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EDITED BY

Jose Antonio Rodriguez Martin,
Instituto Nacional de Investigación y
Tecnología Agroalimentaria (INIA), Spain

REVIEWED BY

Maria Emilia Garbelli,
Università degli studi di Milano Bicocca, Italy
Brina Malnar,
University of Ljubljana, Slovenia

*CORRESPONDENCE

Evren Yalaz
✉ evren.yalaz@trilateralresearch.com

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Who trusts wind farms? A vignette study on tailoring trust-building strategies for inclusive renewable energy transitions

Evren Yalaz^{1*}, Mariano Martín Zamorano¹, Emily Maitland²,
Agata Gurzawska¹, Gábor Szüdi³ and Pamela Bartar³

¹Trilateral Research, Waterford, Ireland, ²Trilateral Research, London, United Kingdom, ³Centre for Social Innovation, Vienna, Austria

Introduction: Climate governance is increasingly contested, with public acceptance of renewable energy projects such as wind farms often facing resistance. This study explores how different trust-building strategies, including science communication, co-creation, benefit sharing, and social media, affect public perceptions of wind energy across diverse socio-demographic groups in four European countries (Austria, Cyprus, Greece, and Spain).

Methods: Drawing on an experimental vignette-based survey developed within the EU-funded VERITY project, we assess the impact of these strategies on two contrasting demographic groups: Group 1 (young, urban, university-educated) and Group 2 (older, rural, without a university degree).

Results: Our findings reveal significant variations in trust and engagement, with Group 1 generally exhibiting more positive attitudes toward wind energy (mean score: 0.49), while Group 2 was neutral or slightly negative (−0.01). Benefit sharing emerged as the most universally effective strategy, improving perceptions across all groups, particularly among sceptical male respondents. Science communication was most effective among women, especially in Group 1, while social media showed minimal or negative impact.

Discussion: The study highlights the importance of tailoring trust-building strategies to different demographic contexts, emphasizing that a one-size-fits-all approach is inadequate for inclusive climate governance. These findings offer actionable insights for policymakers seeking to enhance public trust in renewable energy transitions, aligning local engagement strategies with broader climate diplomacy.

KEYWORDS

trust in science, trust building strategies, inclusive climate governance, wind farms, vignette study

1 Introduction

Climate governance has become an increasingly contested and politically charged domain. The formulation and implementation of climate policies are embedded in disputes over the distribution of responsibilities, perceptions of fairness, and competing geopolitical priorities (Okereke and Coventry, 2016; Newell and Bulkeley, 2017). These tensions are evident in the public's diverging perceptions of climate-related initiatives, particularly renewable energy policies that, while designed to advance environmental goals, generate localized opposition and contestation in certain contexts (Wolsink, 2007; Fast, 2013).

Wind farms serve as a paradigmatic example of this tension. In 2023, wind energy contributed approximately 8% to global electricity production and remains among the most cost-effective sources of low-carbon power (McKenna et al., 2025). However, their public acceptance continues to pose a challenge to meeting targets for wind energy deployment (Scherhauser et al., 2017). Public opposition to wind farms has resulted in the cancellation of numerous proposed projects (Vergine et al., 2024). Public attitudes toward wind energy are shaped by a constellation of factors including trust in institutions (Gross, 2007), perceptions of procedural and distributive justice (Wolsink, 2007), socio-economic impacts such as local economic benefits or costs (Fast, 2013; Kalogiannidis et al., 2025), the extent and quality of public participation in decision-making processes (Walker et al., 2010), and environmental concerns like visual impacts, noise, and effects on wildlife (Kraft and Kraft, 2025). Public acceptance of wind farms varies across different sociodemographic groups. Studies have highlighted how factors such as age, education level, income, and place of residence influence individuals' perceptions and acceptance of wind energy projects (Bertsch et al., 2016; European Commission. Joint Research Centre, 2016). Beyond these social and perceptual dimensions, several contextual factors also shape public acceptance of wind energy, including natural suitability and technical feasibility, such as wind potential, topography, length of coastline, and existing land-use patterns (Wimhurst et al., 2023; Wolniak and Skotnicka-Zasadzień, 2023; Abdullah et al., 2025), the history of wind-energy development and people's exposure to windfarms (Firestone and Kirk, 2019; Dugstad et al., 2020), national policy frameworks, local energy market characteristics, and permitting processes (Leiren et al., 2020). These findings underscore the need for climate governance frameworks that recognize and respond to this diversity.

Controversies surrounding climate technologies are increasingly shaped by cross-border information flows and narratives propagated by climate contrarianism seeking to erode public trust in democratic institutions, including those grounded in scientific expertise (Coan et al., 2021). The resulting scepticism toward climate governance, particularly pronounced among social groups receptive to such narratives, as highlighted by our analysis, has significant global ramifications. Domestic contestation and negotiation dynamics do not remain confined within national boundaries but reverberate upward into multilateral arenas, thereby influencing the dynamics of global climate diplomacy (Flink and Schreiterer, 2010; Biermann and Gupta, 2011). In this context, trust in science-based climate policies becomes both a domestic site of contestation and a transnational currency of influence.

This article contributes to ongoing debates on inclusive and equitable global climate governance by examining how different trust-building strategies affect public perceptions of wind energy across varied sociodemographic groups in four European countries. Drawing on an experimental vignette-based survey, the study investigates the effectiveness of four trust-enhancing methods: (1) science communication, (2) co-creation, (3) benefit sharing, and (4) social media. By identifying which groups are most responsive to which strategies, the article offers empirical insights into designing adaptive governance mechanisms that engage citizens more equitably and inclusively in the energy transition.

This study is part of the EU-funded VERITY project¹, which aims to enhance public trust in science by encouraging informed decision-making based on scientific evidence, identifying trust-building strategies and fostering a more constructive and productive relationship between science and society.

Following this introduction, the paper begins with a review of the existing literature on public trust in science, renewable energy, and wind farms, factors influencing wind energy acceptance, and the effectiveness of different trust-building strategies. This is followed by a detailed description of the study's methodology, including the experimental vignette survey design, participant sampling, data collection, and analytical procedures. The results section presents the key findings, highlighting variations in trust and engagement across demographic groups. The discussion section interprets these findings in relation to existing literature, considering their implications for inclusive climate governance. Finally, the conclusion summarizes the main insights, provides policy recommendations, and suggests directions for future research.

