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Sustainability of local renewable energy projects: A comprehensive framework and an empirical analysis on two islands

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Abstract

Local energy projects have been associated with several benefits for the local community like social cohesion, economic gains, new skills, and environmental awareness. Yet, there is limited research on whether the projects fulfill their sustainability promises, and how the local community perceive the benefits. This research introduces a novel framework to assess the success of a local renewable energy project based on the perceptions of the local population and the initial ambitions of the projects. Using this framework two innovative local renewable energy projects are assessed; one in Tilos island in Greece and the other in El Hierro in Spain. An online questionnaire was used to assess the impact of the project on people's lives, their overall assessment of the project and their willingness to support similar future initiatives. The data show that the economic benefits are not significant when people assess the project, while on the contrary other factors like the environmental benefits, sense of pride, technical parameters institutional seem to have a greater effect. The environmental and institutional factors are also among the ones that influence people's willingness to support and participate in future projects. Overall, we reveal that the two projects are quite successful in the eyes of the local population and offer good case studies with several implications for policymakers and future initiatives.

KEYWORDS
impact evaluation, islands, local energy, local impact, sustainability

1 | INTRODUCTION

Decentralized small scale energy systems that bring closer energy generation and consumption can play an important role in the energy transition. Local renewable energy, especially when coupled with smart grid and storage technologies, holds new possibilities for insular and isolated areas that face multiple challenges the past years. High level of unemployment, land degradation, lack of resources and out-migration combined with lack of affordable, secure, and reliable energy supply are some of the reasons that lead insular communities to look for alternative strategies to promote development (Connell, 2018; Kaldellis & Zafirakis, 2020).

Alongside addressing the energy trilemma (i.e., affordability and access, energy security and environmental sustainability), a sustainable plan centered around a renewable energy project can have multiple local benefits for the communities: new income streams, job opportunities, increase in social cohesion, and new skills and knowledge. These plans are often built around the three main sustainability

pillars, namely environmental, social, economic and they include additional dimensions like cultural, technical, and institutional. As the economic and institutional barriers for small scale renewable energy projects are lowering, many islands around the world with favorable conditions explore these opportunities (Jaramillo-Nieves & del Río, 2010; Kaldellis & Zafirakis, 2020; Al Katsaprakakis et al., 2019; Stuart, 2006).

In relevant literature there is an increased discussion around the factors that influence people's willingness to accept renewable projects, the public attitudes prior to the project implementation, as well as the potential benefits that can result from these initiatives. Among others, scholars in the field have moved significantly beyond the "NIMBY" (Not-In-My-Backyard) hypothesis which stigmatizes objectors of local renewable energy projects as egoistic, misinformed, and ignorant, arguing instead that the perceived fairness in the distribution of relevant costs and benefits and emerging relationships with project developers influence community acceptance (Devine-Wright, 2013; Guan & Zepp, 2020; Segreto et al., 2020; Sloot et al., 2019). Surprisingly however, there is little attention given on the levels of satisfaction with the projects post-implementation. In an attempt to cover this gap, we present a new framework to assess the early-stage performance of a given project considering both specific goals set prior to implementation and emerging ones linking to the notion of "living" projects. We also take our analysis one step further and try to understand which factors tend to affect people's perception regarding the overall, early-stage success of a project and the factors that can influence their willingness to support further initiatives in the future.

An established stream of literature that addresses sustainability at a local level (Hartmuth et al., 2008; Shi et al., 2021). This is because sustainability is not only a global issue and communities are often considered the appropriate level to discuss many sustainability issues (Rae & Bradley, 2012). The present study focuses on two case studies from the small islands of Tilos (Greece) and El Hierro (Spain) that have recently implemented innovative and ambitious renewable energy projects in order to cover the local electricity needs. The results are based on online surveys that were launched on the two islands with questions regarding the success of the project, the impact it has on people's lives, as well as their attitudes towards future projects. The overall aim of the study is to answer the following questions:

1. How successful are the projects according to the local population in each of the sustainability pillars in their early stage of operation?
2. (a) Which factors influence people's perceptions regarding the overall "success" of the projects? (b) Which factors influence people's willingness to support future similar initiatives?
3. What are the possible recommendations for improving the acceptance of similar projects from the communities and how can existing solutions be striven towards producing more benefits for local communities?

The rest of the paper proceeds as follows: in Section 2 we start with a review of the available literature on sustainability analysis of local energy projects with a focus on the relevant frameworks. In Section 3 we introduce the two case studies and the framework. In Section 4 we present the methodology and data collection approach and in Section 6 we present the results of the analysis, which are then discussed in Section 7.

