Energy for Sustainable Development 68 (2022) 40–49

Contents lists available at ScienceDirect

Energy for Sustainable Development

The need for gender-based approach in the assessment of local energy projects

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ARTICLE INFO

Article history:
Received 6 October 2021
Revised 22 February 2022
Accepted 3 March 2022
Available online 22 March 2022

Keywords:
Renewable energy
Gender equity
Women
Islands
Sustainable development

ABSTRACT

Local renewable energy initiatives, that involve the local population, can help empower the communities, economically, culturally, and socially. In many cases, the ambitions of energy projects go beyond mere electricity production and involve issues of energy justice, environmental awareness, and environmental citizenship. However, these aspirations are often forgotten during project assessments, or they fail to include local voices, especially those of women and other marginalized groups. Gender has been given little attention in the energy scholarship and especially during the post-implementation assessment of energy projects due to the belief that energy technologies are gender neutral and beneficial for the whole community. The present study, with a focus on two local energy projects with mixed ownership, challenges this notion. The two case studies are the islands of El Hierro in Spain and Tilos in Greece. A detailed survey based on a series of indicators drawn from the energy justice framework is used to evaluate women's perceptions. By following a feminist approach, this work draws attention on the difference experiences of women and how these are often not acknowledged during the assessment of renewable energy projects. Local renewable energy does not automatically imply energy justice and pluralism. More effort is needed from policy makers to include women in the decision making and to ensure a fair distribution of the benefits of the projects.

Introduction

The gender dimension is gaining a lot of attention in the energy literature, especially in light of the global and EU commitment to the Sustainable Development Goals (SDGs) with both SDG 5 (gender equality) and SDG 7 (affordable and clean energy). The gender-energy nexus literature has focused on how renewable energy (RE) can improve the wellbeing of the local population and especially of women. Most of this research is on less affluent settings and the focus is on improving the practical ability of women to perform their reproductive and care duties in a safe and healthier way (Balakrishnan, 2000; Oparaocha & Dutta, 2011). In the European context more attention is given on the role of women as agents of change, and their underrepresentation in energy communities, in the renewable energy workforce, and policy making (Atina Arbi, 2020; Fraune, 2015; Pearl-Martinez & Stephens, 2016).

So far, there are not any studies analyzing the effect of a renewable energy project post-implementation with a focus on gender aspects in the Global North. Even when the project assessments include local voices, they fail to adopt a gender-based approach or gender is just one of many variables in regression models (Baruah, 2015; Skutsch, 2005). For this reason, various authors call for a gendered approach on energy transition and more concretely around RE projects (Allen et al., 2019; Feenstra & Özerol, 2021; Pearl-Martinez & Stephens, 2016; Skutsch, 2005; Standal & Winther, 2016). The present study is a response to this call and aims to shed light on the differences in the involvement, inclusion and benefits perceived by women and men. Although it's acknowledged that the results are also influenced by individual preferences and perceptions, it's shown that there are significant differences in the expectations and benefits between men and women and these can be traced back to social dimensions like gender inequalities and social roles. This is especially relevant nowadays that the COVID-19 emergency has exacerbated the undervaluation of care work, gender domination and oppression and proved to be a big challenge for gender equality. In the aftermath of the COVID-19 crisis, it is becoming urgent to include gender and energy in national recovery plans and energy planning (Carli, 2020; Sarrasanti et al., 2020).

The focus of this study is on local energy projects that involve various actors like municipalities, public, and private entities. These 'mixed ownership' initiatives aim to provide clean energy, but also to enhance citizen participation and to offer benefits for the local communities. The two case studies are the islands of El Hierro in Spain, and Tilos in Greece. In order to evaluate people's perceptions on the project and

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https://doi.org/10.1016/j.esd.2022.03.001

the effect it has on their lives, a detailed survey with questions driven from the energy justice framework was designed. Using this data, it's discussed if and how renewable energy developments benefit women and strengthen their role in the broader development of the islands, especially compared to men.

The rest of the paper proceeds as follows: Section 2 discusses the relevant literature on gender, RE projects and energy justice, Section 3 introduces the case studies and Section 4 the methodology. Section 5 presents the results; Section 6 offers an in-depth discussion while Section 7 concludes.

Theoretical background

The role of energy in our societies is central as it shapes the sociocultural environment we live in. With the energy transition to renewable sources, new opportunities have opened up as we move away from the 'petro-masculinity' era that is based on a strong relationship between fossil fuels and white patriarchy (Daggett, 2018) to more bottom-up, small scale, decentralized and inclusive projects. These multifaceted projects not only have various benefits for the respective communities, but they can also pave the way for a new dimension of innovative technologies as means for societal transformation (Seyfang & Haxeltine, 2012). According to Avelino & Wittmayer (2016 p. 638) *"is not only about a socio-technical transition from fossil-based fuels to renewable energy, but it is also a socio-political transition from centralized for profit energy companies, to decentralized, not-for-profit community-based and/or Third Sector-based energy cooperatives*".

However, under the current neoliberal growth practices, technological advantages can reinforce long-existing biases and further obfuscate the need for sustainability, health and wellbeing of women and other marginal groups. To embrace the opportunity that local RE projects offer it is important to design inclusive programs that subvert social inequalities. Just by assuming that access to electricity or renewable energy will translate to women empowerment and gender equality, fails to acknowledge the structural problems that have traditionally shaped gender roles. As Mkenda-Mugittu (2003, pp 462) put it: "*the impact of introducing new technologies is generally negative on women's work burdens and serves simply to reinforce their subordinate status and position relative to men*."

Energy justice

A stream of literature that aims to shed light on the inequalities and the impacts energy projects have on different socio-economic groups is energy justice. The concept of energy justice is an established field of study that emerged from the environmental justice movement. Since then, energy justice has been used widely as a framework in academic research (Sovacool & Dworkin, 2015), has been applied in different contexts and with different methodologies (i.e., practice-orientated, quantitative and qualitative), has influenced energy policies and decision-making. This focus on energy justice in policy discussions provides an in-depth analysis of various justice issues present in the energy debate and asks normative questions regarding the burdens of energy transitions, the fair allocation of benefits and the opportunities for participation in the energy systems.

