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The Transition to Clean Energy: Are People Living in Island Communities Ready for Smart Grids and Demand Response?

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Abstract: Islands are widely recognised as ideal pilot sites that can spearhead the transition to clean energy and development towards a sustainable and healthy society. One of the assumptions underpinning this notion is that island communities are more ready to engage with smart grids (SGs) than people on the mainland. This is believed to be due to the high costs of energy on islands and the idea that the sense of community and collective action is stronger on islands than on the mainland. This paper presents findings from a survey conducted to assess people's perception of, and readiness to engage with, SG and demand response (DR) in the communities of three islands taking part in a H2020 project called REACT. The main objective of the survey, conducted in 2020, was to inform the recruitment of participants in the project, which is piloting different technologies required for SGs and DR with communities on the three islands. The results show that many island residents are motivated to take part in SG, to engage with energy saving, and are willing to change some energy-related behaviours in their homes. However, the results also indicate that levels of ownership of, and knowledge and familiarity with, the SG and DR related technologies are extremely low, suggesting that the expected uptake of DR in islands might not be as high as anticipated. This brings into question the readiness of island dwellers for the SG, their role in the deployment of such schemes more widely and the validity of the assumptions often made about island communities. This has significant implications for the design of SGs and DR solutions for islands, including devoting sufficient efforts to build knowledge and awareness of the SG, investing in demonstration projects for that purpose and tailoring interventions based on island communities' motivations.

Keywords: smart grids; demand response; island communities; social acceptance; technology readiness; sustainability; Spain; Italy; Ireland

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1. Introduction

In response to the global challenge of climate change, a green energy transition is needed, based on replacing fossil fuels with renewable energy sources [1,2]. These alternatives, which include wind power and solar photovoltaics (PV), generate intermittent energy. To be able to power electricity provision using renewables, smart energy networks known as smart grids (SG) coupled with demand response (DR) principles are key [3–5]. Achieving a SG entails the engagement of users in managing peak loads, whereby they have to change their electricity consumption patterns and shift their daily activities to when demand on the grid is lower [6]. It is envisaged that homes will become spaces where smart home energy management systems (HEMS) and other ICT-enabled technologies are deployed so that householders either manage their electricity consumption or give permission to third parties to do so on their behalf, and consequently plan their everyday activities accordingly.

Islands are widely recognised as ideal pilot sites which can spearhead the transition to clean energy through SGs and DR technologies that enable localised and renewable energy production and the optimised management of load on the network [7–9], to function as "laboratories for technological, social, environmental, economic and political innovation" [8].

One of the assumptions underpinning this notion is that people living in island communities are more ready to engage with SGs and DR than people on the mainland, mainly due to the higher costs of energy on islands [10,11]. In this regard, the SG can have financial benefits. The geographic characteristics of islands and the challenges related to the provision of electricity services from the mainland [12] make them ideal candidates for deployment from a technical point of view. Another reason is the perceived stronger sense of community among smaller populations on islands compared to mainland communities and neighbourhoods [11,13], suggesting that the typical social barriers attributed to reluctance of DR uptake will be weaker in the case of islands. This posits the question of whether island communities are more likely to adopt these technologies and adapt their lifestyles to provide flexibility through DR and SG technologies. Energy research that has pointed out the role of islands in testing the SG with various DR technologies [14–18] has not adequately considered societal challenges [19]. Meanwhile, policy assessments emphasise the importance of autonomy and energy sustainability for Europe's outer regions including islands, suggesting that public engagement and acceptance remain important challenges to overcome [20], thus maintaining the need for promotional and educational efforts.

The interest in developing SG in islands [8] and the increasing efforts in financing research and development projects for islands in Europe [21] raise an important question of whether island communities are ideally suited for such interventions. Studies have generally found that island residents' knowledge and attitudes towards renewable energy technologies or DR to be positive. Insights from a study on the uptake of solar photovoltaics in French island territories suggest that decisions to install such technologies may be driven by energy insularity (power cuts and comparatively expensive energy bills), though also complicated by other life-course events and a desire to maintain high quality energy services [22]. Where projects on energy management are successful, this also depends on island energy utility companies' efforts to maintain trust with the community, and building on this relationship to encourage participation in DR schemes [23]. Another element is knowledge and understanding of DR and flexibility, which are necessary for people to be motivated. In relation to islanders' knowledge of how DR technologies work and how intermittency can be managed, a distinction is made between formal technical knowledge and other forms of sensory or practical knowledge that can be effective in helping residents adapt to systems in order to offer flexibility to the grid [24].

These findings indicate similarities to mainland communities, where knowledge of the technologies and attitudes to RETs and energy consumption are important determinants for DR adoption. However, exploring the notion of islands as test beds for energy technologies, Skjølsvold et al. [13] noted that islands are often exoticized on a social level, perceived as being "distinct sociomaterial places with a particular form of topography, location in global value chains, and being associated with a form of social exoticism" (p. 7). As such, the presence of a sense of community and kinship is emphasised and presented as an advantage to the implementation of new energy technologies and innovations. However, in some cases, the history of economic and political dependence and peripherality of islands can be a hurdle for economic and sustainable development [25]. Other studies [26] have pointed out that island communities' close-knit nature offers a potential for community energy but also a challenge for gaining the trust and acceptance of sustainable-focused development interventions. These findings focus on what distinguishes island communities from mainland populations. This itself raises the question of what experiments in SG can tell us about their potential for wider deployment. However, existing and future investments in island communities for energy using smart solutions [8], as well as concerns for energy provision for islands [20,21], indicate that the readiness of island dwellers for SG and DR programmes remains an important question requiring further research.

As indicated above, a large number of research and innovation projects have and are focusing on piloting renewable energy technologies and smart energy grids on islands, including the demonstration of several SG technologies, storage and the introduction of renewable energy sources [21]. The research presented in this paper was conducted as part of one of these projects called REACT [27]. The REACT project is seeking to demonstrate the potential of renewable energy systems (RES) on geographical islands to bring economic benefits, decarbonise islands' energy systems, reduce greenhouse gas (GHG) emissions and improve environmental air quality. This is to be achieved by integrating existing and emerging technologies to create a cloud-based solution enabling a SG with the potential to support the energy autonomy of geographical islands, demonstrating the solution on three different islands with differing climate and market contexts, and developing plans for large-scale replication of the REACT solution on five follower islands. The REACT project pilot islands are La Graciosa (Spain), San Pietro (Italy) and the Aran Islands (Ireland). Within these islands, the REACT solution is being piloted in the following towns or population centres: Caleta del Sebo in La Graciosa, Carloforte in San Pietro and Inis Mór, one of the Aran Islands. This paper presents the findings of a survey conducted with a sample of the people living in these towns. An analysis of the survey responses from the survey participants is presented to show whether people living on these islands are motivated to engage in SGs and DR and how ready and willing they are to engage with DR principles and technologies in their homes.

Following this introduction, the remainder of this paper is split into five sections. To contextualise the research, Section 2 presents a discussion of what motivates people to take part in SG and DR programmes, and how the technologies people have in their homes impact on their readiness to do so. Section 3 discusses the methodology applied in the survey research presented. Section 4 presents the findings of the survey. Section 5 discusses whether the findings suggest that people living in island communities are ready to engage with SGs and DR. It then goes on to discuss what the findings suggest are the best strategies to encourage island communities to engage in SGs and DR, including considerations in relation to the design of SG and DR solutions intended for use by island communities. The final section of the paper draws some conclusions as to whether island communities are ready for the SG and the implications of this on broader plans and projects focusing on smart solutions intended for geographical islands.

2. Elements of Smart Grid Readiness: Technical, Economic and Social Considerations

2.1. Technical Requirements for Householder Readiness to Take Part in Smart Grids and Demand Response

When it comes to users and consumption, SGs entail the introduction of demand side management [28]. Traditionally, demand side interventions focused on behavioural change and improving the energy efficiency of appliances in the home, e.g., energy efficient light bulbs [29,30]. In the context of the SG, consumers are expected to engage through DR, which offers them a significant role in the delivery of flexibility by reducing or shifting their electricity usage during periods of stress or constraint [31].