2 | LITERATURE REVIEW

Many renewable energy projects set broader societal goals that go beyond mere electricity production. Local small-scale projects have been praised for the positive impacts they can have on the local communities like income generation effects, in-migration, education, productive diversification, social cohesion, human development, industry creation and income distribution, among others (Hong & Abe, 2012; Jaramillo-Nieves & del Río, 2010; van der Waal, 2020). Participants may be more inclined to get involved in the completion of these aims (Schmid et al., 2016; Seyfang et al., 2014; Strunz, 2014). Towards this direction, regular assessment of project goals implementation as well as of ambitious targets beyond the initial project scope is encouraged in order to seek for excellence and capitalize on project outputs. There is a lot of prior research on the implementation of the projects but very few studies look to what degree projects have managed to achieve sustainability in a broader context. There is also not a commonly accepted method to measure the impact of the projects on local sustainability dimensions. The few available frameworks applied in the literature are either only qualitative (e.g., del Río & Burguillo, 2008) or tend to focus on just one subset of issues like economic (Maqbool et al., 2020), justice and equity (Siciliano et al., 2021; Zhang et al., 2021), and employment (Heinbach et al., 2014), ignoring the holistic nature of sustainability. Gjorgievski et al. (2021) call for more research that combines economic, environmental and technical indicators under a common framework to assess the community impacts of projects. Additionally, project evaluations often come from outsiders—political, technical actors, and fail to include local voices (Ikejemba & Schuur, 2020; Maqbool et al., 2020; Yuan et al., 2021). Various authors have questioned that sustainable development and thus, relevant indicators are "subjective" and call for public participation as a central component in the evaluation of sustainability progress (Bell & Morse, 2003). For instance, McAlpine and Birnie (2006) from the Island of Guernsey highlights the need to "take the indicators into the community" meaning to engage proactively the local population in the design and evaluation of local indicators.

Some recent research has tried to fill this gap with the presentation of new frameworks that include different stakeholders and aspects of sustainability, but mostly in less affluent settings. For instance, Dauenhauer et al. (2020) apply a new sustainability framework to evaluate 65 solar projects in Malawi. They combine a survey and interviews with key stakeholders and use project centric indicators as an assessment tool. Their work is complementary to Katre and Tozzi (2018) who proposed a novel framework based on different metrics and scoring methodology to assess 40 off-grid projects in India. In other research Bhandari et al. (2018) used five sustainability themes and 54 sub-indicators that were weighted from the

community to assess the sustainability of a micro-hydro plant. Terrapon-Pfaff et al. (2014) reviewed 23 local development projects post implementation in various developing countries. The authors conclude that despite the different geographical, social, economic, political, and cultural contexts there are some similarities on the factors that influence mid-term sustainability, like sense of ownership, knowledge capacity, network connections and commitment. In the work of Shoaib and Ariaratnam (2016) in rural Afghanistan, several indicators were used to measure the socioeconomic impacts of community energy at the household level through questionnaires disseminated in the local community. The results indicate that only "modest improvement" was observed, and economic indicators seem to have the lowest improvement scores. In another study from Indonesia the authors concluded that micro hydro projects perform well in most sustainability indicators except economic, as they do not have an economic scheme in place (Purwanto & Afifah, 2016). Armanios (2012) proposed three sets of indicators economic, engineering, and environmental to assess three village water projects in Egypt. The innovation of his approach is the use of a framework that includes the community-of-practice (CoP) approach and the capability approach (CA), while he distinguishes between project goals and practices.

However, the most prominent research that uses indicators to assess the sustainability of renewable energy projects is the one by Ilskog (2008). Using 39 indicators from the five dimensions of sustainability, namely technical, economic, social, environmental, and institutional, the author created a comprehensive method for sustainability evaluation. Since this publication, the framework has been used by various authors, but has also received various criticism. According to Dauenhauer et al. (2020) the indicators used, are more relevant in the country level while often indicators represent the authors conceptualization of sustainability and not the real project results. Additionally, the framework is centered around rural electrification in developing settings and has been applied widely in African countries (Ilskog & Kjellström, 2008) and in other less affluent countries like Nepal, Peru and India (Bhandari et al., 2018; Yadoo & Cruickshank, 2012). The same frameworks cannot be applied to more developed areas where access to electricity, school education and access to clean water are less of an issue.

One of the few studies in more developed settings is the recent analysis of van der Waal (2020) that examined the impact of a community wind project on the local population in Scotland using the changing mapping approach. The authors highlight the need for a comprehensive evaluation framework claiming that often the literature is uncritically positive when it comes to energy communities and their impacts. In another study by del Río and Burguillo (2008, p. 1317) a theoretical framework developed by the authors was used to assess the impact of renewable energy projects on local sustainability in three cases in Spain. The approach includes various stakeholders and 11 indices namely: impact on education, employment, income generation, demographic impacts, energy accessibility, social cohesion and human development, tourism and use of indigenous resources. The study found that the projects have a positive impact on employment and that they can improve the standard of living, and the social cohesion of the communities.

Hicks and Ison (2011) focused only on community-owned projects and analyzed two case studies: Community Energy Scotland and Minwind, Minnesota, USA. Their analysis is qualitative using data from interviews with project directors, project managers, engineers, volunteers, researchers, and other involved actors. The results include technical benefits like energy reliability, but also social benefits like social cohesion, the creation of a common response to problems and economic benefits to the community especially on local labor and business. The review of Jaramillo-Nieves and del Río (2010) is the only article that focuses solely on islands. The authors synthesize ex-ante and post-ante evaluations from small islands around the world. They discuss the importance of small islands as renewable energy hubs and highlight the lack of multicriteria studies that focus on the three dimensions of Sustainable Development (SD), as well as the need for more quantitative and in-depth case studies.

