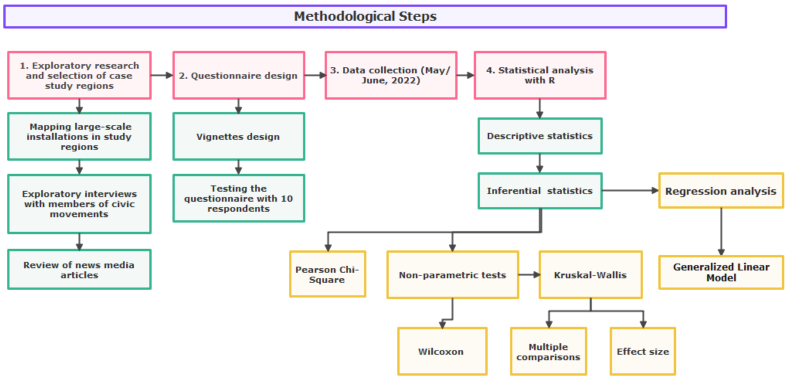
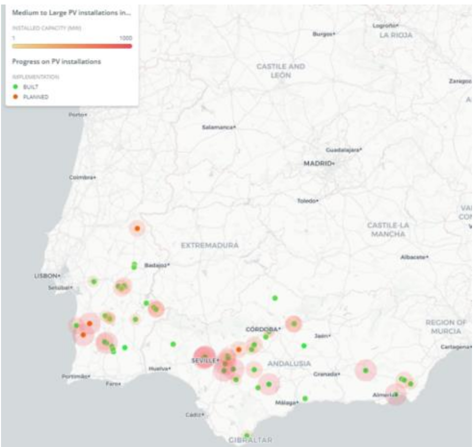


Figure 1 Flowchart of the methodology

3.1 Exploratory inquiry

At the exploratory stage, contextual data was collected and revised via a review of the literature and news media articles (i.e., published by local or national newspapers). A list of the regional and national papers consulted at the exploratory stage and their timespan is provided in supplementary materials (Table S1).

Four exploratory unstructured interviews were conducted with citizens involved in a local civic movement against the implementation of a large solar plant in Alentejo. Interview questions focussed on (i) understanding the causes for these citizens' dissatisfaction and (ii) their overall ideas about the importance of the energy transition. In addition, data collected by the authors on medium and large PV installations in Alentejo and Andalusia (see Figure 2), offers a geographical illustration of the two regions, showing that Andalusia has several built large solar parks (in ~~green~~blue), and Alentejo has ~~three~~two large, planned parks (in ~~dark~~ orange~~), indicating that Alentejo's solar expansion is still catching up to Andalusia's.~~).



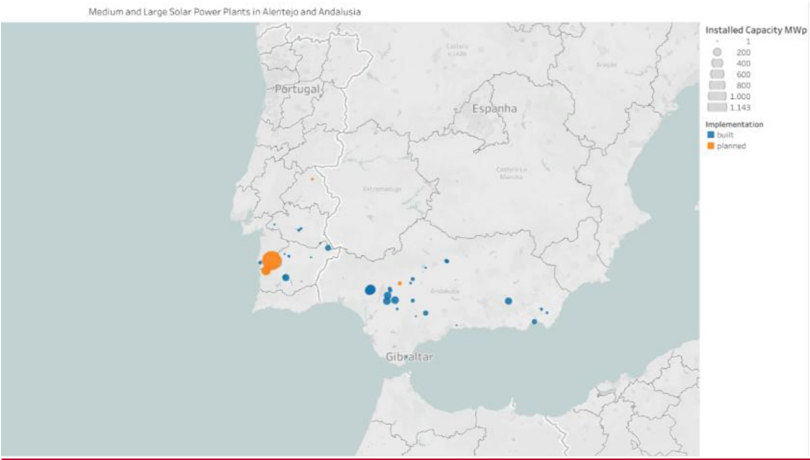


Figure 2 Map of Alentejo and Andalusia's medium and large-scale solar plants <u>*(see interactive version in Tableau)*</u>

The exploratory inquiry, including the results of the interviews, the review of newspaper articles, as well as the mapping of large-scale solar energy installations in Portugal and Spain, informed the selection of the case study regions described in the introduction.

3.2 Research questions

Drawing on the exploratory inquiry, two interrelated research questions guide ~~this~~<u>the</u> article, namely:

1. How do different factors (i.e., compensation, participation, and benefits for more vulnerable communities), relate to citizens' satisfaction with, and interest in, participating in solar energy projects of different sizes?
2. How are different solar sizes perceived to help realize key objectives and values for a sustainable energy transition?

The methodology followed a quantitative approach based on an online survey of a representative sample. After testing the survey questionnaire with 10 respondents, the questionnaire form (created in PHP programming language) was handed to a data collection survey company to collect <u>the </u>responses~~ based on stratified sampling guidelines~~. A final set of 832 valid responses were collected between May and June 2022.

3.3 Questionnaire

The questionnaire, translated into Portuguese and Spanish, had <u>the following </u>four sections:

3.3.1 ~~Section 1 – contextual~~<u>Contextual</u> and sociodemographic background

All participants responded to questions for collecting general background information on their location (region of residence), age, gender, and professional status, as well as contextual information such as whether the respondent "worked or was close to persons who worked in the" fossil fuel industry, nuclear energy industry, renewable energy industry, or other; and whether the respondent would "regularly hear, see, or smell" different types of energy-related infrastructures.

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3.3.2 ~~Section 2 – importance~~Importance of the transition

This section was informed by an understanding of SA as being socially embedded ~~in,~~ and related to ~~diverse aspects, specifically~~ perceptions about the environment and ~~distributional~~distributive, procedural and recognition justice factors [35,37]. The section focused on learning (1) how important the energy transition is to respondents, (2) how important it is that renewable energy systems ensure compatibility with the natural environment and biodiversity (i.e., they do not harm natural habitats), and (3) how important it is that ~~the~~ energy projects offer benefits to more vulnerable citizens. These three questions used a Likert scale of 1 (not important) to 5 (very important), and all survey respondents replied to them.

3.3.3 ~~Section 3 –~~ Vignette experiment

This section contained a vignette experiment [43,44]. Vignette surveys have been used in diverse contexts and research areas, including sociology [45] and psychology [46], as well as social and energy research [29]. A vignette experiment (also called a factorial survey) starts by introducing respondents to a carefully designed and realistic scenario on a specific topic, and then poses one or more questions about the presented scenario. Rather than directly asking about a specific issue, responses are elicited through hypothetical scenarios (e.g., "What would you do if…?"). A collection of vignettes can thus be defined as "a set of systematically varied descriptions of subjects, objects, or situations in order to elicit respondents' beliefs, attitudes, or intended behaviours with respect to the presented vignettes." (p.53)[44].

The experimental vignette methodology in which this study falls into, entailed presenting survey respondents with scenarios to assess two dependent variables, namely satisfaction with, and interest in participating in~~,~~ solar energy projects [43]. The key goal of the vignette experiments was to understand how responses varied with different factors, such as whether local populations are invited to participate and/or compensated for any damages to their livelihoods, and/or if more vulnerable communities benefit from the project. Issues of transparency (e.g., the openness factor) and who is responsible for the investment were also considered.

Each respondent was randomly presented with a total of three vignettes (i.e., one of six from each of the three groups of vignettes for large, medium, and small size solar projects). The vignettes were accompanied by a photograph of a large, medium, or small-scale installation (depending on the vignette group) to help respondents visualize the scenario [36]. After being randomly presented with a vignette, respondents answered two questions about it (see example in Table 1):

Table 1 Vignette example (underlined parts correspond to the factors that varied between the vignettes).

"As you pass by a rural area near you, you see the new installation of solar panels, seemingly covering several kilometres. You know that the local community was <u>invited to participate</u> in the planning process of the solar park, which has been funded by a large utility company. Those who live nearby the installation <u>have not received</u> any sort of compensation for the impacts of the new installation on their livelihoods. The plans and land lease contracts were <u>not openly</u> shared with the community."
1. Would you be satisfied with a such a project? (Choose below the option that is most applicable to you) (1) Not satisfied, (2) poorly satisfied, (3) somewhat satisfied, (4) satisfied, (5) very satisfied.
2. If the possibility was presented to you, would you be interested in participating in such a project? (Choose below the option that is most applicable to you)

(1) Not interested, (2) poorly interested, (3) somewhat interested, (4) interested, (5) very interested

To generate each of the vignette groups contained within the survey, the factorial design (see also Table S2 in supplementary materials) was comprised of 3 factors (A, B and C), each with two levels (negative and positive). The main effect of A, B, and C factors, or of their interaction (AB, AC, BC, ABC), is the difference between the average of the responses corresponding to +1 levels and the average of the responses that correspond to the -1 levels. These two levels (+1 and – 1) are contrasts, and in factorial surveys it is possible to eliminate combinations of factors which are all positive or all negative from the sample, leading to using fewer vignettes and resulting in a fractional factorial design [47]. In this study's design, ABC are all positive, while CBA are all negative, therefore being opposites and aliases, which does not add much information to the relevance of individual factors. Therefore, these factors were excluded from the sample of vignettes for each of the three experiments, ending with a 3-factor and 6-level vignette survey for each of the solar sizes.

For each solar size, the vignette scenarios are similar between them, with only the factor levels changing to enable a thorough comparison [42]. However, variables changed between the three vignette subgroups, as some were not adequate for all solar sizes. For instance, receiving or not receiving compensation for the impacts of the project was a factor included in the case of large-size solar, which is not as appropriate for small-size systems such as rooftop installations.

In the large-size vignette subgroup, the factors were "invitation to participate", "compensation", and "openness" in sharing documents with information regarding the project. For both the medium and small-scale vignettes, the factors were "invitation to participate", the type of funding (i.e., "large company" and "cooperative"; "private" and "public") and "benefits" attained for more vulnerable citizens (see also Figure 3).

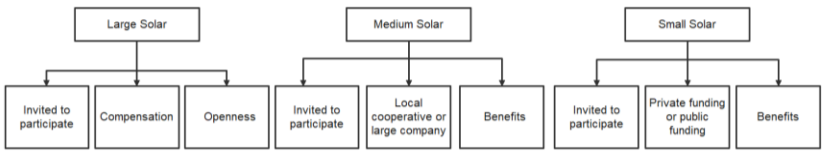

Figure 3 Factors for each solar energy scale.

Table 2 shows the differences contained within the vignettes used, and the sample size for each vignette group.

Table 2. Vignette factors for each type of solar installation and sample size

Codes	**Large-scale solar installations**	**Sample size**
A1	invited to participate, no compensation, no openness	133
B1	invited to participate, compensation, no openness	127
C1	invited to participate, no compensation, openness	144
D1	not invited to participate, compensation, openness	142
E1	not invited to participate, no compensation, openness	164
F1	not invited to participate, compensation, no openness	122
Codes	**Vignettes for medium scale solar installations**	

A2	invited to participate, local cooperative, no benefit	148
B2	invited to participate, large company, no benefit	131
C2	invited to participate, large company, benefits	151
D2	not invited to participate, local cooperative, no benefit	144
E2	not invited to participate, local cooperative, benefits	124
F2	not invited to participate, large company, benefits	134
Codes	**Vignettes for small-scale solar installations**	
A3	invited to participate, private funding, no benefit	129
B3	invited to participate, public funding, no benefit	146
C3	invited to participate, private funding, benefits	132
D3	not invited to participate, public funding, no benefit	140
E3	not invited to participate, private funding, benefits	130
F3	not invited to participate, public funding, benefits	155

3.3.4 Section 4 Objectives and values

All survey respondents responded to the fourththis section, regardless of their vignette subgroup. The section encompassed two questions to learn about the objectives that people find are better accomplished through different solar sizes and the values associated with a sustainable energy transition. Gaining insight into the importance of different objectives and values is relevant to understand citizens and stakeholder preferences regarding the energy transition [6]. The categorical response options provided resulted from a literature review of previous studies regarding large-scale solar energy [11,48] and decentralized systems [24,49], as well as from the results of the exploratory interviews conducted with citizens from the Alentejo region.

3.4 Survey Sampling

A stratified sampling approach was generated by usingapplied, which entails first dividing the target population (i.e., residents in the two case study regions) into mutually exclusive and homogenous population quotas or 'strata'. These survey quotas were based on the census data from Portugal, collected in 2020 [50], and Spain, collected in 2022 [51]. Secondly, a sample was created through a random sampling data collection (conducted by a professional data collection company), which means each member of the population has an equal chance of being selected. The sample parameters have a 95% confidence level and a 5% margin of error, calculated based on the estimated total population of 704707 for Alentejo and a total population in Andalusia of 8437000 people. Table 3 shows the planned stratification (or quotas) of the study regions, considering gender and age groups.

Table 3. Stratified sampling design

Regions	Andalusia	Alentejo
Total	400	400
Male	194	196
Female	206	204
18-24	54	44
25-34	71	88
35-44	100	100
45-54	97	92

55-64	78	76

The vignette sampling process focused on ensuring that the external validity of the vignette samples (i.e., inferences that can be drawn from the experiments) would be extended at the very minimum to the survey's target population [44]. To ensure an appropriate sample for the vignette subgroups within the survey, a statistical power test was done using the R software package PWR[52], which implements power analysis following Cohen's method [53]. Effect size is a statistical measure proposed by Cohen, to learn about the magnitude of the experimental field in vignette experiments. According to the test, the larger the size, the stronger the relationship between variables. A moderate effect size is between 0.2 and 0.5, while a large size can be between 0.8 and 1. In this study, a moderate effect size was assumed. Using the PWR package, the sample size for six groups was calculated to obtain at least 0.80 of power, and a significance level of 0.05. The result was that the samples for the vignettes should have at least 54 respondents. Therefore, all samples for the vignettes (see Table 2) have at least 80% of statistical power, at a 5% error.

3.5 Data and statistical analysis

Except for the respondents' age, all data collected was either ordinal (i.e., qualitative data that includes a ranking), or nominal (i.e., qualitative data with no specific order to it).

Nominal data were analysed in a spreadsheet by taking stock of the frequencies of responses. The visualizations of these frequencies were produced using Tableau software [54].

Ordinal data were analysed through statistical methods. This data includes the responses to section 2 (i.e., importance of the transition to which all survey participants replied) and 3 (i.e., vignette sub-groups in which survey participants were randomly distributed).

The statistical analysis was conducted using R open-source programming language, applying several R packages, namely: PWR[52], "IPSUR", [55]; "ggplot2" [56]; "multcomp" [57]; "tidyverse" [58] and "ggstatsplot" [59].

3.5.1 Descriptive analysis

Using the IPSUR package, the descriptive analysis of the ordinal variables ~~in sections 2 and 3~~ focussed on determining the mean, median and standard deviation values, as well as the means' coefficient of variation, and the measures for skewness, and kurtosis [60,61]. The mode (i.e., most common value in a response variable) was also calculated for the ~~responses to section 4~~nominal variables (i.e., objectives and values) of the survey.

3.5.2 Analysis of the importance of the transition

Pearson Chi-square was used to find if a relation existed between ~~the~~ three different variables related to the importance of the transition (i.e., importance of the energy transition, ~~importance of a transition that benefits more vulnerable citizens and~~ importance that renewable energy systems ensure compatibility with the natural environment and biodiversity (i.e., they do not harm natural habitats~~)),~~), importance of a transition that benefits more vulnerable citizens), based on the differences between observed and expected values. The calculation of Pearson's contingency coefficient then offered a measure for any existing association [62]. The interpretation of the relevance of the measures of the values resulting from association measures is provided by Davis [63].

