ISSN: 2951-6641 (paper) 2951-8156 (online)
https://doi.org/10.54790/rccs.129

ARTICLES/ARTÍCULOS

Energy Transition in Valle del Almanzora: Environmental Impacts and Rural Development

Transición energética en el Valle del Almanzora: impactos ambientales y desarrollo rural

José Carlos Hernández-Gutiérrez
University of Granada, Spain
jchernandez@ugr.es

Guillermo López-Rodríguez
University of Granada, Spain
guillermolopez@ugr.es

Received/Recibido: 12-2-2025
Accepted/Aceptado: 28-4-2025

ABSTRACT

The energy transition constitutes a complex process aimed at gradually replacing fossil fuels with renewable energy sources. Despite the global and geopolitical environmental advantages they offer thanks to their sustainability and potential for energy self-sufficiency, many also generate significant impacts at the local level. This study examines the effects of the installation of photovoltaic and wind energy production facilities on the inhabitants of Valle del Almanzora. The findings indicate positive economic outcomes at both individual and community levels, alongside benefits in combating rural depopulation. At the same time, the research identifies externalities associated with land use, particularly concerning agricultural activity and local ecosystems. The findings contribute to the development of recommendations for the improvement of public policy related to sustainable energy production.

KEYWORDS: energy transition; land use; conflict; Andalusia; renewable energies.

HOW TO REFERENCE: Hernández-Gutiérrez, J. C. and López-Rodríguez, G. (2025). Transición energética en el Valle del Almanzora: impactos ambientales y desarrollo rural. *Revista Centra de Ciencias Sociales*, 4(2), 107-124. https://doi.org/10.54790/rccs.129

The Spanish (original) version can be read at https://doi.org/10.54790/rccs.129

RESUMEN

La transición energética es un proceso complejo cuyo objetivo es la sustitución progresiva de energías fósiles por fuentes renovables. A pesar de sus beneficios medioambientales globales y geopolíticos por su sostenibilidad y autosuficiencia, muchas de ellas tienen efectos a nivel local. Esta investigación analiza las consecuencias para las poblaciones afectadas por la instalación de plantas de producción solar fotovoltaica y eólica en la comarca del Valle del Almanzora. Los resultados reflejan impactos económicos positivos a nivel individual y colectivo, así como beneficios para combatir la despoblación rural. Al mismo tiempo, presenta externalidades respecto a los usos del suelo en relación con la producción agrícola y los ecosistemas locales. El análisis elaborado permite generar recomendaciones de mejora para políticas públicas relativas a la producción energética sostenible.

PALABRAS CLAVE: transición energética; uso del suelo; conflicto; Andalucía; energías renovables.

1. Introduction[1]

Climate change and the instrumentalisation of energy for geopolitical purposes have underscored the need for an additional supply of non-renewable sources (Varela, 2024). The energy transition is a complex, long-term process involving a wide range of public and private actors (Liñán-Chacón, 2024). In this context, Andalusia has advanced a transition strategy that prioritises renewable energy sources and promotes energy-saving and efficiency policies aligned with objectives set at both national and European levels (Díaz-Cuevas *et al.*, 2023a). One tenth of Andalusia's territory possesses high potential for the development of wind energy infrastructure (Barral *et al.*, 2023). Combined with the rapid expansion of photovoltaic installations, this has produced significant local-level impacts.

While this transformation marks a critical step towards a more sustainable energy system and reduced reliance on fossil fuels, its success is highly contingent upon public acceptance (González and Estévez, 2005). The growth of the renewable energy sector has altered land-use patterns and reshaped national energy landscapes, giving rise to numerous conflicts among developers, policymakers and local communities (Calvert and Mabee, 2015; Frantál and Kunc, 2011; Jensen *et al.*, 2018; Van der Horst and Vermeylen, 2012). Such conflicts often originate from diverging interests and the expectations generated prior to the initiation of projects (Liñán-Chacón, 2024). The proliferation of renewable energy installations has enabled the development of analyses addressing the challenges arising from using land for the genera-

tion of renewable energy (Díaz-Cuevas *et al.*, 2016, 2023b; Díaz-Pacheco *et al.*, 2018; Barral *et al.*, 2023).

This study contributes to the existing body of literature on land use implications in the context of renewable energy production. It presents an opportunity to examine how decisions made at the macro-geopolitical level produce consequences at the micro-local scale. What are the local-level effects of the global energy transition? To address this question, the research is structured around three specific objectives: (1) to assess the environmental impacts of the energy transition in Andalusia, (2) to identify its effects on rural development and (3) to offer recommendations for the improvement of public policies relating to sustainability and the energy transition.

In response to the need for primary data, this research adopts a qualitative methodology to address the stated objectives. Eight semi-structured interviews were conducted with Andalusian parliamentarians and local stakeholders from Valle del Almanzora, one of the regions with the highest concentration of renewable energy production in Andalusia. The study is grounded in a conceptual framework focused on the local-level effects of the energy transition, with particular attention to land-use conflicts, the determinants of public acceptance and resistance, and the regulatory context. The analysis explores the economic, ecological and social impacts on municipalities. The conclusions outline the principal limitations of the study and identify key academic gaps, suggesting avenues for future research on the energy transition within an increasingly globalised context.

