

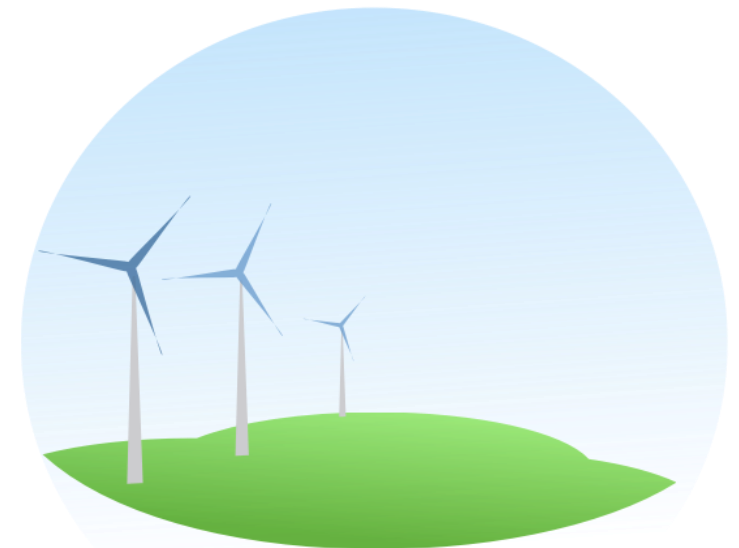
Understanding **citizens' acceptance** of **wind power installations:** A synthesis analysis across five European regions

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Outline

- Introduction
- Methodology
- Results
- Conclusion



Introduction

Wind Turbines

- Key component of the **global transition to clean, renewable energy**
- Reduce dependence on fossil fuels and **help mitigate climate change**
- Provide **long-term, low-cost electricity** once infrastructure is installed
- Support **national energy security**
- Create **local economic opportunities** through construction, maintenance, and related services



<https://education.nationalgeographic.org/>



<https://energy.ec.europa.eu/>

Community acceptance

- Wind power development often faces **resistance from local communities and citizens**, due to:
 - Visual and landscape impact
 - Potential effects on wildlife
 - Concerns about alterations to rural or island environments
 - Noise emissions and shadow flicker affecting nearby residents
 - Challenges related to long-term maintenance
 - Unequal distribution of costs and benefits



<https://www.zhaw.ch/en/engineering/research/interdisciplinary/wind-energy-in-mountainous-regions>



<https://www.pexels.com/photo/tourists-by-the-wind-farm-on-the-sandy-beach-19169513/>

Study objectives

Goals

- Assess citizen acceptance of wind power installations in their local area
- Provide evidence-based recommendations to strengthen cooperation and support sustainable wind power integration

Approach

- MUSA analysis to measure acceptance priorities across multiple criteria
- Statistical correlations between socio-demographics and acceptance levels
- Consideration of external factor, such as exposure to wind power

Method

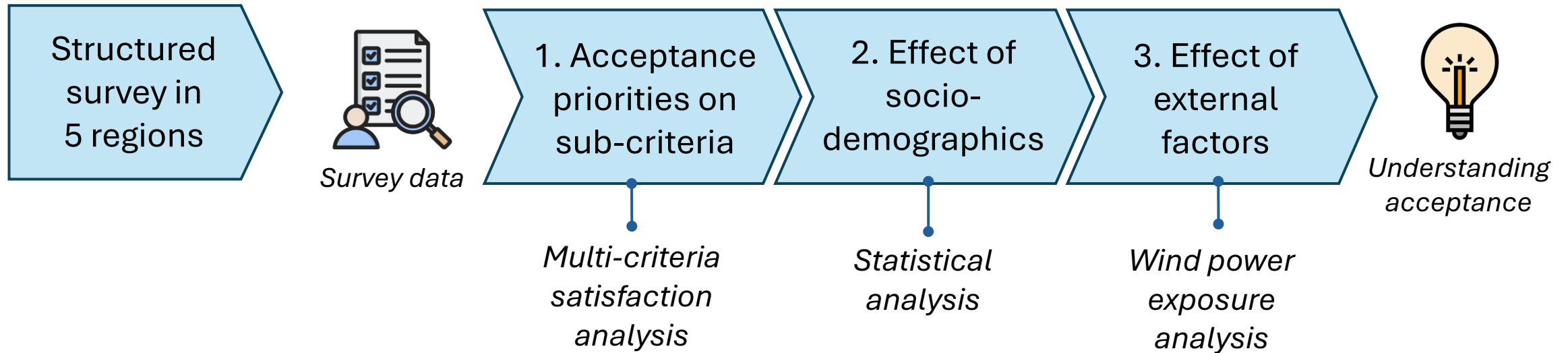
- Structured questionnaire that translates satisfaction into acceptance
- Criteria covering environment, community aspects, and personal benefits
- It was performed in 5 regions in 4 countries (Greece, Italy, Austria, Portugal)



https://www.alibaba.com/product-detail/Portable-Wind-Turbine-2-5mw-Wind_1600737143337.html

Methodology

Methodology



Structured Survey

- Regions of investigation:
 - Pantelleria island (**ITALY**) / *No wind farms*
 - Styria (Gröbming and Irdning) (**AUSTRIA**) / *No wind farms*
 - Viana do Castelo (**PORTUGAL**) / *Operating wind farms*
 - Torres Vedras (**PORTUGAL**) / *Operating wind farms*
 - Evia Island (**GREECE**) / *Operating wind farms*