In addition, the Wilcoxon (non-parametric) test for two independent samples [64] was used to compare levels of importance attributed to the energy transition, accounting for the different regions, based on the median values of the data.

3.5.3 Analysing differences between vignettes

Non-parametric tests were applied to analyse the differences emerging from the descriptive analysis of the vignette results, as ordinal data is not, by principle, normally distributed and therefore does not satisfy the requirements for applying parametric tests (i.e., analysis of variance). These tests are robust in experimental designs and have been frequently used for the analysis of ordinal variables [65]. The Kruskal-Wallis test, a non-parametric alternative to ANOVA, [66] was applied to learn whether the overall differences between medians for satisfaction and interest (i.e., the response variables in the vignette experiment) were statistically significant to changes in different factors for each group of vignettes. When differences between variables were proved to be significant, the Kruskal-Wallis' "effect scale" method [67] was used to measure how meaningful such differences were.

When statistically significant differences were found (i.e., the p-value was lower than the established margin of error of 5%), multiple comparisons were done using the Bonferroni multiple comparisons' test, which compares a pre-defined set of groups to learn which sets or pairs of vignettes have a significant difference between them [68]. Multiple comparisons used the multicomp R package and enabled an understanding of whether the combinations of specific factors contained in the vignettes (e.g., participation, transparency, etc.) contributed to increasing or decreasing citizens' satisfaction and interest in each project.

The graphical outputs of the non-parametric statistical tests conducted were created with the R ggstatsplot package [59], which enabled embedding the results of the statistical tests in the visualizations, thus offering a rigorous visual reporting of the results.

3.5.4 Analysing differences between vignettes and other factors

To gain further insights into how the differences between different vignette groups compared to other external factors, a regression analysis was included. A Generalized Linear Model (GLM) was applied since this model is more appropriate when the (ordinal) response variable is not normally distributed [69].

The GLM, is defined as a type of model that "generalizes linear regression by allowing the linear model to be related to the response variable via a link function and allowing the magnitude of the variance of each measurement to be a function of its predicted value"(p.40)[70]. In this study, applying GLM models gave us insight into how the satisfaction and the interest response variables changed (e.g., satisfaction/interest increased or decreased) among participants from different regions and belonging to different age and gender groups. The GLM thus presented the effects of age, region and gender on the response variables 'satisfaction' and 'interest', within each subgroup (i.e., Large, Medium, and Small). The age variable included in the models was converted into a factor, with five groups (i.e., 18-24, 25-34, 45-54, 55-64, and 65+). The R package used to conduct the regression was "IPSUR" [55].

4. Results

4.1 Sample and respondents' background information

A total of 832 valid responses were collected, including 421 responses from Andalusia and 411 from Alentejo, with 456 respondents self-described as women, and 376 self-described as men (there were no respondents self-describing as non-binary or other). The mean and median age of respondents are the same, namely 39 years for women and 45 for men. Regarding skewness, there is a positive asymmetry (slightly skewed to the left) for age. Kurtosis values (higher than 0.263) indicate a platykurtic distribution, which is in line with census data for the two regions. Figure 4 presents a histogram of the age of respondents.

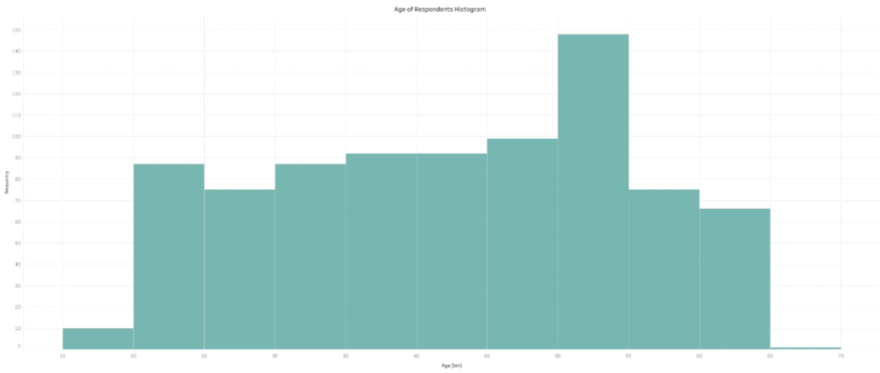

Figure 4 Histogram of respondents' age

Regarding professional status, 62.3% of respondents are employed full-time, 8.65% are employed part-time, 11.30% are unemployed, 7.93% are students, 5.65% are retired, and 4.08% are householders or other. Between regions the numbers are slightly different, in Andalusia only 51.31% are employed full-time, compared to Alentejo where 73.72% are employed full-time.

Most respondents were not professionally engaged in the energy sector, as 92.07% do not work or are close to a person who works in the energy sector, while 3.49% either work or are related to workers in the renewable energy industry and 1.80% to workers in the fossil fuel industry (see Table 4)

Table 4 Frequency of responses on relation of respondents with energy industries

Energy Industry	**Works or is close to person who works in:**	
Fossil fuels	15	2%
Renewable energy	29	3%
Nuclear energy	5	1%
Not applicable	766	92%
Other	17	2%

When asked whether they "regularly see, hear, or smell" different types of energy technologies, small-scale solar, followed by high voltage transmission lines, and large solar parks had the highest occurrences (of 466, 435, and 326 respectively), with the mode value being small scale solar. This further validates the characterization of the two case studies, as regions which are witnessing a solar energy expansion. Table 5 ~~below~~ presents the frequencies of the different options.

Table 5 Frequency of type of technology respondents would regularly see, hear or smell

Regularly see, hear or smell:	**Frequency**
Hydroelectric dam	28%
Wind turbines	30%
Coal station	8%
Solar Park (large)	39%

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High tension cables	52%
Small scale solar	56%
Biomass treatment plant	8%
None	22%
Other	1%

4.2 Importance of the energy transition

The transition is "very important" (5) for at least 50% of the respondents, it is equally "very important" that renewable energy systems are compatible with the natural world and that more vulnerable citizens can benefit from them. The mean values for the three variables (i.e., T1, T2 and T3) are around 4 (corresponding to "important"), as shown in Table 6. The distribution of kurtosis in these variables is lower than 0.263, indicating it is leptokurtic, with most values at the higher end. There is also a negative asymmetry to the right, indicating that higher values (of 4 or 5) are predominant. The same distributions apply to the different regions. However, in the case of Alentejo, the kurtosis values are higher in the three variables, indicating an even more steep leptokurtic distribution. This difference is also due to a higher frequency of values of 1 (not important) and 2 (poorly important) for variable T1, in Andalusia (between 4.28% and 6.18%), compared to the Portuguese case (1.46% and 2.92%).

Table 6 Descriptive statistics of three variables on the importance of the transition

Regions	**Descriptive statistics**					
	T.1 Importance of the energy transition					
	Mean	Standard Deviation	Skewness	Kurtosis	Median	n
Alentejo	4.4	0.73	-1.570692	3.191331	5	411
Andalusia	4.2	0.97	-1.244209	1.077716	5	421
	T.2 Important that renewable energy systems ensure compatibility with the natural environment and biodiversity (i.e., they do not harm natural habitats)					
	Mean	Standard Deviation	Skewness	Kurtosis	Median	n
Alentejo	4.4	0.73	-1.653047	3.242947	**5**	411
Andalusia	4.2	0.97	-1.206453	1.274457	**4**	421
	T.3 Importance that renewable energy systems benefit more vulnerable citizens					
	Mean	Standard Deviation	Skewness	Kurtosis	Median	n
Alentejo	4.4	0.73	-1.627195	3.1237731	**5**	411
Andalusia	4.2	0.90	-1.137980	0.9635106	**4**	421

Wilcoxon's non-parametric test shows a statistically significant difference between the median values of Alentejo and Andalusia, regarding the importance that renewable energy systems ensure compatibility with the natural environment and biodiversity (i.e., they do not harm natural habitats), (p-value is 0.0006542), and that more vulnerable communities benefit from renewable energy systems (p-value is 0.00005391), with Andalusians attributing slightly less importance than Alentejo's respondents (see Table 6). In both cases the p-value is lower than the margin of error (i.e., 5%), therefore it is appropriate to reject the null hypothesis.

Furthermore, Pearsons' correlation coefficient between different pairwise comparisons (see correlation matrix in Table 7), indicates a strong positive relationship (coefficients are close to 1) between the three variables (with p-values <.0001). Therefore, the importance attributed to the energy transition is closely associated with the importance attributed to renewable energy systems that ensure compatibility with the natural environment and biodiversity, and that benefit more vulnerable citizens.

Table 7 Pearson's correlation coefficient matrix for variables T1, T2 and T3

Questions	T3	T2	T1
T3	1.0000000	0.7368718	0.6713527
T2	0.7368718	1.0000000	0.8080352
T1	0.6713527	0.8080352	1.0000000

4.3 Satisfaction and Interest – differences between vignettes

4.3.1 Large size

Regarding the level of satisfaction with respect to the six vignettes for the large size, the median values ranged between 3 ("somewhat satisfied") and 4 ("satisfied"). The vignettes with a higher level of satisfaction were those in which citizens were invited to participate (B1 and C1), citizens were compensated for any negative impacts (B1 and D1), and plans were openly shared (B1 and D1). Vignettes had lower levels of satisfaction when there was no compensation (A1), people were not invited to participate (E1 and F1) and there was no openness (F1). Among these vignettes, C1 (in which people were invited to participate, there was openness in sharing documents, despite no compensation), had the highest frequency (27.78%) in the value 5 ("very satisfied").

These results are statistically significant (i.e., p-value =0.0000001508). The most significant differences are between the following: A1/C1("no compensation" versus "compensation"); A1/D1 ("no compensation and no openness" versus "compensation and openness"); C1/E1 ("invited to participate" versus "not invited to participate"); and D1/E1 ("openness" versus "no openness"). Nevertheless, the Kruskal-Wallis' effect scale test considers the effect of these differences to be small (i.e., the statistical value is 0.0423) (see Figure 5).

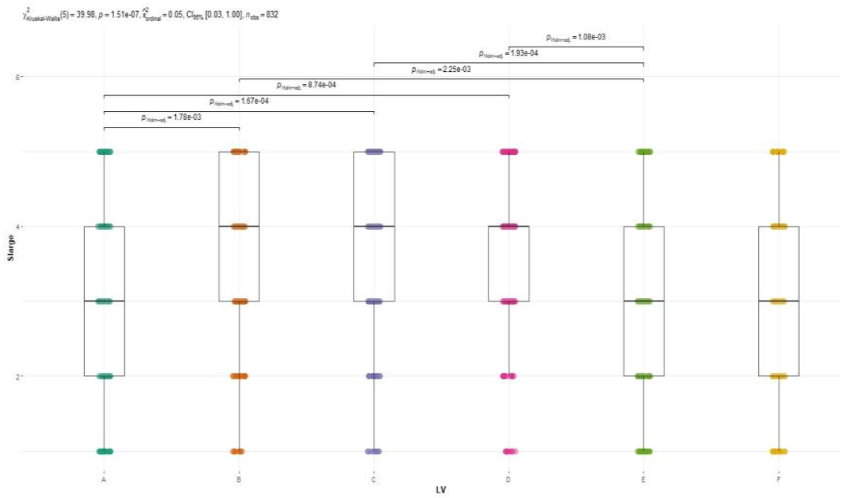

Figure 5. Boxplots of levels of satisfaction with projects ~~in relation to~~ for six large-scale solar ~~installations for six~~ vignettes~~.~~ (LV). The ~~graph~~chart shows the results of the Kruskal-Wallis non-parametric test ~~and differences between pairs of vignettes (LV).~~.

Regarding interest, the median values ranged between 3 and 4. Vignettes with higher values were those in which people were invited to participate (B1 and C1), in which there was compensation (D1 and F1) and openness (D1). Vignette D1 was also the one with the highest frequency in the value 5 (29.58%). These results are statistically significant (i.e., p-value = 0.0000003935). The most significant differences are between vignettes A1/C1 ("invited to participate/no openness" versus "invited to participate/openness"); and A1/D1 ("no compensation/no openness" versus "compensation/openness").

4.3.2 Medium size

In the case of satisfaction with medium-scale projects, differences in medians between vignettes range between values 3 and 4. Vignettes with higher values are C2, E2 and F2, corresponding to those in which citizens are invited to participate (C2) and the project benefits more vulnerable citizens (C2, E2 and F2). The effect size of these differences is moderate (i.e., Kruskal-Wallis' value for effect scale is 0.0738).

The most significant pairs of variables are A2/C2 and B2/C2. Both A2 and B2 do not offer benefits to more vulnerable citizens, while C2 does. C2/D2 is also a significant pair. In C2 citizens are invited to participate and more vulnerable citizens are benefited, while in D2 citizens are not invited to participate and there are no benefits (see Figure 6).

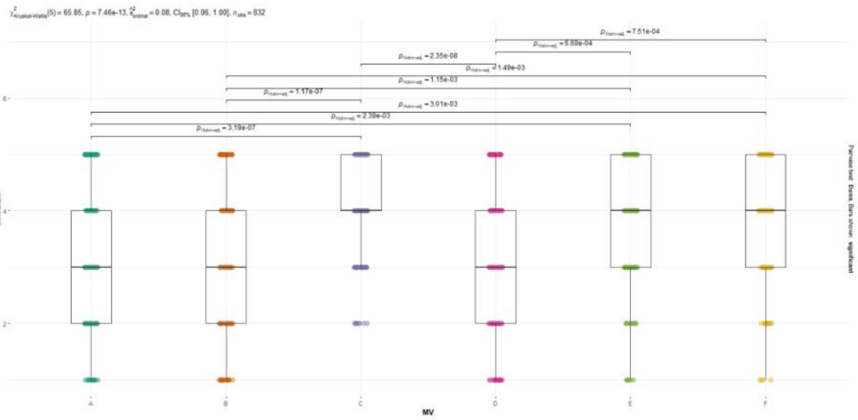

Figure 6. Boxplots of levels of satisfaction ~~in relation to~~ with projects for six medium-scale solar ~~installations for six~~ vignettes~~.~~ (MV). The ~~graph~~chart shows the results of the Kruskal-Wallis non-parametric test ~~and differences between pairs of vignettes (MV).~~.

As for interest in the projects, differences are less pronounced. There is less interest in vignettes A2 and B2 (with a median of 3), in which there is no benefit for more vulnerable citizens, and higher interest in the other four vignettes (with a median of 4). The scenario with the highest frequency in the value 5 is C2 (35.76%) in which citizens are invited to participate and there are benefits for more vulnerable communities.

As for pairwise comparisons, there is a weak significance. Yet the most significant pairs are A2/C2 and B2/C2, in both cases the key difference is that A2 and B2 offer no benefits to local communities, while C2 does.

4.3.3 Small size

Overall, small size vignettes had the highest levels of satisfaction, when compared to the large and medium sizes. All vignettes were highly valued (medians of 4), yet vignette C3 stands out with a median of 5. In this vignette, citizens are invited to participate, and the project brings benefits to more vulnerable citizens. The effect of the existing differences is considered moderate (i.e., 0.0737). Pairwise comparisons show the most significant pairs are A3/C3, B3/C3 (in both pairs the key difference is that A3 and B3 offer no benefits to local communities, while C3 offers benefits), C3/D3 and C3/E3 (in D3 and E3 citizens are not invited to participate, yet they participate in C3) (see Figure 7).