Participation in SG-related DR programmes by household consumers has two key technical requirements. Firstly, households must have a smart meter installed to enable some form of dynamic pricing based on real-time or near real-time consumption patterns [32,33]. However, whilst these enable the implementation of dynamic pricing schemes, on their own they do not ensure significant improvements in demand-side activity [33]. As such, HEMS are a second key requirement if household electricity consumers are to participate actively in DR programmes [34]. Essentially, HEMS are a technology platform comprised of both hardware and software that allow the user to monitor energy usage and production and to manually control and/or automate the use of energy within a household [33]. In this regard, the integration of new ICT capabilities is instrumental in facilitating wider engagement with the SG to achieve various benefits [35].

This is particularly the case in the domestic sector, where automation and direct load control were found to be not only acceptable but also key in broadening engagement with DR programmes [36]. To enable automated DR across all electric loads, heating and cooling systems as well as wet appliances will have to be smart and electric vehicles will require smart charging and discharging [28]. Research has highlighted numerous technical barriers to DR in the domestic sector in relation to ICT [37]. These include the lack of the necessary SG infrastructure in many regions, the diversity of ICT devices on the consumer side from different market providers that follow different communication protocols, creating interoperability issues, as well as security risks and scalability challenges [38].

Research on blocks of buildings and their readiness for demand response has shown similar challenges and potential barriers, which would indicate the propensity to engage with implicit or explicit DR depends on the level of integration of various electricity loads via energy management systems [39]. Accordingly, the heating and cooling services in homes can have different impacts, such as whether they include a thermostat that can be programmed externally, or whether the householders themselves are accustomed to controlling or programming the heating and cooling systems in their homes [40–42]. Given that 64% of the residential sector's energy consumption is used for space heating (Eurostat available at: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190620-1 (accessed on 20 February 2020)), the types of heating and cooling systems that people have installed in their homes are also key to the level of flexibility they can offer the grid in terms of DR. In this context, the penetration of electric, as opposed to gas or wood powered heating, is an important consideration.

2.2. Motivation to Take Part in the Smart Grid and Demand Response

2.2.1. Economic Motivations

Lower energy costs are often cited as the main reason why people might engage with demand side interventions such as DR [43–46]. The expectation is that consumers in their homes will be incentivised through the implementation of time-of-use (TOU) tariffs that vary the cost of electricity throughout the day [40]. Earlier work on the SG has argued that the two main reasons why consumers adopt SG-related technologies are financial benefits and environmental motivations, with the majority expecting economic pay back, suggesting that environmental concerns are not sufficient on their own to affect adoption [47]. A survey of student motivations found similar trends, where the main motivation was to save money, followed by positive environmental benefits, such as reducing energy demand and supporting the integration of renewables into energy networks [48]. However, many factors influence the extent to which price signals can be effective, including the type of pricing mechanism used, climate zone and season, ownership of air-conditioning equipment, and household characteristics such as income [49]. For example, studies have shown that higher income households do not respond well to price signals alone [45]. The way an economic incentive is framed is also important, e.g., is the incentive to use the electricity from the battery communicated as payment or saving [50]. Whilst further research and analysis is needed to assess how well price signals work [51,52], it remains an important factor to consider when assessing the lowering of bills as a motivation for households when choosing to take up TOU tariffs as a way of managing their electricity demand.

2.2.2. Attitudes and Social Norms

Studies based on social norms have examined energy consumption and participation in DR as driven by pro-social motives [53]. Attitudes that pertain to the uptake of DR relate to environmental motivations for individuals and communities to reduce their carbon emissions and contribute to climate change mitigation. Studies have shown that environmental motivations have prompted people to change their energy demand [46,54] and develop new energy-related habits [54]. Studies focusing on personal attributes have identified motivations related to an interest in cutting edge technology [55], awareness of energy consumption and better quality feedback [46], as well as the desire to better control energy consumption [56,57]. Other pro-social motivations that have been highlighted include the ability of households to contribute to the reliability of the grid [58] and to improve their local community [59], as well as feeling empowered to manage and take responsibility as a citizen over their electricity consumption [60]. For example, in a study on the acceptance of TOU tariffs, the interest in national energy independence was a stronger factor than the expected economic benefits for individual households [61]. More broadly, how climate change is framed within national policy has been shown to impact on the likelihood for support and uptake of energy technologies including DR solutions [62].

Feedback technologies play a crucial role in developing awareness with regards to energy consumption, and the energy savings that could be achieved by using it [63]. Motivation to reduce energy consumption by allowing households to compare their consumption to other households in their neighbourhood or community, called comparative feedback, has been developed [64] based on research that works on activating social norms in individuals, i.e., how does an individual behaviour compare to others [65]. Several interventions in this field have utilized social media platforms to enable a comparison of ecological footprint and energy behaviour [66]. This work developed into dedicated online communities to promote energy-saving behaviour through public pledges and competition [67], whilst other research—focused on social media based applications—found that energy consumption reduced significantly through socially mediated incentives and competition [68]. In a similar vein, community-based projects that focused on comparative feedback found longer-term engagement with in home displays when it was coupled with weekly email-based newsletters and sustained communication [69]. In summary, research on energy consumption suggests economic, environmental and norm-activated motivations can all play a part in incentivising behavioural changes at the individual and household levels in relation to energy consumption. These have informed our survey questions pertaining to people's motivation in taking part in DR programmes and participating in the SG, to better understand the readiness of island households and communities for technologies such as the REACT solution, the results of which are presented in Section 4.

2.2.3. Knowledge and Familiarity with SG

Familiarity with the principles and technologies of DR and the SG is a frequently identified barrier to the uptake of TOU tariffs or active DR management across European electricity markets [70]. Familiarity is a key factor in increasing or decreasing social acceptance of technology [71]. In a study on the acceptance of smart meters in the USA, familiarity along with climate change risk perception were found to be the strongest predictors of smart meter acceptance [72]. Arguably, a lack of familiarity with DR is likely to lead to a lack of trust in the interventions of energy utility companies and further reluctance to take up other DR services [73]. Crucially, familiarity has a determining effect on uptake as well, which is very important when considering contexts where DR programmes and innovations are being introduced [74,75]. Li et al. [76] found that lower levels of reported familiarity with DR and SG concepts was correlated with less reported willingness to postpone the use of different appliances in the homes. As such, in the research reported in this paper, we consider familiarity with the concept of the SG and familiarity with the SG and DR related technologies to be an important factor when assessing the readiness of households for the SG.

2.3. Flexible Energy Demand

Considering the household level, the potential for flexible energy demand depends on the level of interest in smart appliances and devices [77,78], attitudes in relation to lifestyle [79] and anxiety over smart technology installation and use difficulty [80]. Earlier research found that in some cases, flexibility was related to the design of the heating system. For example, in homes fitted with insulated underfloor heating (that keeps the warmth for a longer time period), householders are more flexible in the timing of their energy demand [81]. In another example it was found that the inclusion of 'buffer' heating, such as fireplaces, made households happier to be flexible in their energy use, because they could save on their bills whilst enjoying the warmth and comfort in their homes [82]. Overall, earlier research found that householders were able to offer flexibility in relation to their use of several appliances. However, the level of flexibility depends on the appliance and the type of activity associated with it. Mostly, people are more willing to shift the use of their washing machines, dryers and dishwashers more than freezers, fridges and bathroom heaters [82]. Inflexibility is reported in the literature in relation to dining and cooking, where mealtimes and the hours of the day allocated to food preparation are the least flexible, and therefore the use of appliances for those purposes is not amenable to shifting [83]. To summarise, whilst heating flexibility is related to the type of heating equipment and level of insulation, in relation to the different everyday activities, those that pertain to cleaning, household care and laundry are generally more flexible than those pertaining to family life, such as mealtimes and social gatherings.

3. Methods

3.1. Survey Design and Distribution

Taking the literature discussed in the previous section into consideration, it was decided to conduct a survey as part of the REACT project to inform the recruitment of participants in the project, which is piloting different technologies required for SGs and DR with the communities on the three islands that are testing the REACT solution. The paper-based survey was adapted to the specific needs of the REACT project, from a survey conducted by Li et al. (2017). The surveys were distributed to the communities in the towns or population centres where the technology will be deployed as part of the REACT project. These are Caleta del Sebo in La Graciosa, Carloforte in San Pietro and Inis Mór, on one of the Aran Islands. In total, the survey questionnaire included 31 questions, including questions on demographic and household characteristics, home heating and cooling systems, knowledge of and familiarity with SG concepts and DR technologies and motivators for taking part in the SG and DR programmes (see Appendix A, Table A1). The data collected enabled the researchers to assess the communities' perception of, and readiness to engage with, SG-related technologies and DR in order to inform the recruitment strategy for the later stages of the REACT project. The surveys were distributed via schools, community meetings related to the REACT project and by going door to door in the case of Inis Mór.