Understand citizens **acceptance** concerning the *existing* or *future* development of wind power farms

Questionnaire

Environment

Question	Component addressed
Q1	Land use changes
Q2	Biodiversity
Q3	GHG emissions
Q4	Satisfaction from an environmental perspective

Community

Question	Component addressed
Q5	Economic impact on the community
Q6	Effect on community lifestyle
Q7	Safety risks
Q8	Social awareness
Q9	Maintenance and decommissioning
Q10	Satisfaction from a community perspective

Individual

Question	Component addressed
Q11	Personal finances
Q12	Landscape aesthetics
Q13	Noise pollutions
Q14	Shadow flicker
Q15	Satisfaction from the individual's perspective

Question	Component addressed
Q16	Global satisfaction from the installation of wind turbines

Questionnaire

Sector A – Environmental aspects

Question 1: Do you think that the installation of wind turbines on the island of Pantelleria will cause undesired land use changes?

Your answer: To a high degree To a moderate degree Maybe a bit Not at all

Question 2: Are you concerned that wind turbines will harm biodiversity on the island of Pantelleria?

Your answer: To a high degree To a moderate degree Maybe a bit Not at all

Question 3: Do you believe wind turbines can help produce clean energy on the island of Pantelleria?

Your answer: Strongly disagree Disagree Neutral Agree Strongly agree

Question 4: Summarizing question – Environment

From an environmental perspective, would you be positive on the installation of wind turbines on the island of Pantelleria?

Your answer: I am negative I am rather negative I am neutral I am rather positive I am positive

Sector B – Community aspects

Question 5: How do you think the installation of wind turbines on the island of Pantelleria will affect the economy of the island community?

Your answer: Rather negatively Slightly negatively No effect Slightly positively Fairly positively

Question 6: Are you concerned that the installation of wind turbines on the island of Pantelleria will negatively affect the community's lifestyle?

Your answer: To a high degree To a moderate degree Maybe a bit Not at all

Question 7: Do you expect that wind turbines on the island of Pantelleria can pose a safety risk to people and infrastructure?

Your answer: To a high degree To a moderate degree Maybe a bit Not at all

Question 8: Do you agree that the wind turbines on the island of Pantelleria can raise the inhabitants' social awareness and political engagement?

Your answer: Strongly disagree Disagree Neutral Agree Strongly agree

Question 9: Do you agree that wind turbines on Pantelleria will properly function in the long term due to appropriate maintenance and decommissioning actions?

Your answer: Strongly disagree Disagree Neutral Agree Strongly agree

Question 10: Summarizing question - Community

From the community point of view, would you be positive on the installation of wind turbines on the island of Pantelleria?

Your answer: I am negative I am rather negative I am neutral I am rather positive I am positive

Sector C – Individual aspects

Question 11: How do you think the installation of wind turbines on the island of Pantelleria will affect your personal financial situation?

Your answer: Rather negatively Slightly negatively No effect Slightly positively Fairly positively

Question 12: Do you think that the installation of wind turbines on the island of Pantelleria will negatively affect the landscape's aesthetics?

Your answer: Strongly agree Agree Neutral Disagree Strongly disagree

Question 13: To what degree are you concerned about noise pollution from the wind turbines?

Your answer: To a high degree To a moderate degree Maybe a bit Not at all

Question 14: To what degree are you concerned about the shadow flicker from the wind turbines?

Your answer: To a high degree To a moderate degree Maybe a bit Not at all

Question 15: Summarizing question – Individual aspects

From the individual point of view, would you be positive on the installation of wind turbines on the island of Pantelleria?

I am negative I am rather negative I am neutral I am rather positive I am positive

Final Question

Question 16: Taking into account all your previous answers, how would you rate your overall acceptability concerning the installation of wind turbines on the island of Pantelleria?

Your answer: Very low Low Moderate High Very high

Questionnaire

- Socio-demographics:
 - AGE
 - GENDER
 - EDUCATION
 - EMPLOYMENT
 - LIVING IN THE AREA

Socio-demographic information

Question SD1: What is your age?

Your answer: ☐ 18-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 65 or older

Question SD2: What is your gender?

Your answer: ☐ Male ☐ Female ☐ Other ☐ Prefer not to say

Question SD3: What is your level of education?

Your answer: ☐ Secondary schools or lower (e.g., high school) ☐ College or vocational training ☐ Bachelor's degree ☐ Postgraduate degree (Masters, PhD)

Question SD4: Are you currently employed?

Your answer: ☐ Yes, full-time ☐ Yes, part-time ☐ No, not employed ☐ Retired ☐ Student ☐ Prefer not to say

Question SD4.1: If you are currently employed, what is your profession? (Optional)

Your answer:

Question SD5: Have you lived or are you currently living in Pantelleria?