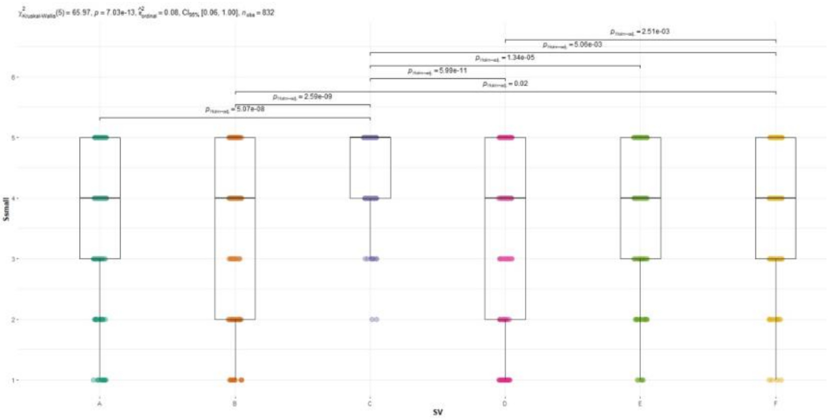

Figure 7. Boxplots of levels of satisfaction ~~in~~ with projects for six small-scale solar ~~installations, comparing six~~ vignettes~~.~~ (SV). The ~~graph~~chart shows the results of the Kruskal-Wallis non-parametric test ~~and differences between pairs of vignettes (SV).~~.

Concerning interest in the project, C3 is also the highest-ranking scenario, with a median of 5, while all others have a median of 4. Nevertheless, pairwise comparisons show a weak significance.

4.4 Regression Analysis of Satisfaction and Interest responses

4.4.1 Satisfaction

The GLM applied to the three vignette subgroups were labelled as GLM 1.1 (large solar); GLM 1.2 (medium solar) and GLM 1.3 (small solar). The three GLM used as intercepts (or the value taken as a constant for the expected mean of y, if x is zero) the mean values of the response variable (i.e., degree of satisfaction) when confronted with vignettes A1 (large solar), A2 (medium solar) and A3 (small solar), the female gender, the lower age group (i.e., 18 to 24 years) and the region of Alentejo.

The results of the GLM 1.1., 1.2 and 1.3, are presented in Table 8, where estimates indicate how levels of satisfaction increased or decreased. Standard errors, z-values (i.e., the number of standard deviations away from the mean, given by the regression coefficient or the estimates divided by the standard error), and p-values are also included.

According to GLM 1.1, with a reference value for A1 vignette (see Table 4 for the vignette descriptions) of 2.38 (95% confidence interval [1.57, 3.30], $p < .001$), respondents' satisfaction increases when presented with vignettes B1, C1 and D1, and there are no statistically significant differences in relation to E1 and F1. Satisfaction also decreases in age groups of 35~~ and ~~-44, and of 55~~ and ~~-64, and it decreases if respondents are from Andalusia, both when presented with vignette A1, as well as with the other vignettes which have higher levels of satisfaction than A1.

~~According to~~In GML 1.2, there are no significant effects between the reference value of A2 and other vignettes, in the respondents' degree of satisfaction. However, satisfaction increases if respondents are male and decreases if they are from Andalusia. Considering there are no statistically significant differences between vignettes, the results for satisfaction regarding medium solar energy projects are equivalent as regards differences in gender and region for all vignettes, based on the reference value~~, i.e.,~~ - A2, with a value of 3.01 (95% CI [1.96, 4.22], $p < .001$). There ~~were~~are also no statistically different results concerning age groups.

~~According to~~In GML 1.3, satisfaction increases when respondents are presented with vignette F3, compared to A3, yet there are no significant differences in other vignettes. Satisfaction decreases in age groups of 55-64, compared to the other age groups, when presented with any of the vignettes. If respondents are from Andalusia, their satisfaction also decreases.

Table 8 Results of the GML 1.1, 1.2 and 1.3

GLM 1.1 Large Solar and Degree of Satisfaction				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values** (*indicate statistically significance)
Vignette A1 (intercept)	2.37887	0.43869	5.423	**0.0000000587 *****
Vignette B1	1.33541	0.39979	3.340	**0.000837 *****
Vignette C1	1.27800	0.38258	3.341	**0.000836 *****
Vignette D1	1.39078	0.39593	3.513	**0.000444 *****
Vignette E1	0.05381	0.28703	0.187	0.851293
Vignette F1	0.44997	0.33330	1.350	0.177011
Gender (male)	0.07032	0.22250	0.316	0.751960
Age~~.group~~ Group [T.25 to 34]	-0.69981	0.46038	-1.520	0.128490
Age~~.group~~ Group [T.35 to 44]	-1.11021	0.42972	-2.584	**0.009778 ****
Age~~.group~~ Group [T.45 to 54]	-0.42684	0.43989	-0.970	0.331890
Age~~.group~~ Group [T.55 to 64]	-1.16279	0.45331	-2.565	**0.010314 ***
Region (Andalusia)	-0.79283	0.21572	-3.675	**0.000238 *****
GLM 1.2 Medium Solar and Degree of Satisfaction				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**~~Pr(>|z|)~~P-values**
Vignette A2 (intercept)	3.00756	0.57154	5.262	**0.000000142 *****
Vignette B2	-0.52813	0.38035	-1.389	0.164982
Vignette C2	17.27600	849.60183	0.020	0.983777
Vignette D2	-0.13548	0.38047	-0.356	0.721789
Vignette E2	1.04347	0.54105	1.929	0.053779
Vignette F2	1.14097	0.58397	1.954	0.050724
Gender (male)	0.69401	0.31386	2.211	**0.027023 ***
Age~~.group~~ Group [T.25 to 34]	-0.22882	0.54398	-0.421	0.674017
Age~~.group~~ Group [T.35 to 44]	-0.16684	0.54312	-0.307	0.758708
Age~~.group~~ Group [T.45 to 54]	-0.05189	0.53520	-0.097	0.922767
Age~~.group~~ Group [T.55 to 64]	-1.03192	0.54708	-1.886	0.059265
Region (Andalusia)	-1.20594	0.32015	-3.767	**0.000165 *****
GLM 1.3 Small Solar and Degree of Satisfaction				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**~~Pr(>|z|)~~P-values**
Vignette A3 (intercept)	3.52692	0.62620	5.632	**0.0000000178 *****
Vignette B3	0.36663	0.43537	0.842	0.39973
Vignette C3	17.39661	899.02154	0.019	0.98456
Vignette D3	-0.68770	0.37486	-1.835	0.06658
Vignette E3	0.83304	0.51662	1.612	0.10686
Vignette F3	1.59679	0.58960	2.708	**0.00676 ****
Gender (male)	0.43798	0.31372	1.396	0.16269
Age~~.group~~ Group [T.25 to 34]	-0.04778	0.62786	-0.076	0.93934

Age~~.group~~ Group [T.35 to 44]	-0.48896	0.59384	-0.823	0.41029
Age~~.group~~ Group [T.45 to 54]	-0.78627	0.55133	-1.426	0.15383
Age~~.group~~ Group [T.55 to 64]	-1.50983	0.57755	-2.614	**0.00894 ****
Region (Andalusia)	-1.38051	0.32766	-4.213	**0.0000251727 *****

Overall, the regression results indicate that Andalusian respondents ~~were~~are less satisfied with the solar energy projects than Alentejo's respondents, with more evidence of a statistically significant result in the case of large solar energy projects. Conversely, male respondents are overall more likely to be supportive of large and medium-scale solar projects, with no significant differences in the case of small solar energy projects.

4.4.2 Interest

For analysing responses to the degree of interest in participating in different solar projects, when presented with the three vignette subgroups, three GLM were applied to the large (GML2.1, medium (GLM2.2), and small solar (GLM2.3) vignette subgroups.

In the three cases, the intercept, or reference value, corresponds to the mean values of the "degree of interest" when confronted with vignettes A1, A2 and A3, respectively, as well as the female gender, the lower age group (i.e., 18~~ to ~~-24 years) and the region of Alentejo.

In GLM2.1, the value of the intercept is 1.53 (95% CI [0.77, 2.37], $p < .001$), and the degree of interest increases in the case of vignettes B1, C1, and D1, with a statistically significant and positive effect. There ~~were~~are no significant results for other vignette factors (i.e., age, region, and gender).

In GLM2.2, the value of the intercept is 3.41 (95% CI [2.30, 4.71], $p < .001$), and a significant and positive effect is found in the case of vignette B2. Respondents from Andalusia have a lower interest in participating and male respondents have a higher interest.

Lastly, in GLM2.3 the value of the intercept is 3.44 (95% CI [2.28, 4.80], $p < .001$). There are no statistically significant results by comparison with other vignettes in this subgroup. Participants from Andalusia are less interested in participating in projects, compared to those from Alentejo.

Overall, ~~in the case of the~~regarding interest in participating in projects, regression analysis results returned less significant differences than in the case of satisfaction with projects. Nevertheless, the values of the intercept are higher in small and medium solar, compared to large solar projects. In addition, when significant results are found, there are similarities to those found for the satisfaction variable, with Andalusia's respondents less positive than Alentejo's respondents and male respondents more positive than female respondents for all the vignettes.

Table 9 presents the results of the regression analysis for the three solar sizes and the factor effects on the interest variable.

Table 9 Results of the GML 2.1, 2.2 and 2.3

GLM 2.1 Large Solar and Degree of Interest				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values** (*indicate statistically significance)
Vignette A1 (intercept)	1.52687	0.40632	3.758	**0.000171 *****
Vignette B1	1.02269	0.40900	2.500	**0.012402 ***
Vignette C1	1.65837	0.47824	3.468	**0.000525 *****
Vignette D1	0.79036	0.37468	2.109	**0.034906 ***
Vignette E1	0.30153	0.32347	0.932	0.351237

Vignette F1	0.73588	0.38509	1.911	0.056012
Gender (male)	-0.15703	0.24530	-0.640	0.522078
Age.~~group~~ Group [T.25 to 34]	-0.31696	0.42505	-0.746	0.455839
Age.~~group~~ Group [T.35 to 44]	-0.13716	0.41373	-0.332	0.740258
Age.~~group~~ Group [T.45 to 54]	0.53615	0.43718	1.226	0.220046
Age.~~group~~ Group [T.55 to 64]	-0.15671	0.43912	-0.357	0.721177
Region (Andalusia)	0.09617	0.23088	0.417	0.677025
GLM 2.2 Medium Solar and Degree of Interest				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**~~Pr(>|z|)~~P-values**
Vignette A2 (intercept)	3.4106	0.6094	5.597	**0.0000000219 *****
Vignette B2	-0.8236	0.4081	-2.018	**0.04355 ***
Vignette C2	1.0060	0.6002	1.676	0.09375
Vignette D2	-0.3177	0.4214	- 0.754	0.45087
Vignette E2	0.6344	0.5591	1.135	0.25654
Vignette F2	0.5952	0.5598	1.063	0.28766
Gender (male)	0.6032	0.3073	1.963	**0.04964 ***
Age.~~group~~ Group [T.25 to 34]	-0.5619	0.5618	-1.000	0.31721
Age.~~group~~ Group [T.35 to 44]	-0.6324	0.5516	- 1.146	0.25159
Age.~~group~~ Group [T.45 to 54]	-0.3427	0.5530	-0.620	0.53540
Age.~~group~~ Group [T.55 to 64]	-0.7514	0.5909	-1.272	0.20354
Region (Andalusia)	-0.9906	0.3063	-3.234	**0.00122 ****
GLM 2.3 Small Solar and Degree of Interest				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**~~Pr(>|z|)~~P-values**
Vignette A3 (intercept)	3.43891	0.63781	5.392	**0.0000000698 *****
Vignette B3	-0.02221	0.48122	-0.046	0.96318
Vignette C3	16.92916	919.77656	0.018	0.98532
Vignette D3	-0.73067	0.43157	-1.693	0.09045
Vignette E3	0.38498	0.54725	0.703	0.48176
Vignette F3	0.50322	0.52303	0.962	0.33599
Gender (male)	0.35276	0.32237	1.094	0.27384
Age.~~group~~ Group [T.25 to 34]	-0.60544	0.56968	-1.063	0.28789
Age.~~group~~ Group [T.35 to 44]	-0.27095	0.59313	-0.457	0.64780
Age.~~group~~ Group [T.45 to 54]	-0.34077	0.56056	-0.608	0.54325
Age.~~group~~ Group [T.55 to 64]	-0.73618	0.59432	-1.239	0.21546
Region (Andalusia)	-0.93868	0.32322	-2.904	**0.00368 ****

4.5 Objectives and values

When choosing between a menu of key objectives for sustainable solar energy installations, and associating them with different solar scales, "economic growth" was mainly associated with the large size (49%, corresponding to 405 occurrences), followed by the medium size (41%) by comparison with small-size installations (10%). However, "Reducing energy production" was mainly associated with medium ~~systems~~ (44%) and large systems (35%), and less with small systems (21%).

Large systems were also more associated with the prospective for "new jobs" (54%), in comparison with small-size installations (10%). The objectives most frequently associated with small-size installations were "integration in landscape" (47%), followed by "protection of biodiversity" (33%) and "community trust" (27%). "Energy as a common good" had a low frequency in the case of the small size (18%), compared to medium (39%) and large (42%) sizes. "A lower energy bill" was mostly associated with the large size (43%), followed by medium (31%) and small (18%). Overall, medium-size systems are strongly associated with all the different options (e.g., economic growth, new jobs, common good, community trust, etc.), while small-size installations are mainly considered important to meet the objectives of "protecting biodiversity" and "integration with the landscape", as illustrated by Figure 8.