3.1.1. Sample Size

In Inis Mór in the Aran Isles roughly 230 households are permanently occupied throughout the year. In total, 81 surveys were collected from households residing there during the winter months. Therefore, our sample is roughly 35% of the permanent residents on the island. The average number of households occupied in Caleta de Sebo on the island of La Graciosa can be conservatively estimated at 150 [84]. In total, 21 surveys were collected in Caleta de Sebo. Therefore, the sample is roughly 13% of the total number of households. In San Pietro on the island of Carloforte there are 2800 households. A total of 77 surveys were collected in San Pietro. Therefore, the sample size is approximately 3% of the total number of households (anecdotal evidence suggests that less people live in Carloforte than is officially indicated in the population census).

3.1.2. Sample Representativeness

To check the representativeness of our samples where possible, we compared the socio-demographic data from the survey to the available population demographics. If there are no data available at the local or regional level, the data from our sample were compered to data at the national level. As shown in Table 1, this comparison indicates that, on the whole, our samples do not differ too greatly from the wider populations to which they were compared.

Table 1. Comparison of survey demographic data with wider community regional and national demographic data in the three islands.

	Socio-Demographic Variable	Survey Results	Wider Community (Regional Level)
Inis Mór, Aran	Age	65% or older: 30% 55 to 64: 20% 45 to 54: 21% 35 to 44: 26% 25 to 34: 2% 18 to 24: 1%	65% or older: 25% 55 to 64: 15% 45 to 54: 18% 35 to 44: 20% 25 to 34: 13% 18 to 24: 8%
	Gender	64% Female; 36% Male	51% Female; 49% Male
	Education	Primary: 7% Lower secondary: 13% Leaving certificate: 23% Post-leaving cert.: 16% Third level: 41%	Primary: 7% Lower secondary:15% Leaving certificate: 24% Post-leaving cert.: 14% Third level: 40%
Carloforte, San Pietro	Age	65% or older: 22% 55 to 64: 19% 45 to 54: 30% 35 to 44: 16% 25 to 34: 13% 18 to 24: 0%	65% or older: 34% 55 to 64: 17% 45 to 54: 19% 35 to 44: 14% 25 to 34: 11% 18 to 24: 5%
	Gender	44% Female; 56% Male	50.9% Female; 49.1% Male
	Education	Primary: 0% Middle school: 5% Diploma: 56% University level: 39%	Primary: 0% Middle school: 28% Diploma: 29% University level: 43%
La Graciosa	Age	65% or older: 14% 55 to 64: 19% 45 to 54: 24% 35 to 44: 24% 25 to 34: 5% 18 to 24: 10%	65% or older: 21% 55 to 64: 11% 45 to 54: 24% 35 to 44: 20% 25 to 34: 15% 18 to 24: 9%
		Wider community (National level)	
	Gender	Female: 52%; Male: 48%	Female: 50%; Male: 50%
	Education	Secondary: 5% Diploma/vocational: 24% University level: 58%	Secondary: 28% Diploma: 27% University level: 45%

3.2. Data Analysis

Data from the collected surveys were entered into Microsoft® Excel. This spreadsheet is used for two purposes. Firstly, to check and revise the responses ensuring missing data and invalid responses were corrected, and secondly to conduct a comparative frequency analysis of the responses from each of the island communities. By conducting the comparative analysis of the responses from each of the islands, we were able to see if there were any noteworthy differences in the survey responses of the islands residents on each of the REACT pilot islands. This was key to enabling us to inform the recruitment strategy for the later stages of the REACT project on each of the pilot islands. It also enabled a consideration of whether our findings might be typical of island communities in general. Given their geographical location, the main differences in the island pertained to the heating and cooling systems installed in respondents' homes, with respondents on Inis Mór mostly using heating and Carloforte largely using cooling appliances. For most variables relating to the SG and DR perceptions and attitudes, the findings show that respondents from the three islands are not significantly different from each other. This enables us to consider the results as indicative of island communities in Europe more generally.

4. Results

In this paper, we present the results from survey responses on the three islands pertaining to respondents' motivations for taking part in DR and the SG, and their readiness to take part in that. To identify respondents' motivations, we asked questions about the impact of energy bills on household expenditure, the importance of saving energy and RET's to respondents and the different factors that might motivate them to take part in the SG. To address their readiness to take part in the SG, we asked questions about the technologies they have in their homes, the SG and DR technologies they would like to adopt, their familiarity with these technologies and how flexible they are willing to be across the use of different household appliances.

4.1. Motivations to Take Part in Demand Response and the Smart Grid

As discussed in Section 2.2, different factors can motivate people to take part in the SG and adopt DR technologies, including financial motivations (e.g., lower bills) and environmental concerns. To gauge how important energy costs are to the respondents, our survey asked what impact their energy bill has on their household budget. The answer categories were provided on a scale from "Very High" to "Very Low". As Figure 1 illustrates, in the case of all three islands, by far most respondents (71% in La Graciosa, 84% in Carloforte and 88% in Inis Mór) indicated that the impact of their energy bill on their monthly expenditure is very high, high or medium. Respondents were also asked to indicate the importance they gave to energy saving and for having RET technologies on their island, using a five-point scale (from "Very Important" to "Not important at all"). As can be seen in Figure 2, the majority of respondents on all three islands indicated a high level of interest in saving energy, with 85% in La Graciosa, 74% in Carloforte and 77% in Inis Mór believing that saving energy is very important. The percentages of respondents reporting that the use of RETs is very important is also high across the three islands, with 80% of respondents in La Graciosa, 71% of respondents in Carloforte and 63% of respondents in Inis Mór indicating that the use of RET is very important on their island (see Figure 2).

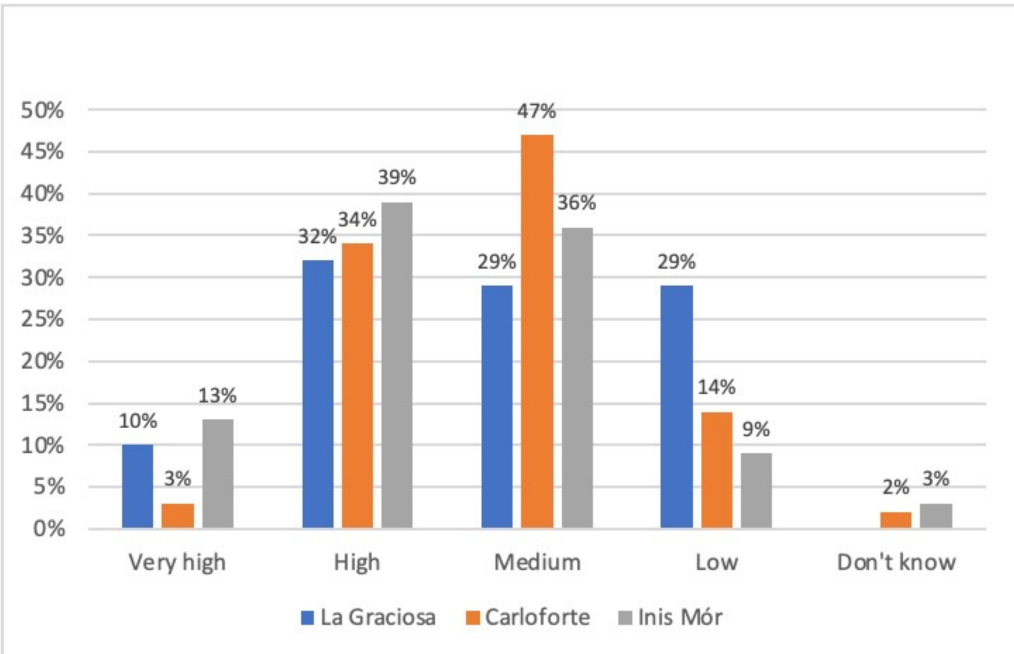


Figure 1. Impact of energy expenditure of households in the three islands.