2 Public perception and trust-building in wind energy: a review of key factors and strategies

2.1 The role of trust in science in accepting wind energy

Public trust in science is crucial for the acceptance of new technologies (Goldenberg, 2023). Studies show that a higher level of public trust in science facilitates public acceptance and adoption of regulations, measures and technologies during the COVID-19 pandemic (Yaddanapudi and Hahn, 2023), biological technologies like stem cell research (Aboalola et al., 2024), nanotechnology (Åm, 2011), and genetically modified food (Hu et al., 2020). Trust in science is also recognized as a decisive factor in the acceptance of renewable energy technologies, particularly wind farms. Yet, trust is multi-dimensional and the existing research identified several distinct dimensions of trust relevant to wind energy acceptance.

First, trust in technology supports confidence in the technical reliability and safety of wind energy systems (Linzenich and Zieffle, 2018). Second, people rarely evaluate energy technologies purely on technical grounds. Trust in stakeholders, including confidence in scientific experts, project developers, and authorities, whether they believe are credible, transparent, and acting fairly, matters (Linzenich and Zieffle, 2018; Dwyer and Bidwell, 2019). Third, institutional trust, including trust in regulatory bodies, scientific institutions, and governance processes, correlates with the public's acceptance of new energy technologies (Bronfman et al., 2015; Dirksmeier and Tuitjer, 2023).

¹ VERITY (deVEloping scientific Research with ethIcs and inTegritY) is a Horizon Europe project (2022–2025, Grant Agreement No. 101058623) aimed at enhancing public trust in science by identifying trust stewards and developing tools and methods to support transparency, responsibility, and engagement in scientific research. <https://verityproject.eu/>. An earlier version of this study is submitted to the European Commission as a project deliverable (Szüdi and Yalaz, 2024).

The relationship between trust in science and acceptance of wind farms is not strictly one-way. Trust typically shapes acceptance by influencing perceived risks/benefits, fairness, and legitimacy; comprehensive frameworks show that trust alters these appraisals, which in turn predict support or opposition (Wüstenhagen et al., 2007; Huijts et al., 2012). Yet the arrow can also run in the other direction: positive experiences with well-run projects, where procedures are inclusive and transparent, can build trust *ex post*, creating feedback loops between fair process, satisfactory outcomes, and rising institutional credibility (Walker et al., 2010; Simcock, 2016). These dynamics are conditioned by intervening factors. Place attachment and identity can moderate how fairness cues translate into acceptance, sometimes sustaining opposition despite high general trust (Devine-Wright, 2009). Broader socio-political narratives and social representations of energy also mediate trust, which may amplify or dampen it regardless of local technical evidence (Batel et al., 2013).

2.2 Current levels and key factors of public acceptance of wind farms

Public acceptance of wind energy represents a critical factor in the successful deployment of renewable energy infrastructure globally. Wind power enjoys broad public support as a clean energy technology. According to the Eurobarometer results, 87% of the EU27 think that wind energy will have a positive effect on our way of life in the next 20 years (European Commission, 2021). Wind energy acceptance is the highest in Europe in countries like Portugal (99%) or Ireland (97%). On the other hand, France (76%) and Romania (76%) fall below the EU27 average. Yet, the translation of this general approval into local acceptance of specific projects remains challenging (European Commission. Joint Research Centre, 2016). This phenomenon, often characterized by the gap between general support for renewable energy and opposition to local developments, has significant implications for meeting climate targets and energy transition goals. This gap is particularly pronounced in countries with high general support but significant local resistance, suggesting that acceptance is not simply a matter of environmental attitudes but involves complex local considerations (Bidwell and Affairs, 2015; European Commission. Joint Research Centre, 2016). The complexity of social acceptance extends beyond simple NIMBY (Not In My Backyard) explanations and requires complex frameworks that account for social and psychological, economic, environmental, procedural and participatory, and contextual and cultural factors.

Research identifies several critical social and psychological determinants of wind farm acceptance. Perceived fairness of project planning processes significantly influences both general and local acceptance (Linzenich and Zieffle, 2018). Social beliefs about positive outcomes strongly correlate with wind farm acceptance, often outweighing economic considerations (Groth, 2015). The role of community identity and place attachment also influences acceptance, with communities viewing wind and sea resources as important local assets that should benefit local populations (Frolova et al., 2022).

Economic considerations play a complex role in wind farm acceptance. While economic benefits can enhance acceptance, the distribution of costs and benefits is crucial. Studies show that the spatial distance between costs incurred and benefits derived significantly affects acceptance levels (Devlin, 2005). Community

benefit schemes can increase support, but their effectiveness depends on framing and implementation. Research demonstrates that collective rather than individual benefits are more effective in building support (Vuichard et al., 2019). While proponents and a large group of citizens with weak preferences for local wind energy projects favor financial benefits, these benefits cannot win over the small group of opponents (Knauf, 2022).

Environmental concerns present both positive and negative influences on acceptance. While support for greenhouse gas reduction motivates acceptance (De Salvo et al., 2021), concerns about landscape impacts, noise, and wildlife effects create opposition (European Commission. Joint Research Centre, 2016; Leiren et al., 2020). The perception of infrasound from wind turbines consistently emerges as a negative factor across multiple studies (Langer et al., 2018). Landscape and visual impacts represent particularly significant concerns, with studies showing that aesthetic considerations can outweigh environmental benefits in some contexts (De Salvo et al., 2021). The frequency of visual exposure to turbines, rather than mere proximity, correlates strongly with acceptance levels (Olson-Hazboun et al., 2016).

Procedural justice and public participation emerge as critical determinants of acceptance across multiple studies. Research consistently shows that information gathering and meaningful participation positively impact acceptance (Langer et al., 2018). The quality and timing of public engagement processes influence outcomes. Three levels of public involvement - information, consultation, and participation - each contribute differently to acceptance, with meaningful participation being most effective (De Luca et al., 2020).

Acceptance factors vary significantly across different geographical and cultural contexts. European studies reveal substantial differences between countries with established wind energy sectors and those with limited experience (Leiren et al., 2020). In regions with little prior wind energy experience, factors such as technical characteristics and environmental impacts play different roles compared to established markets. Cultural values and perceptions of natural resources influence acceptance patterns. In coastal communities, perceptions of the sea as a local resource and concerns about joint use of marine resources significantly affect offshore wind acceptance (Frolova et al., 2022).