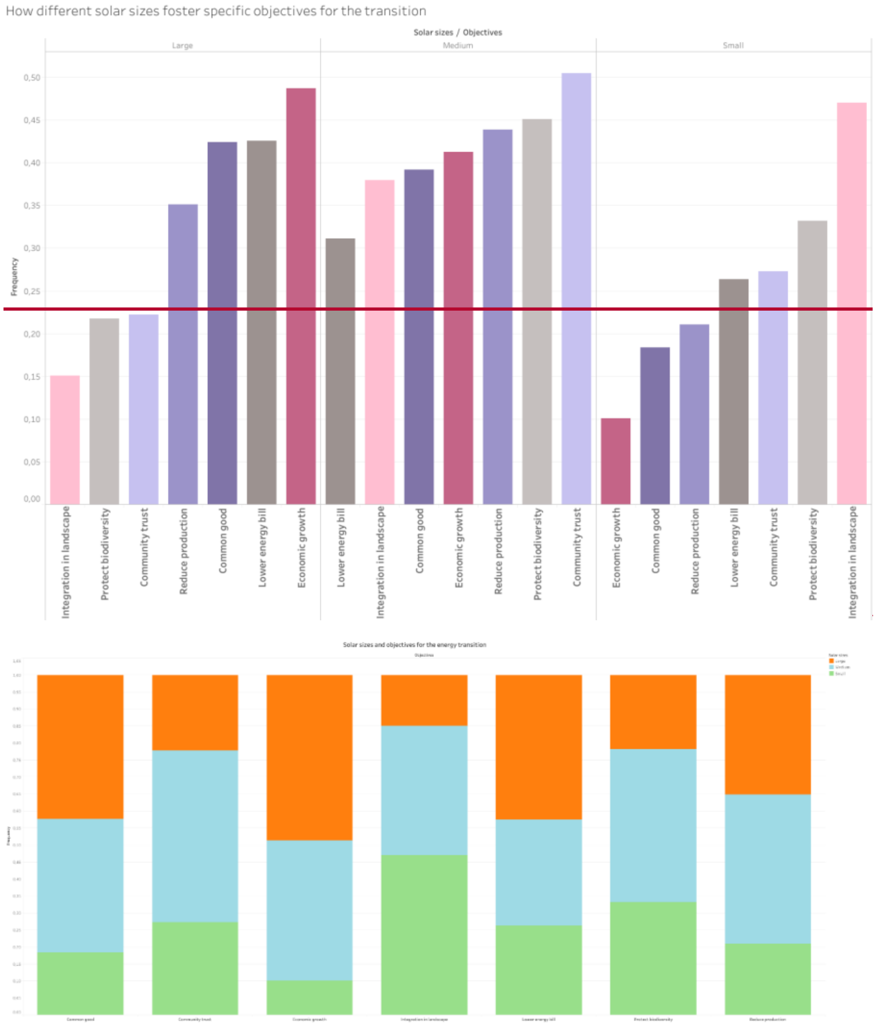

Figure 8 Objectives related to different solar scales

Regarding the most valued aspects to ensure a sustainable energy transition, those with higher frequency were profitability (54%), which corresponds also to the mode value, followed by transparency (48%) and clean energy (42%). Other highly valued ideas included autonomy (25%), community trust (26%), and holistic planning (17%). However, when comparing the two regions, the values attributed showed a contrast. For instance, while "ease" (referring to being easy to implement) is quite valued in Andalusia (69%) it is the least valued aspect in Alentejo (31%), by contrast, "local" is the most valued aspect in Alentejo (61%) while it is the least valued in Andalusia (39%). Table 10 presents the frequencies, which are illustrated in Figure 9.

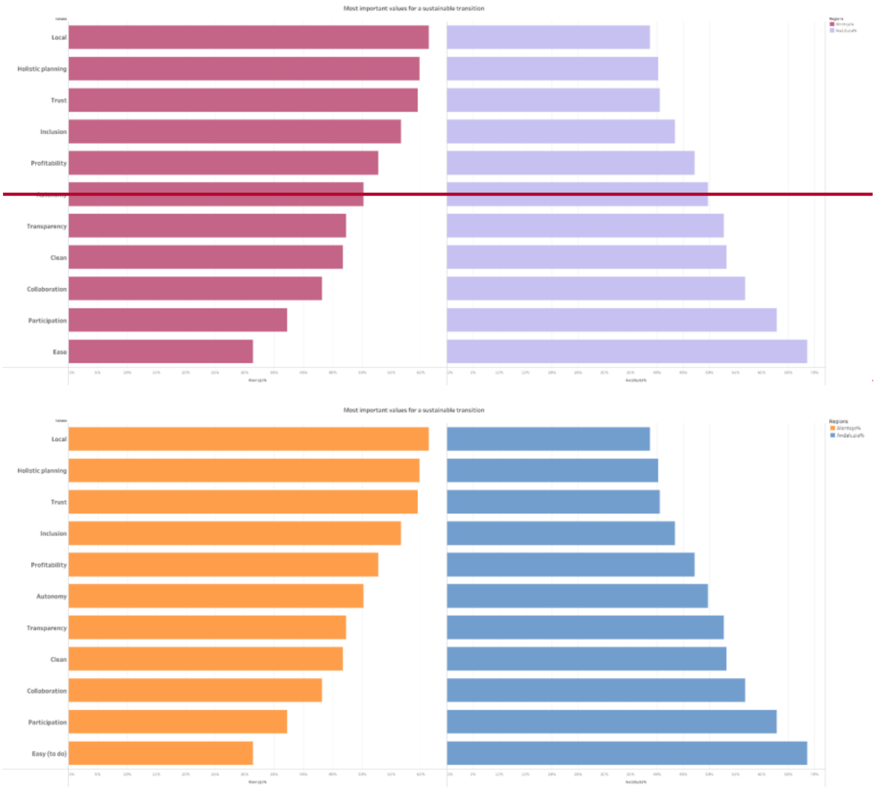

Figure 9 Values considered important for a sustainable transition

Table 10 Frequency of Values for Alentejo, Andalusia and in total

Values	**Alentejo%**	**Andaluzia%**	**Total %**
Local	61%	39%	**9%**
Participation	37%	63%	**15%**
Collaboration	43%	57%	**15%**
Inclusion	57%	43%	**16%**
Holistic planning	60%	40%	**17%**
~~Easy~~Easy (to do)	31%	69%	**18%**
Autonomy	50%	50%	**25%**
Trust	59%	41%	**26%**
Clean	47%	53%	**42%**
Transparency	47%	53%	**48%**
Profitability	53%	47%	**54%**

5. Discussion

Solar photovoltaic energy is generally well received. In large-scale solar projects, citizens' satisfaction with, and interest in, is moderate to high, implying that news media coverage of

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citizens' protests and contestation of large-scale solar parks in the two regions reflects outlier opinions, rather than those of the majority. As observed in studies of the opposition to wind energy, people with stronger opinions against a project seem to be the most vocal in public discussions [71]. The slight differences between the two regions indicate that societal dissatisfaction with large-scale solar is ~~reactionary~~reactive since Andalusia has undergone an earlier development of investments and its rural landscapes are already populated by these installations. This finding also supports the idea of the relational nature of SA [37], indicating that SA can be conditioned not only by other local and interrelated policies but also by the local energy geographical history [9].

Given the choice, citizens are willing to participate in large-scale energy systems, which offers evidence that EC needs to be further encouraged in the context of centralized systems [8]. For large-scale solar, being invited to participate is the most relevant factor for ensuring citizens' satisfaction and interest (as the vignettes that included this aspect ranked higher). Thus, strengthening EC in the context of large-scale solar requires policies that foster citizens' participation in projects, which are typically implemented through a top-down approach [11]. In this context, municipalities ~~are~~ have a critical role to play as intermediaries between investors and local populations [40].

Notwithstanding the importance of participation in centralized systems, citizens from these regions prefer small distributed systems, followed by medium-scale installations, indicating that small and medium systems are the optimal geography for higher levels of EC within a community [41]. ~~A higher~~The preference for small systems is akin to findings from a survey in Switzerland, according to which the SA of solar energy decreases as installations' size increases [36].

The importance that renewable energy systems ensure compatibility with the natural environment and biodiversity was highly valued and strongly correlated to the importance attributed to the energy transition, indicating that citizens' environmental awareness is significant, regardless of their support or opposition to different types of solar installations. This finding is conducive to an understanding of SA as being embedded in broader societal concerns [28,35], such as weighting impacts on natural habitats and biodiversity against the need for a fast decarbonization [37].

Citizens were more interested in participating in projects offering benefits to more vulnerable populations, suggesting concerns with inclusivity, and indicating that a relational dimension is also applicable to EC [72]. Both Portugal and Spain are among the countries most vulnerable to energy poverty in the European Union, therefore citizens would be expected to care that new projects can help more vulnerable communities [73,74]. However, tackling energy poverty in the context of large-scale solar investments is still largely unexplored, despite evidence that historically large-scale energy transformations have meant also energy-related social injustices [75]. This is a crucial aspect for the advancement of EC policies while meeting energy justice goals [5,72]. Another minor, yet significant difference ~~regards to~~concerns gender, with male respondents consistently more interested in large and medium-scale projects, and middle to older age citizens generally less interested, which points to the importance of understanding the conditions that make energy projects appealing to women's participation and to the participation of older generations [76,77].

Transparency is a key factor for higher levels of satisfaction and interest in large-scale solar installations and was highly valued for a sustainable energy transition. Thus, transparency can have a positive impact on fostering community acceptance of large-scale solar projects [6]. Likewise, transparency and openness in sharing data and project plans (key principles of collective prosumer initiatives) [41,78], may foster greater possibilities for citizens' involvement in new centralized solar projects.

Nevertheless, there are discrepancies between peoples' preferences and their ideas about the key values for a sustainable energy transition. On the one hand, satisfaction and interest in projects rank higher if more vulnerable citizens can benefit from them. On the other hand, a key value for a sustainable transition is profitability and large systems are perceived as the most relevant for ensuring "the common good", rather than decentralized small systems, such as energy communities. Yet, by definition, energy communities should result in social and environmental benefits for local communities, rather than being profit-driven [79]. Indeed, a reduction in energy costs would likely be greater with larger systems resulting from profit-driven investments. However, there is equally a high potential for collective prosumers, such as energy communities, to contribute to a reduction of energy costs [80,81]. These findings indicate a lack of information regarding the benefits and costs of the different types of installations. A recent review also found that a key barrier to SA of solar photovoltaic panels is limited information about the technologies [82]. Energy literacy should thus be a key policy goal since without being appropriately informed citizens face barriers to becoming protagonists of the transition [83].

6. Conclusion

SA and EC are both embedded in broader societal concerns, and multiple factors can affect local support for multi-scalar solar projects, as well as citizens' interest in becoming actively involved. Among these factors, policies that enable higher participation of citizens and benefit more vulnerable communities, including in large-scale solar installations, are important. Nevertheless, the relative importance of these factors, when compared to the overall satisfaction with different scales, indicates that there is a high level of SA for all types of solar projects, although communities already exposed to large-scale solar landscapes are bit less satisfied.

Effectively informing and communicating to citizens what small and medium size installations are and how they can benefit local communities, as well as women and older citizens is important for expanding EC. Regional and national energy planners should take extra effort in disseminating new energy models (e.g., energy communities) among local populations, explaining their costs and benefits. It is equally important to negotiate trade-offs between large-scale investments and small-scale systems.

There is still a wide gap in research to meet the goals of fostering EC in an inclusive way, while advancing with a rapid and sustainable energy transition. Future research on interactions between SA and EC, should focus on measuring the positive impacts of involving local communities in large-scale projects, and promoting transparency in planning practices, while being mindful that local communities will need to adapt to new land uses for landscapes that frame their cultural identities and on which they may depend for their livelihoods. Finally, issues of whether the energy transition is to be a profitable process and/or guided by wellbeing and energy justice principles, cannot be detached from considerations of scale and attention to the possibility of effectively ensuring citizens' inclusive ability to participate and benefiting from new energy systems.

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Scales of solar energy: Exploring citizen satisfaction, interest, and values in a comparison of regions in Portugal and Spain

Inês Campos, Miguel Brito and Guilherme Luz

1. Introduction

The energy transition requires new energy geographies, and the participation of citizens across regions and countries [1]. While energy cooperatives, based on citizens' collective investments in small to medium-scale solar energy projects flourish across Europe, new discussions emerge on the sustainability of large-scale solar installations [2,3]. Large centralized solar installations are fostering a debate on the social acceptability (SA) of new solar landscapes [4,5], as they may compete with other land uses and have negative impacts on local activities, such as rural tourism [3,6]. Furthermore, research is still lacking on how energy citizenship (EC), or the active involvement of citizens as protagonists in new energy systems [7], is developing in the context of different solar geographies, derived from both centralized and decentralized systems [8].

Thus, the expansion of new renewable energy geographies, requires insights from both SA and EC perspectives [8,9]. Informed by these two interrelated research fields, this article aims to shed light into citizens' acceptance and participation in multiscale solar projects. The overall goal is to explore how citizens perceive the urgency of the energy transition and gain further insight into the conditions that make citizens most satisfied with and interested in participating in different solar energy projects– from large installations to small and medium-scale production.

To address this goal, the study focuses on two Southern European regions - Alentejo (Portugal) and Andalusia (Spain) - and draws on a representative survey (n=832). There has been an expansion of large-scale solar energy projects in the past decade in the two regions [10,11]. These regions have witnessed a boom in decentralized solar energy production supported by national legislation and by incentives for the growth of 'prosumers' - i.e., self-consumers of small-scale energy from renewable sources, at the individual and/or collective level [12,13], including energy communities and cooperative investments [14,15], often led by citizens' investments [16,17]. Wind energy is less suitable for these regions, particularly in their in-land and rural areas.

Alentejo region is likely to host the biggest solar energy installations in Portugal, at least in two locations. One example is the project planned for Cercal village, consisting of five photovoltaic installations in adjacent areas, with a total installed capacity of 275 MWp, expected to produce about 596 GWh/year and cover 137,05 hectares of farmland. A group of circa 200 residents and local entrepreneurs has been opposed to the project, creating a civic movement to prevent its implementation. Four participants of this movement were interviewed at an exploratory stage of this study. Their reasons for opposing the project related to the perceived impacts on local social, economic, and environmental sustainability, while they considered small and medium-scale installations to be sustainable alternative solutions. Interviewees mentioned that Andalusia was facing similar challenges, leading the authors to investigate this region.

In Southern Spain, Andalusia has also been the focus of a surge in solar energy investments, sparking debates regarding the sustainability of massive solar installations for over a decade [10]. In Malaga, newspapers reported local protests in 2021-22 backed by the slogan "Renewables yes, but not this way!" [18]. Protests delayed the approval of dozens of large-scale photovoltaic projects proposed across the region. According to news media, the major causes for concern have been the possible negative environmental impacts of these power plants on agricultural lands, as well as their impact on local rural tourism activities. In Castellar de la Frontera (Andalusia), communities have also been concerned with the impact of large-scale solar farms on ecologically protected regions [19].

Both regions are vulnerable to climate change impacts, mainly due to increased temperatures, more frequent heat waves and a reduction in precipitation [20,21]. These regions offer a setting to investigate SA and EC in the context of a multi-scale solar expansion, while gathering insights relevant for other regions and countries in South Europe [22].

To systematize the analysis of citizens' preferences in relation to different solar scales, three "sizes" were identified based on the two countries' regulatory frameworks [23], and on their prevailing solar energy production models [24,25]. The small size refers to installed capacities of up to 1000 kWp. This type of installation may be as small as a rooftop solar in households and/or may be implemented by an energy community, where its members collectively pay for the solar panels and, through an internal agreement, share, self-consume and/or sell the energy produced. Relevant regulatory frameworks are the DL15/2022 that comprises specific legislation for self-consumption and energy communities in Portugal and the RD-L 244/2019 for self-consumption in Spain. The medium size refers to solar projects with an installed capacity of between 1 and 50 MWp. Medium-size installations can fall under the energy community concept, or they can be owned by an industry player. They can also take the form of "agrivoltaic", enabling the joint development of farming activities and energy production [26]. The reason for the 50 MWp threshold relates to Portuguese and Spanish legislations, which consider that only installations larger than 50 MWp require an Environmental Impact Assessment. Finally, within a centralized distribution configuration, the large size refers to projects with an installed capacity of above 50 MWp, which may include storage facilities, the development of high voltage transmission lines and floating solar photovoltaic projects. Relevant regulatory frameworks in Spain are the RD-L 6/2022, and in Portugal the DL30-A/2022.

In what follows, we outline the theoretical background for this study, followed by the methodological approach and data analysis methods, and then present the results of the survey in part 4. The findings are discussed in relation to current literature on SA and EC in part 5, and key implications for future research are summarized in the conclusion.

2. Background

Studies of social acceptance (SA) [27–29] and energy citizenship (EC) [7,30] are strongly interrelated and offer a theoretical background for this study.