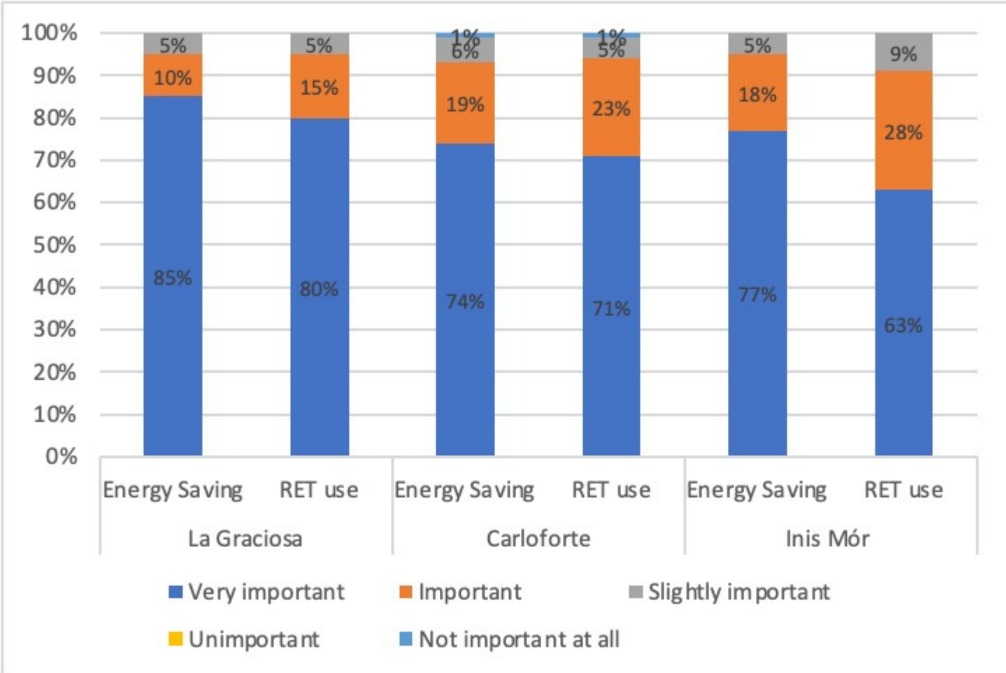


Figure 2. Importance of energy saving and RET use for households in the three islands.

In our survey, we asked respondents if the factors listed in Figure 3 would motivate them to accept SGs and use smart appliances. The answer categories provided were "Strongly motivating", "Motivating", "Slightly motivating", "Not motivating" and "I don't care." In terms of respondents' motivations to take part in the SG and DR programmes, our findings echo those of the earlier studies discussed in Section 2, which have found that people are motivated by economic and environmental concerns. By far, the majority of respondents from all three islands (88% in La Graciosa, 78% in Carloforte and 83% in Inis Mór) would be strongly motivated or motivated by a reduction in their energy bills to accept SGs and the use of smart appliances (see Figure 3). In relation to environmental and altruistic motivations, the results show that the majority of respondents (75% in La Graciosa, 65 % in Carloforte and 83% in Inis Mór) would be strongly motivated to accept SGs and the use of smart appliances to reduce CO_2 emissions (see Figure 3). As illustrated in Figure 3, giving your house a more sustainable character was also found to be strongly motivating or motivating by a majority of respondents (75% in La Graciosa, 70% in Carloforte and 52% in Inis Mór).

Interestingly, respondents were not as strongly motivated to accept SGs and the use of smart appliances by the prospect of sharing results on social media or comparing their household's energy consumption to other households as the literature in this field often assumes (see Figure 3). Only 15% of respondents in Carloforte and 17% of respondents in Inis Mór indicated that they would be strongly motivated by sharing results on social media to accept SGs and the use of smart appliances. The number of people motivated by this is slightly more encouraging in the case of La Graciosa, with 41% of respondents indicating that they would be strongly motivated by the prospect of sharing results on social media. However, this approach to motivating people to accept SGs and the use of smart appliances is unlikely to be successful in the other two islands, where the majority of respondents (59% in Carloforte and 64% in Inis Mór) did not care about sharing results on social media or are not motivated by this to adopt SGs and the use of smart appliances. The findings relating to the potential of motivating respondents by enabling them to compare their household's energy consumption to that of other households is also less encouraging than might be expected, with only 18% of respondents in Carloforte and 19% of respondents in Inis Mór indicating that they would be motivated by this to accept SGs and the use of smart appliances. Again, the number of respondents that would be motivated by this is slightly more encouraging in the case of La Graciosa, with 38% of respondents indicating that they would be strongly motivated to accept SGs and the use of smart appliances if this enabled them to compare their household's energy consumption to that of other households.

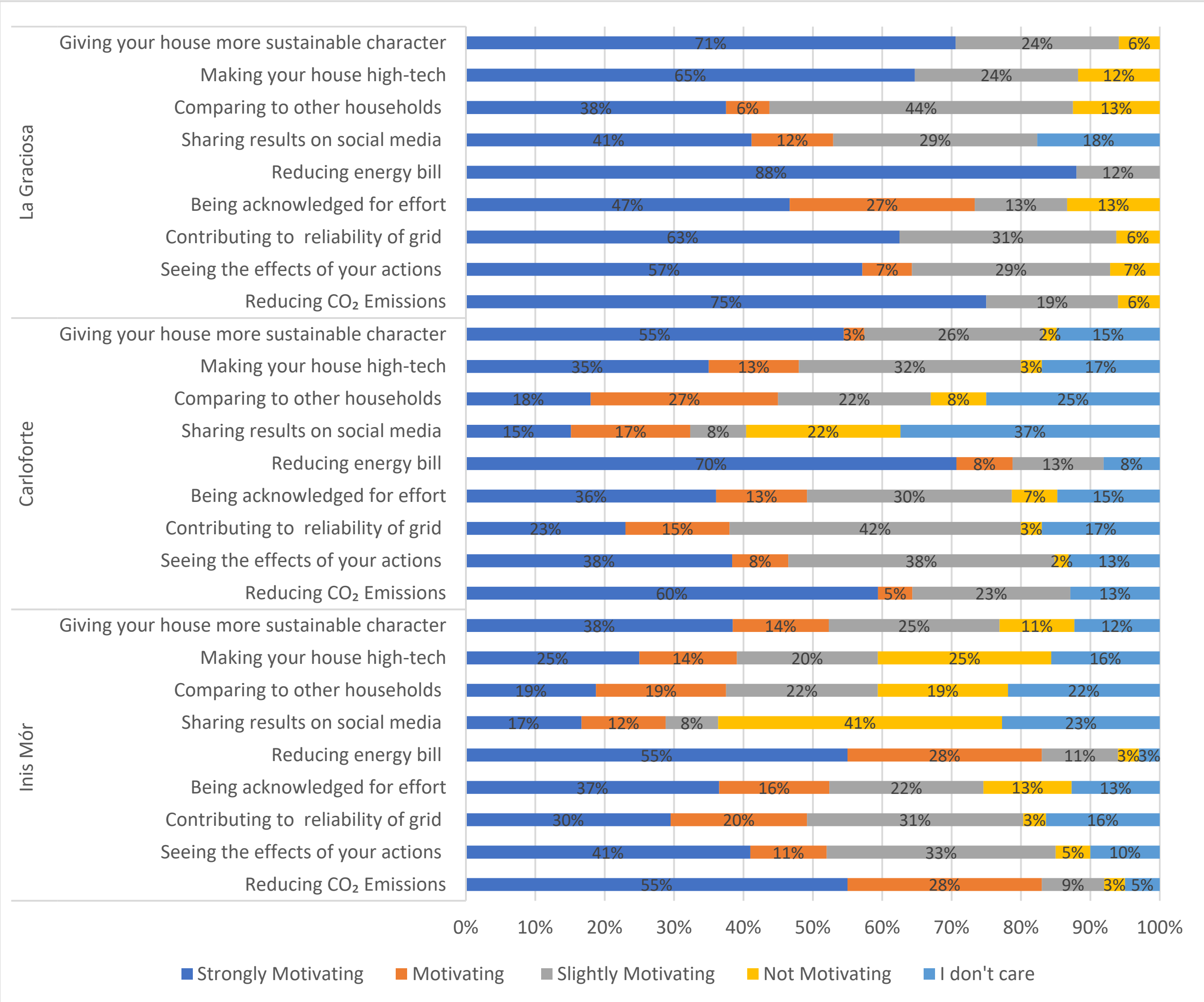


Figure 3. Motivating factors for the uptake of DR technologies.