A second extensive pathway of research analyze the factors that influence people's perceptions on renewable energy and their willingness to accept and support projects on their area. This research that emerged as a response to the literature that was treating communities as an obstacle in the implementation of renewable energy projects focusing on the NIMBY. This new approach argues that project specific factors influence public acceptance. These factors can include the local impacts, the levels of trust and familiarity with the management organization, and issues of procedural and distributive justice (Devine-Wright, 2013; Guan & Zepp, 2020; Segreto et al., 2020; Sloot et al., 2019). Demographic variables like gender, education and age, have been found to also play an important role influencing acceptance of energy projects (Devine-Wright, 2013; Ek & Persson, 2014). However, this research stream is limited on the pre-implementation stage.

Very few studies discuss how a positive experience with RE can increase the acceptance and willingness to support further projects. For instance, van der Horst (2005) found that people who live closer to a wind turbine changes people risk perception while Bauwens and Devine-Wright (2018) argue that the attitudes are different for people who live in proximity to a proposed project compared to those who live close to an existing project. In this line, the present study focuses on areas that already have implemented energy projects and explores the willingness of the local population to support and participate in future similar initiatives.

3 | THE CASE STUDIES AND THE FRAMEWORK

3.1 | Overview of the case studies

For the present study we tested a proposed framework in two real-life settings. As del Río and Burguillo (2008, p. 1317) put it: "Case studies allow the identification of economic and social relationships which are hidden in quantitative studies." In our study the use of two case studies allows us to capture the detailed social, environmental, and economic effects which will be otherwise difficult to capture.

The territorial dimension is the local level, and the indicators are evaluated on the island level. With the term community we refer to

the people who reside permanently within the island territory. The two islands chosen for this study are the island of El Hierro in the Canary Islands in Spain, and the island of Tilos, in Dodecanese in South-East Aegean Sea, in Greece. These islands are pioneers in the renewable energy transition with aspirations that could be considered as of going beyond simply renewable energy and touch upon social, economic, and environmental issues. Additionally, they are the two flagship projects of renewable energy innovation on Southern European islands that are currently in the implementation stage (Tsagkari, 2020). Although the boundaries of the island allow us to define the community and facilitate the research design a word of caution from Connell (2018, p. 2) is appropriate as "islands are far from synonymous with community; they involve diverse and contested interests and contain hierarchies, conflicts, tensions and resistance to 'outsiders,' both people and projects."

Tilos with a population of about 500 people is not interconnected with the mainland grid but belongs to the Kos-Kalymnos electricity system that relies on two thermal stations. To deal with the so-far dominant, oil-based energy model in the Aegean Sea, an innovative, local scale RES-based energy storage system was designed and implemented. The project consists of a wind turbine a photovoltaic park, $NaNiCl_2$ batteries for energy storage, energy management that extends to capture water-energy nexus aspects, and introduction also of clean electromobility elements. The project not only provides clean energy and electricity autonomy but according to Boulogiorgou and Ktenidis (2020, p. 399): "Tilos island offered as a natural living lab where are examined the sustainability and the interoperability of the energy solution." Other aspirations of the project include the creation of a sustainable tourism model locally, new employment opportunities, income generation, pro-environmental behavior and in-migration of young people to the island. In order to enhance a sustainable behavior among the local population several educational and training activities were organized at the initial stages of the project. An important component of the Tilos project is the design of a Demand Side Management and an intelligent Energy Management program that will manage the demand. However, the smart meters in the households are still at a very initial/pilot stage and for this reason are not included in the analysis.

Gorona del Viento is the flagship project of the El Hierro island, the smallest of the Canary Islands. Before the implementation of the project, the island relied on diesel consumption with elevated costs and emissions. Currently, a hydro-wind power plant that combines a wind farm along with a pumped-storage hydroelectric power station operates on the island. The Gorona del Viento project has a mixed ownership; the Local Government Council (Cabildo) a 60%, the private energy company Endesa (30%) and the regional government of the Canary Islands (10%). El Hierro has a strong sustainability profile (Garcia Latorre et al., 2019). A sustainability plan is designed since 1996, and the island was declared a Biosphere Reserve in 2000 making it worldwide known as the "Sustainable Island." This plan along with the Gorona del Viento project aim to make the island energy self-sufficient, support sustainable tourism, boost green growth, and protect the natural and cultural history of the island (del Viento, 2020). Similarly with the case of Tilos, environmental campaigns and trainings ensure that people are aware and informed.

3.2 | The framework

Inspired from previous research and the relevant literature gaps, discussed in Section 2, we designed an innovative framework to analyze people's perceptions on the success of the project post-implementation and their willingness to support future projects adapted to the island specific cases and oriented towards the project-specific goals. The framework is focused on the local sustainability impacts and does not include a measurement of global environmental, social, and economic effects. The survey questions reflect the five dimensions of sustainability namely economic, institutional, social, technical, and environmental (after Bhattacharyya, 2012; Ilskog, 2008). The use of indicators allows us to evaluate the progress towards specific initial and emerging goals. In order to choose the adequate indicators, we followed the criteria proposed by Shaaban and Scheffran (2017) and Ilskog (2008) presented in Table 1.