Socioeconomic factors influence acceptance patterns, though not always in expected ways. Research from Greece found that acceptance is not simply a class issue, as attitudes proved independent of income levels (Skiniti et al., 2022). However, studies from Poland show correlations between age, education, income, and willingness to financially support wind farm development (Rauba and Zimińska, 2018).

2.3 Intervention strategies to enhance public acceptance of wind farms

This study examines how four key intervention strategies, which include science communication, co-creation, benefit sharing, and social media advocacy, influence different dimensions of social acceptance in wind farm development.

Research on science communication in wind energy contexts primarily focuses on information provision and transparency

measures. Studies examine how technical information about wind energy impacts public perceptions and acceptance levels (European Commission, Joint Research Centre, 2016). Science communication shows mixed effectiveness in improving social acceptance. While providing accurate information about wind energy can positively influence public attitudes (Cousse, 2021), the impact is often limited when used in isolation. The effectiveness of science communication depends heavily on the source's credibility and the timing of communication campaigns over a longer period of time (Le Maitre et al., 2024). Community liaison officers can play an important mediation role between the project developers and local communities. Yet, as Le Maitre et al. (2024) note that it is not guaranteed that these officers will be trusted by community members.

The importance of co-creation for building public trust is well-documented. Research has shown that when individuals perceive decision-making processes as inclusive and responsive, their acceptance of scientific initiatives increases, even in cases involving potential risks or trade-offs (Stilgoe et al., 2014). Moreover, co-creation aligns with broader shifts toward responsible research and innovation (RRI), which call for more democratic and socially attuned science-society relations (Owen et al., 2012). By embedding community voice into the development process, co-creation fosters a sense of ownership and legitimacy, thereby enhancing the social robustness of science-driven interventions such as renewable energy infrastructure.

Solman et al. (2021) conducted a systematic literature review on co-production in the wind energy sector that examines public engagement beyond traditional stakeholder participation. The review identifies three modes of co-production: local co-production, collective co-production, and virtual co-production. These three distinct modes of co-production “cover a broad spectrum of ways in which local and non-local publics engage in decisions about where, when, how and by whom wind energy projects are designed, developed and managed over time.” While co-creation emerges as one of the most effective intervention strategies, its effectiveness lies in its ability to transform citizens from passive recipients to active “co-creators and co-producers of electricity and planning decisions” (Gjørtler Elkjær et al., 2021). However, challenges exist when co-creation is perceived as instrumentally-driven rather than genuinely collaborative (Ryder et al., 2023).

Prior research has shown that benefit sharing, particularly in the form of community ownership, can significantly enhance public acceptance of renewable energy projects by addressing concerns about fairness and economic exclusion (Scherhauser et al., 2017). When local residents perceive that they have a tangible stake in the success of a project, opposition is likely to diminish and trust is more readily established (Gross, 2007). Benefit-sharing mechanisms such as cooperatives contribute not only to distributive justice but also to the long-term sustainability and legitimacy of scientific and technological innovations. Studies analyze both direct financial benefits and broader community development initiatives. Benefit sharing shows strong potential for enhancing social acceptance when implemented effectively. San Martin et al. demonstrate that “benefit sharing and meaningful community participation schemes” serve as key “mechanisms to attain the social license to operate new renewable energy projects” (San Martin et al., 2022).

Previous studies suggest that social media can play a significant role in amplifying support for science and sustainability, particularly among younger audiences (Brossard and Scheufele,

2013; Vraga and Bode, 2017). Yet, social media presents a double-edged sword for wind energy acceptance. A sentiment analysis of 3,269 mentions across Facebook, Instagram, Quora, and Reddit platforms reveals that renewable energy, including wind, receives favorable coverage when described as “clean,” “sustainable,” and “efficient” (Durmuş Şenyapar, 2024). The same study also highlights wind energy faces criticism for “visual and noise pollution concerns and potential effects on wildlife.” Critically, O'Brien's research reveals that “community based opposition groups appear to be effectively leveraging social media to escalate local concerns, and are prominent contributors to renewable energy discourse on the social media platform Twitter®” (O'Brien, 2016). This highlights social media's potential to amplify opposition rather than support.

This study contributes to the literature on renewable/wind energy acceptance by providing systematic evidence of how trust-building strategies perform across distinct socio-demographic groups. By comparing young, urban, highly educated respondents with older, rural populations in Austria, Cyprus, Greece, and Spain, it demonstrates that the effectiveness of interventions is not uniform but conditioned by demographic position. In doing so, the paper moves beyond the prevailing focus on aggregate attitudes or single-case studies, offering new insights into the heterogeneous social bases of wind energy acceptance and the demographic specificity of trust-building strategies.

Furthermore, the study enriches policy debates by challenging the adequacy of one-size-fits-all approaches to climate governance. The findings show that strategies to build trust in renewable energy must be tailored not only to local socio-political contexts but also to demographic cleavages within societies. This dual emphasis connects theoretical work on trust in science with applied questions of climate governance, renewable energy diplomacy, and social inclusion, highlighting how differentiated engagement strategies can enhance both fairness and effectiveness in the energy transition.

3 Materials and methods

This study employed an experimental vignette survey design to examine how specific trust-building strategies influence public attitudes toward wind energy as a proxy for science-related perceptions. The survey builds on the empirical foundation established by the VERITY project, which identified societal concerns and trust-enhancing strategies through a combination of qualitative fieldwork, expert interviews, and focus groups. These insights were translated into a structured quantitative survey using carefully developed vignettes.

Vignettes—short, precisely crafted descriptions of hypothetical situations (Atzmüller and Steiner, 2010)—are widely used in social science research to elicit reflexive responses. In this study, vignettes were embedded in a survey format, with participants rating their reactions using a 5-point Likert scale. Respondents were asked to assess each scenario from a first-person perspective, allowing for a more immersive and realistic evaluation of trust-related dynamics.

A total of five vignettes were developed. The first, adapted from the Special Eurobarometer 516 (European Commission, 2021), was neutral in tone and designed to measure baseline attitudes toward wind farms. The remaining four vignettes each introduced one of the

TABLE 1 Vignette study structure.