The high percentages of respondents that perceive the impact of energy costs on household expenditure to be significant and the use of RETs to be important, combined with participants' high levels of interest in saving energy, are encouraging in terms of island residents' motivations to take part in the SG and DR programmes. Similarly encouraging are the high numbers of respondents reporting that they would be motivated by the potential of reducing their energy bills and lowering their CO_2 emissions to use the technologies required for DR. However, respondents' 'readiness' to take part in the SG and DR depends on the technologies they currently have in their homes, how they use them and whether they are prepared to adopt enabling technologies such as smart meters, HEMs and smart appliances. These issues were explored in our survey and the findings are presented in the following section.

4.2. Readiness to Take Part in Demand Response and the Smart Grid

This section presents the responses from the survey questions related to the respondent's existing heating and cooling systems, their current ownership of SG technologies and their willingness to adopt them, their familiarity with the SG concept and their knowledge and familiarity with the SG and DR technologies.

4.2.1. Household Heating and Cooling Systems

The existence of heating and cooling systems and their type (central or individual), as well as whether they use a thermostat, are good indicators of the likelihood for people to shift their heating/cooling or turn it off to offer flexibility. As discussed in Section 2, how people heat or cool their homes is key to the level of flexibility they can offer the grid in terms of DR. None of the respondents in Inis Mór use air-conditioning whilst homes in Carloforte use both heating and cooling to achieve thermal comfort. Unexpectedly, only four households in La Graciosa reported having cooling systems whilst only one household has a mobile heating unit. The results are summarised in Table 2.

Table 2. Heating and cooling systems of the respondents in the three islands.

	Heating			Cooling		
La Graciosa	*With Heating*	5%		*With Cooling*	20%	
	Central		–	Central		50%
	Individual		100%	Individual		25%
	Both types		–	Both types		25%
	Other		–	Other		–
Carloforte	*With Heating*	81%		*With Cooling*	67%	
	Central		11%	Central		85%
	Individual		74%	Individual		9%
	Both types		10%	Both types		2%
	Other		5%	Other		4%
Inis Mór	*With Heating*	100%		*With Cooling*	5%	
	Central		78%	Central		75%
	Individual		4%	Individual		25%
	Both types		6%	Both types		–
	Other		12%	Other		–

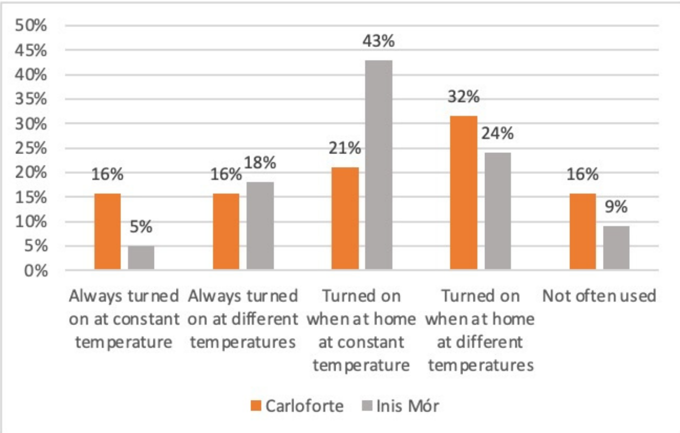
In La Graciosa, only 5% of households have individual heaters and only 20% of those surveyed had air-conditioning installed in their homes. Of those, half (50%) have a centralized cooling system, 25% have individual units and another 25% have both systems. Therefore, the findings of our survey in relation to the potential for DR control for thermal load is not encouraging in the case of La Graciosa.

For Carloforte, 81% of those surveyed have heating in their homes, split across central, individual or other types (biomass burners). The majority have individual heating units, with only 11% having a centralized heating system, indicating that a minority would have the option to include automated heating controls as part of the REACT solution in their homes. For cooling, 67% of respondents have air-conditioning, and of those, 85% have a central cooling system in their homes, whilst 9% have individual air-conditioning for separate rooms, 2% have both and 4% have other cooling devices such as fans.

In Inis Mór, all respondents have heating equipment installed in their home and none of them have air-conditioning equipment. The majority (78%) there have central heating, while 4% have only individual heating units and 6% from Inis Mór have both central and individual heating equipment. The individual heating units used by the respondents from Inis Mór are typically storage heaters, stoves or solid fuel heaters.

With respect to thermostats for heating, none of the households surveyed in La Graciosa had any thermostats since they did not have central heating. In Carloforte, only 41% of respondents reported having a thermostat for heating. Of those, 32% have the heating on when at home set at different temperatures and 21% have it set at a constant temperature. In Carloforte, 16% of respondents have the heating on all the time at a constant temperature whilst 16% have their heating at different temperatures for each room. The remaining 16% of respondents reported that they did not use the thermostat often.

In Inis Mór, 63% of respondents relied on thermostats to control their heating systems. Of those, the majority have the heating turned on when they are at home at a constant temperature (43%) or at different temperatures across the house (24%). The remainder have the heating always on, including 18% at different temperatures and only 6% at a constant temperature, whilst 9% reported not using heating often. Figure 4a compares heating control behaviours for Carloforte and Inis Mór. Overall, this shows that the majority do use the thermostats albeit in different ways. In this context, there is potential to consider having their heating controlled remotely if needed, due to their familiarity with controlling the temperature in their homes centrally. This is an encouraging indicator in terms of the familiarity with temperature or heating control remotely. However, the majority of the heating systems in Inis Mór are not electric and moving them to electric heat pumps would require significant investment, alongside related barriers to the electrification of heating [85].



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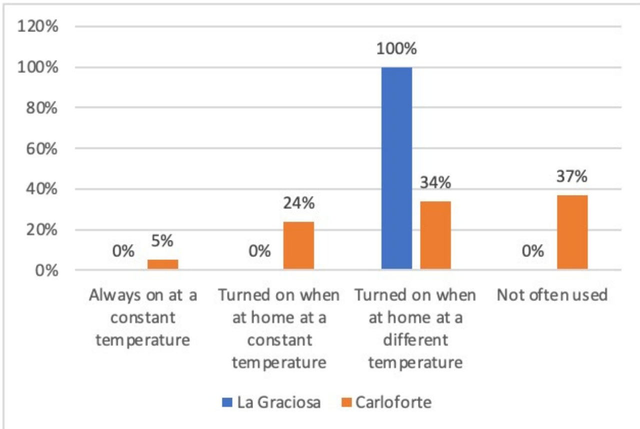


(b)

Figure 4. (**a**) Heating system use among respondents in Carloforte and Inis Mór islands; (**b**) Cooling system use among respondents in La Graciosa and Carloforte islands.

For the control of cooling systems, in La Graciosa, only four respondents reported having an air-conditioning system in their homes, and of those, three homes have a centralised cooling system. Further, 10% of the respondents have a thermostat that they use to turn on the cooling when at home, allowing for different temperatures for each room (see Figure 4). Therefore, in relation to heating and cooling, the potential of DR control is not encouraging. In Carloforte, only 5% of those surveyed have the cooling always on, 24% have the cooling on when they are at home at a constant temperature and 34% have it set at a different temperature. None of the respondents in Inis Mór have air-conditioning in their homes. Figure 4b compares cooling control behaviours of La Graciosa and Carloforte.

4.2.2. Familiarity with Smart Grids and Demand Response and Their Enabling Technologies

The survey asked respondents how familiar they are with the concept of the SG prior to being contacted by members of the REACT project team. The responses offered were 'Never heard of it', 'Heard a little but don't understand the concept', 'Heard a lot but don't understand the concept', 'Know a little about the concept' or 'Know a lot about the concept.' A large proportion of respondents from all three islands said that they had never heard of the concept of the SG prior to being contacted by the REACT project team or they had heard of it but didn't understand the concept (58% in La Graciosa, 80% in Carloforte and 74% in Inis Mór). Very few of the respondents (5% in La Graciosa, 3% in Carloforte and 8%

in Inis Mór) said they knew a lot about the concept of the SG prior to being contacted by the project team (see Figure 5).