2. Effects of the energy transition on the local environment

The energy transition aims to progressively replace fossil fuel sources with more environmentally sustainable forms of energy production that are able to guarantee greater levels of energy independence (González, 2023). This process is rooted in the commitments made as part of the 2015 Paris Climate Agreement (COP21), which emphasised the urgent need to reduce greenhouse gas emissions in order to limit global warming (Mielgo, 2018).

In Spain, the expansion of renewable energy production has been driven by a continuously evolving regulatory framework. Royal Decree-Law 15/2018 marked a key moment by promoting the energy transition and consumer protection. This was followed by Royal Decree-Law 23/2020, which introduced measures for economic recovery, and Law 7/2021, which established the core principles guiding the transition. More recently, Royal Decree-Law 6/2022 introduced expedited procedures for environmental assessment, including the application of positive administrative silence to accelerate project approvals (Terrón-Santos, 2024). Finally, in response to the energy crisis triggered by the war in Ukraine, further provisions were introduced under

Royal Decree-Law 5/2023, while environmental zoning tools have been developed to support the deployment of wind and photovoltaic infrastructure throughout the country (Spanish Ministry for Ecological Transition and the Demographic Challenge [MITECO], 2023).

Overall, society recognises the role of renewable energy in addressing challenges such as climate change and energy security (Kontogianni *et al.,* 2014; Ellis *et al*., 2007). However, resistance tends to increase when projects are sited near residential areas – a phenomenon commonly referred to as "Not In My Back Yard" (NIMBY). Such objections typically focus on the visual impact of wind turbines and solar farms, as well as perceptions that economic benefits disproportionately favour external investors at the expense of local communities (Barral *et al*., 2023; Pasqualetti, 2011; González and Estévez, 2005). Nonetheless, public acceptance is widely acknowledged as a crucial factor in the success of renewable energy initiatives; without local support, projects frequently encounter delays and social conflict (González and Estévez, 2005).

Unlike fossil fuels, renewable energy sources require significantly larger land areas due to their lower energy densities (Liñán-Chacón, 2024; Van Zalk and Behrens, 2018). In addition, the intermittency of renewable generation, combined with the need for larger infrastructure, contributes to an expanded territorial footprint (Capellán-Pérez *et al*., 2019; Sánchez-Contreras, 2024). These conditions result in a variety of impacts: visual impacts, through the transformation of the landscape by wind turbines and photovoltaic installations (Frolova *et al*., 2015; Liñán-Chacón, 2024); impacts on biodiversity, including the loss of habitats and species in affected areas (Haines-Young, 2009); soil and water impacts, such as increased risks of compaction, erosion and disruption of hydrological regimes, with potential increases in flooding (Sterling *et al*., 2013; Bajocco *et al*., 2012); and heritage impacts, through the disturbance of archaeological and cultural sites (Muñoz-Campillo, 2024).

In Spain, many renewable energy facilities are located on agricultural and livestock land, resulting in altered land-use patterns and market dynamics where landowners often opt to lease or sell their property for such projects (Terrón-Santos, 2024). Social conflicts associated with renewable energy developments typically arise from tensions among stakeholders with divergent interests, varying motivations and contested territorial claims (Warren and McFadyen, 2010; Von der Dunk *et al*., 2011). These tensions may emerge both during the planning phase and after project commissioning, and exhibit similar patterns in both the wind and photovoltaic sectors (Ávila, 2018; Frantál *et al*., 2023; Liñán-Chacón, 2024). Conflicts are frequently driven by differing expectations between local stakeholders and external investors, perceptions of injustice due to unequal distribution of benefits, lack of transparency (Terrón-Santos, 2024), and unforeseen environmental, landscape or administrative impacts (Liñán-Chacón, 2024). Nevertheless, despite their adverse effects on social cohesion, conflicts also expose systemic shortcomings and can serve as a form of political participation (Cuppen, 2018).

The literature indicates that the equitable and transparent distribution of economic benefits, coupled with local participation, fosters greater acceptance and reduces conflict (Liñán-Chacón and Frolova, 2024; Munday *et al.*, 2011). In particular, projects that involve citizen engagement in decision-making, ensure direct benefits to municipalities and maintain compatibility with traditional land uses in the primary sector tend to be more successful. Conversely, the absence of these elements – often due to a regulatory framework focused primarily on quantitative incentives – has sidelined qualitative considerations such as environmental protection and energy democracy, understood as inclusive power relations and ownership models (Frolova *et al.*, 2015; Szulecki, 2018). Moreover, the urgency to accelerate the energy transition for climate and security reasons has at times resulted in the exclusion of local communities from the decision-making process (Devine-Wright, 2014).

3. Qualitative approaches to the study of the global-local dynamics

This research establishes a connection between the macro and micro scales of the energy transition. By conducting an analytical case study bounded by geographical and temporal space (Szmolka and De Cueto, 2011), the effects of the global energy transition on local policies can be identified. Given Andalusia's significant potential for renewable energy production, the Valle del Almanzora region was selected as the case study site to examine the localised effects of the energy transition. This choice was motivated by the presence of multiple renewable energy sources in the area, including wind and solar photovoltaic installations, alongside a well-established history of renewable energy production spanning the last two decades.