We organize the Factors under the main five sustainability Dimensions. In each Dimension there are several Factors, and each Factor is further characterized through a set of Indicators. Each Indicator is then associated with a question for the questionnaire (Appendix A). We used a Likert scale that ranged from 1 (strongly disagree) to 5 (strongly agree) for positive statements regarding the effect of the project on the indicator examined. The overall scores corresponding to each variable and each Dimension were then aggregated. As seen in Table 2 some Factors (economic and technical) have only one Indicator. This is because these Factors are easier to measure with one question, while others, like the social and institutional, are more complex and multidimensional. Thus, in order to avoid oversimplification, we chose multiple Indicators.

Multiple linear regression was conducted in Python 3.8.5 to test the relative importance of the variables on people's perceptions on the success of the project and their willingness to support and participate in future projects. Except from the indicators presented in Table 4, we also included Gender and Island as dummy variables, with "men" and "El Hierro" as reference categories, respectively.

3.3 | Economic dimension

The economic dimension measures the project's contribution to income-generating activities. The direct economic benefits are some of the more well-studied in the relevant literature (Allan et al., 2011; Slattery et al., 2011) and include reductions in the electricity bill and direct payments and/or compensations. The indirect economic benefits like job openings, and productive diversification of the area are more difficult to measure. In El Hierro there were no direct payments to the community due to the unified price system in the Spanish territory (see Tsagkari and Jusmet (2020). In the case of Tilos there was a small reduction in the electricity bill of the community that lead to economic savings. In our framework the economic dimension is expressed as "new economic opportunities" and is associated with the projects' ambition to boost the economy on the respective islands indirectly and mostly through tourist activities.

3.4 | Environmental dimension

The environmental dimension at the local level deals with the way the projects affect the environment directly, like the impact on the local environment and the land esthetics. Opposition to local energy projects due to the impact on land esthetics has led to cancelation and delays of projects worldwide. Although some impact of the renewable energy is unavoidable, a careful spatial design can minimize the visual and esthetic impacts. Beyond that, local renewable energy projects can have also indirect environmental impacts as they can encourage sustainable behaviors at personal and household level, reduce energy consumption and promote energy conservation (Gubbins, 2007; Rogers et al., 2008). Such behaviors can be included in the environmental dimension (Ilskog, 2008). Thus, in our study the environmental dimension consists of four items grouped under one factor: reliable energy, clean energy, energy savings, minimum impact on land esthetics, increased awareness about climate change, and awareness about renewable energy post-implementation.

TABLE 1 Selection criteria of indicators

Selection criteria	Description
Data availability	The possibility to collect data from surveys.
Consistency with objective	The ability to reflect the ambitions and expectations of the projects.
Independency	Indicators should not have an inclusion relationship at the same level.
Measurability	The indicators should be measurable.
Robust	The indicators shall be formulated clearly enough to be replicable in their application.
Comprehensive	The indicators need to cover all major aspects of sustainable development.
Simplicity	Ease of understanding by the local community.
Sensitivity	Capacity for allowing trend analysis.
Reliability	Unbiased and apt to capture both positive and negative issues.

Source: Adapted from Ilskog (2008) and Shaaban and Scheffran (2017).

3.5 | Institutional dimension

The institutional dimension refers to the organization issues of the project and the interactions between actors which shape the decision making and the power dynamics (Hoppe et al., 2015). The institutional sustainability is central for local projects, and it requires effective local governance structures which are also inclusive ensuring participation from all the members of the community (Katre & Tozzi, 2018). In our analysis we aim to capture this dimension with four indicators: active participation of the local population, active participation of the local government, effectiveness of the local government, and inclusion of different voices, grouped under the variable "organizational structure."

3.6 | Social

The social outcomes are less tangible and thus, more difficult to measure. Some of the social benefits observed in the literature include the increase of self-confidence and autarky of the population and their

TABLE 2 The framework with the dimensions, factors, indicators and the relevant project goals

Sustainability dimension	Factors	Indicators	Relevant project goals	Question number (Appendix A)
Economic	Economic benefits	New economic opportunities	Boost the economy on the islands	Q5
Social	Social cohesion	Sense of community	Energy independence, community building	Q6
	Sense of pride for the island	Sense of pride for the island		Q7
	Autonomy	Feeling less dependent from the mainland		Q8
Environmental	Environmental development	Energy savings	Provide the islands with clean and reliable energy with minimum environmental impact and create sustainable behaviors on the island.	Q9
		Clean energy		Q10
		Increased awareness about climate change		Q11
		Increased awareness about renewable energy		Q12
		Esthetics		Q13
Institutional	Organizational structure	Community involvement	Participation of the local inhabitants and the local authorities	Q14
		Inclusion		Q15
		Participation of local governance		Q16
		Effectiveness of local governance		Q16
Technical	System design	Appropriative system design to cover the local needs.	Innovative systems	Q30

level of engagement in other local initiatives, increased social cohesion, and immigration of young people to the area (Süsser & Kannen, 2017). Especially in the isolated environment of islands, the energy projects can help the community function and prosper without being dependent on energy imports from the mainland (Rae & Bradley, 2012). The social impacts are quite diverse making the creation of a single factor difficult. For this reason, the social dimension consists of three separate factors: "social cohesion," "autonomy," and "sense of pride."

3.7 | Technical

The technical dimension refers to specific technical issues, many of which are difficult to be captured from the local community or are interrelated with other dimensions (Ilskog, 2008). In our research we chose to refer to the system design (combination of hydro and wind energy for El Hierro and batteries and wind/solar energy for Tilos) and the satisfaction of the users with this design as the adequate solution to cover their electricity needs.