The concept of SA of renewable energy technologies (i.e. RET) developed by Wustenhagen and colleagues [31], has been largely informed by empirical findings on case studies of wind energy acceptance, while solar energy, by comparison, was thought to be broadly accepted. SA considers three dimensions, namely socio-political, community and market acceptance [29] and therefore, assumes a multi-stakeholder perspective [32]. Participation is considered a key factor for higher acceptance of new energy projects [33,34]. More recently, SA has developed into a 'critical approach', increasingly concerned with the (in)justice aspects of RET, including distributive, procedural and recognition justice, and understanding SA as being "socially embedded and co-constructed" [35] (p.2). Within this critical approach, research of large-scale wind installations found that (monetary or in-kind) compensation for any negative impacts of projects is important for local communities [29]. Also, research into large-scale solar energy projects concluded these foster concerns at the community level [36,37], although the same type of project continues to enjoy a high acceptance from a policy and top-down perspective [38], as well as market acceptance [26].

Community acceptance of large-scale solar installations is framed by key issues such as "green-on-green, scale, place attachment, policy, process and justice"(from highlights: [37]). Specifically, Roddis and colleagues [37] named "green-on-green tensions" (p.239) as those emerging when concerns for mitigating climate change clashed with concerns over wildlife preservation, leading to opposition to renewable energy projects. For instance, in their study there were concerns with the extent to which large-scale solar projects required using land in spaces previously untouched, thus competing with alternative land uses (e.g., for agriculture, biodiversity preservation and/or rural tourism activities), while the need for decarbonizing the energy system was also recognized. In this context, citizens highlighted a lack of political attention to alternative solutions for producing solar energy (e.g., such as the proliferation of small and medium scale installations using pre-existing infrastructure). Thus, acceptance of RET has been characterised as having a "relational nature" [37], meaning that community acceptance of a particular project is informed by broader policy views on e.g. local development, land management and diverse local, regional and even international governance issues.

Thus, this article considers interrelations between citizens' attribution of importance to the energy transition and their opinions on the importance of an energy transition that creates synergies with environmental protection and preservation, to which we broadly refer to as being "compatible with the natural environment and biodiversity". Furthermore, issues related to procedural and distributive justice were integrated by questioning how citizens' satisfaction with energy projects changed according to whether citizens are invited to participate, and to whether those impacted by projects are offered compensation and/or projects benefit more vulnerable communities.

Next to SA, the EC concept proposed by Devine-Wright [7], addresses people as active participants, democratically engaged in sustainable energy transitions. Citizens are participating in the energy transition by engaging politically and taking part in various types of collective energy-related projects as users, consumers, prosumers, supporters, and/or protesters [30]. Although EC refers to both individual and collective action, a recent review concluded that research has been strongly focussed on communities and democratic participation in energy-related decisions, with a particular emphasis on decentralized systems, and with less focus on centralized and large-scale systems [8]. From an EC perspective, citizens shift from passive to active actors in the energy transition, through participation in energy investments, consumption choices, and in supporting or protesting in view of effective policies for advancing the energy transition [39]. However, it is not always clear how EC can be combined with inclusivity and justice goals, particularly when participation implies direct investments from citizens, and does not account for broader socioeconomic inequalities [39,40].

Specifically, how citizens can be active participants in centralized systems, such as large-scale solar energy systems, has received little attention in EC literature [8]. By contrast, EC is mainly addressed in the context of studies of prosumers, or citizens involved in social innovations, and/or social movements, including protest movements in the scope of energy policies [41]. Finally, while the concept is increasingly a research focus, there is still little evidence of how citizens who are not involved in any type of energy project, can exert and/or are willing to exert their (energy) citizenship rights. Indeed, while EC assumes active behavioural changes at the individual level, there has been less focus on citizens' rights when confronted with new energy projects in which they are not invited to participate [39]. To enable a focus on 'citizens', this study opted for a representative survey to learn how citizens feel about potential energy projects.

3. Methodology

The methodology started with an exploratory and qualitative approach, leading to the selection of the case study regions, and proceeded with a quantitative study, based on an online survey, which contained a vignette experiment [42,43]. Strict ethical procedures and requirements were followed, providing all research participants with informed consent, and following internal ethical guidelines approved by the ethical committee of the Faculty of Sciences of the University of Lisbon. Data collection was fully anonymous, and no personal data was collected.

Figure 1 is a flowchart of the different methodological steps undertaken and described in the following paragraphs.

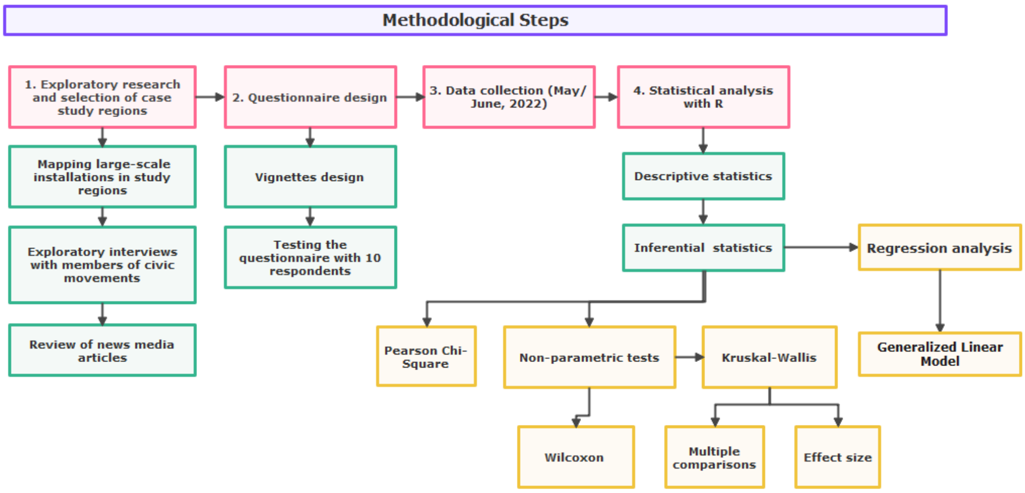

Figure 1 Flowchart of the methodology

3.1 Exploratory inquiry

At the exploratory stage, contextual data was collected and revised via a review of the literature and news media articles (i.e., published by local or national newspapers). A list of the regional and national papers consulted at the exploratory stage and their timespan is provided in supplementary materials (Table S1).

Four exploratory unstructured interviews were conducted with citizens involved in a local civic movement against the implementation of a large solar plant in Alentejo. Interview questions focussed on (i) understanding the causes for these citizens' dissatisfaction and (ii) their overall ideas about the importance of the energy transition. In addition, data collected by the authors on medium and large PV installations in Alentejo and Andalusia (see Figure 2), offers a geographical illustration of the two regions, showing that Andalusia has several built large solar parks (in blue), and Alentejo has two large, planned parks (in orange).

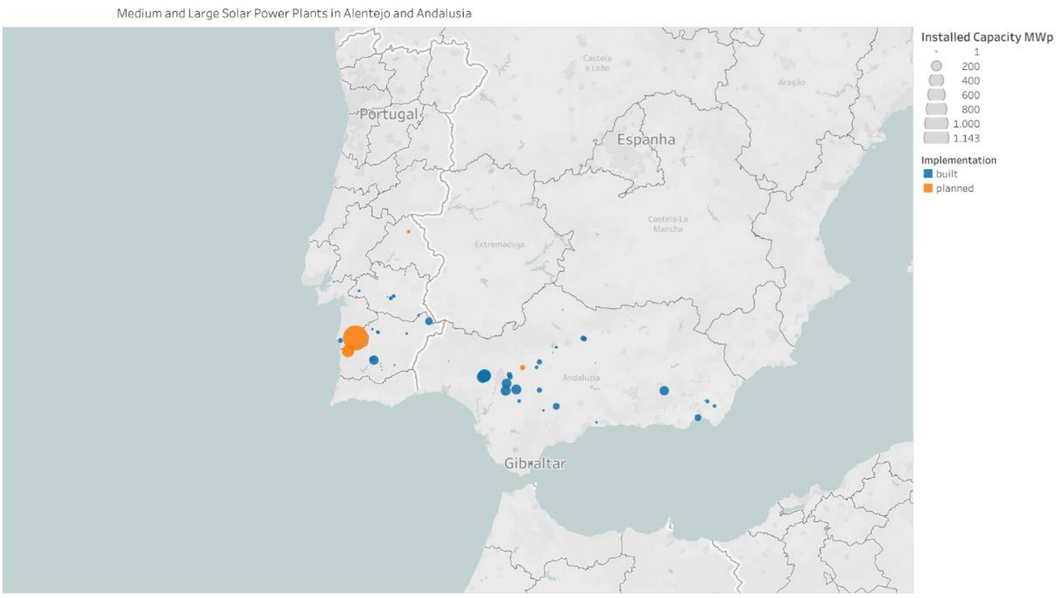

Figure 2 Map of Alentejo and Andalusia's medium and large-scale solar plants (see [interactive version](#) in Tableau)

The exploratory inquiry, including the results of the interviews, the review of newspaper articles, as well as the mapping of large-scale solar energy installations in Portugal and Spain, informed the selection of the case study regions described in the introduction.

3.2 Research questions

Drawing on the exploratory inquiry, two interrelated research questions guide the article, namely:

1. How do different factors (i.e., compensation, participation, and benefits for more vulnerable communities), relate to citizens' satisfaction with, and interest in, participating in solar energy projects of different sizes?
2. How are different solar sizes perceived to help realize key objectives and values for a sustainable energy transition?

The methodology followed a quantitative approach based on an online survey of a representative sample. After testing the survey questionnaire with 10 respondents, the questionnaire form (created in PHP programming language) was handed to a data collection survey company to collect the responses. A final set of 832 valid responses were collected between May and June 2022.

3.3 Questionnaire

The questionnaire, translated into Portuguese and Spanish, had the following four sections:

3.3.1 Contextual and sociodemographic background

All participants responded to questions for collecting general background information on their location (region of residence), age, gender, and professional status, as well as contextual information such as whether the respondent "worked or was close to persons who worked in the" fossil fuel industry, nuclear energy industry, renewable energy industry, or other; and whether the respondent would "regularly hear, see, or smell" different types of energy-related infrastructures.

3.3.2 Importance of the transition

This section was informed by an understanding of SA as being socially embedded and related to perceptions about the environment and distributive, procedural and recognition justice factors [35,37]. The section focused on learning (1) how important the energy transition is to respondents, (2) how important it is that renewable energy systems ensure compatibility with the natural environment and biodiversity (i.e., they do not harm natural habitats), and (3) how important it is that energy projects offer benefits to more vulnerable citizens. These three questions used a Likert scale of 1 (not important) to 5 (very important), and all survey respondents replied to them.

3.3.3 Vignette experiment

This section contained a vignette experiment [43,44]. Vignette surveys have been used in diverse contexts and research areas, including sociology [45] and psychology [46], as well as social and energy research [29]. A vignette experiment (also called a factorial survey) starts by introducing respondents to a carefully designed and realistic scenario on a specific topic, and then poses one or more questions about the presented scenario. Rather than directly asking about a specific issue, responses are elicited through hypothetical scenarios (e.g., "What would you do if…?"). A collection of vignettes can thus be defined as "a set of systematically varied descriptions of subjects, objects, or situations in order to elicit respondents' beliefs, attitudes, or intended behaviours with respect to the presented vignettes." (p.53)[44].

The experimental vignette methodology in which this study falls into, entailed presenting survey respondents with scenarios to assess two dependent variables, namely satisfaction with, and interest in participating in solar energy projects [43]. The key goal of the vignette experiments was to understand how responses varied with different factors, such as whether local populations are invited to participate and/or compensated for any damages to their livelihoods, and/or if more vulnerable communities benefit from the project. Issues of transparency (e.g., the openness factor) and who is responsible for the investment were also considered.

Each respondent was randomly presented with a total of three vignettes (i.e., one of six from each of the three groups of vignettes for large, medium, and small size solar projects). The vignettes were accompanied by a photograph of a large, medium, or small-scale installation (depending on the vignette group) to help respondents visualize the scenario [36]. After being randomly presented with a vignette, respondents answered two questions about it (see example in Table 1):

Table 1 Vignette example (underlined parts correspond to the factors that varied between the vignettes).

"As you pass by a rural area near you, you see the new installation of solar panels, seemingly covering several kilometres. You know that the local community was invited to participate in the planning process of the solar park, which has been funded by a large utility company. Those who live nearby the installation have not received any sort of compensation for the impacts of the new installation on their livelihoods. The plans and land lease contracts were not openly shared with the community."
1. Would you be satisfied with a such a project? (Choose below the option that is most applicable to you) (1) Not satisfied, (2) poorly satisfied, (3) somewhat satisfied, (4) satisfied, (5) very satisfied.
2. If the possibility was presented to you, would you be interested in participating in such a project? (Choose below the option that is most applicable to you) (1) Not interested, (2) poorly interested, (3) somewhat interested, (4) interested, (5) very interested

To generate each of the vignette groups contained within the survey, the factorial design (see also Table S2 in supplementary materials) was comprised of 3 factors (A, B and C), each with two levels (negative and positive). The main effect of A, B, and C factors, or of their interaction (AB, AC, BC, ABC), is the difference between the average of the responses corresponding to +1 levels and the average of the responses that correspond to the -1 levels. These two levels (+1 and – 1) are contrasts, and in factorial surveys it is possible to eliminate combinations of factors which are all positive or all negative from the sample, leading to using fewer vignettes and resulting in a fractional factorial design [47]. In this study's design, ABC are all positive, while CBA are all negative, therefore being opposites and aliases, which does not add much information to the relevance of individual factors. Therefore, these factors were excluded from the sample of vignettes for each of the three experiments, ending with a 3-factor and 6-level vignette survey for each of the solar sizes.

For each solar size, the vignette scenarios are similar between them, with only the factor levels changing to enable a thorough comparison [42]. However, variables changed between the three vignette subgroups, as some were not adequate for all solar sizes. For instance, receiving or not receiving compensation for the impacts of the project was a factor included in the case of large-size solar, which is not as appropriate for small-size systems such as rooftop installations.

In the large-size vignette subgroup, the factors were "invitation to participate", "compensation", and "openness" in sharing documents with information regarding the project. For both the medium and small-scale vignettes, the factors were "invitation to participate", the type of funding (i.e., "large company" and "cooperative"; "private" and "public") and "benefits" attained for more vulnerable citizens (see also Figure 3).

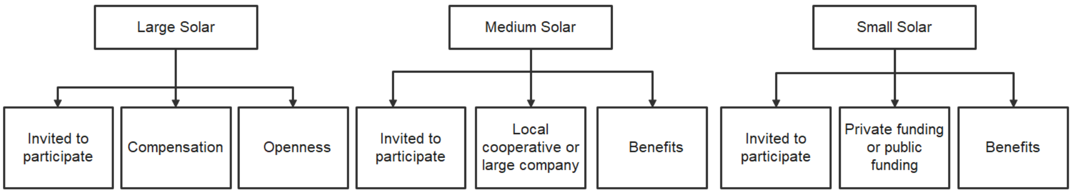

Figure 3 Factors for each solar energy scale.

Table 2 shows the differences contained within the vignettes used, and the sample size for each vignette group.