Your answer: ☐ I am currently living in Pantelleria ☐ I have lived in the past ☐ I have never lived in Pantelleria ☐ Prefer not to say

Question SD5.1: In which area? (Optional)

Your answer:

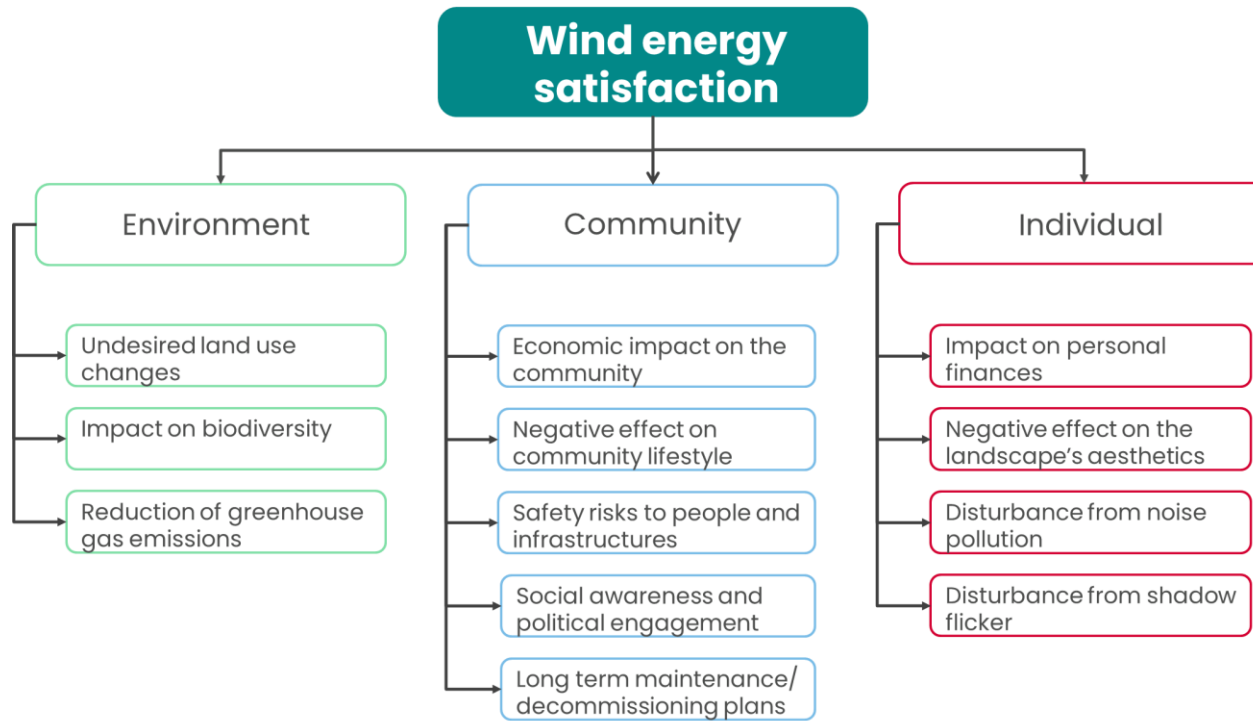
Participation

Pilot Site	ITALY Pantelleria island	AUSTRIA Gröbming and Irdning	PORTUGAL Viana do Castelo	PORTUGAL Torres Vedras	GREECE Evia island
Nr. of responses	79	44	65	50	77