The concept of energy justice is multifaceted and includes i) procedural justice that focuses on inequalities in the process and governance ii) distributive justice that discusses the unequal distribution of benefits and burdens that result from an energy development and iii) recognition justice that addresses the representation of various stakeholders and the diversity of their needs (Jenkins et al., 2016). The three aspects of energy justice are interconnected and failure in one aspect can trigger failure in another aspect. This three-tenet framework offers a conceptual tool that can help researchers and policy makers to situate the values and expectations of an energy project and to assess the outcomes (Jenkins, 2018). According to Sovacool et al. (2017) it can also be an analytical tool that allows researchers "to understand how values get built or marginalized into energy systems or to resolve common energy problems." Despite the longer history of the environmental and climate justice framework, the energy justice approach was used in the present work as a framework with a "key" concept (energy) and a set of concrete principles, and it's focus on policy relevance (Jenkins, 2018). Additionally compared to the wider "sustainability framework" and "gender-energy" nexus approach, the energy justice framework focuses on where (in)justice occurs within energy systems, and how justice might be achieved. Other frameworks like women in environment (WED), and ecofeminism deal preliminary with issues of poverty and are not yet fully developed to allow the application in issues like energy (Clancy et al., 2003) Furthermore, the local and decentralized character of the case studies and the specific focus on gender further support the effort to bring together energy and gender scholars through the application of the energy justice framework (a more detailed analysis is offered at Lacey-Barnacle et al., 2020). For these reasons, the energy justice framework was chosen as the underlying conceptual framework in the present study to shed light on gender justice issues emerging from local scale renewable energy projects.

Energy justice and gender

Despite the parallelism between energy justice and other justice issues, the discussion around gender equality in the process of a just energy transition is limited (Lieu et al., 2020). The concept of procedural energy justice is mostly discussed in the context of decentralized local projects that aim to achieve high levels of energy democracy. It is concerned with dismantling the existing power structures and enhancing broader public participation and pluralism in energy decisions. Procedural energy justice calls for a more equal and inclusive system, away from the patriarchal structures that are embedded in the old fossil fuel arrangements. However, very rarely it has recognized the gender dimension and the inclusion of those who have been historically excluded from the decision making. Women empowerment is not only a result of access to resources, like clean energy, but it is also involvement in decision making and participation in deliberative processes (MacEwen & Evensen, 2021). Even if their opinions and expectations are heard during the design phase, women's voices are often excluded in the project assessments which are mostly done by technicians, managers, and governments. Who often refer to the impact of a technology on "people", or "communities" in a gender-blind approach (Clancy et al., 2011).

Project success is also gender specific and women and men have different energy needs and priorities. This is mostly due to the social roles attributed to genders, with women being the primary caretakers and house keepers. For instance, Räty and Carlsson-Kanyama (2010) examined the different patterns of energy use of men and women in four countries and found that men use more energy for travelling and eating out, while women have bigger energy needs related with hygiene and household chores. This indicates different consumption patterns, resulting from different needs and societal roles. Mang-Benza (2021) refers to this as 'Gender Blindness' in energy policy and argues that it can perpetuate and amplify the already existing inequalities. (Boyd et al., 2019)use the term 'hangover legacy' to refer to renewable energy systems that mimic the legacies of the male dominated fossil industry. Clancy and Feenstra (2019) argue that "*There is a growing interest in the gender-energy nexus literature in the potential role of women as agents of change, either as energy entrepreneurs, or as decision-makers in energy policy, or as employees in the energy sector. However, there is limited evidence related to the European Union, as to whether or not the energy transition is benefitting from greater gender equality*".

Indeed, most of the few available studies come from the Global South where energy is often associated directly with a better quality of life, more free time, increased income, and entrepreneurship opportunities (Balakrishnan, 2000; Oparaocha & Dutta, 2011; Zahnd & Kimber, 2009). A healthier environment in the house is another

important benefit as women are often impacted using unsafe indoor heating and cooking (Mohapatra et al., 2018). Thus, given that energy poverty is also a gendered issue and women can gain more benefits than men from clean energy (Nguyen & Su, 2021), sustainable energy and technologies are also associated with women empowerment. However, this is not always the case.

Historically women have been less favored in expanded development plans (Shiva, 1992; Sultana, 2009). For instance, post-implementation research on an Indian biogas program revealed that women and men have different perceptions on the benefits of the projects (Cecelsk, 2000). In another research in India, the authors mention that the solar park "*exacerbates the gendered social, economic and political asymmetries of adjacent villages*" burdening mostly the lowest caste women (Stock & Birkenholtz, 2020). A report from a solar project in Southern Morocco also indicates that despite the aspirations to promote gender equality, the observed outcome was not as expected and women were generally underrepresented, while their role in the society did not change significantly (Wuppertal Institute; Germanwatch, 2015). In their research of a solar mini grid in rural northern Zambia, Johnson et al. (2019) found that although there were many benefits for the local community these were not evenly distributed among men and women. As a result of an electrification project, women in Peru found themselves with extended working time and more care responsibilities (Fernández-Baldor et al., 2014). Similarly, Wiese (2020) examined gendered aspect of micro micro-hydropower projects in Sidama, Ethiopia. They conclude that women were less included in the process, enjoyed less benefits, and their energy needs were not sufficiently recognized and addressed. Amorim and Teixeira (2018) in their policy brief of energy transition in Brazil, South Africa, China, and India report that the energy transition policies do not ensure fair allocation of benefits for women. All the aforementioned studies highlight the need for more gendered energy studies and the need for sex-disaggregated data that will guide policy.

Looking in the Global North, the idea that women and men in the have the same relationship to energy has been widely questioned. Various concerns have been raised around the exacerbation of these differences as a result of the energy transition (Fathallah & Pyakurel, 2020). Some of the topics studied sparsely in the literature include different patterns of energy consumption, different practices as well as differences in the willingness to change established energy practices (Feenstra & Özerol, 2021). These differences are important in the context of gender equality and justice (Fraune, 2018) and challenge the idea that energy discussions in the global North are gender neutral. The present paper aims to answer some of the questions posed by (Clancy & Roehr, 2003 pp. 17):

> 'Are the lives of women and men affected differently in terms of the energy forms they use? If gender differences towards energy exist, are women and men able to exercise choices that reflect those differences about energy? Do women and men in the North have different preferences for energy policy?'