Vignette number	Explored factor	Vignette text
Vignette 1	No prompt	Imagine that there is a new wind farm planned where you live. How do you think this new wind farm will affect your life in the next years?
Vignette 2	Science communication	Imagine that there is a new wind farm planned where you live. The wind farm project has been long studied by environmental scientists. Scientific reports are shared with citizens. City hall meetings are held by scientists to explain why this wind farm is needed. How do you think this new wind farm will affect your life in the next years?
Vignette 3	Co-creation	Imagine there is a new wind farm planned where you live. The wind farm has been discussed with the residents for a long time. Citizen initiatives have been involved in the planning and development of the project. Regular feedback from the citizens is collected and incorporated into the wind farm project. How do you think this new wind farm will affect your life in the next years?
Vignette 4	Benefit sharing	Imagine that there is a new wind farm planned where you live. The wind farm will take the form of an energy cooperative. Local residents will be able to become a member of this cooperative and be the co-owners of the wind farm. The benefits generated by the wind farm will be distributed locally to the members of the cooperative. There will be annual dividends (distribution of the profits) to the cooperative members. How do you think this new wind farm will affect your life in the next years?
Vignette 5	Social media	Imagine that there is a new wind farm planned where you live. The wind farm project is positively welcomed by influential people on social media. It has become a highly mentioned topic in different social media platforms. Influential people on social media talk about its positive aspects in detail. How do you think this new wind farm will affect your life in the next years?

selected trust-building strategies: (1) science communication, (2) co-creation, (3) benefit sharing, and (4) social media (see: [Table 1](#)). Each strategy was isolated in its respective vignette to assess its distinct impact on public perceptions.

Following the best practices outlined by [Aguinis and Bradley \(2014\)](#), the vignettes were written in accessible language and piloted with a small group of participants from varied backgrounds. Feedback from this pilot phase informed revisions to improve clarity and relevance. To reduce potential bias from sequence effects such as the recency effect, that is recalling an earlier vignette and answering the later vignette accordingly, the order of vignette presentation was randomized with the exception of the baseline vignette, which always appeared first.

Vignette-based methods are found to be most effective when scenarios are perceived as personally relevant and realistic, enhancing respondents' engagement and the validity of their reactions ([Hughes and Huby, 2004](#)). Accordingly, the hypothetical scenarios in this study were carefully designed to reflect plausible, everyday situations, with the aim of eliciting responses that approximate actual behavior. Data were collected using closed-ended questions presented on a five-point Likert scale, allowing for consistent measurement and ease of quantitative analysis. To further increase realism, the vignettes were framed in the first person, encouraging participants to respond from their own perspective and thus simulate real-life decision-making.

To facilitate a clear analysis of differences in trust and attitude formation, the study employed a purposive sampling strategy. Two contrasting sub-samples—Group 1 and Group 2—were constructed based on sociodemographic factors known to correlate with trust in science. Group 1 consisted of university students and graduates aged 18–30, living in urban settings and presumed to hold higher baseline trust in science. Group 2 included participants over the age of 50, with no university degree and residing in rural areas, who were expected to display greater skepticism.

Building on existing literature, we selected age, education, and place of residence as the primary criteria for sample construction. This decision was informed by both practical and theoretical considerations. From a practical standpoint, age, education level, and urban/rural residence are demographic characteristics that can be reliably identified and controlled for during recruitment. While other variables—such as religiosity or political orientation—are also known to influence trust in science, they are less straightforward to operationalize in controlled sampling frameworks and would have introduced additional complexity beyond the scope of this study.

Theoretically, our choice was grounded in well-documented associations between these demographic factors and trust in science. For example, education has consistently been identified as a strong predictor of trust, with more highly educated individuals tending to be better informed about scientific issues and more positively inclined toward scientific institutions ([Mousoulidou et al., 2022](#)).² Similarly, age has been shown to shape science perceptions; according to the *Special Eurobarometer 516: European citizens' knowledge and attitudes towards science and technology* ([European Commission, 2021](#), p. 37), younger people are more likely to find science accessible and express greater curiosity about scientific developments. In terms of residence, both the Eurobarometer and prior VERITY research ([Antoniou and Iordanou, 2023](#)) have highlighted a rural–urban divide, with rural populations exhibiting comparatively lower levels of trust in science (see also: [Krause et al., 2019](#)). Taken together, these findings informed our assumption that younger, educated, urban residents are more

² We acknowledge some mixed evidence regarding the relationship between the level of education and trust in science, as also discussed by [Antoniou and Iordanou \(2023\)](#).

likely to hold favorable views of science than their older, less-educated, rural counterparts (Table 2).

Data collection was conducted in four European countries—Austria, Cyprus, Greece, and Spain. Country selection was primarily informed by logistical feasibility, as members of the VERITY consortium were based in these locations and were thus able to facilitate data collection, including in geographically remote rural areas. Beyond practical considerations, these countries also exhibited comparable public attitudes toward wind energy, the focal topic of the study. According to the *Special Eurobarometer 516: European citizens' knowledge and attitudes towards science and technology* (European Commission, 2021, p. 21), public perceptions of wind energy in all four countries aligned closely with the EU27 average, indicating a shared baseline of moderate support. Nonetheless, we acknowledge a limitation in this selection: Austria recorded a slightly higher rate of negative perceptions toward wind energy compared to the other three countries. The historical trajectories of wind energy adoption also differ across the four countries studied. The first European wind farm opened on the Greek island of Kythnos in 1982 (Wind Europe, n.d.). Greece experienced continuous growth during the 1990s–2000s, reaching over 5.5 GW by 2025 (Hellenic Wind Energy Association (HWEA), 2025). Spain began developing modern wind farms in the early 1990s and now exceeds 30 GW of installed capacity. In 2023, wind energy became the country's largest source of electricity, covering over 24% of national demand. Spain ranks fifth worldwide and second in Europe (after Germany) in total installed wind capacity (Spanish Wind Energy Association, n.d.). Austria entered the modern wind-energy phase in the mid-1990s, with steady expansion and growth thereafter (Jaksch-Fliegenschnee et al., 2022). By contrast, Cyprus is a late wind energy adopter. Its first large-scale facility was commissioned in 2010–2011. Since then, it has marked a gradual national uptake with a capacity of 157.5MWe, as in 2021 (Cyprus Energy Regulatory Authority, 2022). While these divergences do not invalidate the cross-country comparison, they introduce contextual nuances that should be taken into account when interpreting the findings (Table 3).