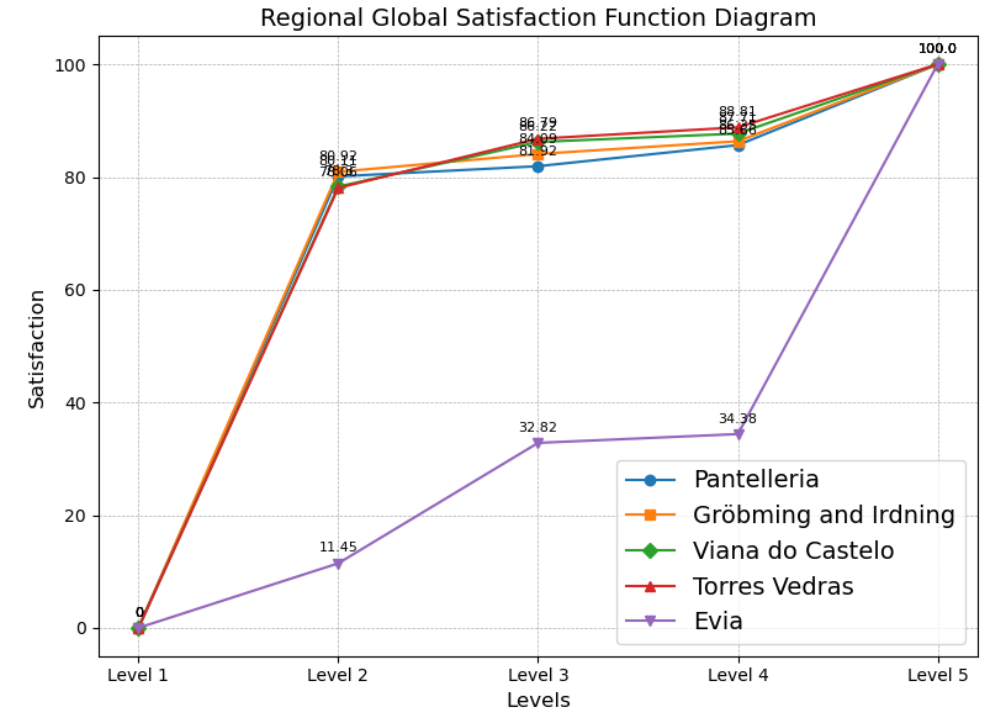


Acceptance priorities on sub-criteria

MUSA at the pilot sites



Structure of the MUSA criteria tree

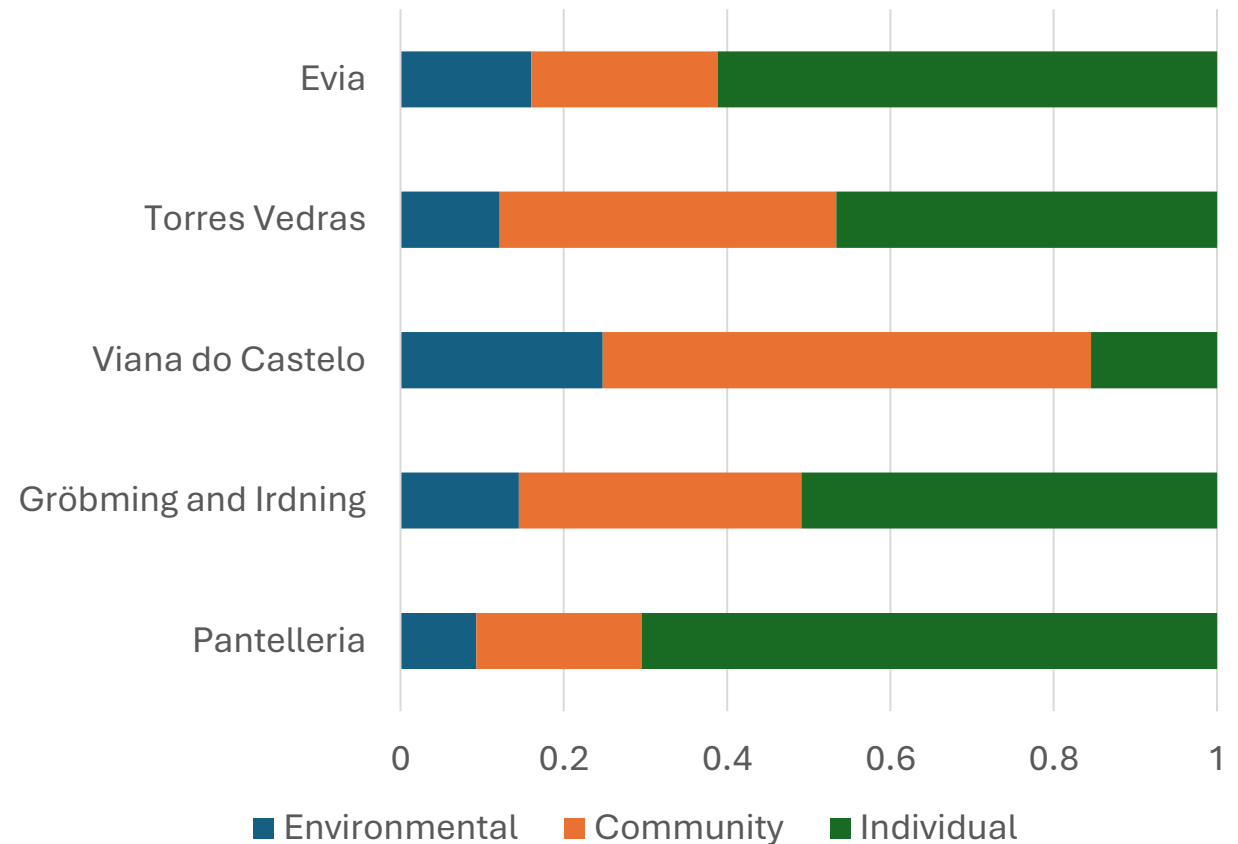


Regional overall acceptance value function diagram

- The participants at the pilot sites present relatively high satisfaction/acceptance

Criteria importance comparison

- Different regions present different priorities on criteria:
 - **Pantelleria** and **Styria (Gröbming, Irdning)** assign greater weight to **individual aspects**, particularly the impact on personal finances
 - **Torres Vedras** also emphasizes **individual aspects**, with the highest weight on disturbance from shadow flicker
 - **Evia** gives highest weight to **individual aspects** as well, especially the negative effect on landscape aesthetics
 - By contrast, **Viana do Castelo** places more weight on **community aspects**, notably long-term maintenance and decommissioning planning.



Effect of socio-demographics

Effect of socio-demographics on citizens' acceptance

- We performed a **statistical analysis** to investigate if and how each of the socio-demographic features affects acceptability
- The list of **socio-demographics features**:

Feature	Feature Values	Feature Type
COUNTRY	1) Italy, 2) Austria, 3) Portugal, 4) Greece	Nominal
AGE GROUP	1) 18-24, 2) 25-34, 3) 35-44, 4) 45-54, 5) 55-64, 6) 65 or older	Ordinal
GENDER	1) Male, 2) Female, 3) Other, 4) Prefer not to say	Nominal
EDUCATION LEVEL	1) Secondary schools or lower (e.g., high school) , 2) College or vocational training, 3) Bachelor's degree, 4) Postgraduate degree (Masters, PhD)	Ordinal
EMPLOYMENT	1)Full-time, 2) Part-time, 3) Not employed, 4) Retired, 5) Student, 6) Prefer not to say	Nominal
RESIDENCE	1) Yes, currently, 2) Yes, in the past, 3) Never, 4) Prefer not to say	Nominal