The use of the energy justice framework on gender related topics has been an emerging field of research. Feenstra and Özerol (2021) offer a comprehensive review of literature and conclude that despite the limited available research, the energy justice framework can be applicable in analyzing energy policy through a gender lens. Feenstra (2002) when discussing the essential elements for a gender sensitive energy policy refers to an approach that takes into consideration the energy needs of both genders, increases the participation of women in the sector, and uses gender-disaggregated data to guide the principles of the policy. In this line., in this study I highlight the need to embed a gender approach in all the stages of a project's life cycle from design to evaluation under the energy justice principles and the need for sex-disaggregated data. By applying the energy justice framework in two specific case studies in affluent settings I aim to open up a discussion around gender aspects of the energy transition in the Global North.

Case studies

The two case studies chosen are the islands of El Hierro, in Spain and Tilos, in Greece. These islands were chosen as they are worldwide examples of renewable energy projects on small islands, with ambitions that do not only include electricity production, but also socio-economic benefits for the communities (European Union, 2021). Additionally, both cases have been praised for the great public acceptance and participation of the local communities (Boulogiorgou & Ktenidis, 2020; Frydrychowicz-Jastrzębska, 2018). Both islands belong to the EU periphery, which faces high levels of poverty and economic stagnation (Bouzarovski & Tirado Herrero, 2017). For the present study the focus is on island territories as their communities are generally well defined and the effects of a project easier to measure. However, by referring to communities one should not assume that they are homogenous, as islands are also arenas for contested power, hierarchies, and conflicts (Connell, 2018). In fact, is this, heterogeneity that interests us. The two case studies were selected based on their similarities rather than differences (Mills et al., 2012), which allows to me to point out some patterns and common issues around gender aspects and the RE projects and thus open up a relevant discussion.

Tilos, also known as the first 100% renewable island in the Mediterranean, is a small island, with about 500 inhabitants. Women in Tilos are a smaller group than men, but they are an active part of the society working in municipality, tourist business, agriculture, and food cooperatives. The innovative RE project is a hybrid system working with batteries that are recharged by a wind turbine and a solar park. The project is led by the research team of Soft Energy Applications & Environmental Protection Laboratory (Piraeus University of Applied Sciences PUAS), the Hellenic Electricity Distribution Network Operator (HEDNO), and the private company Eunice. Prior to the implementation of the project, the island was relying on electricity from an underwater cable through a very unstable connection that resulted in frequent blackouts. The high cost of diesel was a burden not only for the residents of Tilos but for the whole country as the difference in the price was subsidized from the mainland (Marula Tsagkari & Roca Jusmet, 2020). The project is part of the bigger sustainability plan of the island that aims to revitalize the local economy, create jobs, attract young people on the island and boost economic growth without compromising the environment (Boulogiorgou & Ktenidis, 2020; Notton et al., 2017). The project managers made significant efforts to include the local population throughout the process, mostly though open meetings, educational campaigns, and consultation (Tsagkari et al., 2020). WWF was the responsible organization for these activities and all the relevant information around the consultations and trainings is available online.[1]

El Hierro, is the smallest of the Canary Islands, with a registered population of around 10.000 people. In reality, the population of permanent residents on the island is around 6.000 people (private communication with the local government). Due to the distance from the mainland the electricity demand of the island was covered through imported oil. In an effort to take advantage of the full potential of the island's ideal conditions, to become more autonomous, and to reduce the electricity costs, the island implemented an innovative RE project. Nowadays, a hydro-wind power plant with a wind farm and a pumped-storage hydroelectric power station supplies the island with clean energy. The project has a mixed ownership model including the El Hierro Island Council, the private company Endesa, the Canary Islands Institute of Technology and the Autonomous Community of the Canary Islands (Tsagkari, 2020). The initiative aims to make El Hierro the first electricity self-sufficient island that does not rely on imported fuels and costly thermal stations (Frydrychowicz-Jastrzębska, 2018; Garcia Latorre et al., 2019). The project goals also include benefits for the local community like new income opportunities, tourist activities, social cohesion, and less dependency

[1] https://www.tiloshorizon.eu/tilos-deliverables/leaflets-and-guides.html.

from the mainland. The local population was involved through public consultation and open meetings (Tsagkari et al., 2020).

Methodology

Research design

The analysis is based on online- surveys sent to the local populations between November 2020 and March 2021 and complemented with an analysis of the relevant technical reports and policy briefs. The overall purpose of the online survey was to evaluate the effect of the projects on people's lives. However, for the present study the statistical analysis is focused on gender differences in binary terms due to the methodological limitations. In total 145 questionnaires were collected from El Hierro (45.5% men, 53.8% women and 0.69% other, response rate 42%) and 50 from Tilos (54% men, 46% women, response rate 51%). The surveys were disseminated through the platform Survey Anyplace and with the support of the local municipalities. The survey response rate was calculated as the number of returned questionnaires divided by the total sample who were sent/given the survey initially. A limitation of the methodology that needs to be acknowledged, is the idea that the ones who replies the survey are the ones most involved with the topic (French, 1981).

Overall, given the small size of the population on the islands modest sample sizes are acceptable (Sovacool et al., 2018). In the case of Tilos, with a population less than 1000, we calculated the sample size as the 10% of the population (Albaum et al., 1985). In case of El Hierro the sample is accepted for the adult population (based on Instituto Nacional de España, 2022) of the island at 95% (+/− 8).

Participants were asked to use a 5-points Likert Scale of a disagreement (1) and agreement (5) with a positive affirmation regarding the project. *t*-Tests were used to compare the mean of the subsamples with a significance level of 0.05. Nonetheless, due to the small sample size this can lead to misjudgments. Especially for small sample sizes it is essential to identify outliers and distribution of quartiles. For this reason, boxplots were used to visualize the results.