Table 2. Vignette factors for each type of solar installation and sample size

Codes	**Large-scale solar installations**	**Sample size**
A1	invited to participate, no compensation, no openness	133
B1	invited to participate, compensation, no openness	127
C1	invited to participate, no compensation, openness	144
D1	not invited to participate, compensation, openness	142
E1	not invited to participate, no compensation, openness	164
F1	not invited to participate, compensation, no openness	122
Codes	**Vignettes for medium scale solar installations**	
A2	invited to participate, local cooperative, no benefit	148
B2	invited to participate, large company, no benefit	131
C2	invited to participate, large company, benefits	151
D2	not invited to participate, local cooperative, no benefit	144
E2	not invited to participate, local cooperative, benefits	124
F2	not invited to participate, large company, benefits	134
Codes	**Vignettes for small-scale solar installations**	
A3	invited to participate, private funding, no benefit	129
B3	invited to participate, public funding, no benefit	146
C3	invited to participate, private funding, benefits	132
D3	not invited to participate, public funding, no benefit	140
E3	not invited to participate, private funding, benefits	130
F3	not invited to participate, public funding, benefits	155

3.3.4 Objectives and values

All survey respondents responded to this section, regardless of their vignette subgroup. The section encompassed two questions to learn about the objectives that people find are better accomplished through different solar sizes and the values associated with a sustainable energy transition. Gaining insight into the importance of different objectives and values is relevant to understand citizens and stakeholder preferences regarding the energy transition [6]. The categorical response options resulted from a literature review of previous studies regarding large-scale solar energy [11,48] and decentralized systems [24,49], as well as from the results of the exploratory interviews conducted with citizens from the Alentejo region.

3.4 Survey Sampling

A stratified sampling approach was applied, which entails first dividing the target population (i.e., residents in the two case study regions) into mutually exclusive and homogenous population quotas or 'strata'. These survey quotas were based on the census data from Portugal, collected in 2020 [50], and Spain, collected in 2022 [51]. Secondly, a sample was created through a random sampling data collection (conducted by a professional data collection company), which means each member of the population has an equal chance of being selected. The sample parameters have a 95% confidence level and a 5% margin of error, calculated based on the estimated total population of 704707 for Alentejo and a total population in Andalusia of 8437000 people. Table 3 shows the planned stratification (or quotas) of the study regions, considering gender and age groups.

Table 3. Stratified sampling design

Regions	Andalusia	Alentejo
Total	400	400
Male	194	196
Female	206	204
18-24	54	44
25-34	71	88
35-44	100	100
45-54	97	92
55-64	78	76

The vignette sampling process focused on ensuring that the external validity of the vignette samples (i.e., inferences that can be drawn from the experiments) would be extended at the very minimum to the survey's target population [44]. To ensure an appropriate sample for the vignette subgroups within the survey, a statistical power test was done using the R software package PWR[52], which implements power analysis following Cohen's method [53]. Effect size is a statistical measure proposed by Cohen, to learn about the magnitude of the experimental field in vignette experiments. According to the test, the larger the size, the stronger the relationship between variables. A moderate effect size is between 0.2 and 0.5, while a large size can be between 0.8 and 1. In this study, a moderate effect size was assumed. Using the PWR package, the sample size for six groups was calculated to obtain at least 0.80 of power, and a significance level of 0.05. The result was that the samples for the vignettes should have at least 54 respondents. Therefore, all samples for the vignettes (see Table 2) have at least 80% of statistical power, at a 5% error.

3.5 Data and statistical analysis

Except for the respondents' age, all data collected was either ordinal (i.e., qualitative data that includes a ranking), or nominal (i.e., qualitative data with no specific order to it).

Nominal data were analysed in a spreadsheet by taking stock of the frequencies of responses. The visualizations of these frequencies were produced using Tableau software [54].

Ordinal data were analysed through statistical methods. This data includes the responses to section 2 (i.e., importance of the transition to which all survey participants replied) and 3 (i.e., vignette sub-groups in which survey participants were randomly distributed).

The statistical analysis was conducted using R open-source programming language, applying several R packages, namely: PWR[52], "IPSUR", [55]; "ggplot2" [56]; "multcomp" [57]; "tidyverse" [58] and "ggstatsplot" [59].

3.5.1 Descriptive analysis

Using the IPSUR package, the descriptive analysis of the ordinal variables focussed on determining the mean, median and standard deviation values, as well as the means' coefficient of variation, and the measures for skewness, and kurtosis [60,61]. The mode (i.e., most common value in a response variable) was also calculated for the nominal variables (i.e., objectives and values) of the survey.

3.5.2 Analysis of the importance of the transition

Pearson Chi-square was used to find if a relation existed between three different variables related to the importance of the transition (i.e., importance of the energy transition, importance that renewable energy systems ensure compatibility with the natural environment and biodiversity (i.e., they do not harm natural habitats), importance of a transition that benefits more vulnerable citizens), based on the differences between observed and expected values. The calculation of Pearson's contingency coefficient then offered a measure for any existing association [62]. The interpretation of the relevance of the measures of the values resulting from association measures is provided by Davis [63].

In addition, the Wilcoxon (non-parametric) test for two independent samples [64] was used to compare levels of importance attributed to the energy transition, accounting for the different regions, based on the median values of the data.

3.5.3 Analysing differences between vignettes

Non-parametric tests were applied to analyse the differences emerging from the descriptive analysis of the vignette results, as ordinal data is not, by principle, normally distributed and therefore does not satisfy the requirements for applying parametric tests (i.e., analysis of variance). These tests are robust in experimental designs and have been frequently used for the analysis of ordinal variables [65]. The Kruskal-Wallis test, a non-parametric alternative to ANOVA, [66] was applied to learn whether the overall differences between medians for satisfaction and interest (i.e., the response variables in the vignette experiment) were statistically significant to changes in different factors for each group of vignettes. When differences between variables were proved to be significant, the Kruskal-Wallis' "effect scale" method [67] was used to measure how meaningful such differences were.

When statistically significant differences were found (i.e., the p-value was lower than the established margin of error of 5%), multiple comparisons were done using the Bonferroni multiple comparisons' test, which compares a pre-defined set of groups to learn which sets or pairs of vignettes have a significant difference between them [68]. Multiple comparisons used the multicomp R package and enabled an understanding of whether the combinations of specific factors contained in the vignettes (e.g., participation, transparency, etc.) contributed to increasing or decreasing citizens' satisfaction and interest in each project.

The graphical outputs of the non-parametric statistical tests conducted were created with the R ggstatsplot package [59], which enabled embedding the results of the statistical tests in the visualizations, thus offering a rigorous visual reporting of the results.

3.5.4 Analysing differences between vignettes and other factors

To gain further insights into how the differences between different vignette groups compared to other external factors, a regression analysis was included. A Generalized Linear Model (GLM) was applied since this model is more appropriate when the (ordinal) response variable is not normally distributed [69].

The GLM, is defined as a type of model that "generalizes linear regression by allowing the linear model to be related to the response variable via a link function and allowing the magnitude of the variance of each measurement to be a function of its predicted value"(p.40)[70]. In this study, applying GLM models gave us insight into how the satisfaction and the interest response variables changed (e.g., satisfaction/interest increased or decreased) among participants from different regions and belonging to different age and gender groups. The GLM thus presented the effects of age, region and gender on the response variables 'satisfaction' and 'interest', within each subgroup (i.e., Large, Medium, and Small). The age variable included in the models was converted into a factor, with five groups (i.e., 18-24, 25-34, 45-54, 55-64, and 65+). The R package used to conduct the regression was "IPSUR" [55].

4. Results

4.1 Sample and respondents' background information

A total of 832 valid responses were collected, including 421 responses from Andalusia and 411 from Alentejo, with 456 respondents self-described as women, and 376 self-described as men (there were no respondents self-describing as non-binary or other). The mean and median age of respondents are the same, namely 39 years for women and 45 for men. Regarding skewness, there is a positive asymmetry (slightly skewed to the left) for age. Kurtosis values (higher than 0.263) indicate a platykurtic distribution, which is in line with census data for the two regions. Figure 4 presents a histogram of the age of respondents.

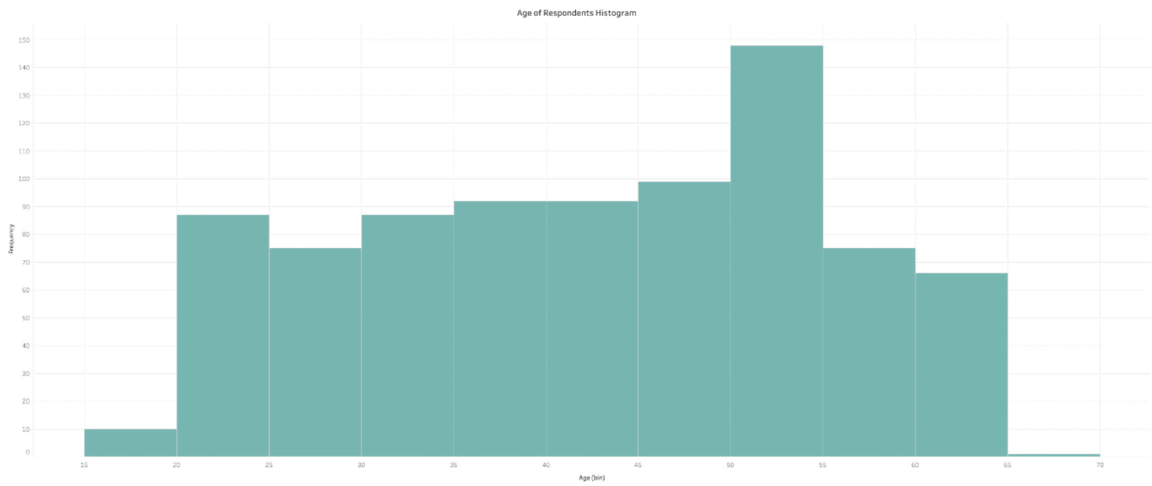

Figure 4 Histogram of respondents' age

Regarding professional status, 62.3% of respondents are employed full-time, 8.65% are employed part-time, 11.30% are unemployed, 7.93% are students, 5.65% are retired, and 4.08% are householders or other. Between regions the numbers are slightly different, in Andalusia only 51.31% are employed full-time, compared to Alentejo where 73.72% are employed full-time.

Most respondents were not professionally engaged in the energy sector, as 92.07% do not work or are close to a person who works in the energy sector, while 3.49% either work or are related to workers in the renewable energy industry and 1.80% to workers in the fossil fuel industry (see Table 4)

Table 4 Frequency of responses on relation of respondents with energy industries

Energy Industry	Works or is close to person who works in:	
Fossil fuels	15	2%
Renewable energy	29	3%
Nuclear energy	5	1%
Not applicable	766	92%
Other	17	2%

When asked whether they "regularly see, hear, or smell" different types of energy technologies, small-scale solar, followed by high voltage transmission lines, and large solar parks had the highest occurrences (of 466, 435, and 326 respectively), with the mode value being small scale solar. This further validates the characterization of the two case studies, as regions which are witnessing a solar energy expansion. Table 5 presents the frequencies of the different options.

Table 5 Frequency of type of technology respondents would regularly see, hear or smell

Regularly see, hear or smell:	Frequency
Hydroelectric dam	28%
Wind turbines	30%
Coal station	8%
Solar Park (large)	39%
High tension cables	52%
Small scale solar	56%
Biomass treatment plant	8%
None	22%
Other	1%

4.2 Importance of the energy transition

The transition is "very important" (5) for at least 50% of the respondents, it is equally "very important" that renewable energy systems are compatible with the natural world and that more vulnerable citizens can benefit from them. The mean values for the three variables (i.e., T1, T2 and T3) are around 4 (corresponding to "important"), as shown in Table 6. The distribution of kurtosis in these variables is lower than 0.263, indicating it is leptokurtic, with most values at the higher end. There is also a negative asymmetry to the right, indicating that higher values (of 4 or 5) are predominant. The same distributions apply to the different regions. However, in the case of Alentejo, the kurtosis values are higher in the three variables, indicating an even more steep leptokurtic distribution. This difference is also due to a higher frequency of values of 1 (not important) and 2 (poorly important) for variable T1, in Andalusia (between 4.28% and 6.18%), compared to the Portuguese case (1.46% and 2.92%).

Table 6 Descriptive statistics of three variables on the importance of the transition

Regions	Descriptive statistics					
	T.1 Importance of the energy transition					
	Mean	Standard Deviation	Skewness	Kurtosis	Median	n
Alentejo	4.4	0.73	-1.570692	3.191331	5	411

Andalusia	4.2	0.97	-1.244209	1.077716	5	421
	T.2 Important that renewable energy systems ensure compatibility with the natural environment and biodiversity (i.e., they do not harm natural habitats)					
	Mean	Standard Deviation	Skewness	Kurtosis	Median	n
Alentejo	4.4	0.73	-1.653047	3.242947	**5**	411
Andalusia	4.2	0.97	-1.206453	1.274457	**4**	421
	T.3 Importance that renewable energy systems benefit more vulnerable citizens					
	Mean	Standard Deviation	Skewness	Kurtosis	Median	n
Alentejo	4.4	0.73	-1.627195	3.1237731	**5**	411
Andalusia	4.2	0.90	-1.137980	0.9635106	**4**	421

Wilcoxon's non-parametric test shows a statistically significant difference between the median values of Alentejo and Andalusia, regarding the importance that renewable energy systems ensure compatibility with the natural environment and biodiversity (i.e., they do not harm natural habitats), (p-value is 0.0006542), and that more vulnerable communities benefit from renewable energy systems (p-value is 0.00005391), with Andalusians attributing slightly less importance than Alentejo's respondents (see Table 6). In both cases the p-value is lower than the margin of error (i.e., 5%), therefore it is appropriate to reject the null hypothesis.

Furthermore, Pearsons' correlation coefficient between different pairwise comparisons (see correlation matrix in Table 7), indicates a strong positive relationship (coefficients are close to 1) between the three variables (with p-values <.0001). Therefore, the importance attributed to the energy transition is closely associated with the importance attributed to renewable energy systems that ensure compatibility with the natural environment and biodiversity, and that benefit more vulnerable citizens.

Table 7 Pearson's correlation coefficient matrix for variables T1, T2 and T3

Questions	T3	T2	T1
T3	1.0000000	0.7368718	0.6713527
T2	0.7368718	1.0000000	0.8080352
T1	0.6713527	0.8080352	1.0000000

4.3 Satisfaction and Interest – differences between vignettes

4.3.1 Large size

Regarding the level of satisfaction with respect to the six vignettes for the large size, the median values ranged between 3 ("somewhat satisfied") and 4 ("satisfied"). The vignettes with a higher level of satisfaction were those in which citizens were invited to participate (B1 and C1), citizens were compensated for any negative impacts (B1 and D1), and plans were openly shared (B1 and D1). Vignettes had lower levels of satisfaction when there was no compensation (A1), people were not invited to participate (E1 and F1) and there was no openness (F1). Among these vignettes, C1 (in which people were invited to participate, there was openness in sharing documents, despite no compensation), had the highest frequency (27.78%) in the value 5 ("very satisfied").

These results are statistically significant (i.e., p-value =0.0000001508). The most significant differences are between the following: A1/C1("no compensation" versus "compensation"); A1/D1 ("no compensation and no openness" versus "compensation and openness"); C1/E1 ("invited to participate" versus "not invited to participate"); and D1/E1 ("openness" versus "no openness"). Nevertheless, the Kruskal-Wallis' effect scale test considers the effect of these differences to be small (i.e., the statistical value is 0.0423) (see Figure 5).