The literature review revealed significant information gaps concerning the local-level impacts of the energy transition, prompting a qualitative exploratory study focused on the generation and analysis of primary data. To this end, eight semi-structured interviews were conducted with key stakeholders engaged in various aspects of the energy transition. The sample includes two Andalusian parliamentarians with experience in sustainable development (P1 and P2), who provide insights into the regional implications of energy transition policies on energy production. Additionally, six interviews were conducted with local stakeholders in Valle del Almanzora, offering perspectives on the energy transition's effects at the local level. The data collected is rich and diverse, encompassing the perspectives of two mayors (I2 and I6), two landowners hosting wind turbines (I3 and I4), a local entrepreneur (I1) and a rural technician (I5).

The interviews were conducted in two distinct phases. Initially, the Andalusian parliamentarians were contacted in October 2024, with interviews carried out via telephone and in writing. Subsequently, interviews with local stakeholders in Valle del Almanzora took place in December 2024, predominantly through face-to-face meetings (five interviews) and one telephone interview.

The average duration of the interviews was approximately 30 minutes, with face-to-face sessions recorded for subsequent analysis. At the local level, participants demonstrated a keen interest in contributing to the research, providing valuable information and facilitating contact with additional stakeholders. Local contacts were recruited through non-probabilistic sampling based on purposive criteria, employing convenience and snowball sampling techniques.

The data analysis was conducted using grounded theory, a method previously applied to investigate poorly understood phenomena (López-Rodríguez, 2022), which allows the exploration of key themes grounded in the perceptions of the participants (Richardson and Kramer, 2006). By examining participants' personal perspectives (Strauss and Corbin, 2002; Franzosi, 1998), analytical categories were developed by integrating those identified in the literature with subcategories emerging from the interviews (Lieblich *et al*., 1998). The literature review highlighted several key elements, including the effects on landscape (Langer and Wooliscroft, 2018; Krauss *et al*., 2011), impacts on fauna and flora (Gutiérrez and Herrera, 2023), proximity to inhabited areas (Liñán-Chacón, 2024) and administrative challenges (*ibid.*). The research is centred on examining the local effects of the energy transition, which constitutes the study's primary category. Based on the literature, two main categories have been identified to facilitate analysis: the environmental impacts of these policies and their effects on rural development. By analysing these key elements, the study not only identifies the principal effects but also formulates recommendations to enhance public policy.

Table 1

Research strategy

Central category	Main categories	Theoretical categories	Subcategories
Local effects of the energy transition	Environmental impact	Pollution	Noise Visual
		Ecosystem alteration	Migratory birds Local wildlife
	Rural development	Land uses	Rainfed crops Waste land Hunting land
		Local economy	Public revenue Individual income
		Rural depopulation	Service provision Population retention

Source: own research (2024).

 https://doi.org/10.54790/rccs.129

4. Effects of the energy transition on the local environment in Andalusia

The transition to renewable energy sources is a global process that has been unfolding across various regions since the late 20th century (FCDS, 2023).a In recent years, the production of renewable energy has grown significantly, influenced by targets set by the European Union, which aims to achieve a 40% share of renewable energy by 2030. Spain's commitment to this transition is reflected in its Strategic Energy and Climate Framework, the 2030 Integrated National Energy and Climate Plan and the Long-Term Decarbonisation Strategy 2050 (Terrón-Santos, 2024). Beyond environmental imperatives, the invasion of Ukraine has reinforced the urgency of diversifying energy sources and increasing energy savings and renewable generation (Muñoz-Campillo, 2024).

Driven by both environmental and strategic motivations, this transformation involves a fundamental shift in energy production and consumption patterns, with direct implications for decision-making at the local level (Bielsa *et al.*, 2024). At the regional political level, the energy transition is viewed as a shift from fossil fuels to renewable sources (P1), with the aim of promoting more responsible energy consumption that enhances efficiency and reduces the carbon footprint (P2). While the transition is seen as beneficial to the productive model, public services and household economies (P2), it can also result in negative externalities, such as visual pollution and the conversion of productive agricultural land (P1).

In an increasingly interconnected world, global drivers are producing effects on a regional and autonomous community level, generating negative outcomes that may trigger social tensions related to land use. As previously discussed, the spatial demands of renewable energy infrastructures have led to the widespread use of rural areas for the location of wind and photovoltaic installations (Frolova *et al.*, 2019). Achieving the proposed renewable energy targets thus entails trade-offs for rural territories, necessitating changes in land use that affect local populations and current economic structures (Terrón-Santos, 2024). Some scholars argue that, in certain cases, renewable energy production may provoke conflict comparable to that associated with fossil fuel extraction, leading to social contestation (Sánchez-Contreras, 2024; Temper *et al.*, 2020).

Nevertheless, despite the potential challenges of renewable energy production in rural contexts, it can also generate positive economic and social impacts. The selected case study illustrates the diverse consequences that the energy transition has had on the Valle del Almanzora region in the last decade. The significance of this case lies in its capacity to shed light on the impacts across multiple municipalities within the area, which is strategically situated between Almería and Granada. The region's connectivity also facilitates the distribution of wind and photovoltaic energy production, with key installations including wind farms in Serón (Carrascal I and II, Cerradilla I and II, and Serón I and II) and Tíjola and photovoltaic pro-

jects in Alcóntar and Caniles. The methodological strategy structures the analysis around two principal areas. The first focuses on environmental impacts, particularly in relation to different forms of pollution and the alteration of ecosystems. The second examines the effects on rural development, including changes in land use, impacts on local economies and the contribution of renewable energy projects to combating rural depopulation.