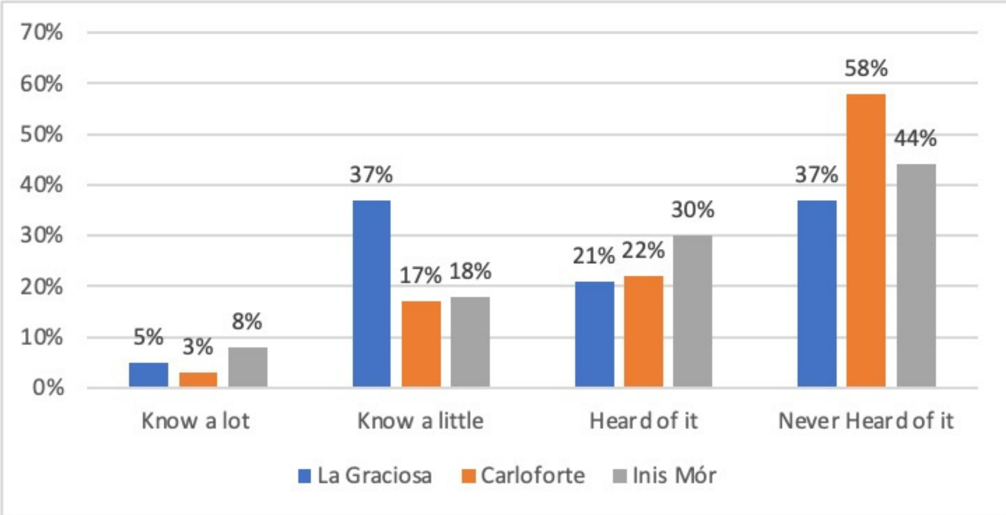


Figure 5. Familiarity of the three island residents with the Smart Grid concept.

Respondents were also asked how familiar they are with the different SG and DR enabling technologies listed in Figure 6. With regards to each of the technologies, they were asked to state whether they had 'Never heard of it', 'Heard of it but do not understand it', 'Know a little about it', 'Know a lot about it' or whether they own such technology. In La Graciosa, only 5% of research participants own a smart meter and only 5% know a lot about smart meters. In the case of Carloforte, only 1% have a smart meter and only 1% know a lot about them. In Inis Mór only 1 % have a smart meter and only 4% know a lot about them. In addition, many of the respondents had never heard of a smart meter (30% in La Graciosa, 65% in Carloforte and 49% in Inis Mór). Given that smart meters are a key enabling technology for engaging with the SG and DR, these figures are not encouraging. In the case of HEMs, the figures are no more encouraging, with no respondents in Carloforte owing a HEMs and only 1% of respondents from Inis Mór and 5% of respondents in La Graciosa owning a HEMs. Again, for in-home displays, the situation is similar, with no installations amongst the sample in La Graciosa and Carloforte, and only 10% in La Graciosa and 3% in Carloforte knowing a lot about them. In Inis Mór, only 1% have an in-home display and only 4% reported confident levels of knowledge and understanding of these technologies. This suggests that the existing level of knowledge and understanding of the concepts of SG or DR and the technologies and devices that would have to be installed or deployed in homes is limited. Therefore, concentrated efforts are needed to increase the awareness and familiarity of island residents with these technologies to ensure the success of any deployment plans for islands communities to be realised.

Overall, as illustrated in Figure 6, very few of the respondents from all three islands owned or had a significant knowledge of any of the SG and DR enabling technologies. The majority of the respondents reported that they have not heard of most of the SG and DR technologies included in the survey (see Figure 6). In Inis Mór and Carloforte, around half of the respondents reported never to have heard of the technologies with the exception of electric vehicles, solar photovoltaic panels and smart washing machines. Levels of familiarity are slightly higher in La Graciosa. Of note (see Figure 6), is the very small number of respondents that own one of the DR technologies or report to know a lot about them, especially in Carloforte and Inis Mór. In all three islands, the very low levels of knowledge and familiarity with smart meters, in-home displays and HEMs is concerning, given their importance as enabling technologies for DR and the SG [33].

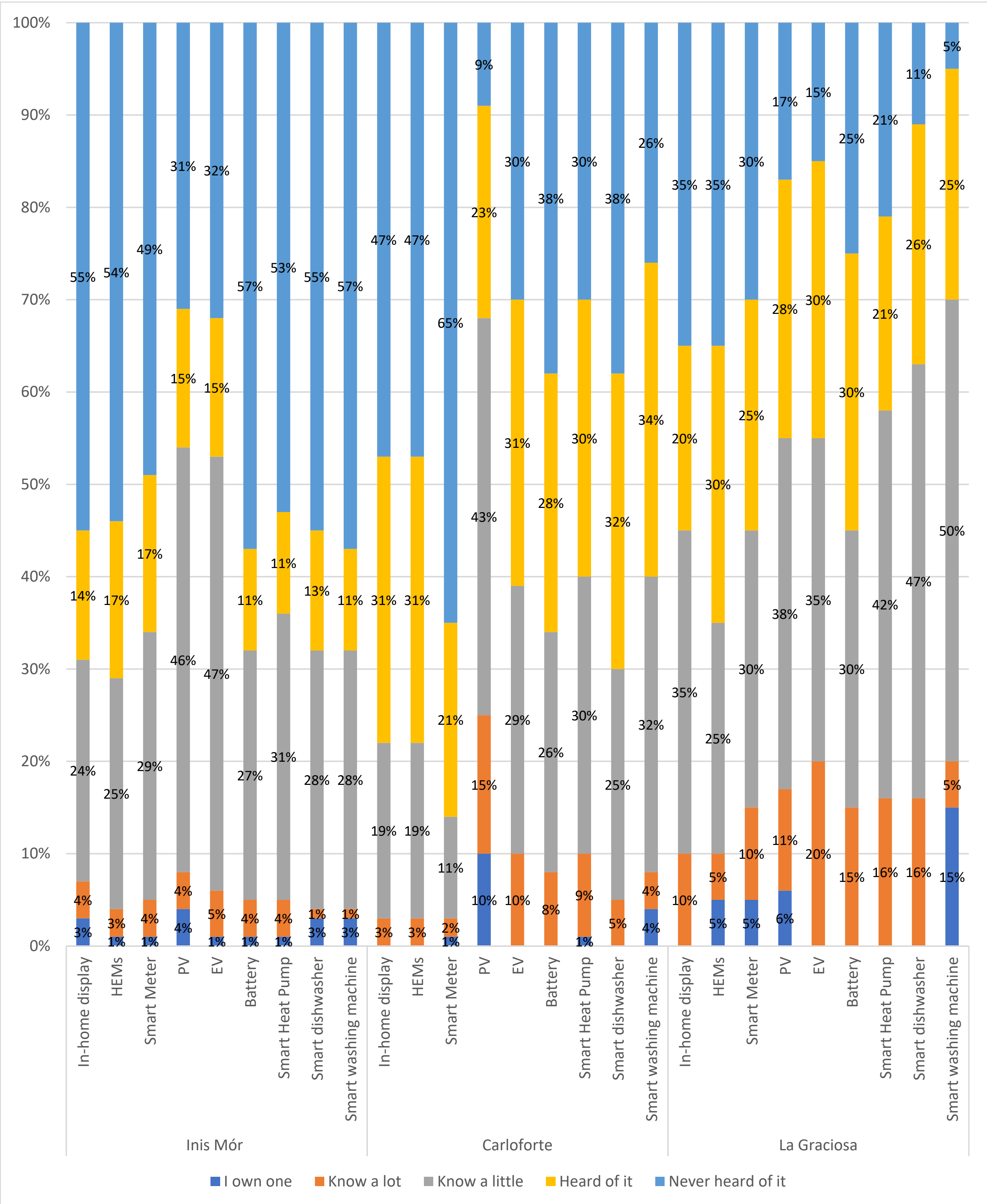


Figure 6. Familiarity of the three island residents with various Smart Grid technologies.

4.2.3. Respondents' Willingness to Adopt SG Enabling Technologies

Given the very low levels of ownership of SG and DR technologies reported by respondents, their willingness to adopt these technologies in the future is key to their engagement in the SG and DR in the future. Respondents were asked which of the different SG enabling technologies listed in Figure 6 they would like to use in their home. The results (see Figure 7) show that respondents in La Graciosa were the most positive about these technologies. However, even in La Graciosa, only 52% of respondents indicated that they would like to use a smart meter or HEMs in their homes, which as discussed in Section 2 are key enabling technologies for the SG. The lowest support for SG and DR enabling technologies comes from Carloforte, where respondents are the least willing of the respondents on the three islands surveyed to adopt such technologies. In Carloforte, only 14% of respondents said they would like to use a smart meter in their home, although a more encouraging percentage of respondents (39%) said they would like to use a HEMS. In Inis Mór, the percentages of respondents that indicated they would like to use SG enabling technologies is more encouraging overall than is the case for Carloforte, with 41% indicating that they would like to use a smart meter and 40% indicating they would like to use a HEMs. Overall, the results suggest a reluctance amongst a significant number of island residents when it comes to adopting or installing various SG and DR related technologies, such as heat pumps, EVs, smart metering or technologies that would allow the management of the energy loads in their homes, such as HEMs or in-home displays.