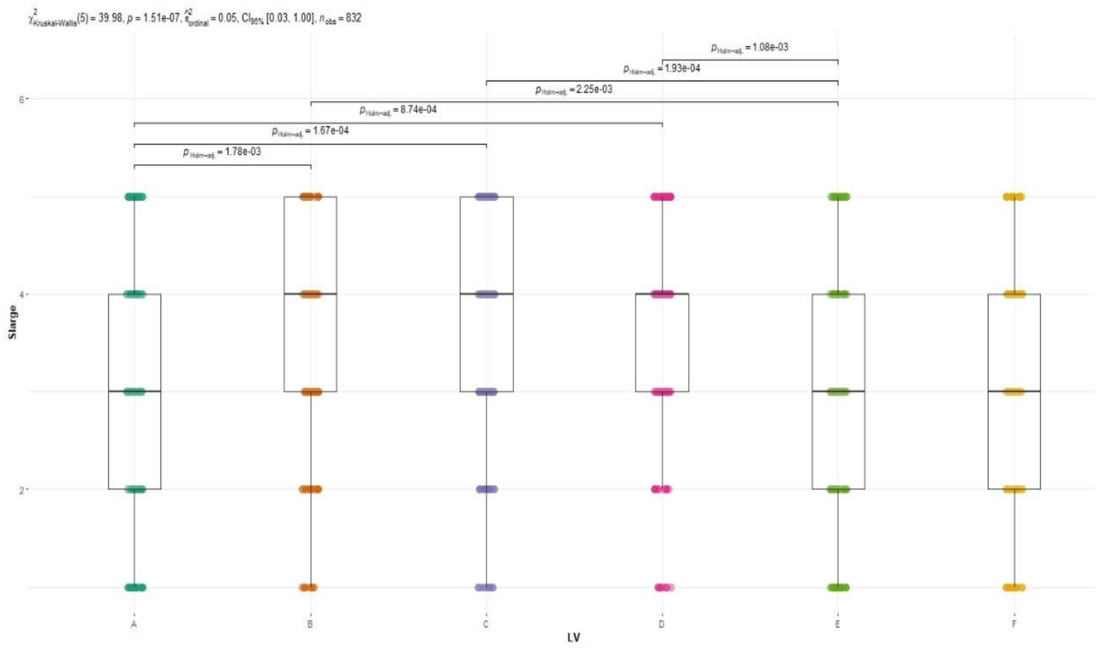

Figure 5. Boxplots of levels of satisfaction with projects for six large-scale solar vignettes (LV). The chart shows the results of the Kruskal-Wallis non-parametric test.

Regarding interest, the median values ranged between 3 and 4. Vignettes with higher values were those in which people were invited to participate (B1 and C1), in which there was compensation (D1 and F1) and openness (D1). Vignette D1 was also the one with the highest frequency in the value 5 (29.58%). These results are statistically significant (i.e., p-value = 0.0000003935). The most significant differences are between vignettes A1/C1 ("invited to participate/no openness" versus "invited to participate/openness"); and A1/D1 ("no compensation/no openness" versus "compensation/openness").

4.3.2 Medium size

In the case of satisfaction with medium-scale projects, differences in medians between vignettes range between values 3 and 4. Vignettes with higher values are C2, E2 and F2, corresponding to those in which citizens are invited to participate (C2) and the project benefits more vulnerable citizens (C2, E2 and F2). The effect size of these differences is moderate (i.e., Kruskal-Wallis' value for effect scale is 0.0738).

The most significant pairs of variables are A2/C2 and B2/C2. Both A2 and B2 do not offer benefits to more vulnerable citizens, while C2 does. C2/D2 is also a significant pair. In C2 citizens are invited to participate and more vulnerable citizens are benefited, while in D2 citizens are not invited to participate and there are no benefits (see Figure 6).

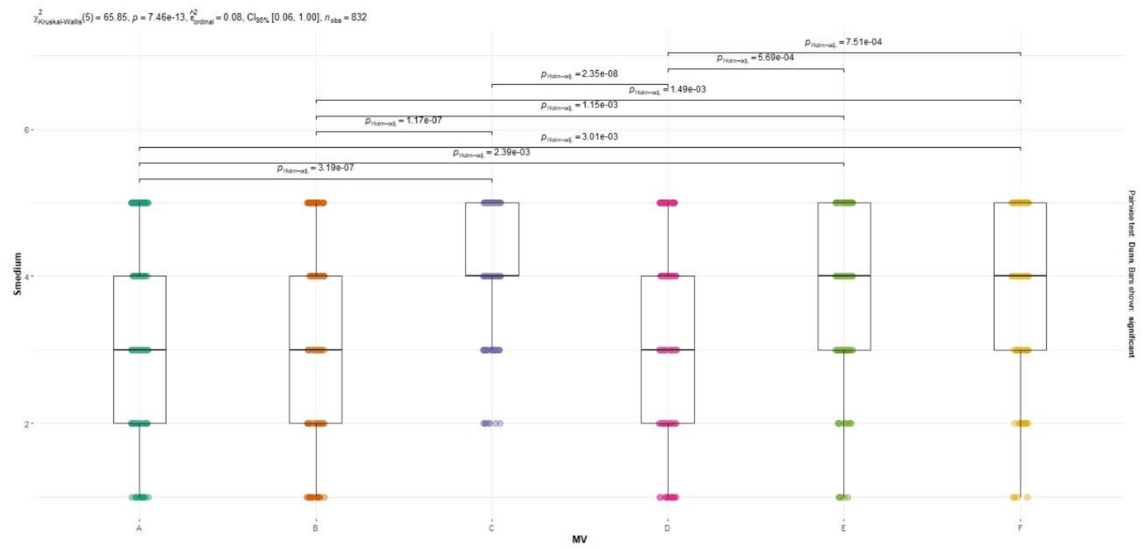

Figure 6. Boxplots of levels of satisfaction with projects for six medium-scale solar vignettes (MV). The chart shows the results of the Kruskal-Wallis non-parametric test.

As for interest in the projects, differences are less pronounced. There is less interest in vignettes A2 and B2 (with a median of 3), in which there is no benefit for more vulnerable citizens, and higher interest in the other four vignettes (with a median of 4). The scenario with the highest frequency in the value 5 is C2 (35.76%) in which citizens are invited to participate and there are benefits for more vulnerable communities.

As for pairwise comparisons, there is a weak significance. Yet the most significant pairs are A2/C2 and B2/C2, in both cases the key difference is that A2 and B2 offer no benefits to local communities, while C2 does.

4.3.3 Small size

Overall, small size vignettes had the highest levels of satisfaction, when compared to the large and medium sizes. All vignettes were highly valued (medians of 4), yet vignette C3 stands out with a median of 5. In this vignette, citizens are invited to participate, and the project brings benefits to more vulnerable citizens. The effect of the existing differences is considered moderate (i.e., 0.0737). Pairwise comparisons show the most significant pairs are A3/C3, B3/C3 (in both pairs the key difference is that A3 and B3 offer no benefits to local communities, while C3 offers benefits), C3/D3 and C3/E3 (in D3 and E3 citizens are not invited to participate, yet they participate in C3) (see Figure 7).

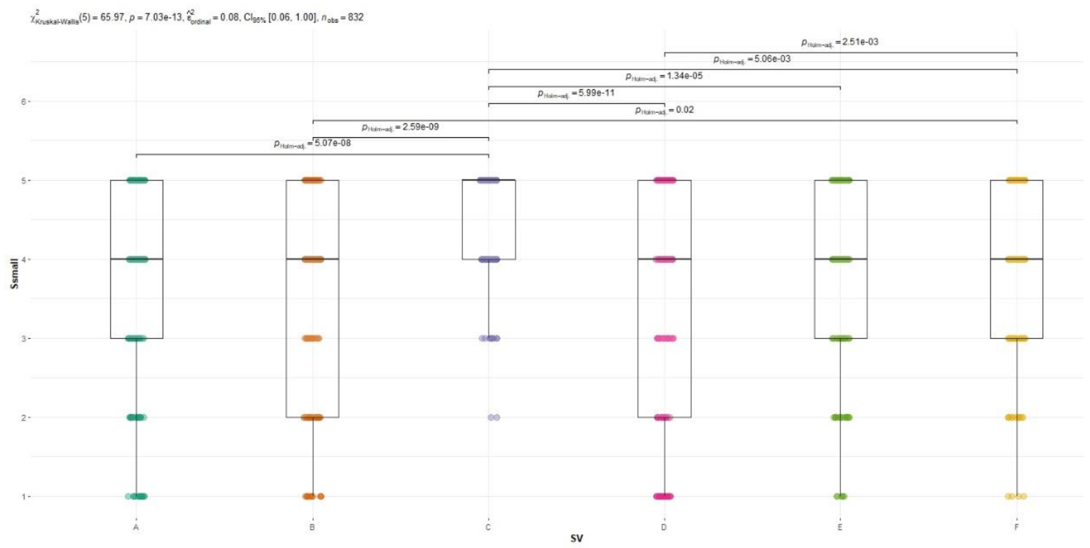

Figure 7. Boxplots of levels of satisfaction with projects for six small-scale solar vignettes (SV). The chart shows the results of the Kruskal-Wallis non-parametric test.

Concerning interest in the project, C3 is also the highest-ranking scenario, with a median of 5, while all others have a median of 4. Nevertheless, pairwise comparisons show a weak significance.

4.4 Regression Analysis of Satisfaction and Interest responses

4.4.1 Satisfaction

The GLM applied to the three vignette subgroups were labelled as GLM 1.1 (large solar); GLM 1.2 (medium solar) and GLM 1.3 (small solar). The three GLM used as intercepts (or the value taken as a constant for the expected mean of y, if x is zero) the mean values of the response variable (i.e., degree of satisfaction) when confronted with vignettes A1 (large solar), A2 (medium solar) and A3 (small solar), the female gender, the lower age group (i.e., 18 to 24 years) and the region of Alentejo.

The results of the GLM 1.1., 1.2 and 1.3, are presented in Table 8, where estimates indicate how levels of satisfaction increased or decreased. Standard errors, z-values (i.e., the number of standard deviations away from the mean, given by the regression coefficient or the estimates divided by the standard error), and p-values are also included.

According to GLM 1.1, with a reference value for A1 vignette (see Table 4 for the vignette descriptions) of 2.38 (95% confidence interval [1.57, 3.30], $p < .001$), respondents' satisfaction increases when presented with vignettes B1, C1 and D1, and there are no statistically significant differences in relation to E1 and F1. Satisfaction also decreases in age groups of 35-44, and of 55-64, and it decreases if respondents are from Andalusia, both when presented with vignette A1, as well as with the other vignettes which have higher levels of satisfaction than A1.

In GML 1.2, there are no significant effects between the reference value of A2 and other vignettes, in the respondents' degree of satisfaction. However, satisfaction increases if respondents are male and decreases if they are from Andalusia. Considering there are no statistically significant differences between vignettes, the results for satisfaction regarding medium solar energy projects are equivalent as regards differences in gender and region for all vignettes, based on the reference value - A2, with a value of 3.01 (95% CI [1.96, 4.22], $p < .001$). There are also no statistically different results concerning age groups.

In GML 1.3, satisfaction increases when respondents are presented with vignette F3, compared to A3, yet there are no significant differences in other vignettes. Satisfaction decreases in age groups of 55-64, compared to the other age groups, when presented with any of the vignettes. If respondents are from Andalusia, their satisfaction also decreases.

Table 8 Results of the GML 1.1, 1.2 and 1.3

GLM 1.1 Large Solar and Degree of Satisfaction				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values** (*indicate statistically significance)
Vignette A1 (intercept)	2.37887	0.43869	5.423	**0.0000000587 *** **
Vignette B1	1.33541	0.39979	3.340	**0.000837 *** **
Vignette C1	1.27800	0.38258	3.341	**0.000836 *** **
Vignette D1	1.39078	0.39593	3.513	**0.000444 *** **
Vignette E1	0.05381	0.28703	0.187	0.851293
Vignette F1	0.44997	0.33330	1.350	0.177011
Gender (male)	0.07032	0.22250	0.316	0.751960
Age Group [T.25 to 34]	-0.69981	0.46038	-1.520	0.128490
Age Group [T.35 to 44]	-1.11021	0.42972	-2.584	**0.009778 ** **
Age Group [T.45 to 54]	-0.42684	0.43989	-0.970	0.331890
Age Group [T.55 to 64]	-1.16279	0.45331	-2.565	**0.010314 * **
Region (Andalusia)	-0.79283	0.21572	-3.675	**0.000238 *** **
GLM 1.2 Medium Solar and Degree of Satisfaction				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values**
Vignette A2 (intercept)	3.00756	0.57154	5.262	**0.000000142 *** **
Vignette B2	-0.52813	0.38035	-1.389	0.164982
Vignette C2	17.27600	849.60183	0.020	0.983777
Vignette D2	-0.13548	0.38047	-0.356	0.721789
Vignette E2	1.04347	0.54105	1.929	0.053779
Vignette F2	1.14097	0.58397	1.954	0.050724
Gender (male)	0.69401	0.31386	2.211	**0.027023 * **
Age Group [T.25 to 34]	-0.22882	0.54398	-0.421	0.674017
Age Group [T.35 to 44]	-0.16684	0.54312	-0.307	0.758708
Age Group [T.45 to 54]	-0.05189	0.53520	-0.097	0.922767
Age Group [T.55 to 64]	-1.03192	0.54708	-1.886	0.059265
Region (Andalusia)	-1.20594	0.32015	-3.767	**0.000165 *** **
GLM 1.3 Small Solar and Degree of Satisfaction				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values**
Vignette A3 (intercept)	3.52692	0.62620	5.632	**0.0000000178 *** **
Vignette B3	0.36663	0.43537	0.842	0.39973
Vignette C3	17.39661	899.02154	0.019	0.98456
Vignette D3	-0.68770	0.37486	-1.835	0.06658
Vignette E3	0.83304	0.51662	1.612	0.10686
Vignette F3	1.59679	0.58960	2.708	**0.00676 ** **
Gender (male)	0.43798	0.31372	1.396	0.16269
Age Group [T.25 to 34]	-0.04778	0.62786	-0.076	0.93934
Age Group [T.35 to 44]	-0.48896	0.59384	-0.823	0.41029
Age Group [T.45 to 54]	-0.78627	0.55133	-1.426	0.15383
Age Group [T.55 to 64]	-1.50983	0.57755	-2.614	**0.00894 ** **
Region (Andalusia)	-1.38051	0.32766	-4.213	**0.0000251727 *** **

Overall, the regression results indicate that Andalusian respondents are less satisfied with the solar energy projects than Alentejo's respondents, with more evidence of a statistically significant result in the case of large solar energy projects. Conversely, male respondents are overall more likely to be supportive of large and medium-scale solar projects, with no significant differences in the case of small solar energy projects.

4.4.2 Interest

For analysing responses to the degree of interest in participating in different solar projects, when presented with the three vignette subgroups, three GLM were applied to the large (GML2.1, medium (GLM2.2), and small solar (GLM2.3) vignette subgroups.

In the three cases, the intercept, or reference value, corresponds to the mean values of the "degree of interest" when confronted with vignettes A1, A2 and A3, respectively, as well as the female gender, the lower age group (i.e., 18-24 years) and the region of Alentejo.

In GLM2.1, the value of the intercept is 1.53 (95% CI [0.77, 2.37], $p < .001$), and the degree of interest increases in the case of vignettes B1, C1, and D1, with a statistically significant and positive effect. There are no significant results for other vignette factors (i.e., age, region, and gender).