3.8 | Dependent variables

Two items measured respondents' satisfaction with the project: "Overall Project Assessment" and "Overall impact of the Project on Personal life" (Cronbach Alpha: .82). In order to measure people's view towards similar future projects we used two items, namely: "Support similar initiatives in the future" and "Participate in similar initiatives in the future" (Cronbach Alpha: .73).

4 | METHODOLOGY

4.1 | Data collection

The design of our survey is based on the methodology proposed by Oppenheim (1992). We developed the applied questionnaire in an interactive approach to assure its appropriateness and applicability (Preston, 2009). The first draft of the questionnaire was reviewed by experts and the changes considering wording, question order and clarity were incorporated in the second draft. The questionnaire was then translated into Greek and Spanish respectively from native experts, A pilot study was conducted in June 2019, when 22 questionnaires were collected in Tilos. Certain changes were incorporated after the pilot study leading to a third draft that was then reviewed again by experts.

The initial plan to conduct door to door surveys was not possible due to covid restrictions. Instead, the questionnaires were designed and disseminated online through the platform Survey Anyplace (Edegem, Antwerpen). Various local collaborators led the dissemination including municipalities and local newspapers. The surveys were also posted on social media. The online surveys took place between December 2020 and February 2021. In the case of Tilos where the is a big percentage of elderly population, in parallel with online questionnaires, hard copies were also collected with the support of the local municipality.

TABLE 3 Key characteristics of the survey respondents for El Hierro ($N = 145$) and Tilos ($N = 50$)

	N	
Variable	**El Hierro (%)**	**Tilos (%)**
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

In total, 145 questionnaires were collected from El Hierro and 50 from Tilos. For the small population of Tilos (<500 adult permanent residents) we calculated the sample size with the rule of the 10%, meaning we needed at least 30 responses. According to (Sovacool et al., 2018) a sample < 100 can be adequate for small population whose viewpoints are often excluded in the literature. For El Hierro, where the adult population is about 7000 people, we defined the sample size based on marginal error with confidence level of 95%. According to Data Star, "acceptable" margin of error used by survey researchers falls between 4% and 8% at the 95% confidence level. Thus, our sample of 145 is acceptable at the 95% confidence level with a margin error ± 8. The demographics of the sample are summarized in Table 3. Comparison with census data indicated that the sample is representative in terms of gender and education, however people above 55 yo are under-represented in our sample in both cases. We followed a random sampling technique, in order to avoid human bias in selecting samples but also because this technique requires minimal knowledge of the population compared to other methods (Acharya et al., 2013). Nonetheless, we acknowledge that a potential limitation associated with online surveys is that non-responses can lead to sample selection bias, as often those with a strong positive or negative opinion about the energy project are those who complete the questionnaire.

5 | RESULTS

We conducted a mixed ANOVA to compare the mean ratings of financial, technical, environmental, and institutional performance for El Hierro ($F(3, 576) = 28.07$, $p < .001$) and Tilos ($F(3,196) = 10.15357$,

p <.001). Post hoc comparisons using the Tukey HSD test (Figure 1) indicated that the mean score for the economic pillar for E Hierro is significantly lower than the environmental ($\Delta M = 0.789$, $p < .001$), the institutional ($\Delta M = 0.440$, $p < .001$), the social ($\Delta M = 0.903$, $p = .001$) and the technical ($\Delta M = 1.0828$, $p < .001$). The institutional pillar is significantly more successful than the social for El Hierro ($\Delta M = 0.463$, $p < .001$) and the environmental ($\Delta M = -0.3487$, $p < .05$). For Tilos the environmental dimension is found to be marginally less successful than the economic ($\Delta M = 0.3952$, $p < .05$) and the institutional ($\Delta M = 0.6404$, $p < .05$). Overall, the Tilos community rates the project on their island as more successful in all four of the pillars, compared to El Hierro. The aggregated scores of each project in each dimension of sustainability are presented Figure 2.

Confirmatory Factor Analysis (CFA) was used to examine the relationship between the institutional and environmental indicators and the factors that we assigned to them (Appendix B). In this way we examine if the observed items share a common cause. We set the threshold at 0.7 and all the factors scored higher (Appendix A). Finally, using variance inflation factors (VIFs) we confirmed that multicollinearity was not an issue (maximum VIF = 2.34, Appendix C).

The multiple regression analysis indicated that the institutional factors are positively related with people's perception on the success of the project and their interest to support and participate on future projects (Table 4). The feeling of pride about the island as a result of the project make people consider the project overall more successful. Perceived environmental impacts were very positively related with people's perceptions on the project success and had a significant impact on their interest to join

TABLE 4 The effects and (standard errors) for two models

	Project satisfaction	Future project
Intercept	0.9578 (0.622)	1.7389 (0.768)
Economic	0.1978 (0.1161)	0.0818 (0.1246)
Social cohesion	0.0464 (0.1250)	−0.0462 (0.1342)
Autonomy	−0.0065 (0.1407)	0.0496 (0.1235)
Sense of pride	0.2950 (0.1453)*	−0.0008 (0.1510)
Environmental	0.1767 (0.0445)**	0.1735 (0.0478)**
Institutional	0.2195 (0.1798)*	0.7177 (0.1931)**
Technical	0.4307 (0.1184)**	0.4046 (0.1271)*
Age	−0.1313 (0.0832)	0.0186 (0.0893)
Gender	−0.4062 (0.2166)	−0.5114 (0.2325)*
Island	0.4348 (0.2603)	−0.8949 (0.2795)*

*p < .05; **p < .001.