Analysis Methodology

STEPS

- We first examined the **overall acceptability (Q16)**
- Then, the acceptability from three **different perspectives**
 - Environmental (Q4) 
 - Community (Q10) 
 - Individual (Q15) 
- Then, for each of the 12 **sub-criteria (Q1-Q3, Q5-Q9, Q11-Q15)**
- Then, we isolated the data for each different country and examined the effect on all questions (**Q1-Q16**)

TESTS

- We first examined whether there is a strong association between each pair of feature-question
 - **Chi-square test of independence + Cramer's V**
- For the two ordinal features (AGE GROUP, EDUCATION), we investigated the presence of a monotonic trend
 - **Spearman's ρ correlation**
- We assessed if the distribution of acceptance differs significantly across the groups of the two ordinal features
 - **Kruskal-Wallis H tests**
- For the features that significantly affected responses, we examine how the specific values influence scores
 - **Ordinal logistic regression**

Overall acceptability

Overall Acceptability (Q16)

Chi-Square tests of independence and Cramer's V

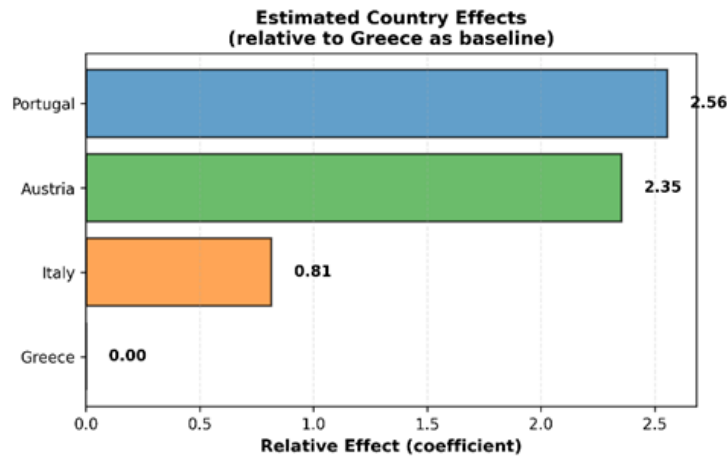
Feature	χ^2	p-value	Degrees of freedom (df)	Cramer's V	Interpretation
COUNTRY	99.17	0.0000	12	0.32	Significant association, strong effect
AGE GROUP	17.67	0.6093	20	0.12	Not significant, weak effect
GENDER	14.74	0.2562	12	0.12	Not significant, weak effect
EDUCATION LEVEL	18.26	0.1080	12	0.14	Not significant, weak effect
EMPLOYMENT	15.08	0.7719	20	0.11	Not significant, weak effect
RESIDENCE	17.06	0.1475	12	0.13	Not significant, weak effect

Kruskal-Wallis and Spearman correlation

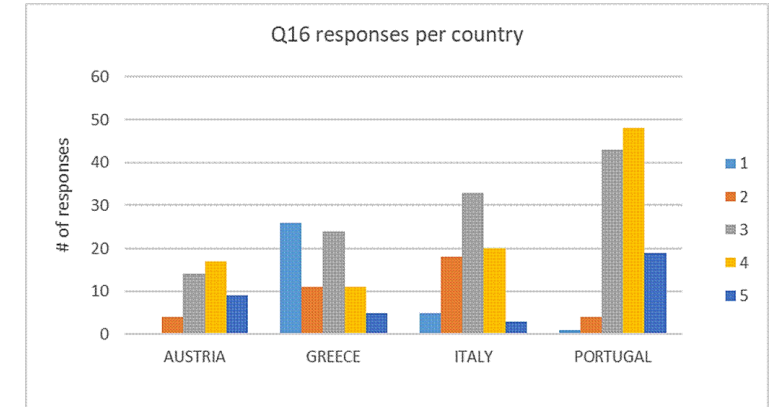
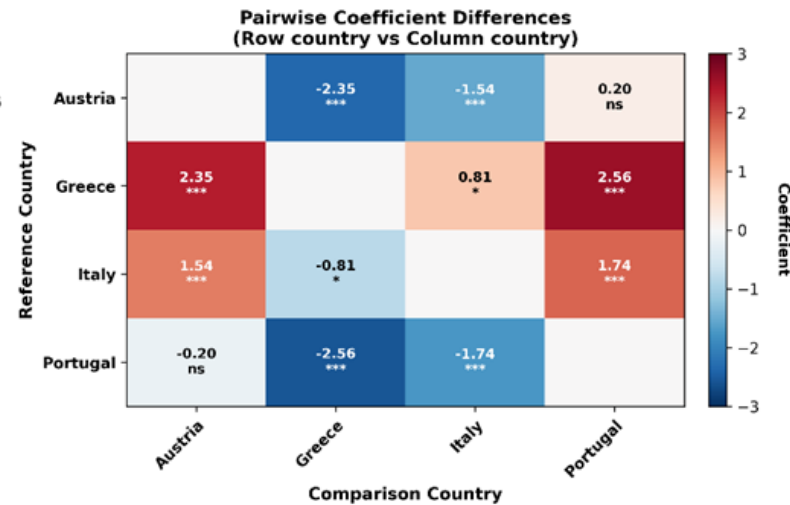
Ordinal Feature	Correlation Analysis		Kruskal-Wallis Test		Interpretation
	Spearman's ρ	p	Kruskal-Wallis H	p	
AGE GROUP	-0.04	0.5279	1.92	0.7510	Not significant association
EDUCATION LEVEL	-0.08	0.1654	7.79	0.0996	Not significant association