The sample was not disaggregated by gender from the begging to avoid bias. By using gender in the present study, the focus is on the women-men binary, and the roles and privileges attributed to each, which however are not biologically determined. Respondents were asked their 'gender identity' and the options included 'male', 'female', 'other'. Almost all of the participants (99,5%) identified with the two first categories which is why the analysis is limited in those two. Other authors have examined the role of other sociodemographic variables like age, income, and education in the public opinion about energy projects and the results provide some support for the argument that personal variables can influence the acceptance of projects. Although the present study focuses mostly on gender, it is important to control also for other personal variables to avoid biases.

A Seemingly Unrelated Regression (SUR) is used to estimate the effects of gender on the three dependent variables, while controlling for educational level, income, and age (see Appendix A). SUR was developed is used to estimate models with more than one dependent variables, and accounts for contemporaneous correlation (Zellner, 1962). We choose SUR over simple OLS to account for between-regression variance. SUR is more robust compared to ordinary least squares (OLS) with regards to the specification of heteroscedastic disturbances. SUR consists of multiple regression equations it's of which corresponds to one response variable and incorporates a correlated error matrix. In this study, the SUR model was applied to test the effect of various demographic variables on three dependent variables: success, benefits, and participation in the projects. The SUR model can be written as:

$$Y = Xb + U \quad (1)$$

with:

$$\begin{matrix} Y_1 \\ \Gamma Y_2 \urcorner_{3Cxl} \\ Y_3 \end{matrix} = \begin{bmatrix} X_1 & 0 & 0 \\ 0 & X_2 & 0 \\ 0 & 0 & X_3 \end{bmatrix}_{3Cxk} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix}_{kx1} + \begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix}_{3Cx1.}$$

where Y1 is 'Benefits', Y2 is 'Success' and Y3 is 'Participation'; Xi is the matrix of explanatory variables. The vector βi are the different coefficients to be estimated with k1, k2 and k3 coefficients for the respective equation such that the total number of coefficients is k = k1 + k2 + k3. U is the vector of residuals E(U) = 0;

Thus, the covariance matrix W of all the error terms is:

$$E(UU\prime) = \Omega = \Sigma \otimes I \quad (2)$$

with Σ error covariance matrix with elements σij, where σij, = EUiUl′, i, l = 1,2,3, ⊗ = Kronecker product. If cj is the jth respondent in the sample this structure assumes that the errors are correlated across the indicators for each respondent, and uncorrelated across different respondents, where C is the total number of respondents in the sample.

The framework

The framework draws on the energy justice concept with its three dimensions, namely, distributional, procedural, and recognition as those were presented in Section 1. This framework is widely used in studies that aim to connect issues of social justice to the energy system and to highlight how costs and burdens of the energy production are unequally disseminated in the society. The analysis is based on the approach of Wiese (2020) with a focus on the gender aspect. For this analysis, justice of recognition is related with the specific expectations of women from the energy project. The small number of categorical data and the number of different categories does not allow us to perform statistical analysis for this indicator. For this reason, this indicator is qualitative and thus discussed only at a theoretical level.

Procedural justice discusses the equal inclusion and participation of women in the decision-making processes (Sovacool & Dworkin, 2015). Here I distinguish between inclusion and participation as two different sides of procedural justice. This is because being included in the discussion does not equal participation in the decision making (Jenkins et al., 2016) Distributional justice refers to the allocation of benefits and opportunities. I chose to refer to social and economic benefits as those were some of the initial ambitions of the projects. In the relevant literature economic and social benefits are important parameters in the success and acceptance of a project (Bauwens & Devine-Wright, 2018; Segreto et al., 2020; Stadelmann-Steffen & Dermont, 2021; Walker et al., 2010). Especially factors like social cohesion and feeling of autonomy that are recently gaining attention in the energy literature were included (del Río & Burguillo, 2008; Šahović & Da Silva, 2016; van der Waal, 2020). This is because by introducing a new technology to a place is also an "intervention(s) in a space of social relations" (Standal & Winther, 2016). An overview of the framework is presented in Table 1. Although the three energy justice elements differ, there is degree of interrelation and mutual reinforcement between them (Hanke et al., 2021). For this study, the energy justice framework is the conceptual tool that helps discuss and analyze the results.

Results

When asked about their expectations from the project of clean energy most women in both islands rated as number one reason the 'access to reliable energy'. This can be explained from the time that women spend in their houses as primary care takers and housekeepers. Additionally, many of the women in the sample, own small business (tourist shops, handicrafts, clothes etc.) which are being mostly hit from power cuts. In both cases women rated higher "climate change

Table 1
I indicators assigned to each energy justice framework aspect, the null hypotheses, and the corresponding survey question.

Energy justice framework	Indicator	Null hypothesis	Questions
Justice of recognition	Expectations	Women and Men have similar expectations from the project	Choose what is your main expectation from the project
Participatory justice	Participation	Women and Men felt equally included and consulted in the various phases of the project.	I felt my voice was heard in all the stages of the project. I felt that the local community was actively involved in the design of the project.
Distributive justice	Success	Women and Men assess similarly the success of the project.	Overall, I assess the Project as unsuccessful (1)- successful (5)
	Benefits	Women and Men perceive equally the benefits of the project	The project increased the economic opportunities I see for myself on the island The project made me feel less dependent on the mainland The project brought me closer with other people on the island The project connected me with the land and the island

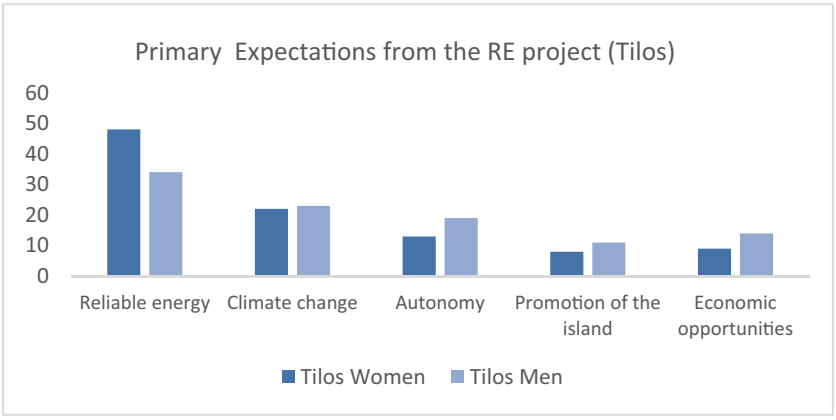


Fig. 1. Different expectations from the RE projects by gender for Tilos.

mitigation" as an expectation from the project. On the contrary, men in both islands ranked higher than women the economic opportunities and the autonomy of the island (Figs. 1 and 2).