To ensure accessibility across diverse populations, the mode of administration varied: Group 1 completed the survey online via LimeSurvey, while Group 2 participants, who belonged to a harder-to-reach group, were engaged through face-to-face or telephone-assisted formats. This mixed-mode approach enabled inclusion of older rural participants who might otherwise be underrepresented. The potential influence of survey mode on response patterns was not formally examined and remains a methodological limitation of this study. Data collection was coordinated by the four national project partners, who followed shared sampling criteria while adapting the recruitment to local contexts. Each partner relied on institutional or community

TABLE 2 Sampling criteria.

Sample groups	Age	Education	Residency	Gender
Group 1	18–30	University students/ graduates	Urban	Female (50%) Male (50%)
Group 2	50+	No university degree	Rural	Female (50%) Male (50%)

For the urban/rural definition, see Eurostat's classification: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Urban-rural_typology.

TABLE 3 Perception of wind farms in four country cases.

Country	Perception of wind farms	
	Total positive	Total negative
Greece	91	4
Spain	92	3
Cyprus	93	4
Austria	85	13
EU-27	87	9

Source: 'Special Eurobarometer 516 European citizens' knowledge and attitudes towards science and technology' (European Commission, 2021, p. 21).

networks to recruit participants for Group 1 (younger, urban, university-educated) and Group 2 (older, rural, without a university degree). For Group 1 recruitment: In Austria, the Centre for Social Innovation (ZSI) distributed the survey link through university mailing lists. In Spain, the link was shared through student networks at Barcelona-based universities. In Greece, the University of West Attica (UniWA) researchers distributed the link directly to students at the University of West Attica and other Athens-based universities to ensure disciplinary diversity. In Cyprus, UCLan Cyprus distributed the survey in their own university network. For Group 2 recruitment: In Austria, ZSI organized two “research salons” with seniors in Lower Austria and Burgenland. In Spain, printed surveys were conducted through home visits in rural Granada. Two telephone interviews were conducted in this country case. In Greece, UniWA collaborators conducted printed surveys in a northern Greek village and nearby communities. In Cyprus, UCLan researchers recruited older participants from senior centres and village coffee shops in the districts of Nicosia and Larnaca. These procedures ensured cross-national consistency in methodology while accommodating demographic and logistical differences across sites.

To ensure that both sample sub-groups were homogeneous in terms of age, education, and residence, responses falling outside these predefined categories were excluded. For Group 1, out of 124 completed online surveys, 38 were ineligible due to age, residence, or education criteria, which resulted in 86 valid cases for analysis. For Group 2, of the 79 completed paper surveys, 10 were excluded because respondents held a university degree or did not report education level, leaving 69 eligible responses included in the final dataset. The final sample comprised 155 eligible responses. We aimed to achieve gender balance across both sampling cohorts. This objective was successfully met in Group 2, where the final sample included 33 men and 36 women, reflecting near-equal representation. In contrast, Group 1 displayed some gender disparity, with approximately 60% of respondents identifying as women. This imbalance may reflect a greater level of interest or willingness to participate among women university students in the subject matter, potentially indicating higher engagement with topics related to science, trust, and environmental issues within this demographic. The data collection took place between 25 March and 15 April 2024.

Although the sample was non-random, this deliberate contrast between Group 1 and Group 2 maximized analytical clarity by allowing for the detection of differential effects across demographic divides. This methodological approach is aligned with recommendations from Hopkin et al. (2015) for small-sample, theory-driven comparative research (Table 4).

TABLE 4 Distribution of survey responses in Group 1 and Group 2 per country and gender.

Survey distribution	Group 1*	Group 2°	Total
Total received	103	79	182
Total eligible	86	69	155
Country			
Austria	28	23	51
Cyprus	9	10	19
Greece	24	15	39
Spain	25	21	46
Gender			
Man	33	33	66
Woman	52	36	88
Other	1	0	1

The anonymised full survey dataset is publicly available in open access at the Zenodo repository: <https://doi.org/10.5281/zenodo.11444667>.

* Group 1: under 30, studying at a university or having at least a Bachelor's degree, living in an urban setting.

°Group 2: above 65, not holding a tertiary degree, living in a rural environment.

To analyze the data, we first recoded the responses onto a numerical scale consistent with the structure of the five-point Likert items. Specifically, responses were mapped from -2 (“very negative”) to $+2$ (“very positive”), with 0 representing a neutral stance. This transformation enabled straightforward quantitative comparison across vignettes and groups. Next, the dataset was segmented into two predefined cohorts, and we calculated the mean response for each vignette within each group. To assess the precision of these estimates, we computed 95% confidence intervals around the means, assuming a normal distribution of responses. The reported margins of error thus represent the range within which the true population mean is expected to fall 95% of the time, under this distributional assumption. Given the relatively small sample size and the coarse granularity of the Likert scale, we acknowledge that these assumptions may not fully reflect the underlying response distributions. As such, the results should be interpreted as indicative rather than conclusive, and caution is warranted in drawing strong statistical inferences. Finally, to assess the relative impact of each trust-building lever, we calculated the mean difference between each treatment vignette and the neutral baseline vignette. This involved subtracting each respondent's baseline score from their score on each treatment vignette and then computing the average of these differences along with corresponding 95% confidence intervals, following the same approach described above.

4 Results

We aimed to collect data from two demographically distinct sub-samples expected to diverge in their attitudes toward science and scientific interventions, including renewable energy technologies and wind farms. Specifically, we hypothesized that Group 1—composed of younger, university-educated, urban residents—would exhibit a more favorable view of wind farms than Group 2, comprising older, less-educated individuals living in rural areas. This hypothesis was grounded in existing literature linking age, education, and residence

to variations in trust in science. Our results confirmed this initial expectation. When responses to the baseline (neutral) vignette were recoded on a five-point Likert scale ranging from -2 (very negative) to $+2$ (very positive), Group 1 exhibited a mean score of 0.49 , suggesting moderate support for wind farms. In contrast, Group 2's mean score was -0.01 , indicating a neutral stance, if slightly negative. This divergence persisted across all treatment vignettes, with Group 1 consistently displaying more positive average responses than Group 2 (see: Table 5).