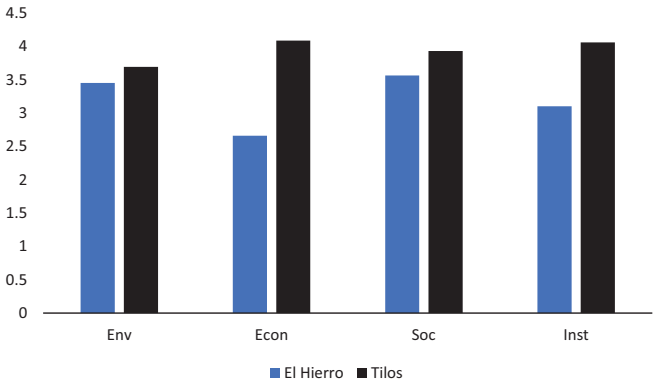

FIGURE 1 Tukey test results for El Hierro (left) and Tilos (right)

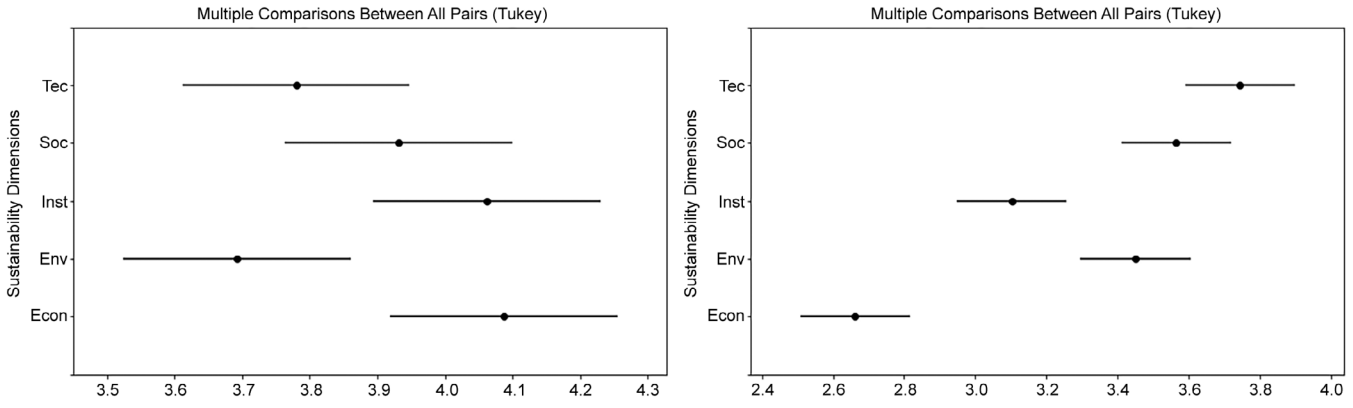

FIGURE 2 Aggregated scores of each dimension for each project

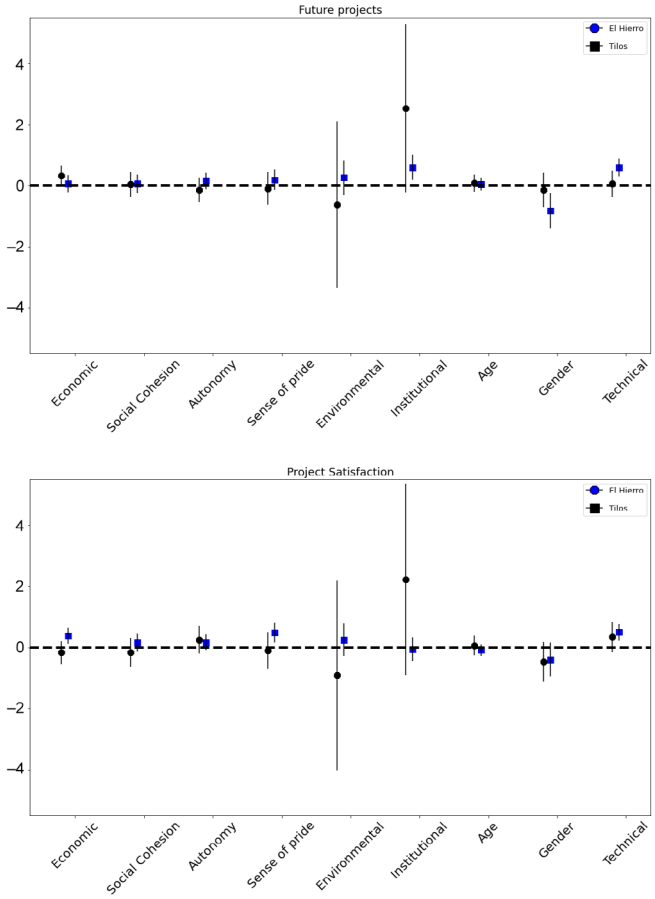

FIGURE 3 Effects of different factors on people's assessment of satisfaction with the project (A) and willingness to support and participate in future projects (B) for El Hierro and Tilos. On the vertical axis are independent variables and on the horizontal axis the size and the direction of the effect

and support future projects. Regarding the socio-economic factors, women seemed to be less interested to be involved in a future project. Age did not seem to play an important role during the pre-implementation phase. In Figure 3 we present the effects of the independent variables on the two models. In line with our research question, we chose not to present the intercepts and the island effect on the graph.