Participation & inclusion

In El Hierro women rate their participation in the project design and implementation significantly lower than men [$M_M = 2.81$, $M_F = 2.30$, two-sample t (142) = 1.98, p = 0.02]. They also felt their voice was less heard throughout the process [$M_M = 2.88$, $M_F = 2.49$, two-sample t (142) = 1.98, p = 0.05. Similarly, Tilos women also rate significantly lower their participation [$M_M = 4.15$, $M_F = 3.60$, two-sample t (48) = 2.01, p = 0.008]. However, they felt their voice was included sufficiently during the processes [$M_M = 4.37$, $M_F = 4.35$, two-sample t (48) = 2.01, p = 0.91]. This is an indication that although women were involved in the deliberative process and expressed their views, they were not actively involved in the process (Figs. 3–6).

Benefits

The benefits were divided into economic benefits and social. The economic benefits for both cases were expected to be mostly indirect

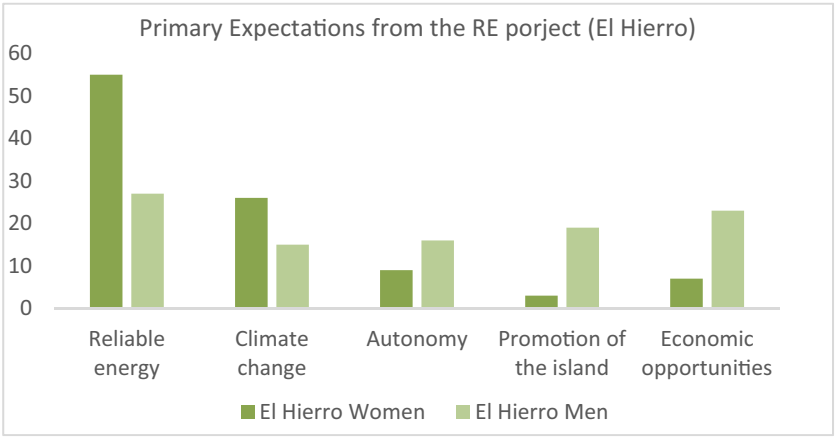
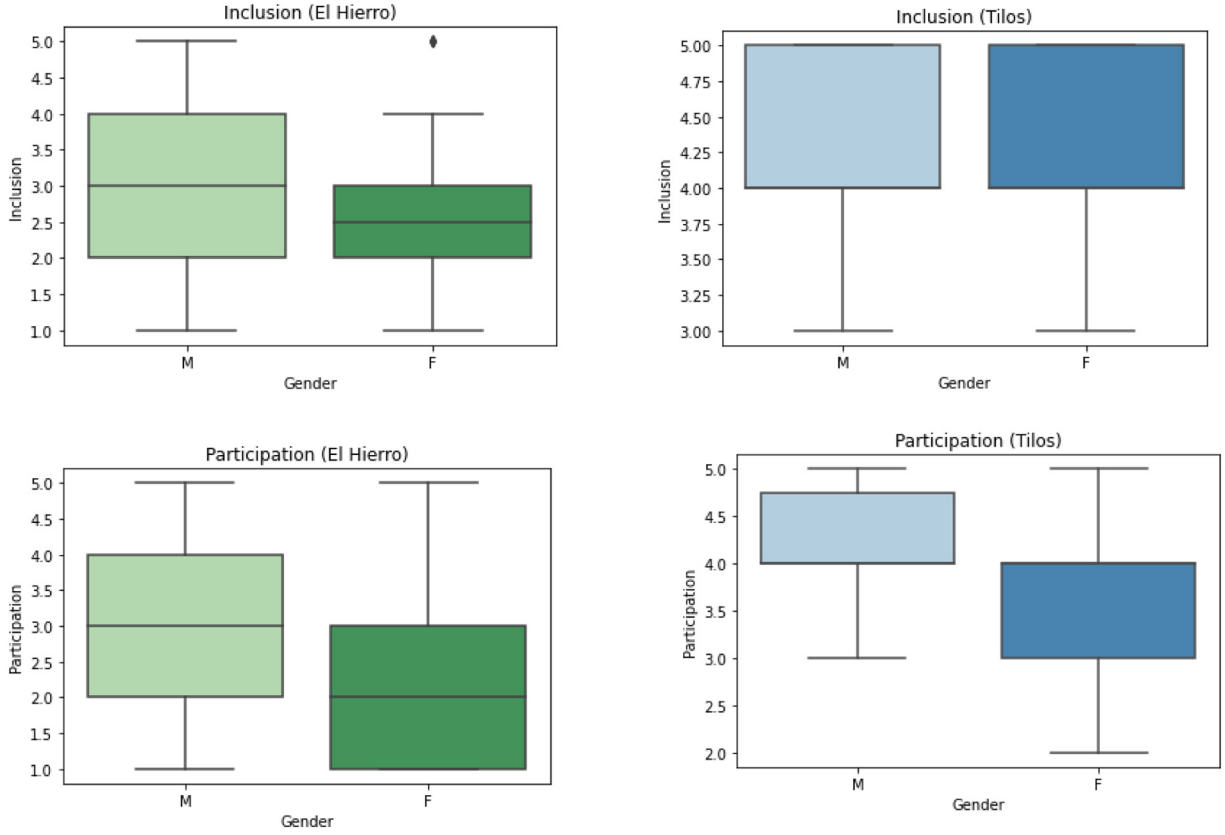


Fig. 2. Different expectations from the RE projects by gender for El Hierro.