Gender-based analysis revealed additional insights. Across cohorts, women tended to hold more favorable views of wind farms than men. In Group 1, the mean response for men was 0.42 , while for women it was 0.56 . The gender gap was more pronounced in Group 2. Women in Group 2 had a positive mean score of 0.17 , whereas men were the only subgroup to register a negative average, with a mean of -0.21 . Notably, the margin of error for Group 2 was somewhat larger, reflecting greater variability within this group. Nonetheless, this finding suggests that older men are particularly sceptical toward wind energy and may require targeted engagement strategies. This gender divergence was not only evident in baseline perceptions but also persisted across all treatment vignettes, indicating that the observed differences are stable rather than vignette-specific.

These dynamics are visualized in Figure 1, which presents group and gender-level differences using a radar chart. The visual format highlights the persistent generational divide in wind energy perception and underscores the larger gender-based divergence within Group 2. The chart's V1 values represent responses to the neutral baseline vignette. Subsequent positions (V2 through V4) reflect increasing positivity across both groups, though to different degrees. Importantly, V5 (social media advocacy) emerges as an outlier, showing negligible or even negative shifts in perception for Group 2.

In summary, the data demonstrate consistent attitudinal differences along demographic lines, with younger, educated, urban women expressing the highest support for wind energy, and older, rural men the lowest. These findings emphasize the importance of demographic tailoring in trust-building strategies for renewable energy transitions. In the next sub-sections, we will present our findings for each of the vignettes (science communication, co-creation, benefit sharing and social media).

4.1 Science communication

The first vignette addressed science communication, and its formulation was guided by prior findings from the VERITY project. The scenario was designed to reflect a bi-directional, participatory model of engagement, in which credible scientists present their findings to the public in local town hall meetings, fostering mutual dialogue and transparency. This framing aimed to replicate a realistic setting that emphasizes respectful, community-based interaction between scientific experts and citizens.

As shown in Table 5, science communication emerged as the third most effective trust-building method, following benefit sharing and co-creation. In both groups, its mean impact was slightly lower than that of co-creation, yet it still produced a measurable positive shift in attitudes. However, the magnitude of this effect varied considerably between demographic groups. Group 1 (younger, educated, urban) exhibited a mean score of 0.90 , compared to just 0.13 in Group 2

TABLE 5 Differences in attitudes towards wind farms in Group 1 and Group 2 for each vignette.

Mean $\pm$ error of mean for vignette	Group 1	Group 2
Neutral	0.49 $\pm$ 0.20	-0.01 $\pm$ 0.25
Science communication	0.90 $\pm$ 0.20	0.13 $\pm$ 0.27
Co-creation	0.99 $\pm$ 0.20	0.22 $\pm$ 0.27
Benefit sharing	1.07 $\pm$ 0.20	0.43 $\pm$ 0.31
Social media	0.52 $\pm$ 0.20	-0.06 $\pm$ 0.30

(older, less educated, rural). The relative shift from the baseline was also more substantial for Group 1 (+0.41) than for Group 2 (+0.14), underscoring the greater resonance of science-based communication with younger audiences.

Across both demographic groups, women expressed more favorable attitudes toward science-based communication about wind energy than men. Among Group 1, women rated science communication slightly higher (0.92 ± 0.30) than their male peers (0.85 ± 0.27), while among Group 2, women again showed higher acceptance (0.33 ± 0.40) compared with men (-0.09 ± 0.37). This consistent gender difference indicates that science-oriented information and outreach tend to resonate more strongly with female respondents, although women's evaluations, particularly among younger participants, were also more varied, which suggests both higher enthusiasm and greater critical engagement.

Indeed, science communication produced the lowest attitudinal shift among the four active interventions in Group 2, surpassing only social media (which had a negligible or zero effect across both groups, as discussed in Section 3.5). These findings suggest that, while effective for certain segments of the population, science communication may have limited reach or persuasive power among older or less scientifically engaged demographics, particularly when compared to approaches involving direct material benefits or participatory decision-making.

In summary, science communication proved to be an effective trust-building strategy for younger, more educated audiences, but had limited influence among older, rural participants. Women in both groups expressed more favorable attitudes toward science-based communication than men. These results highlight the importance of targeting communication strategies to specific demographic contexts and suggest that participatory and benefit-oriented approaches may be more impactful for segments of the population that are less responsive to traditional science-led outreach.

4.2 Co-creation

The second vignette focused on co-creation, reflecting the principle of early and sustained citizen involvement in shaping scientific and technological developments. The scenario described a wind farm project developed through ongoing dialogue with local residents, where citizen initiatives actively contributed to the planning process and their feedback was regularly integrated into the project's evolution. This framing emphasized procedural fairness and agency, situating citizens not merely as recipients of expert knowledge but as co-designers of innovation in their communities.

Table 5 indicates that co-creation emerged as the second most effective trust-building method across both demographic groups, following benefit sharing. In Group 1, co-creation produced a mean score of 0.99, only marginally lower than that of benefit sharing, while in Group 2, the mean score was 0.22, indicating a more modest effect. The magnitude of the attitudinal shift was similarly differentiated: among younger, urban, and university-educated participants (Group 1), co-creation led to a mean increase of 0.50 from the baseline vignette, compared to a mean increase of 0.23 in the older, rural, less-educated cohort (Group 2). Despite this contrast, co-creation outperformed science communication and social media advocacy in both groups, though it remained less impactful than benefit sharing.