6 | DISCUSSION

In this paper, we proposed a comprehensive framework to assess local energy sustainability indicators. Instead of following a predetermined set of indicators, we designed a set of indicators with the focus on community perceptions and based on the goals of the projects. The framework considers the five main sustainability dimensions: economic, environmental, social, institutional, and technical.

The two projects examined on the present study are considered pioneers in the sustainability transition. However, as in many cases there is a lack of post-implementation assessment that can shed light on the actual early-stage success of the project, not only with regards to its initial targets, but also concerning the emerging expectation and new sets of goals. In the present study we examined how successful these two projects are in each of the sustainability dimensions. We concluded that overall, the projects are quite successful as they score > 2.5 in most of the dimensions.

In El Hierro, the economic dimension seemed to be the less successful. This is in line with our initial predictions as the direct economic benefits for the communities are minimal due to the policy design of the unified electricity price system in the Spanish territory (see Tsagkari and Jusmet (2020) for more details). On the contrary, in Tilos the economic benefits were ranked quite high, indicating that the reduction in the electricity bill although small is important. At the same time, El Hierro is bigger than Tilos, making the distribution of economic benefits more difficult. Regarding Tilos, the rest of sustainability dimensions outscored the environmental one, which might be explained by the presence of more radical views concerning the environmental impact of an even limited in footprint RES installation, and/or the fact of high awareness of the residents concerning the rich fauna and rare bird species present on the island. This aligns with the results of Stephanides et al. (2019) who also reported high levels of environmental concerns among the residents of Tilos, which nonetheless, did not translate into negative attitudes towards the renewable energy project.

Relevant literature has discussed that the economic impacts are often limited and less visible, (Munday et al., 2011; Terrapon-Pfaff et al., 2014), however this does not seem to affect people's perception regarding the success of the project. Despite the initial beliefs that economic motives are one of the main reasons why people support local renewable energy projects, more recent studies claim that financial considerations are not the only factors underpinning support (Jager, 2006; Korcaj et al., 2015; Sloot et al., 2019) and are often supplemented by environmental and social motives. According to Rogers et al. (2008) people do not have high expectations of direct economic benefits from local energy projects. Our research adds an extra layer to this discussion by assessing the factors that influence people's perception of a "successful project" post-implementation and during the early stages of operation. Economic benefits are not significant when people assess the project, while on the contrary the environmental benefits seem to play an important role. This resonates with the relevant research on sustainable behavior that defends the idea that environmental reasons can be more effective in promoting sustainable behavior than financial (Sloot et al., 2019).

The social aspects were examined separately due to their high heterogeneity that did not allow us to group them in one Factor. The social dimension scored high in both cases indicating that the organizational structure was perceived as successful. Sense of pride for the island, which is a result of the recognition and attention the islands gained from the project, were important factors for the assessment of the project as successful. In both cases, the projects served as a marketing strategy for the islands promoting sustainable tourism and attracting scientists and environmental conscious visitors. The relationship between a sense of pride and renewable energy projects is rather neglected in the relevant literature. Walker et al. (2010) briefly refer to the sense of pride as an important outcome of a renewable energy project according to the local population. This can explain the importance our participants gave to this sentiment as a significant factor that makes the project successful.

The institutional factors which are often excluded from similar research, were proven to influence positively people's perceived success of the project. The positive role of the local government and its ability to solve effectively disputes as well as the participation and inclusion of the public seem to make a project successful in the eyes of the community. This is in line with the relevant literature that has highlighted the important role of the local authorities in energy transition as well as the importance of community consultation and engagement in order to ensure the project's acceptance overtime (D'Souza & Yiridoe, 2014; Guan & Zepp, 2020; Hanley & Nevin, 1999; Hoppe et al., 2015; Kooij et al., 2018).Thus, our findings complement a growing body of literature that argues that more direct participation from local people and a stronger local government increases social acceptance and improves their experiences.

Technical factors seem to significantly influence people's perception satisfaction with the projects, as well as their willingness to support similar initiatives in the future. Indeed, it has been discussed that the use of adequate technology is an important factor when it comes to public acceptance of a renewable project as different types of technologies can also have different impacts (Bergmann et al., 2006; del Río & Burguillo, 2008) Bergmann et al., 2006; del Río and Burguillo (2008). In the case studies examined here the technical dimension scored quite high meaning that the technology chosen was seen as the best option to cover the needs of the islands. In line with Terrapon-Pfaff et al. (2014) we can also argue that in small scale and local projects, technology only cannot define the sustainability of a project.

Regarding the impact of gender in the willingness to participate in future projects our results are in line with the previous research of Stephanides et al. (2019) in Tilos, who also reported that men are more supportive towards RES than women and more likely to be involved. Observations from other countries (e.g., Fraune, 2015) report similar results. Gender-sensitive energy research is a rather new field that draws from the feminist literature and social sciences and studies the gender gap in citizen participation in renewable energy projects and how it is related with structures of power like the gender wealth gap. Further analysis is needed in this direction. This aspect further highlights the importance of socio-economic factors play in people's perceptions regarding local renewable energy projects.