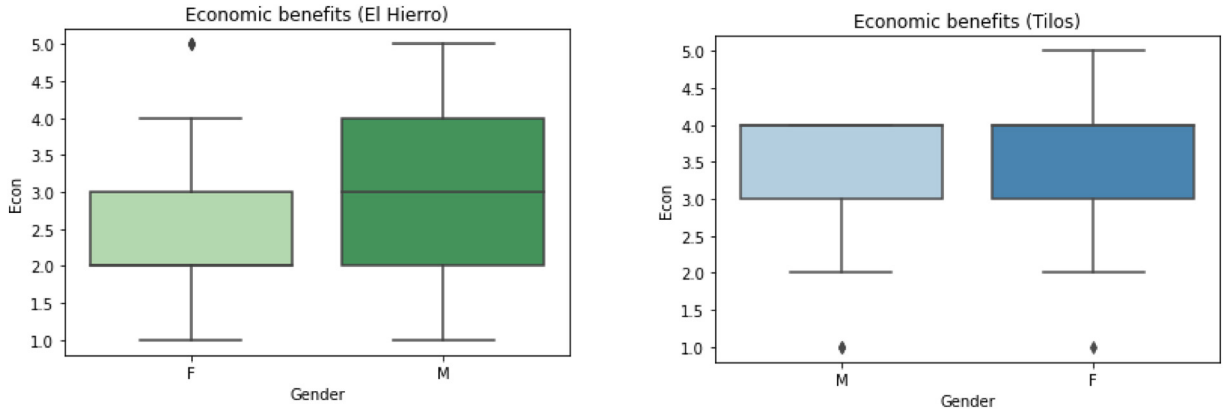
Figs. 3–6. Boxplots of participation and Inclusion by gender in El Hierro (green) and Tilos (blue).

as there was not direct payments to the residents. Indirect benefits include new job opportunities, increase of tourist arrivals, attractive business environment etc. The residents of the islands were asked if the project "Increased the economic opportunities they see for themselves on the island". For the case of El Hierro one can observe that women rate the perceived economic benefits lower than men [$M_M = 3.03$, $M_F = 2.49$, two-sample t (142) = 1.97, p = 0.008], while for Tilos there was not a significant difference at the 0.05 level [Tilos ($M_M = 3.35$, $M_F = 3.35$, two-sample t (48) = 2.01, p = 0.91)] (Figs. 7–8).

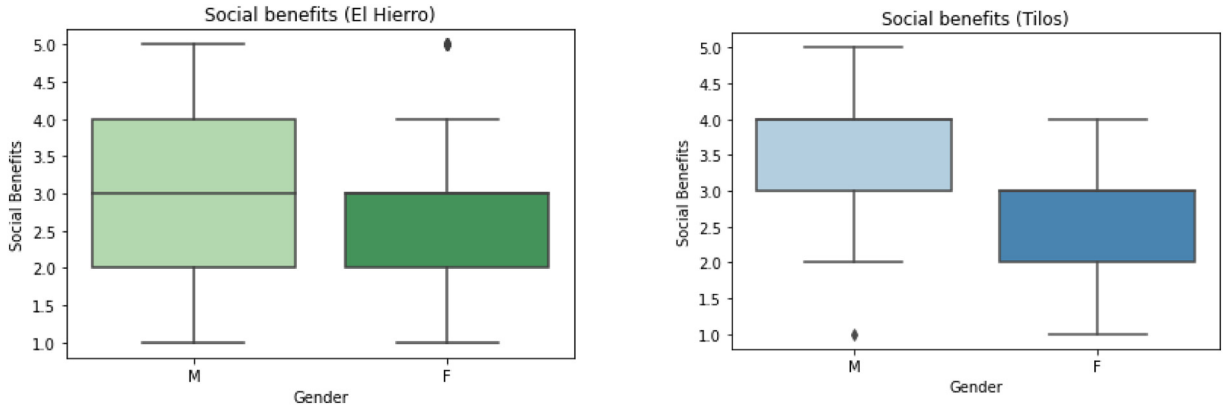
The projects were expected to have a social effect mostly by increasing the social cohesion of the residents, enhancing their feeling of autonomy and connection with their land. The local communities were asked questions regarding social cohesion, feeling of independency and connection with the land. Then the mean score of all questions was calculated to create the variable "Social Benefits". The results indicate that women claim to perceive fewer social benefits than men in El Hierro [$M_M = 2.79$, $M_F = 2.77$, two-sample t (142) = 1.97, p = 0.092], however the difference is not significant at the 0.05 level. In Tilos the difference is higher and significant at the 0.05 level, according to the *t*-test [$M_M = 3.56$, $M_F = 2.73$, two-sample t (48) =2.01, p = 0.008] (Figs. 9–10).

Success of the project

The success of a project is difficult to measure and depends on many factors especially the different expectations of women and men from



Figs. 7–8. Boxplots of economic benefits by gender in El Hierro (green) and Tilos (blue).



Figs. 9–10. Boxplots of social benefits by gender in El Hierro (green) and Tilos (blue).

the project. Overall women were less satisfied with the project than men in both El Hierro [$M_M = 3.78$, $M_F = 3.13$ two-sample t (142) = 1.97, p = 0.0002] and Tilos [$M_M = 4.56$, $M_F = 4.17$, two-sample t (48) = 2.01, p = 0.042]. This can be explained because reliable energy, which was a primary expectation for women requires a fully functional system without power cuts. In Tilos there are still frequent power cuts due to technical and bureaucratic reasons that go beyond the RE project. In El Hierro the project is also not yet mature enough as a stand-alone system. On the contrary, the economic benefits that ranked higher above men, are already visible mostly due to the advertisement of the islands worldwide in the pre-implementation phase (Figs. 11–12).