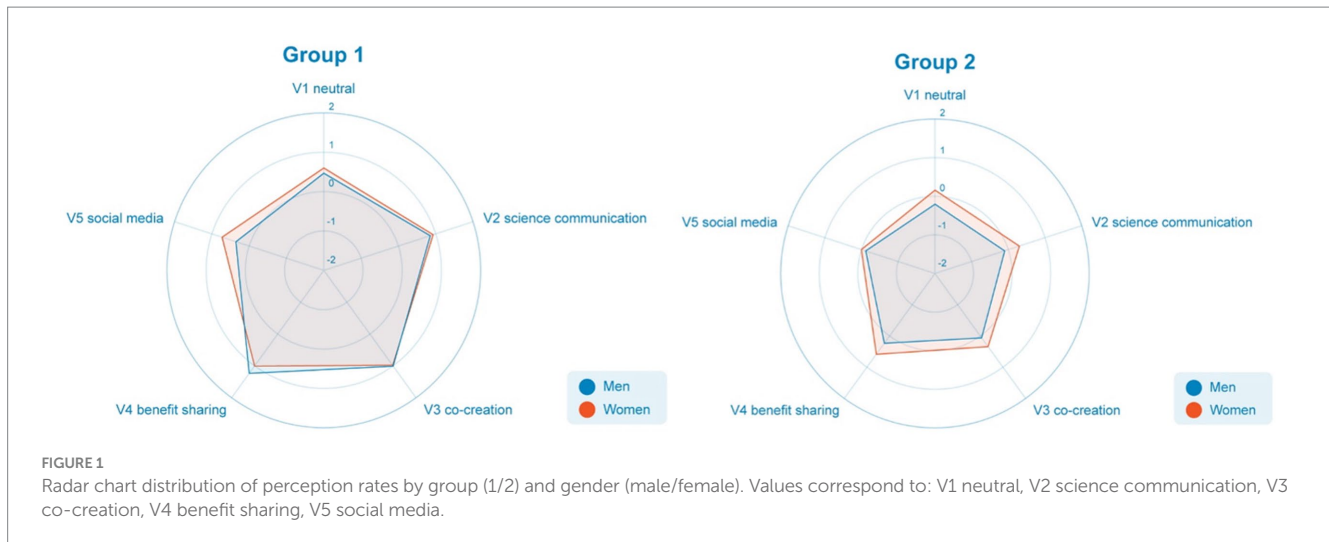
Patterns toward co-creation also differed by gender. Among Group 1 participants, men and women expressed similar mean evaluations (1.00 ± 0.24 for men, 0.96 ± 0.30 for women). However, younger men showed the largest relative improvement in attitudes toward wind farms, suggesting that co-creation evokes particularly strong positive associations in this group. Younger women also viewed co-creation favorably, though their responses were more dispersed, indicating a wider range of opinions. Among Group 2 participants, women rated co-creation somewhat higher (0.36 ± 0.40) than men (0.06 ± 0.40), reflecting a modestly more positive but broadly similar perception of this engagement strategy. These findings suggest that while co-creation is a broadly effective strategy for enhancing public acceptance, its influence may be conditioned by socio-demographic factors, particularly age, education level, and gender.

4.3 Benefit sharing

The third vignette addressed benefit sharing, and was formulated to reflect a model in which local residents are not only stakeholders but also financial co-owners of the wind energy infrastructure. The scenario described the wind farm as an energy cooperative, enabling residents to become members and receive annual dividends from the profits generated by the project. This approach emphasizes the redistribution of economic gains and the alignment of local and project interests through direct material participation.

Table 5 demonstrates that benefit sharing was the most positively received trust-building strategy across both demographic groups. Although the mean overall score in Group 2 (0.43) was approximately half that of Group 1 (1.07), benefit sharing was the only method to produce a comparably strong positive shift in both groups, with a mean increase of 0.58 in Group 1 and 0.45 in Group 2 from the baseline vignette. This makes it the most effective intervention for the older, rural, and less-educated cohort, and the only strategy whose impact is not markedly skewed by demographic differences.

Among older participants (Group 2), benefit sharing yielded a substantially greater effect than any other method. For younger participants (Group 1), its impact was similar in magnitude to that of co-creation, yet still emerged as the most effective method overall. Notably, benefit sharing generated equally strong positive shifts among men and women in Group 2, each showing a mean increase of 0.44 points, suggesting its cross-cutting appeal within this group. Among younger respondents, benefit sharing had a particularly pronounced effect on men. In Group 1, the mean response for men increased by 0.79, nearly double the increase observed among women in the same group.



These findings underscore the salience of benefit sharing as a trust-enhancing mechanism capable of bridging attitudinal gaps between age, gender, and socio-economic subgroups. The capacity of locally distributed ownership models—such as energy cooperatives—to foster a sense of inclusion and fairness may be especially important for increasing acceptance among groups typically less supportive of wind energy initiatives.

4.4 Social media

The fourth vignette focused on social media advocacy, presenting a scenario in which the proposed wind farm received positive attention from influential online figures across multiple platforms. The framing suggested that these individuals not only endorsed the project but also highlighted its benefits in detail, contributing to broader visibility and public discourse online. This vignette aimed to reflect the increasingly prominent role of digital influencers and social media ecosystems in shaping public perceptions of scientific and environmental issues.

Our findings align with the existing literature on the ambiguous impact of social media exposure on trust in science and offer further nuance to this ongoing debate. As shown in Table 5, the vignette describing social media endorsement by influencers had minimal overall effect on participants' attitudes toward wind farms. Specifically, the mean response in Group 1 increased by just 0.03, while Group 2 showed a slight decrease of -0.04 relative to the baseline. These negligible shifts suggest that social media-based advocacy, when delivered by generic "influential people," lacks persuasive power across both demographic cohorts.

However, disaggregating the data by gender reveals more complex dynamics. In particular, two subgroups, young men in Group 1 and older women in Group 2, responded negatively to the social media vignette, with attitudes declining relative to their baseline perceptions. A plausible explanation is that these respondents may view influencer endorsements as inauthentic or manipulative, leading to a backfire effect that reduces trust rather than reinforcing it.

5 Discussion

This study, by using a vignette-based survey centered on wind farm development, explores how four commonly proposed methods for building trust in science, which include science communication, co-creation, benefit sharing, and social media advocacy, are received by two demographically contrasting groups. Our analysis reveals a number of important patterns that can inform the design and deployment of engagement strategies across different segments of society.

5.1 Interpreting key findings

Among all tested strategies, benefit sharing emerged as the most effective trust-building method. This vignette, which presented a wind farm organized as a local energy cooperative offering annual dividends to residents, led to the largest attitudinal shift across both demographic groups. While Group 1 (young, educated, urban) reported a higher absolute mean score (1.07), the magnitude of change was nearly identical in Group 2 (older, less educated, rural), with mean increases of 0.58 and 0.45, respectively. Crucially, benefit sharing was the only method that produced a substantial and comparable positive shift in both groups, indicating its cross-cutting appeal.