7 | CONCLUSIONS AND POLICY IMPLICATIONS

The results of the present study can be used as a planning tool to guide local energy projects. By assessing people's perceptions on the success of energy projects we identified areas that can play a key role for the acceptance of future similar projects. In this way we provide a basis for actions that will satisfy these criteria. Firstly, instead of addressing only energy related needs social, economic and environmental issues should be considered. For instance, the sense of pride that we found to be an important factor for a successful project can be enhanced through successful management strategies, and promo campaigns. Additionally, practitioners can appeal to the environmental motives in order to ensure acceptance and the success of the project.

Another important aspect is the role of the local government and the inclusion of the local population. Building strong support among the community members and working closely with the local government can help practitioners design and operate successful projects. Providing quality information regarding the project and allowing the public to voice their concerns should be built through transparent processes and continue even after the design phase. Targeting women through specific empowerment and involvement campaigns and ensuring their participation can be an effective strategy to overcome the gender divide regarding the willingness to support and participate in future projects. Our results enhance the idea that project related factors can increase the acceptance of a renewable energy project pre- and post-implementation. These factors are complex and case specific and the project design should be adapted in the specific local context and the needs of the communities.

Local energy projects can produce real and important benefits for the communities and have tangible sustainability impacts, despite their

small size. In the present research the two projects are quite successful in the eyes of the local communities. To a large degree they managed to respond effectively to expectations and goals in a broader sustainability context, stressing the important role that local RES projects may play in small-scale remote island communities. People in both cases based their evaluations of the project mostly on environmental, social, and institutional factors while the economic benefits were not important. Along with the environmental benefits, factors like sense of pride for the island provide a way to influence the success of the projects. Based on that, we also identified a number of policy approaches that can improve the acceptability of future interventions.

The present study focuses on two small islands, which are "testbeds" for new technologies and "sustainability hubs." Their controlled environment allows for experimentation with new technologies that will then be transferred in other areas and scale-up. For this reason, the present analysis offers some useful insights on the impact of the projects on local sustainability issues that can improve the design of future similar initiatives.

In terms of methodological approach, the present study employed a novel framework to assess projects post-implementation considering the perceptions of the local communities and the aspirations of the projects. We acknowledge that our indicators cannot be generalized as they are project specific, however we encourage future research that will develop its individual set of indicators but within a common structure allowing for comparisons. The two projects examined here are still at an initial stage and continually evolving through time and our research captures the public opinion at a specific point of time. Longitude surveys will shed light on how people's perceptions might change over time as the projects mature and to highlight any actions for improvement of the projects.

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APPENDIX A

Questionnaire (translated in English)

Q1	What gender do you most identify with?	• Male • female • other
Q2	What is your age?	• 25–34 years old • 35–44 years old • 45–54 years old • 55–64 years old • 65–74 years old •75 years or older
Q3	What is the highest level of education you have completed?	• Primary education • Secondary education • Bachelor or Master's degree • Doctorate degree • No educational level • Other
Q4	What is your employment type?	• Full-time employment •Part-time employment •Unemployed •Retired •Student •Other
Q5	The project increased the economic opportunities you see for yourself on the island	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q6	The project brought you closer with other people on the village/island	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q7	The project made you feel less dependent on the mainland	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q8	The project made you feel proud for the island	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q9	The project motivated you to conserve energy	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q10	So far, the Hybrid Power Station is fully operational, producing local clean energy	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q11	After the completion of the project, I am more familiar with the topic of climate change	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q12	After the completion of the project, I am more familiar with the topic of renewable energy	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q13	The project did not affect the landscape esthetics	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q14	The community was actively involved in the project	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q15	I feel that my voice was heard and respected during the design and implementation of the project	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q16	The local government contributed to the project design and implementation	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q17	The role of the local government on the project was positive	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q18	The system design (combination of Wind, solar and batteries) is adequate and suitable for the island?	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q19	Considering the impact of the project on your personal life, I am	1 = Not satisfied at all,2,3,4,5 = Very satisfied
Q20	Taking into account all the information and your current knowledge, my overall evaluation of the project?	1 = Very Negative,2,3,4,5 = Very Positive
Q22	Knowing what I know now, I would you support similar projects in the future	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree
Q23	Knowing what I know now, I would you support similar projects in the future	1 = Strongly Disagree, 2, 3, 4, 5 = Strongly Agree

APPENDIX B

Confirmatory Factor Analysis Results (for Environmental and Institutional Dimensions).

Variables	Factor 1	Factor 2
Community involvement	1.01	
Participation of local government	0.70	
Effectiveness of local government	0.88	
Inclusion	1.099	
Awareness about climate change		0.81
Awareness about renewable energy sources		0.79
Energy savings		0.81
Esthetics		0.80
Clean energy		1.15

APPENDIX C

Variance inflation factor (VIF)

Const	33.85071
Econ	1.648397
Social cohesion	1.805292
Autonomy	1.979295
Sense of pride	1.994733
Technical	2.309763
Env	2.355711
Inst	2.229551
Gender	1.156952
Age	1.107552