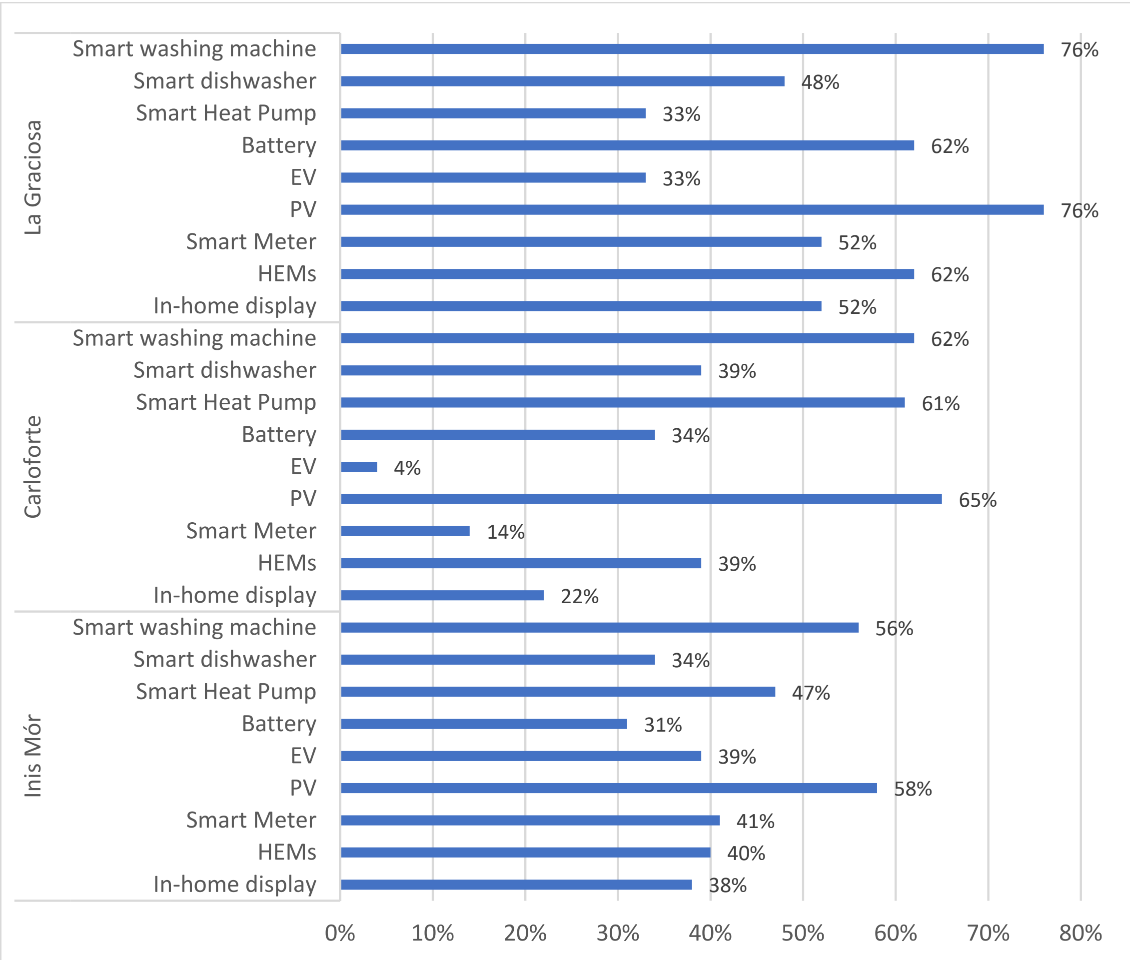
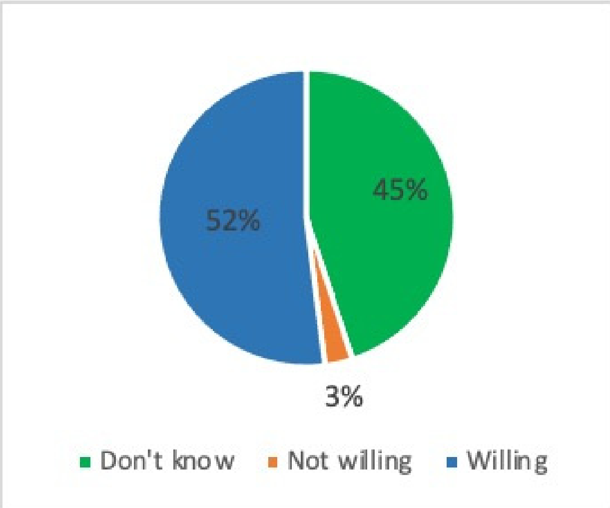


Figure 7. Willingness of island respondents to use SG enabling technologies.

4.2.4. Willingness to Invest in Smart and Renewable Energy Technologies

Given the low levels of ownership of SG and DR enabling technologies, the level of investment that respondents are willing to make to install RETs or SG-related technologies is important to consider. Respondents were asked how much they are willing to invest (as one-off investment) for installing RETs or smart energy control systems in their homes. The responses offered were "less than €99", "between €100 and €499", "between €500 and €999", "between €1000 and €4999", "€5000 or more", "I don't know" and "Not willing to invest". Figure 8a below shows that in Inis Mór, almost half (52%) of the respondents were willing to invest, with the majority (39%) preferring to pay between €1000 and €4999, followed by 25% who prefer to pay between €500 and €999 (Figure 8b).



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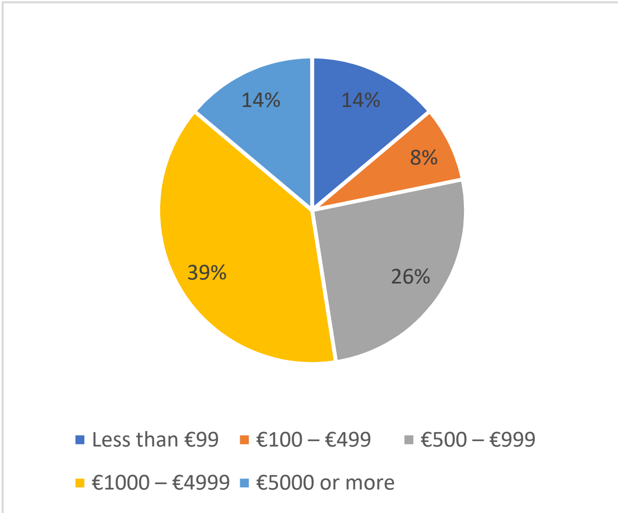
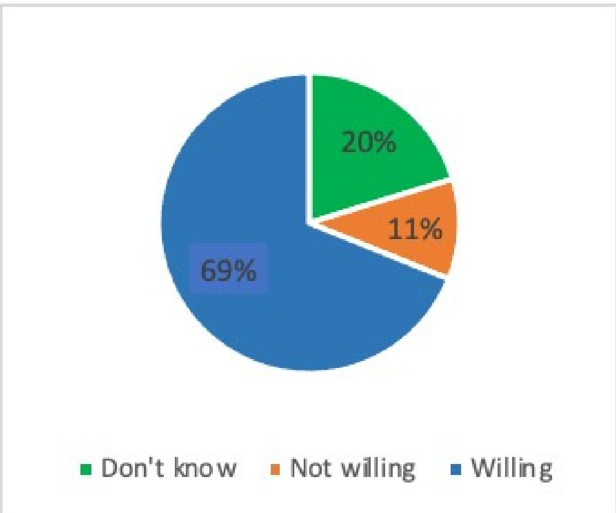


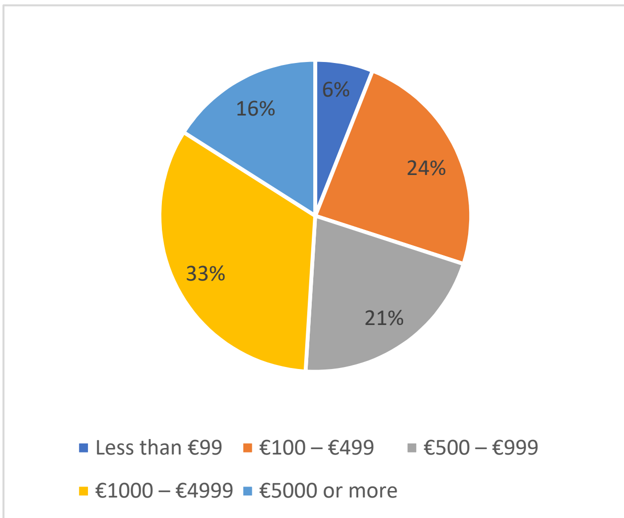
(b)

Figure 8. (**a**) Willingness to pay for SG technologies in Inis Mór, Aran Isles; (**b**) Range of payment respondents are willing to make in Inis Mór, Aran Isles.