In order to ensure that gender is an important factor among other personal variables a Seemingly Unrelated Regression including both islands. A variance inflation factor (VIF) analysis was used to detect multicollinearity (Appendix B) and residual plots and Q-Q plot to control for linearity an normality (Appendix C). The internal consistency of the scales is acceptable (Cronbach alpha >0.70)

The results are presented in Table 2 and one can observe that the explanatory variable "Gender" remains significant at the 0.05 level in all three cases. The variable "Island" is always significant indicating that there are significant differences between the two islands. Interestingly the variable "Income" is statistically significant for the perceived benefits meaning that people with higher income tend to feel they perceive more benefits from the RE projects.

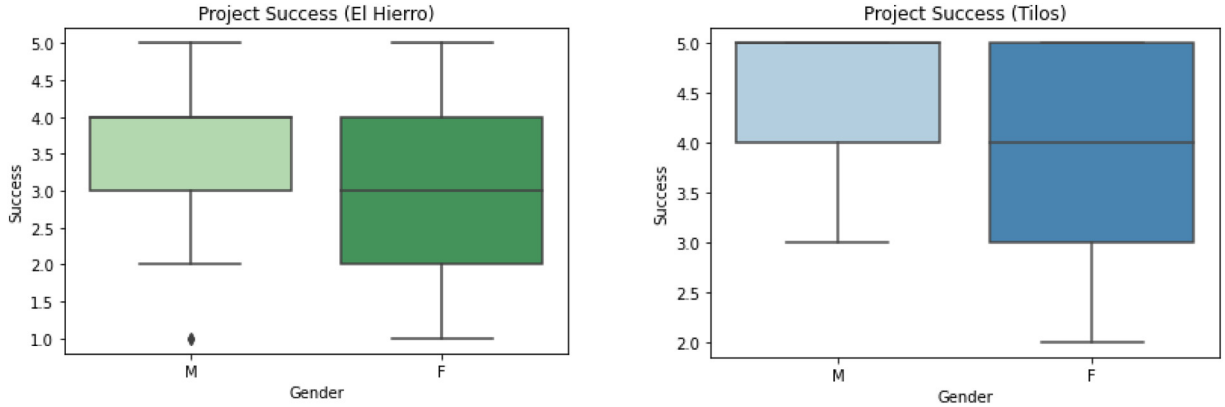
Discussion

In the present study sex disaggregated data is used to shed light on the various gender aspects around two RE projects and to discuss to what extend gendered energy justice is achieved. From participation and inclusion of women during the initial stages, to their expectations and from actual benefits and the success of the project to future perspectives, the results show that there are significant differences between men and women in almost all aspects.

Justice of recognition

Overall, the two projects seem to be aligned with the needs of the local people and recognize the local community as an important factor in the success of the project. The main expectations of woman were the need for clean and reliable energy followed by climate change mitigation. This is line with the relevant research of the past decades that highlights that women have a greater concern about environmental issues and are more eco-conscious (Dietz et al., 2002; Pearson et al., 2017; Tranter, 2011). Access to reliable energy is another important concern for women, associated with their social roles as caretakers and housekeepers, but also with their entrepreneurship and occupation in small business.

The results confirm previous research that has pointed out that energy needs and priorities are gender specific and thus, men and women have different aspirations from RE projects (J Clancy et al., 2012; Wiese, 2020). It also adds on the research on the wider lack of recognition of women's needs in the process and distribution of social goods including leisure, health and education (Fraser, 1995). The projects took into consideration women's energy needs, however, did not include sex-disaggregated data. Some of the goals are also common for both gender which means that these goals are not related with the need to empower women.



Figs. 11–12. Boxplots of project success assessment by gender in El Hierro (green) and Tilos (blue).

Table 2
Seemingly Unrelated Regression (SUR) results.

	Parameter	Std. Err.	p-value
Dependent variable: benefits			
const	1.3427	0.3906	0.0006
Gender	−0.3019	0.1479	0.0412[b]
Education	−0.0816	0.0817	0.3178
Income	0.5745	0.0648	0**
Island	1.0055	0.1782	0**
Age	0.0368	0.0585	0.5288
Dependent variable: success			
const	3.2791	0.3899	0**
Gender	−0.9115	0.1476	0**
Education	0.1876	0.0815	0.0214*
Income	0.069	0.0647	0.2858
Island	0.5345	0.1778	0.0026**
Age	−0.0352	0.0584	0.5467
Dependent variable: participation			
const	3.2115	0.3763	0
Gender	−0.6479	0.1424	0*
Education	0.1818	0.0787	0.0209*
Income	0.0469	0.0624	0.4523
Island	0.9078	0.1716	0**

[b] *p 0.05 **p 0.01.

Procedural justice

The procedural justice analysis refers mostly to the design and implementation stages and the involvement and inclusion of women. The technical documents indicated that the communities were consulted and participated in the initial stages in an effort to minimize complaints and enhance energy democracy.

Despite that, women overall, felt less included in the initial stages and even if they felt that their voices were heard they did not participate actively. This indicates lower level of energy democracy and participatory energy justice and highlights the fact that a simple bottom-up approach does not guarantee energy justice if it's not concerned with the equitable participation of all groups and during the whole process. Especially in the case of Tilos, it is obvious that inclusion of the different voices needs to be translated into actual participation in the decision making in order to ensure participatory energy justice. This research indicates that there is need for actions that focus mostly on enhancing the participation of women. For instance, in other similar cases where there were specific training programs, campaigns targeting specifically women (Balakrishnan, 2000; Osnes, 2013), this led to broader participation and inclusion. These results are not unique in the field and underline the long standing practices of unequal gender roles and power structures in the decision making (Alston & Whittenbury, 2013; Karvonen, 2017).

Distributive justice

Regarding the economic and social benefits of the project that can enhance distributional justice, the analysis concludes that women perceived less benefits than men. This is in line with (Wiese, 2020) who reported that women gained less benefits than they expected and less benefits than men. The present study, being the first one to examine the benefits of an energy project post-implementation clearly shows that even in the Global North women perceive less the benefits of innovative energy projects than men. This could be attributed to the more long- term expectations of women (e.g., climate change mitigation), as well as their feeling of exclusion that alienated them from the projects. In Tilos, both men and women rate the economic benefits as successful and there is not a significant difference between the genders. This can be explained by the demographics of the island as there are many couples who perceived economic benefits as a household. At the same time, all the households had a small reduction of 3% in their monthly bill which made the benefits on the island more tangible (Tsagkari & Roca Jusmet, 2020). In El Hierro both genders rated the economic benefits really low, however there was not a significant gender difference. This lack of economic benefits can be attributed to the early stage of the project and the specific circumstances of COVID-19 that has affected especially the tourist industry.