4.1. Environmental impact

Southern Spain is a region of strategic interest for large-scale renewable energy projects, due to its high energy potential and low population density (Sánchez-Contreras, 2024). However, these megaprojects also entail a range of negative impacts, including effects on the landscape (Langer and Wooliscroft, 2018; Krauss *et al*., 2011), impacts on fauna and flora (Gutiérrez and Herrera, 2023), proximity to inhabited areas (Liñán-Chacón, 2024) and administrative challenges (*ibid*.). The underlying causes of conflict help to identify critical factors, as the absence of a unified framework for environmental land assessment often results in arbitrary planning – one of the main reasons cited for public opposition (Muñoz-Campillo, 2024).

4.1.1. Noise and visual pollution

The analysis reveals that the primary sources of conflict associated with wind energy production relate to its impact on the landscape, the scale of the installations and additional concerns such as adverse effects on local tourism and proximity to inhabited areas (Liñán-Chacón, 2024). Other studies have similarly found that perceptions of these issues are more pronounced in densely populated areas, where visual intrusions and disturbances caused by nearby installations are a heightened source of concern (Frantál *et al*., 2023). In the case study, the location of wind farms on the boundary between municipalities emerged as a significant source of tension (I1, I2, I5), particularly where residents experienced noise and visual pollution without receiving economic or social benefits in return. Interview data revealed a strong consensus regarding the negative impact of noise (I1, I2, I3, I4, I5, I6) and visual pollution, both in terms of landscape disruption (I2, I3, I4, I5, I6) and night-time light pollution (I5). While interviewees acknowledged that noise pollution was initially problematic, they noted that advancements in technology have significantly reduced acoustic impacts in recent years (I4, I6). Nevertheless, the expansion of wind infrastructure continues to generate considerable visual impact, which remains a recurrent factor in conflicts related to this energy source. Moreover, a lack of communication and coordination between facility operators and local authorities has been identified as a key contributor to local opposition (Liñán-Chacón and Frolova, 2024).

4.1.2. Ecosystem alteration

Research findings also highlight additional concerns related to the impact on ecosystems and local development (Langer and Wooliscroft, 2018), with improved site selection and the implementation of mitigation measures identified as key to reduc-

ing negative outcomes (Liñán-Chacón, 2024; Lüdeke, 2017). The installation of wind turbines affects both residents and the landscape and is associated with significant ecological disruption (I1, I2, I3, I4, I6). According to interviewees, these installations have had a detrimental impact on various species, including eagles and bats (I3), steppe birds (I1) and migratory birds (I6), all of which are disrupted by turbines situated along their flight paths. In addition to these ecological effects, interviewees expressed concern about the potential for environmental contamination in the event of mechanical failure, specifically citing the risk of gear oil leakage from turbines (I1).

4.2. Effects on rural development

The energy transition has significant implications for rural development. This study identifies key factors including changes in land use, the economic viability of renewable energy projects and their potential to mitigate rural depopulation. Findings indicate increased productivity on previously uncultivated land, as well as notable differences between the impacts of wind turbines and photovoltaic panels (I3, I5). The installation of renewable energy parks has contributed to the strengthening of municipal finances, indirectly resulting in improved public services, infrastructure and overall quality of life, thus enabling them to better retain their population (I2, I6).

4.2.1. Land use

Interviewees reported that many local landowners have opted to lease their land for the installation of wind turbines or solar panels. In most cases, this decision is motivated by higher financial returns, particularly in comparison to traditional farming activities (I1, I2, I3, I4, I6). This is especially the case in areas with rainfed agriculture, where land profitability is low (I2, I3, I5, I6), or on uncultivated land with limited economic value (I4, I5, I6). However, shifting land use from agriculture to energy production raises concerns about potential dependency on foreign agri-food imports, should domestic agricultural output decline (Barral *et al.*, 2023), generating additional situations of reliance for key products. The literature suggests that the most sustainable land-use approach combines agricultural activity with renewable energy systems (*ibid.*; Dinesh and Pearce, 2016). Interviewees also noted important distinctions between the spatial impacts of wind and solar technologies (I3, I5). While wind energy allows for continued agricultural (I3, I5) or hunting use (I4, I5) of the land, photovoltaic installations typically require the land to be temporarily transferred, limiting alternative or simultaneous productive activities (I3, I5). In the selected case, it is evident that the installation of wind turbines often permits the continuation of traditional agricultural practices, as well as unrestricted access to the land by its owners. As one interviewee explains:

> I can now access my land, which was left to me by my father. I can go in and put up whatever I want. But then nothing – they take everything away, fence it off and you're not even allowed to enter. That's what they've told me. What we do is remove all the trees [...] fence off the land, install the panels and you can no longer go in there any more. And I don't know... then there's the impact: you no longer see trees, you no longer see life – only solar panels (I3, 2024).

It is important to take these factors into account when assessing the implementation of renewable energy generation facilities. Solar photovoltaic energy has experienced the most significant growth in recent years due to its scalability for both individual and large-scale projects, now accounting for 14.6% of energy production in Spain (Muñoz-Campillo, 2024). However, in Andalusia, this expansion has led to conflicts, with 20% of land-use disputes related to renewable energy projects involving photovoltaic installations (Liñán-Chacón, 2024). At the time of the interviews, several participants were negotiating the installation of solar panels (I1, I3, I4, I5, I6), although one interviewee expressed concerns about the success of the negotiations, citing restricted access to their land and lower profitability compared to wind energy (I3). Another participant reflected on the difficulty of balancing traditional land uses with the integration of renewable energy infrastructure (I2).