This effect was particularly pronounced among younger men in Group 1, who exhibited a mean increase of 0.79—the highest observed among all subgroup combinations. The strength of response suggests that direct material participation in scientific initiatives can significantly enhance acceptance, especially when individuals perceive concrete, personal benefits. These findings are consistent with broader research on distributive justice and local ownership models in renewable energy (Scherhauer et al., 2017).

In contrast, science communication produced more gendered responses. While it was moderately effective overall, it was particularly well received by women in both groups, especially in Group 1, where the mean response reached 0.90. Men, by comparison, rated science communication lower than both co-creation and benefit sharing. These gender differences suggest that women may respond more positively to transparent, expert-led engagement framed around

relational trust and local relevance (Nisbet et al., 2002; Reincke et al., 2020).

5.2 Comparative analysis

Our findings broadly reflect the existing literature on demographic influences on trust in science. Group 2—comprising older, rural, less-educated individuals—began from a neutral or slightly negative baseline (mean score: -0.01) and exhibited a smaller average shift across all vignettes ($+0.20$), compared to Group 1's mean baseline of 0.49 and average increase of $+0.38$. These differences likely stem from a combination of lower scientific literacy, less frequent exposure to participatory governance, and entrenched scepticism toward technocratic institutions (Krause et al., 2019; European Commission, 2021).

Crucially, these findings underscore the importance of contextualized trust-building strategies. Methods that rely on cognitive persuasion, such as science communication or digital campaigns, may be insufficient when foundational trust in scientific institutions is weak. In such contexts, engagement efforts may need to begin by rebuilding interest in science itself, as recommended in (Szüdi et al., 2024).

5.3 Implications for inclusive climate governance

To ensure inclusive and socially robust climate governance, outreach efforts must be demographically tailored. Our results suggest that:

- Benefit sharing is highly effective across all demographic segments and should serve as a cornerstone in public engagement strategies.
- Co-creation evokes generally positive attitudes across both groups. It is especially valuable for younger men, who showed the largest relative improvement in attitudes toward wind farms. Older men, who otherwise display the most scepticism toward wind farms, their perception only increases when they are directly involved in the planning or development process of wind farms through co-creation or benefit-sharing methods (with benefit sharing being the most important method).
- Science communication should be designed to resonate more strongly with women, particularly when emphasizing transparency, local impact, and the presence of credible messengers.
- For Group 2, trust-building should be understood as a long-term process requiring sustained, relationship-based strategies rather than one-off campaigns.

Moreover, findings emphasize the need for locally grounded communication. Participants responded more favorably to vignettes featuring tangible, familiar settings (e.g., town hall meetings) than to abstract or media-driven endorsements.

In light of these findings, we offer the following recommendations for policy makers and renewable energy developers:

- Integrate benefit sharing and co-creation mechanisms into the planning and implementation of renewable energy

projects. These methods demonstrably increase public acceptance and trust, especially in marginalized or sceptical populations.

- Avoid over-reliance on social media as a trust-building tool. Our data show that social media advocacy had virtually no net effect and even triggered negative shifts among some subgroups, including younger men and older women.
- Develop demographic-specific outreach strategies. For example, younger men may respond best to economic inclusion (e.g., cooperatives), while older women may benefit from tailored digital literacy initiatives.

These recommendations align with a broader movement toward responsible and participatory innovation, wherein communities are not merely consulted but embedded in the development and governance of scientific initiatives (Owen et al., 2012).

5.4 Study strengths and limitations

A key strength of this study is the intentional contrast between two demographically distinct groups, allowing for meaningful comparisons in trust-building efficacy. The vignette method also enabled the exploration of realistic scenarios while maintaining experimental control.

However, the study is subject to several limitations. The use of non-random, purposive sampling limits generalizability beyond the surveyed populations. While country-level variation was explored descriptively, small sample sizes constrained our ability to perform robust cross-national comparisons. As a result, potential country-specific effects on attitudes toward wind energy could not be controlled for, and the generalizability of demographic patterns across national settings remains uncertain.

Finally, further research should examine underexplored moderators such as political affiliation, media literacy, and perceived procedural fairness, which may significantly shape trust dynamics but fell outside the scope of the present study.

6 Conclusion

The relationship between trust in science and acceptance of wind energy projects represents a critical factor in the successful deployment of renewable energy infrastructure. As countries worldwide pursue energy transitions to meet climate goals, understanding the social dimensions of wind farm acceptance has become increasingly important for policymakers, developers, and communities. This study reaffirms that trust-building strategies for renewable energy must be tailored to the demographic contexts in which they are deployed. By comparing younger, urban, university-educated respondents with older, rural populations across four European countries, our findings show that acceptance of wind farms is shaped not only by general attitudes toward science but also by age, education, gender, and place of residence. Benefit sharing emerged as the most universally effective strategy, while co-creation and science communication proved more effective for specific groups, underscoring the inadequacy of one-size-fits-all approaches.

In doing so, this study contributes to the literature on renewable energy acceptance by providing systematic, comparative evidence of how different socio-demographic groups respond to distinct trust-building interventions. It moves beyond aggregate attitudes or local case studies to demonstrate the demographic specificity of trust, adding nuance to existing scholarship on public engagement with wind energy.

The findings also speak to broader debates in climate diplomacy. Trust in science functions not only as a domestic determinant of project acceptance but also as a form of transnational currency in shaping the legitimacy of climate policy. Understanding how trust is fostered—or undermined—within societies enriches the design of inclusive governance mechanisms and strengthens the credibility of climate commitments at international level.

Future research should expand this approach beyond the four European cases examined here. Comparative analyses across diverse regions and political contexts could further clarify how demographic cleavages intersect with local histories, institutional trust, and global narratives. Additional trust-building strategies, including digital deliberation and hybrid participatory models, call for exploration to identify pathways that can both enhance social inclusion and secure public support for renewable energy transitions.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repository and accession number(s) can be found at: <https://zenodo.org/records/11444667>.

Ethics statement

The studies involving humans were approved by Centre for Social Innovation Ethics Commission. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

EY: Methodology, Investigation, Data curation, Conceptualization, Writing – original draft, Writing – review & editing. MZ: Writing – original draft, Writing – review & editing. EM: Methodology, Writing – original draft, Formal analysis, Data curation. AG: Conceptualization, Writing – review & editing. GS: Writing – original draft, Data curation, Writing – review & editing. Methodology, Formal analysis. PB: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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