In GLM2.2, the value of the intercept is 3.41 (95% CI [2.30, 4.71], $p < .001$), and a significant and positive effect is found in the case of vignette B2. Respondents from Andalusia have a lower interest in participating and male respondents have a higher interest.

Lastly, in GLM2.3 the value of the intercept is 3.44 (95% CI [2.28, 4.80], $p < .001$). There are no statistically significant results by comparison with other vignettes in this subgroup. Participants from Andalusia are less interested in participating in projects, compared to those from Alentejo.

Overall, regarding interest in participating in projects, regression analysis results returned less significant differences than in the case of satisfaction with projects. Nevertheless, the values of the intercept are higher in small and medium solar, compared to large solar projects. In addition, when significant results are found, there are similarities to those found for the satisfaction variable, with Andalusia's respondents less positive than Alentejo's respondents and male respondents more positive than female respondents for all the vignettes.

Table 9 presents the results of the regression analysis for the three solar sizes and the factor effects on the interest variable.

Table 9 Results of the GML 2.1, 2.2 and 2.3

GLM 2.1 Large Solar and Degree of Interest				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values** (*indicate statistically significance)
Vignette A1 (intercept)	1.52687	0.40632	3.758	**0.000171 *** **
Vignette B1	1.02269	0.40900	2.500	**0.012402 ***
Vignette C1	1.65837	0.47824	3.468	**0.000525 *** **
Vignette D1	0.79036	0.37468	2.109	**0.034906 ***
Vignette E1	0.30153	0.32347	0.932	0.351237
Vignette F1	0.73588	0.38509	1.911	0.056012
Gender (male)	-0.15703	0.24530	-0.640	0.522078
Age Group [T.25 to 34]	-0.31696	0.42505	-0.746	0.455839
Age Group [T.35 to 44]	-0.13716	0.41373	-0.332	0.740258
Age Group [T.45 to 54]	0.53615	0.43718	1.226	0.220046
Age Group [T.55 to 64]	-0.15671	0.43912	-0.357	0.721177
Region (Andalusia)	0.09617	0.23088	0.417	0.677025
GLM 2.2 Medium Solar and Degree of Interest				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values**
Vignette A2 (intercept)	3.4106	0.6094	5.597	**0.0000000219 *** **
Vignette B2	-0.8236	0.4081	-2.018	**0.04355 ***
Vignette C2	1.0060	0.6002	1.676	0.09375
Vignette D2	-0.3177	0.4214	- 0.754	0.45087
Vignette E2	0.6344	0.5591	1.135	0.25654

Vignette F2	0.5952	0.5598	1.063	0.28766
Gender (male)	0.6032	0.3073	1.963	**0.04964 ***
Age Group [T.25 to 34]	-0.5619	0.5618	-1.000	0.31721
Age Group [T.35 to 44]	-0.6324	0.5516	- 1.146	0.25159
Age Group [T.45 to 54]	-0.3427	0.5530	-0.620	0.53540
Age Group [T.55 to 64]	-0.7514	0.5909	-1.272	0.20354
Region (Andalusia)	-0.9906	0.3063	-3.234	**0.00122 ****
GLM 2.3 Small Solar and Degree of Interest				
Coefficients	**Estimate**	**Std. Error**	**Z value**	**P-values**
Vignette A3 (intercept)	3.43891	0.63781	5.392	**0.0000000698 *****
Vignette B3	-0.02221	0.48122	-0.046	0.96318
Vignette C3	16.92916	919.77656	0.018	0.98532
Vignette D3	-0.73067	0.43157	-1.693	0.09045
Vignette E3	0.38498	0.54725	0.703	0.48176
Vignette F3	0.50322	0.52303	0.962	0.33599
Gender (male)	0.35276	0.32237	1.094	0.27384
Age Group [T.25 to 34]	-0.60544	0.56968	-1.063	0.28789
Age Group [T.35 to 44]	-0.27095	0.59313	-0.457	0.64780
Age Group [T.45 to 54]	-0.34077	0.56056	-0.608	0.54325
Age Group [T.55 to 64]	-0.73618	0.59432	-1.239	0.21546
Region (Andalusia)	-0.93868	0.32322	-2.904	**0.00368 ****

4.5 Objectives and values

When choosing between a menu of key objectives for sustainable solar energy installations, and associating them with different solar scales, “economic growth” was mainly associated with the large size (49%, corresponding to 405 occurrences), followed by the medium size (41%) by comparison with small-size installations (10%). However, “Reducing energy production” was mainly associated with medium (44%) and large systems (35%), and less with small systems (21%).

Large systems were also more associated with the prospective for “new jobs” (54%), in comparison with small-size installations (10%). The objectives most frequently associated with small-size installations were “integration in landscape” (47%), followed by “protection of biodiversity” (33%) and “community trust” (27%). “Energy as a common good” had a low frequency in the case of the small size (18%), compared to medium (39%) and large (42%) sizes. “A lower energy bill” was mostly associated with the large size (43%), followed by medium (31%) and small (18%). Overall, medium-size systems are strongly associated with all the different options (e.g., economic growth, new jobs, common good, community trust, etc.), while small-size installations are mainly considered important to meet the objectives of “protecting biodiversity” and “integration with the landscape”, as illustrated by Figure 8.

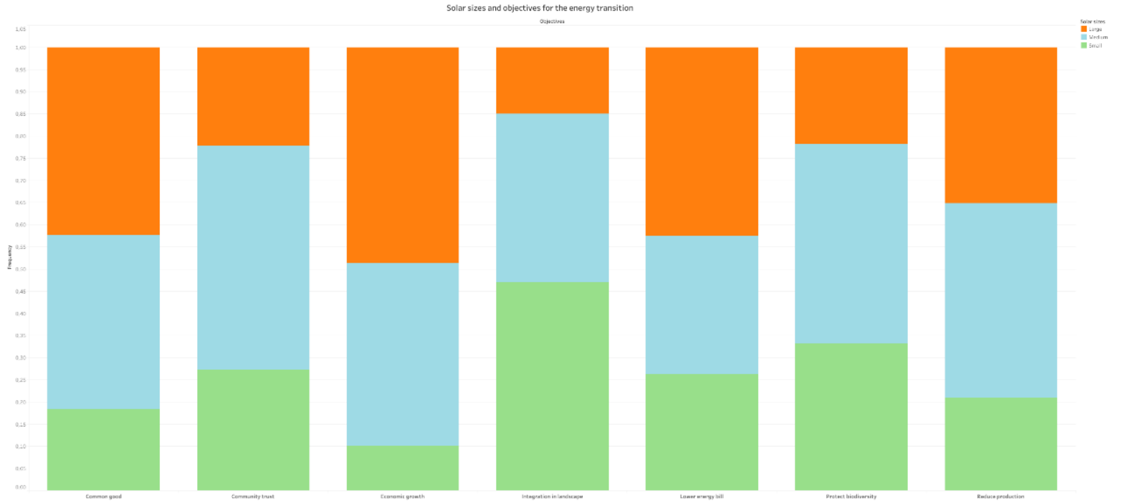

Figure 8 Objectives related to different solar scales

Regarding the most valued aspects to ensure a sustainable energy transition, those with higher frequency were profitability (54%), which corresponds also to the mode value, followed by transparency (48%) and clean energy (42%). Other highly valued ideas included autonomy (25%), community trust (26%), and holistic planning (17%). However, when comparing the two regions, the values attributed showed a contrast. For instance, while "easy" (referring to being easy to implement) is quite valued in Andalusia (69%) it is the least valued aspect in Alentejo (31%), by contrast, "local" is the most valued aspect in Alentejo (61%) while it is the least valued in Andalusia (39%). Table 10 presents the frequencies, which are illustrated in Figure 9.

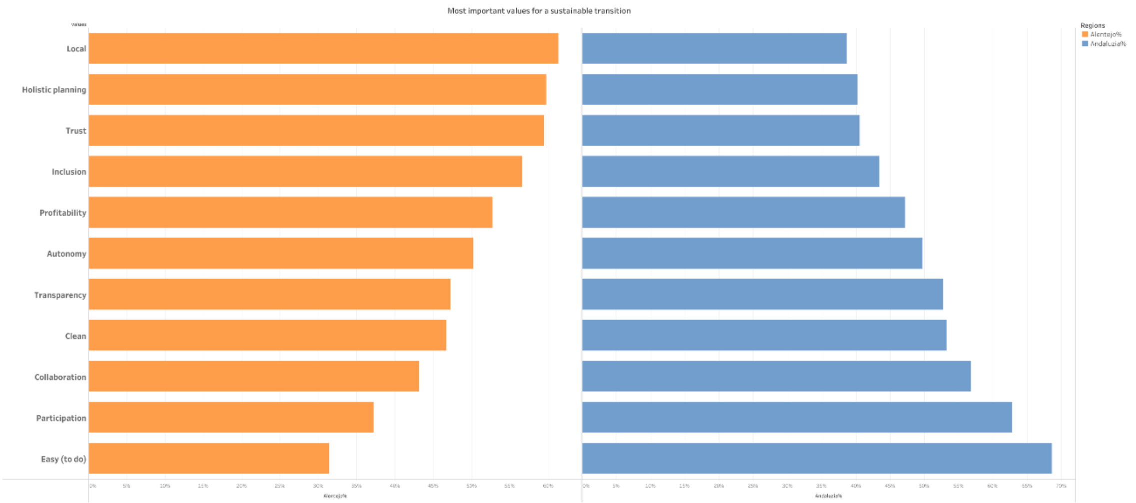

Figure 9 Values considered important for a sustainable transition

Table 10 Frequency of Values for Alentejo, Andalusia and in total

Values	Alentejo%	Andaluzia%	Total %
Local	61%	39%	**9%**
Participation	37%	63%	**15%**
Collaboration	43%	57%	**15%**
Inclusion	57%	43%	**16%**
Holistic planning	60%	40%	**17%**

Easy (to do)	31%	69%	**18%**
Autonomy	50%	50%	**25%**
Trust	59%	41%	**26%**
Clean	47%	53%	**42%**
Transparency	47%	53%	**48%**
Profitability	53%	47%	**54%**

5. Discussion

Solar photovoltaic energy is generally well received. In large-scale solar projects, citizens' satisfaction with, and interest in, is moderate to high, implying that news media coverage of citizens' protests and contestation of large-scale solar parks in the two regions reflects outlier opinions, rather than those of the majority. As observed in studies of the opposition to wind energy, people with stronger opinions against a project seem to be the most vocal in public discussions [71]. The slight differences between the two regions indicate that societal dissatisfaction with large-scale solar is reactive since Andalusia has undergone an earlier development of investments and its rural landscapes are already populated by these installations. This finding also supports the idea of the relational nature of SA [37], indicating that SA can be conditioned not only by other local and interrelated policies but also by the local energy geographical history [9].

Given the choice, citizens are willing to participate in large-scale energy systems, which offers evidence that EC needs to be further encouraged in the context of centralized systems [8]. For large-scale solar, being invited to participate is the most relevant factor for ensuring citizens' satisfaction and interest (as the vignettes that included this aspect ranked higher). Thus, strengthening EC in the context of large-scale solar requires policies that foster citizens' participation in projects, which are typically implemented through a top-down approach [11]. In this context, municipalities have a critical role to play as intermediaries between investors and local populations [40].

Notwithstanding the importance of participation in centralized systems, citizens from these regions prefer small distributed systems, followed by medium-scale installations, indicating that small and medium systems are the optimal geography for higher levels of EC within a community [41]. The preference for small systems is akin to findings from a survey in Switzerland, according to which the SA of solar energy decreases as installations' size increases [36].

The importance that renewable energy systems ensure compatibility with the natural environment and biodiversity was highly valued and strongly correlated to the importance attributed to the energy transition, indicating that citizens' environmental awareness is significant, regardless of their support or opposition to different types of solar installations. This finding is conducive to an understanding of SA as being embedded in broader societal concerns [28,35], such as weighting impacts on natural habitats and biodiversity against the need for a fast decarbonization [37].

Citizens were more interested in participating in projects offering benefits to more vulnerable populations, suggesting concerns with inclusivity, and indicating that a relational dimension is also applicable to EC [72]. Both Portugal and Spain are among the countries most vulnerable to energy poverty in the European Union, therefore citizens would be expected to care that new projects can help more vulnerable communities [73,74]. However, tackling energy poverty in the context of large-scale solar investments is still largely unexplored, despite evidence that historically large-scale energy transformations have meant also energy-related social injustices [75]. This is a crucial aspect for the advancement of EC policies while meeting energy justice goals [5,72]. Another minor, yet significant difference concerns gender, with male respondents consistently more interested in large and medium-scale projects, and middle to older age citizens generally less interested, which points to the importance of understanding the conditions that make energy projects appealing to women's participation and to the participation of older generations [76,77].

Transparency is a key factor for higher levels of satisfaction and interest in large-scale solar installations and was highly valued for a sustainable energy transition. Thus, transparency can have a positive impact on fostering community acceptance of large-scale solar projects [6]. Likewise, transparency and openness in sharing data and project plans (key principles of collective prosumer initiatives) [41,78], may foster greater possibilities for citizens' involvement in new centralized solar projects.

Nevertheless, there are discrepancies between peoples' preferences and their ideas about the key values for a sustainable energy transition. On the one hand, satisfaction and interest in projects rank higher if more vulnerable citizens can benefit from them. On the other hand, a key value for a sustainable transition is profitability and large systems are perceived as the most relevant for ensuring "the common good", rather than decentralized small systems, such as energy communities. Yet, by definition, energy communities should result in social and environmental benefits for local communities, rather than being profit-driven [79]. Indeed, a reduction in energy costs would likely be greater with larger systems resulting from profit-driven investments. However, there is equally a high potential for collective prosumers, such as energy communities, to contribute to a reduction of energy costs [80,81]. These findings indicate a lack of information regarding the benefits and costs of the different types of installations. A recent review also found that a key barrier to SA of solar photovoltaic panels is limited information about the technologies [82]. Energy literacy should thus be a key policy goal since without being appropriately informed citizens face barriers to becoming protagonists of the transition [83].

6. Conclusion

SA and EC are both embedded in broader societal concerns, and multiple factors can affect local support for multi-scalar solar projects, as well as citizens' interest in becoming actively involved. Among these factors, policies that enable higher participation of citizens and benefit more vulnerable communities, including in large-scale solar installations, are important. Nevertheless, the relative importance of these factors, when compared to the overall satisfaction with different scales, indicates that there is a high level of SA for all types of solar projects, although communities already exposed to large-scale solar landscapes are bit less satisfied.

Effectively informing and communicating to citizens what small and medium size installations are and how they can benefit local communities, as well as women and older citizens is important for expanding EC. Regional and national energy planners should take extra effort in disseminating new energy models (e.g., energy communities) among local populations, explaining their costs and benefits. It is equally important to negotiate trade-offs between large-scale investments and small-scale systems.

There is still a wide gap in research to meet the goals of fostering EC in an inclusive way, while advancing with a rapid and sustainable energy transition. Future research on interactions between SA and EC, should focus on measuring the positive impacts of involving local communities in large-scale projects, and promoting transparency in planning practices, while being mindful that local communities will need to adapt to new land uses for landscapes that frame their cultural identities and on which they may depend for their livelihoods. Finally, issues of whether the energy transition is to be a profitable process and/or guided by wellbeing and energy justice principles, cannot be detached from considerations of scale and attention to the possibility of effectively ensuring citizens' inclusive ability to participate and benefiting from new energy systems.

7. References

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