4.2.2. Local economies

The installation of wind farms has generated measurable economic benefits at both individual and community levels. The literature broadly reports positive public perceptions, principally because rental payments for turbine sites flow directly to landowners (Barral *et al.*, 2023). In the present case study, owners receive an annual return exceeding 2% of each turbine's output (I3, I4), supplemented by compensation for plots of land situated within the sweep of turbine blades (I1, I3, I4). These revenues, guaranteed for periods of twenty years or more, constitute a stable source of secondary income (I3, I4, I6), often surpassing wages, pensions (I6) or the profits from cereal cultivation (I1, I2), and can even be combined with existing olive or almond production (I3).

> The vast majority are located in formerly unproductive hillsides, so for families that have benefited from them, they're an incredible opportunity. They go from having a hill that was literally worthless to having a wind installation that will generate income for them... I don't know exactly how much, but it must be around six to ten thousand euros a year. So, a family is able to considerably increase its income in a good year (I5, 2024).

 https://doi.org/10.54790/rccs.129

Wind-energy projects also stimulate local labour markets by demanding a skilled workforce, some of whom are drawn from the surrounding region (I1, I2, I4, I6). At the same time, local economies benefit from high-value building licences (I2, I3, I6) and other renewable-energy levies (I2, I5, I6); one municipality reportedly receives more than €1 million annually from such sources (I2, I3), a significant amount considering it has just 2,000 inhabitants. Finally, local firms that transition to renewable electricity enjoy substantial savings on energy costs (I1).

4.2.3. Combating rural depopulation

Due to the increase in revenue for local tax offices, the mayors interviewed regard renewable energy as a strategic opportunity to mitigate rural exodus and counteract depopulation (I2, I6). Both emphasise that the income generated from renewable energy projects not only helps retain the existing population but also has the potential to attract new residents to the area (I2, I6).

> Our villages are becoming depopulated because people are not coming, and they are no longer seen as attractive places to live. But if I have renewable energy projects supporting the village, then I can say to someone: "Hey, do you work remotely? Come to my town – we have broadband [...] The town council will give you a €3,000 annual subsidy to help cover your expenses. I'll offer you an incentive so that you can live here and build a life project." [...] Here we have the ideal place for people to live. And with the revenue that these renewable energy projects could generate, we could make the village more attractive – through tax incentives or by setting up nurseries where children have space to play (I2, 2024).

The revenues have enabled one municipality to maintain essential education and health services and even to fund new social services, which the municipality provides to the autonomous community as a whole (I6). Simultaneously, these funds have allowed for the repair and improvement of infrastructure such as streets, parks and sanitation systems (I6). This case reflects observations made by other interviewees, who highlighted the opportunities that renewable energy revenues offer to municipalities with similar characteristics (I2, I5, I6). As noted, these revenues not only support the provision of services but also facilitate fiscal improvements (I2), help avoid tax increases (I6) and allow for energy bill offsets (I3), all of which can make rural areas more attractive places for people to live (I2).

5. Conclusions and recommendations

The energy transition is a global process with significant geopolitical implications that directly affect local contexts. Although its objectives are universal, the process manifests differently in each local environment where it takes place. Countries such as Spain, which are shifting from fossil fuel-based energy production models to renewable energy sources, must consider both the negative effects and positive impacts associated with this transition. Understanding the externalities arising from the energy transition provides not only economic benefits but also social advantages, improving the quality of life for local populations. This research analyses the effects of the geopolitics of energy at the local level, focusing on the Valle del Almanzora region as a case study. The identified effects are primarily environmental, with special attention given to various types of pollution and their influence on rural development. Public policies play a crucial role in both mitigating the negative impacts associated with the transition and maximising opportunities, particularly in terms of rural development.

The findings of this research align with existing literature, confirming that opposition is generally not directed at renewable energy itself but rather at the construction of facilities near urbanised areas due to their adverse effects on residents' health. Moreover, land-use impacts reveal a greater willingness to approve wind installations over photovoltaic projects, owing to wind power's better output and the possibility of combining it with agricultural activities. The economic profitability of wind energy stands out, especially when compared to rainfed crops, and is even more pronounced in the case of previously unproductive land.

Interviewees highlighted the importance of renewable energy production as a means to mitigate or curb rural depopulation. Revenues generated from taxes related to energy production plants contribute to improving local public services, creating employment and enhancing residents' quality of life. There is consensus among the interviewed mayors regarding the positive role of income from renewable energy production in retaining and attracting population to rural areas. This represents a key finding of the study, marking one of the most significant positive impacts of the energy transition on regions experiencing progressive depopulation.

This research design may be replicated in other case studies to further assess the local impacts of the energy transition. Methodologically, the involvement of interviewees has been essential to both data generation and the interpretation of relevant academic literature. Their contributions offer crucial insights into locally specific dynamics that are embedded within broader global processes. Based on the findings, the following recommendations for public policy improvement are proposed:

- Develop formal mechanisms for citizen participation that include representation from municipalities, landowners, neighbourhood associations and energy project operators. These bodies should meet regularly from the planning phase through to implementation, and hold real decision-making authority.