Overall Acceptability (Q16)

Ordinal logistic regression for the COUNTRY feature



Significance: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ns = not significant



Reference country	p and coef per country
Austria	Greece (0.000 , -2.3536) Italy (0.000 , -1.5392) Portugal (0.603, 0.2015)
Italy	Austria (0.000 , 1.5391) Portugal (0.000 , 1.7405) Greece (0.031 , -0.8147)
Greece	Italy (0.031 , 0.8144) Austria (0.000 , 2.3536) Portugal (0.000 , 2.5550)
Portugal	Italy (0.000 , -1.7406) Austria (0.603, -0.2015) Greece (0.000 , -2.5553)

- The acceptance levels in Greece and Italy are significantly lower than in Austria and Portugal, while for Greece in particular, all other countries provide significantly higher values.

Acceptability from different perspectives

Environmental Perspective (Q4)



Chi-Square tests of independence and Cramer's V

Feature	χ^2	p-value	Degrees of freedom (df)	Cramer's V	Interpretation
Country	102.77	<0.0001	12	0.33	Significant association, strong effect
Age group	20.78	0.4104	20	0.13	Not significant, weak effect
Gender	20.93	0.0515	12	0.15	Not significant, weak effect
Education level	22.35	0.0338	12	0.15	Significant association, weak effect
Employment	22.51	0.3135	20	0.13	Not significant, weak effect
Residence	15.35	0.2229	12	0.13	Not significant, weak effect

Kruskal-Wallis and Spearman correlation

Ordinal Feature	Correlation Analysis		Kruskal-Wallis Test		Interpretation
	Spearman's ρ	p	Kruskal-Wallis H	p	
Age group	-0.05	0.3775	3.81	0.4317	Not significant association
Education level	-0.08	0.1778	14.82	0.0051	Significant association.

The ordinal logistic regression for EDUCATION LEVEL indicates a non-statistically significant effect ($p = 0.348$, coefficient = 0.1138)

Environmental Perspective (Q4)



Ordinal logistic regression for the COUNTRY feature

- The acceptance levels in Greece are significantly lower than in all other countries, while the acceptance levels in Portugal are significantly higher than in all other countries
- Although Austrians are generally positive about the installation of wind turbines (see Q16 results), they are concerned about the environmental impact.

Reference country	p and coef per country
Austria	Greece (0.016 , -0.9288) Italy (0.344, 0.3257) Portugal (< 0.001 , 1.4243)
Italy	Austria (0.344, -0.3257) Portugal (0.002 , 1.0991) Greece (0.001 , -1.2543)
Greece	Italy (0.001 , 1.2547) Austria (0.016 , 0.9287) Portugal (< 0.001 , 2.3533)
Portugal	Italy (0.002 , -1.0987) Austria (< 0.001 , -1.4246) Greece (< 0.001 , -2.3532)

Community Perspective (Q10)



Chi-Square tests of independence and Cramer's V

Feature	χ^2	p-value	Degrees of freedom (df)	Cramer's V	Interpretation
Country	114.25	<0.0001	12	0.35	Significant association, strong effect
Age group	16.57	0.6810	20	0.11	Not significant, weak effect
Gender	15.78	0.2016	12	0.13	Not significant, weak effect
Education level	17.58	0.1292	12	0.14	Not significant, weak effect
Employment	15.82	0.7274	20	0.11	Not significant, weak effect
Residence	12.86	0.3797	12	0.11	Not significant, weak effect

Kruskal-Wallis and Spearman correlation

Ordinal Feature	Correlation Analysis		Kruskal-Wallis Test		Interpretation
	Spearman's ρ	p	Kruskal-Wallis H	p	
Age group	-0.05	0.3775	2.96	0.5643	Not significant association
Education level	-0.08	0.1778	13.18	0.0104	Significant association

The ordinal logistic regression for EDUCATION LEVEL indicates a non-statistically significant effect ($p = 0.704$, coefficient = 0.0448)

Community Perspective (Q10)



Ordinal logistic regression for the COUNTRY feature

- These results indicate that the acceptance levels in Portugal are significantly higher than in all other countries, while the acceptance levels in Greece are significantly lower than in Austria and Portugal.
- Respondents in Italy hold diverse opinions regarding the community perspective, with no clear trend distinguishing their responses from those of Greece and Austria

Reference country	p and coef per country
Austria	Greece (0.002 , -1.2132) Italy (0.136, -0.5137) Portugal (< 0.001 , 1.3429)
Italy	Austria (0.136, 0.5141) Portugal (0.000 , 1.8566) Greece (0.060, -0.6995)
Greece	Italy (0.060, 0.6999) Austria (0.002 , 1.2140) Portugal (< 0.001 , 2.5562)
Portugal	Italy (< 0.001 , -1.8566) Austria (< 0.001 , -1.3424) Greece (< 0.001 , -2.5563)