In terms of social benefits, men in Tilos seemed to believe that the project enhances their connection with the community and the land, while they feel less dependent from the mainland. This feeling of autonomy was one of the main expectations for men. At the same time, they are the ones who spend more time outside their houses working or at the local coffee shop where discussions around the project and involvement with the managers was taking place in informal settings.

Conclusion

New technological innovations are often seen as gender neutral, while energy interventions are often assessed in a gender-blind way. The present study is a primary effort to shed light into the gender aspect of local energy projects using sex-disaggregated data. By focusing on the various stages of a project's lifecycle one can argue that a gender approach should be embedded in every step consultation and design to post-implementation assessment and benefit allocation. This research not only underlines the need for more similar studies and approaches, but also paves the way for more bottom-up policies, that take into consideration the needs of various groups. By examining two case studies in Europe, I highlight the fact that engendering the energy transition is a relevant policy issue not only for the Global South as often assumed (Fathallah & Pyakurel, 2020) but also for the Global North.

Although there is some preliminary evidence that women's participation in the energy transition can have a positive impact due to their greater perception of risk and environmental awareness the discussion is still preliminary (Carlsson-Kanyama et al., 2010; Clancy & Roehr, 2003; Fraune, 2016; Offenberger & Nentwich, 2010). Given the results of the present study, the need for programs and policies should focus on dismantling the current power structures and increase the participation of women in the energy transition is important in order to avoid the masculinization of the renewable energy sector.

In line with Rosenberg et al. (2020) this study also provides evidence that SDG 7 (energy access) and SDG 5 (gender equality) should be examined in parallel as there are complex and underlining asymmetries that should not be overlooked. Access to clean and reliable energy through an innovative project might not benefit equally women and men in the community. If a project wants to be thriving and successful in the local community should not be designed and evaluated in a gender-neutral way, but rather pay attention to these groups that have been traditionally marginalized and excluded from the processes. Energy transition is a feminist issue and should be studied as such. Through the lenses of a feminist energy justice perspective, one can see different pathways that can build new energy systems and healthy communities. Only in this way the benefits of the energy transition will be equally distributed in the communities in line with social justice claims (Cecelsk, 2000; Oparaocha & Dutta, 2011)

This study cannot claim generalizability as the results, although may show a trend, are not applicable to other settings. This is because of the specific cultural and social characteristics in the research areas as well as the specific design of the projects. However, our cases might point to a number of emerging issues regarding gender aspects in the energy transition in the Global North and call for further studies that analyze the effects of power imbalances in energy transition and discussions on why gender differences might occur.

Gender differences were presented in binary terms due to the methodological limitations and the specifics of the case studies. By considering women as a homogenous group with similar views, we overlook the intersectionality of feminism and exclude other forms of oppression like ethnicity, class, and ability. Additionally, there are important limitations in the use of close ended questions that give limited insight on complex issues living no space for further elaboration. Despite these limitations the present study highlights the need for more sex disaggregated data that can guide energy policies. Future studies should expand the focus on the different variations of female identities and on other traditionally overlooked groups as well as on different geographies.

Declaration of competing interest

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

Appendix A. Categories of explanatory variables used in multiple regression

Variable	*N*	
	El Hierro (%)	Tilos (%)
Gender		
Male	45,5	54
Female	53,8	46
Age		
<25	8	4
25–34	22	12
35–44	24	58
45–54	20	14
55–64	17	10
>65	8	2
Education		
Primary education	1	4
Secondary education	28	68
Bachelor or master's degree	56	24
Doctorate degree	2	4
No educational level	3	0
Other	10	0
Monthly gross income		
<1000 euros	24	43%
1001–2000	35	32%
2001–3000	23	12%
3001–4000	10	6%
4001–5000	5	4%
5001–6000	1	1%
>6000	2	2%

Appendix B. Variance inflation factor (VIF)

const	33.99241
Gender	1.07428
Education	1.264276
Income	1.115197
Island	1.215928
Age	1.177397

Appendix C

Figure: Residual plot. The normal probability plot of the residuals is approximately linear supporting the condition that the errors are normally distributed.

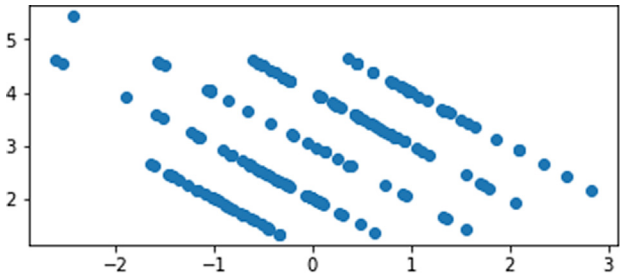
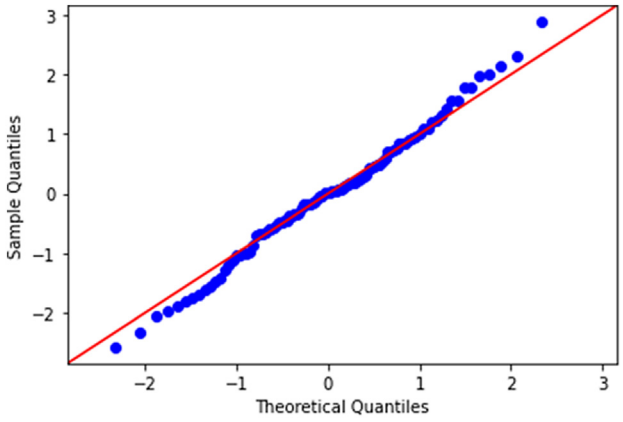


Figure: "quantile-quantile" plot (Q-Q plot) indicating that the data distribution is close to normality.



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