- Establish a municipal fund to which a fixed percentage of the income generated by each renewable energy plant is allocated. This fund should have a dual purpose: (1) to distribute benefits transparently and equitably, thereby building citizen trust and (2) to retain and attract population through investment in local infrastructure and priority rural development projects.

- Introduce tax incentives for landowners who practise dual land use – maintaining livestock or agricultural activities alongside wind installations – to prevent biodiversity loss.

6. Funding

This research is part of the project "The Potential of Andalusia for Europe's Energy Security in the Context of the Crisis of the International Order" (PRY080/22; principal investigator: José Antonio Peña Ramos), funded by the Fundación Pública Andaluza Centro de Estudios Andaluces as part of its 12th Call for Research Projects (2022). The authors wish to express their gratitude to all participants for their valuable contributions to this research.

7. Bibliography

Avila, S. (2018). Environmental justice and the expanding geography of wind power conflicts. *Sustainability Science*, *13* (3), 599-616. https://doi.org/10.1007/s11625-018-0547-4

Bajocco, S., De Angelis, A., Perini, L., Ferrara, A. and Salvati, L. (2012). The impact of land use/land cover changes on land degradation dynamics: a Mediterranean case study. *Environmental management*, *49*, 980-989.

Barral, M. Á., Ruiz Díez, A., Prados, M.-J., García-Marín, R. and Delicado, A. (2023). Energías renovables y cambios de usos del suelo en el sur de la Península Ibérica: una lectura territorial de la política energética. *Boletín de la Asociación de Geógrafos Españoles*, (97). https://doi.org/10.21138/bage.3356

Bielsa, J., Cazcarro, I. and Rodríguez-López, G. (2024). El impacto socioeconómico local de las energías renovables en España: un análisis entre escalas y tiempos. *Papeles de Energía*, (26), 63-92. https://www.funcas.es/articulos/el-impacto-socioeconomico-local-de-las-energias-renovables-en-espana-un-analisis-entre-escalas-y-tiempos/

Calvert, K. and Mabee, W. (2015). More solar farms or more bioenergy crops? Mapping and assessing potential land-use conflicts among renewable energy technologies in Eastern Ontario, Canada. *Applied Geography*, *56*, 209-221. https://doi.org/10.1016/j.apgeog.2014.11.028

Capellán-Pérez, I., De Castro, C. and González, L. J. (2019). Dynamic energy return on energy investment and material requirements in scenarios of global transition to renewable energies. *Energy Strategies Reviews*, *26*, 1-26. https://doi.org/10.1016/j.esr.2019.100399

Cuppen, E. (2018). The value of social conflicts. Critiquing invited participation in energy projects. *Energy Research & Social Science*, *38*, 28-32. https://doi.org/10.1016/j.erss.2018.01.016

Devine-Wright, P. (2014). *Renewable Energy and the Public. From NIMBY to Participation*. London: Routledge.

Díaz-Cuevas, M. d. P., Fernández Tabales, A. and Pita López, M. F. (2016). Energía Eólica y Paisaje. Identificación y cuantificación de paisajes afectados por instalaciones eólicas en Andalucía. *Boletín de la Asociación de Geógrafos Españoles*, (71), 397-430. https://doi.org/10.21138/bage.2288

Díaz-Cuevas, M. d. P., Márquez Sobrino, P. and Pérez Pérez, B. (2023b). Transición energética en espacios naturales protegidos andaluces: limitaciones y criterios de planificación. *Geografía: cambios, retos y adaptación: libro de actas. XVIII Congreso de la Asociación Española de Geografía, Logroño, 12 al 14 de septiembre de 2023* (1st ed., pp. 1045-1053). Asociación Española de Geografía-Universidad de La Rioja.

Díaz-Cuevas, M. d. P., Orozco Frutos, G., Prieto Campos, A. and Pérez Pérez, B. (2023a). Geografía de la energía solar en Andalucía (Sur de España): Nuevos datos y posibilidades de análisis. *Cuadernos Geográficos*, *62*(2), 163-183. https://doi.org/10.30827/cuadgeo.v62i2.27775

Díaz-Pacheco, J., Hewitt, R., López Díez, A. and Dorta Antequera, P. J. (2018). Valoración de Bases de Datos de Usos de Suelo para la localización y distribución espacial de la energía solar y eólica en España. *Investigaciones Geográficas: Una Mirada Desde El Sur*, (56), 114-137. https://doi.org/10.5354/0719-5370.2018.51333

Dinesh, H. and Pearce, J. M. (2016). The potential of agrivoltaic systems. *Renewable and Sustainable Energy Reviews*, *54*, 299-308.

Ellis, C. J., Coppins, B. J., Dawson, T. P. and Seawardc, M. R. D. (2007). Response of British lichens to climate change scenarios: Trends and uncertainties in the projected impact for contrasting biogeographic groups. *Biological Conservation*, *140*(3-4), 217-235. https://doi.org/10.1016/j.biocon.2007.08.016

Frantál, B. and Kunc, J. (2011). Wind turbines in tourism landscapes: Czech experience. *Annals of Tourism Research*, *38*(2), 499-519. https://doi.org/10.1016/j.annals.2010.10.007

Frantál, B., Frolova, M. and Liñán-Chacón, J. (2023). Conceptualizing the patterns of land use conflicts in wind energy development: Towards a typology and implications for practice. *Energy Research & Social Science*, *95*, 1-13. https://doi.org/10.1016/j.erss.2022.102907

Franzosi, R. (1998). Narrative analysis —or why (and how) sociologists should be interested in narrative. *Annual Review of Sociology*, *24*(1), 517-554.