Individual Perspective (Q15)



Chi-Square tests of independence and Cramer's V

Feature	χ^2	p-value	Degrees of freedom (df)	Cramer's V	Interpretation
Country	146.71	0.0000	12	0.39	Significant association, strong effect
Age group	27.58	0.1196	20	0.15	Not significant, weak effect
Gender	20.44	0.0593	12	0.15	Not significant, weak effect
Education level	35.25	0.0004	12	0.19	Significant association, weak effect
Employment	18.50	0.5545	20	0.12	Not significant, weak effect
Residence	25.76	0.0116	12	0.17	Significant association, weak effect

Kruskal-Wallis and Spearman correlation

Ordinal Feature	Correlation Analysis		Kruskal-Wallis Test		Interpretation
	Spearman's ρ	p	Kruskal-Wallis H	p	
Age group	-0.02	0.6763	3.91	0.4188	Not significant association
Education level	-0.05	0.3661	23.92	0.0001	Significant association

The ordinal logistic regression for EDUCATION LEVEL indicates a non-statistically significant effect ($p = 0.621$, coefficient = 0.0586)

Individual Perspective (Q15)



Ordinal logistic regression for the **COUNTRY** feature

- Respondents in AUSTRIA and PORTUGAL are more receptive to the installation of wind turbines than those in ITALY and GREECE (possibly because they foresee individual benefits in the long term).

Reference country	p and coef per country
Austria	Greece (<0.001, -2.0659) Italy (<0.001, -1.5818) Portugal (0.106, 0.6073)
Italy	Austria (<0.001, 1.5816) Portugal (<0.001, 2.1892) Greece (0.191, -0.4842)
Greece	Italy (0.192, 0.4838) Austria (<0.001, 2.0655) Portugal (<0.001, 2.6729)
Portugal	Italy (<0.001, -2.1890) Austria (0.106, -0.6073) Greece (<0.001, -2.6730)

Individual Perspective (Q15)



Ordinal logistic regression for the **RESIDENCE** feature

- Participants who have lived in the area in the past provide significantly higher acceptability values than all others

Reference residence value	p and coef per value
Yes, now	Yes, past (0.024 , 1.2099) No (0.305, -0.2914) No say (0.115, -1.1818)
Yes, past	Yes, now (0.024 , -1.2099) No (0.009 , -1.5013) No say (0.007 , -2.3921)
No	Yes, now (0.305, 0.2913) Yes, past (0.009 , 1.5011) No say (0.254, -0.8907)
No say	Yes, now (0.115, 1.1827) Yes, past (0.007 , 2.3928) No (0.254, 0.8913)

Acceptability based on subcriteria

Acceptability based on subcriteria

- **COUNTRY** is a variable that significantly influences the responses across ALL questions!
 - The most pronounced differences were observed in Q9, which concerns long-term maintenance of wind turbines and decommissioning plans
 - Respondents from Greece and Italy expressed notably more negative views compared to those from Portugal and Austria
 - $p < 0.0001$ and coef > 2.25 , in all cases!
- This indicates a **low level of trust in maintenance and decommissioning actions in Greece and Italy**, suggesting country-specific perceptions and experiences play a key role in shaping attitudes toward wind turbine management.

Acceptability based on subcriteria (Q1-Q3)



QUESTION	COUNTRY	AGE GROUP	GENDER	EDUCATION LEVEL	EMPLOYMENT	RESIDENCE
Undesired land use changes (Q1)	✓	✗	✗	✓	✗	✗
Impact on biodiversity (Q2)	✓	✗	✗	✓	✗	✗
Help produce clean energy (Q3)	✓	✗	✗	✗	✗	✗

- Higher educational level appears to be linked with:
 - higher concern about **undesired land use changes** (weak effect)
 - higher concern about potential **biodiversity impacts** (weak effect)

Acceptability based on subcriteria (Q5-Q9)



QUESTION	COUNTRY	AGE GROUP	GENDER	EDUCATION LEVEL	EMPLOYMENT	RESIDENCE
Economic impact on the community (Q5)	✓	✓	✗	✗	✗	✗
Negative effect on community lifestyle (Q6)	✓	✗	✗	✓	✗	✗
Safety risks to people and infrastructures (Q7)	✓	✗	✓	✗	✗	✗
Raise social awareness & political engagement (Q8)	✓	✓	✗	✓	✗	✗
Long term maintenance & decommiss. plans (Q9)	✓	✗	✗	✓	✗	✗

- Older individuals tend to perceive the **economic impact** of wind turbines on the community more favorably than younger ones
- Individuals with higher education levels tend to be more concerned about the potential negative effects on **community lifestyle**, and believe they can raise the **inhabitants' social awareness and political engagement**
- Male individuals are less concerned of **safety risks** to people and infrastructures than female ones

Acceptability based on subcriteria (Q11-Q14)



QUESTION	COUNTRY	AGE GROUP	GENDER	EDUCATION LEVEL	EMPLOYMENT	RESIDENCE
Impact on personal finances (Q11)	✓	✓	✓	✓	✗	✗
Negative effect on the landscape's aesthetics (Q12)	✓	✗	✗	✓	✗	✗
Disturbance from noise pollution (Q13)	✓	✗	✗	✗	✗	✗
Disturbance from shadow flicker (Q14)	✓	✗	✗	✗	✗	✗