Frolova, M., Frantál, B., Ferrario, V., Centeri, Cs., Herrero-Luque, D., Grónás, V., Martinát, S., Puttilli, M., Da Silva-Almeida, L. and D'Angelo, F. (2019). Diverse energy transition patterns in Central and Southern Europe: a comparative study of institutional landscapes in the Czech Republic, Hungary, Italy, and Spain. *Hungarian Journal of Landscape Ecology (Tajokologiai Lapok)*, *17*, 65-89. https://doi.org/10.56617/tl.3571

Frolova, M., Prados, M. J. and Nadaï, A. (2015). Emerging renewable energy landscapes in southern European countries. In M. Frolova, M. J. Prados y A. Nadaï (Eds.), *Renewable Energies and European Landscapes: Lessons from Southern European Cases* (pp. 3-24). Dordrecht: Springer Netherlands.

Foundation for Conservation and Sustainable Development (FCDS) (November 24, 2023). FCDS reveals the timeline of the global energy transition. https://fcds.org.co/fcds-revela-linea-de-tiempo-de-transicion-energetica/

González Ríos, I. (2023). La acción de las Comunidades Autónomas ante la transición energética. In N. Caicedo Camacho (Coord.), *Informe de Comunidades Autónomas 2022* (pp. 123-167). Barcelona: Instituto de Derecho Público.

González, M. I. and Estévez, B. (2005). Participación, comunicación y negociación en conflictos ambientales: energía eólica marina en el Mar de Trafalgar. *Arbor*, *181*(715), 377-392.

Gutiérrez Mejía, G. and Herrera González, E. A. (2023). *Análisis de la incidencia de reflexión solar sobre un sistema fotovoltaico.* Trabajo Fin de Máster, University of Rosario.

Haines-Young, R. (2009). Land use and biodiversity relationships. *Land use policy*, *26*, S178-S186.

Jensen, D., Baird, T. and Blank, G. (2018). New landscapes of conflict: land-use competition at the urban–rural fringe. *Landscape Research*, 44(4), 418-429. https://doi.org/10.1080/01426397.2017.1413173

Kontogianni, A., Tourkolias, C. H., Damigos, D. and Skourtos, M. (2014). Assessing sea level rise costs and adaptation benefits under uncertainty in Greece. *Environmental Science & Policy*, *37*, 61-78. https://doi.org/10.1016/j.envsci.2013.08.006

Krauss, K. W., From, A. S., Doyle, T. W., Doyle, T. J. and Barry, M. J. (2011). Sea-level rise and landscape change influence mangrove encroachment onto marsh in the Ten Thousand Islands region of Florida, USA. *Journal of Coastal Conservation*, *15*(4), 629-638.

Kruse, A. and Mickovski, S. B. (2018). Glossary on renewable energy and landscape quality: the glossary. *Journal of Landscape Ecology*, (2), 7-96. https://researchonline.gcu.ac.uk/en/publications/glossary-on-renewable-energy-and-landscape-quality-the-glossary

Langer, K. and Wooliscroft, B. (2018). The acceptance of wind energy in a leading country and low deployment country of wind energy: A cross-national comparative analysis. *Renewable Energy Focus*, *27*, 111-119. https://doi.org/10.1016/j.ref.2018.09.003

Lieblich, A., Tuval-Mashiach, R. and Zilber, T. (1998). *Narrative Research: Reading, Analysis and Interpretation*. Thousand Oaks: SAGE.

Liñán Chacón, J. (2024). *Transición energética en España: Los aspectos ambientales, sociales y culturales de los conflictos sobre los usos del suelo.* Doctoral thesis, University of Granada. Institutional repository of the University of Granada. https://hdl.handle.net/10481/92571

Liñán-Chacón, J. and Frolova Ignatieva, M. (2024). Los parques eólicos como fuente de conflictos y oportunidades: análisis de buenas y malas prácticas de casos españoles. In F. J. García-Delgado, M. Hernández-Hernández, A. Martínez-Puche, L. A. Hortelano Mínguez y V. M. Zapata Hernández (Eds.), *(Con)textos de desarrollo local. Dos décadas de Geografía aplicada (2003-2023)* (pp. 279-300). Asociación Española de Geografía (AGE)-Local Development Working Group of the Asociación Española de Geografía (GTDL-AGE). https://doi.org/10.21138/dl.2024.lc

López-Rodríguez, G. (2022). Building military expeditionary culture: Spanish Army after international operations. *Defense & Security Analysis*, *38*(4), 410-430.

Lüdeke, J. (2017). Energía eólica marina: buenas prácticas en evaluación, mitigación y compensación de impactos. *Journal of Environmental Assessment Policy and Management*, *19*(01). https://doi.org/10.1142/S1464333217500053

Mauro, G. (2019). The new «windscapes» in the time of energy transition: A comparison of ten European countries. *Applied Geography*, *109*, 1-15.

Mielgo, P. (2018). La transición energética: retos, oportunidades y riesgos. *Cuadernos de Pensamiento Político*, *58*, 15-24. https://www.jstor.org/stable/26477380

Ministerio para la Transición Ecológica y el Reto Demográfico (MITECO) (2023). *Zonificación ambiental para energías renovables: Eólica y Fotovoltaica.* https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/evaluacion-ambiental/zonificacion_ambiental_energias_renovables.html

Munday, M., Bristow, G. and Cowell, R. (2011). Wind farms in rural areas: How far do community benefits from wind farms represent a local economic development opportunity? *Journal of Rural Studies*, *27*(1), 1-12.

Muñoz-Campillo, M. E. (2024). *Efectos sinérgicos sobre el territorio en una zona de acumulación de plantas fotovoltaicas: estudio en Los Alcores (Sevilla).* Master's Thesis, Loyola University. Loyola University Institutional Repository. https://hdl.handle.net/20.500.12412/6135

Pasqualetti, M. J. (2011). Social barriers to renewable energy landscapes. *Geographical Review*, *101*(2), 201-223.

Pasqualetti, M. and Stremke, S. (2018). Energy landscapes in a crowded world: A first typology of origins and expressions. *Energy Research & Social Science*, *36*, 94-105.

Richardson, R. and Kramer, E. H. (2006). Abduction as the Type of Interference that Characterizes the Development of a Grounded Theory. *Qualitative Research*, *6*(4), 497-513.

Sánchez Contreras, J. (2024). *«Colonialismo energético» y «Despojo racializado»: comunidades indígenas en defensa del territorio frente al despliegue de parques eólicos a gran escala en el Istmo de Tehuantepec, México.* Doctoral thesis, University of Granada. Institutional repository of the University of Granada. https://hdl.handle.net/10481/96208

Sterling, S. M., Ducharne, A. and Polcher, J. (2013). The impact of global land-cover change on the terrestrial water cycle. *Nature Climate Change*, *3*(4), 385-390.

Strauss, A. and Corbin, J. (2002). *Bases de la investigación cualitativa. Técnicas y procedimientos para desarrollar la teoría fundamentada*. Medellín: University of Antioquia.

Szmolka, I. and De Cueto, C. (2011). *Objeto y método de la política comparada*. Granada: University of Granada.

Szulecki, K. (2018). Conceptualizing energy democracy. *Environmental Politics*, *27*(1), 21-41. https://doi.org/10.1080/09644016.2017.1387294

Temper, L., Avila, S., Del Bene, D., Gobby, J., Kosoy, N., Le Billon, P., Martinez-Alier, J., Perkins, P., Roy, B., Scheidel, A. and Walter, M. (2020). Movements shaping climate futures: A systematic mapping of protests against fossil fuel and low-carbon energy projects. *Environmental Research Letters*, *15*(12), 1-23.

Terrón-Santos, D. (2024). Desarrollo rural sostenible y renovables: cuestiones más allá de la zonificación. *Actualidad Jurídica Ambiental*, (142), 1-47. https://doi.org/10.56398/ajacieda.00358

Van der Horst, D. and Vermeylen, S. (2012). Ownership claims, valuation practices, and the unpacking of energy-landscape conflicts. *International Review of Sociology*, *22*(3), 429-445. https://doi.org/10.1080/03906701.2012.730822

Van Zalk, J. and Behrens, P. (2018). The spatial extent of renewable and non-renewable power generation: A review and meta-analysis of power densities and their application in the US. *Energy Policy*, *123*, 83-91. https://doi.org/10.1016/j.enpol.2018.08.023

Varela, A. (2024). Transición energética y cambios geopolíticos – necesidad de una estrategia general. *Revista de Marina*, *141*(998). https://revistamarina.cl/es/articulo/transicion-energetica-y-cambios-geopoliticos-necesidad-de-una-estrategia-general

Von der Dunk, A., Grêt-Regamey, A., Dalang, T. and Hersperger, A. M. (2011). Defining a typology of peri-urban land-use conflicts – A case study from Switzerland. *Landscape and Urban Planning*, *101*(2), 149-156. https://doi.org/10.1016/j.landurbplan.2011.02.007

Warren, C. R. and McFadyen, M. (2010). Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland. *Land Use Policy*, *27*(2), 204-213. https://doi.org/10.1016/j.landusepol.2008.12.010

Notes

1 The authors thank all participants for their contribution to this research.

José Carlos Hernández-Gutiérrez

José Carlos holds a bachelor's degree in Political and Administrative Sciences from the University of Granada (2017), a master's degree in Latin American Studies from the University of Salamanca (2019) and a PhD in Social Sciences from the University of Granada (2024). He has undertaken research stays at the Institute of International Relations at the University of São Paulo, Brazil (2018), at El Colegio de México's Centre of International Studies (2021) and at the Centre for Political Studies at the National Autonomous University of Mexico (2022 and 2024). His main line of investigation is the impact of insecurity and violence on electoral behaviour and political violence against women.

Guillermo López-Rodríguez

A doctor of political science, specialising in military studies (2023), he also holds a bachelor's degree in Political Science (2017) and a master's degree in Public Management (2018). His roles have included a stint as a researcher for the Spanish Army's Training and Doctrine Command (2018), during which time he contributed to drafting the document "Future Terrestrial Operational Environment 2035". In 2020, he completed a research stay at the Faculty of Political Science, Government and International Affairs at Tel Aviv University in Israel. In addition to his research work, he has also taught at the University of Mostar, Bosnia and Herzegovina, and at the Georgian Institute of Public Affairs. His research focuses on military organisations, hybrid threats, future scenarios and unconventional warfare.