- More female than male participants perceive a positive effect on their **personal financial situation**
- Older respondents tend to perceive the **personal financial impact** more positively
- Individuals with higher education levels tend to view the **financial impact** slightly less positively, and are more concerned about the negative effects of wind turbines in the **landscape's aesthetics** (small effect)

Per country analysis



Greece

- As education level increases, concern about potential harm to biodiversity tends to increase (Q2)
- Older respondents tend to express lower levels of concern regarding various potential impacts of wind turbines (Q2, Q5, Q6, Q12, Q13)
- Men and women differ meaningfully in their overall acceptability (Q16), with women being slightly more positive



Italy

- Men and women differ meaningfully in their perceptions of safety (Q7) and visual disturbance (Q14) caused by wind turbines, with men being less concerned
- Opinions from people living in the area differ substantially from non-residents in how they perceive overall personal impacts of wind turbine projects (Q15), with those living in the area being more positive
- Individuals in different employment categories differ notably in their perceptions of noise pollution caused by wind turbines (Q13), with retired people being slightly less concerned



Austria

- Older respondents are less concerned about land use changes caused by wind turbines (Q1), but more concerned about aesthetic impacts (Q12)
- Men and women differ meaningfully in how they perceive the role of wind turbines in generating clean energy (Q4), with women being more positive



Portugal

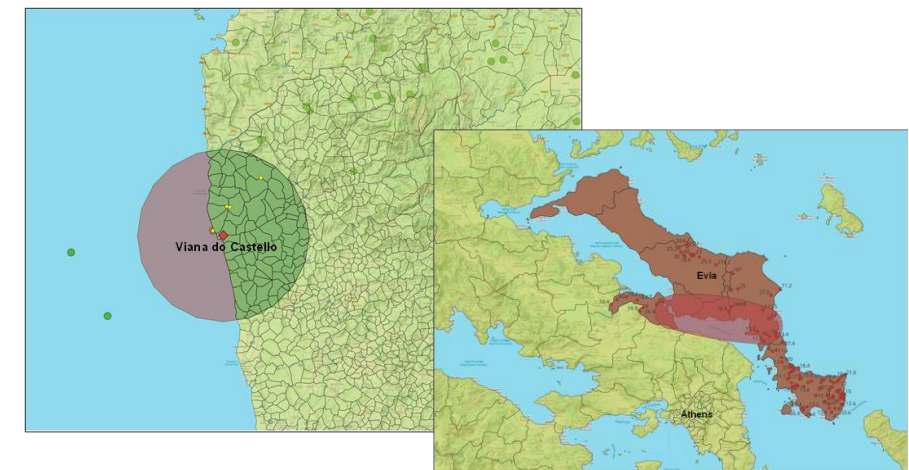
- Additional demographic variable: AREA (*Torres Vedras or Viana do Castelo*)
- Perceptions of community lifestyle impacts (Q6) differ across the two regions, with those living in *Torres Vedras* being more concerned
- Living in the area influences how positively individuals view the environmental benefits of wind turbines, with those lived in the past being more concerned

Exposure to wind power farms

Exposure to wind power farms

Pilot case	Zone of analysis (km ²)	Population	Installed capacity (MW)	Status of capacity	Number of wind farms
Styria (AT)	3355	84381	0	None	0
Viana do Castelo (PT)	986	208732	69	Operating	3
			600	Announced	1
Torres Vedras (PT)	988	188570	126	Operating	7
Pantelleria (IT)	83	7282	0	None	0
Evia (GR)	5996	272874	947	Operating	52
			1728	Pre-construction	39
			69.6	Announced	2

Pilot case	Density of wind farms (wind farms/km ²)	Capacity per population (kW per capita)
Styria (AT)	0.000	0.000
Viana do Castelo (PT)	0.003	0.331
Torres Vedras (PT)	0.007	0.668
Pantelleria (IT)	0.000	0.000
Evia (GR)	0.009	3.470



Exposure to wind power farms

- Initial considerations:
 - Wind power exposure seems to explain the low acceptance in Evia/Greece and high in Styria/Austria.
 - Still more investigation is needed on other external factors
 - Qualitative analyses and interviews can aid towards that

Conclusion and Future Work

Key findings

- The **acceptance levels** in Greece and Italy are significantly lower than in Austria and Portugal, while for Greece in particular, all other countries provide significantly higher values
- The **Portuguese are the more positive**, the **Greeks are the more negative!**
- **Greeks and Italians** expressed notably more negative views about **long-term maintenance** and **decommissioning plans**
- **Older individuals** tend to perceive the **community and personal financial impact** more positively than younger individuals
- **Higher education levels** appear to be linked with higher concern about specific environmental, community, and individual impacts

Future Work

- What are other factors that could affect acceptance?
 - geographic: landscape type, tourism intensity
 - political and governance: transparency, regulatory quality and enforcement
 - social and cultural: media coverage tone, disinformation
 - operational: grid integration quality
 - biodiversity and environment: bird migration routes, endemic species, proximity to protected areas
 - ...



<https://news.sustainability-directory.com/news/wind-technology/>

Thank you!

Questions?