Figure 9a, below, shows that in Carloforte the majority of the respondents were willing to invest (69%), with 33% preferring to pay between €1000 and €4999, followed by 24% who prefer to pay between €500 and €999 (Figure 9b).



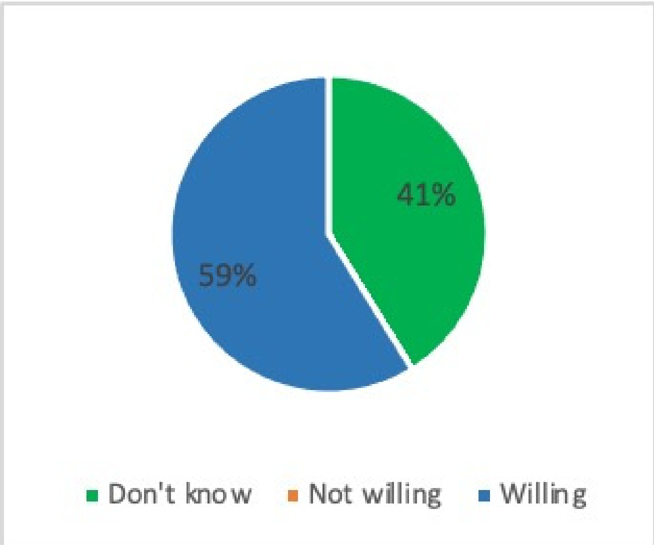
(a)



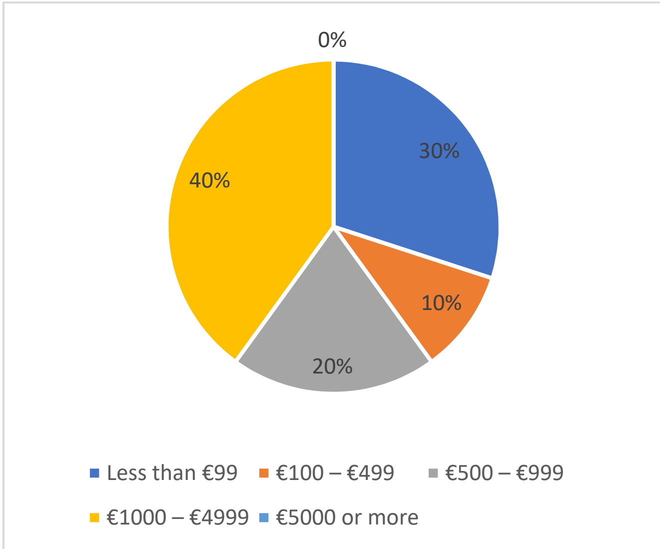
(b)

Figure 9. (**a**) Willingness to pay for SG technologies in Carloforte; (**b**) Range of payments respondents are willing to make in Carloforte.

In La Graciosa, as shown in Figure 10a, 59% will consider investing in SG technologies compared to 41% who do not know whether they are willing or not. Of these, 30% are willing to pay less than €99, 10% are willing to pay between €100 and €499, 20% are willing to pay between €500 and €999 and 40% are willing to pay between €1000 and €4999 (as shown in Figure 10b). The results suggest that more transparent communication is needed with respect to how much these technologies cost and what levels of investments and subsidies should be considered if more RET assets are desired. Therefore, for the majority of respondents, it can be seen that people are willing to invest in DR and RET technologies. However, a large proportion of the respondents in the three surveys were not willing to pay more than €500. This is important to consider when designing residential solutions, which should have realistic and feasible costs.



(**a**)



(**b**)

Figure 10. (**a**) Willingness to pay for SG technologies in La Graciosa; (**b**) Range of payment respondents are willing to make in La Graciosa.

5. Discussion

The survey results from the three islands are important for considering how ready and likely residents are in islands in Europe to participate in the SG and to adopt the various enabling technologies in their homes. Given the results discussed in Section 4, there is potential insofar as the respondents' motivations are concerned. The high importance of energy bills for households on islands and the high levels of reported willingness to save energy and adopt RETs are encouraging and correspond with the literature on islands as communities generally motivated to take part in sustainable energy transitions [9]. In this section, we discuss the results in comparison to findings from the literature exploring acceptance of TOU, DR and SG-related technologies, and knowledge and perceptions of the SG and smart appliances. Although the majority of these studies were conducted on mainland communities and households, we consider their findings relevant to our results, highlighting the salient issues that should be considered in assessing the readiness of island communities for the SG and when implementing DR and SG-related interventions in islands.

The cost of energy is argued to be a key motivator for the uptake of new and innovative energy technologies for the home and many argue that financial incentives are the most important motivators for people to change their behaviour, and respond to DR programming and flexibility requirements [40,86]. This is also evident in our results, showing that environmental motivations are also important for respondents, corresponding with findings on residents in general in relation to non-economic factors increasingly reported in the literature as a determinant in people's motivation for DR uptake [46,87]. However, previous studies on TOU have also highlighted the limitations of economic motivations alone [44,45], especially for higher income groups or those that do not use electricity for space heating and cooling [88]. Equity and fairness concerns were also raised in earlier research [89], particularly in relation to low-income groups and price rises where households do not have the means to respond to mechanisms such as TOU, e.g., not having a thermostat to control temperature settings [89]. Whilst wealthier households are able to invest in energy saving solutions for their homes [90], the transition to greener and smarter homes risks driving poorer households into further poverty and exclusion. Accordingly, DR implementation should only follow sufficient investment in energy efficiency for lower-income homes and maintaining the voluntary contracting based of TOU. Importantly, the context within which DR interventions are made, i.e., the household appliances and equipment and the extent to which homes on the island require investment, should also be considered. In this regard, the readiness of the three islands with respect to the SG should carefully consider how far can the economic motivations of the islanders be effective in incentivising them to respond positively to DR requests. Importantly, equity and justice considerations should be taken into account to ensure energy transitions for island communities are just.

As mentioned earlier, familiarity and knowledge with the principles and technologies of SG and DR is imperative for participation in and adoption of such systems [70,73]. However, our survey found that many people living on the REACT pilot islands have little or no understanding of the smart grid and the technologies required to interact with it, with very small proportions of respondents reporting any familiarity or experience of using it. This is reflected in their lack of willingness to install most of the DR technologies in their homes, particularly the enabling technologies, as they do not know enough about how these technologies work or how they might impact their everyday life. We note that smart meters, in-home displays and HEMs for households that wish to participate in DR are the necessary infrastructure that is required, and therefore the reluctance of individual households to install these technologies in their homes suggests that island communities may not be as ready to lead in sustainable energy transitions as has been argued in the literature. This low level of readiness is also reflected in the limited penetration of controllable heating and cooling equipment in the homes of the respondents in our survey and the challenges associated with transforming the domestic sector towards electric heating such as heat pumps [85]. Even though the respondents' reported behaviours for saving and thermostat use are encouraging, the limited proportion of households with programmable thermostats suggests a low level of technological readiness.

A further barrier to readiness to engage in the SG and DR that emerges from our survey results is that respondents are generally not motivated by mechanisms that activate social norms related to energy consumption [65], such as comparing their energy performance to others or using social media platforms to motivate and compete, in order to reduce or change their electricity consumption. In this regard, whilst the community aspect of islands relative to social cohesion [25] should not be ignored, relying on competition and comparison as a driver for engagement will have limited traction with islanders. Therefore, although islands possess characteristics that can make them ideal testbeds for new the SG, efforts should focus on how DR and SG interventions are designed, and caution should be taken when making assumptions of what can motivate householders to adopt new technologies in their homes and to adapt their lifestyles to accommodate the requirements of the SG and localised renewable energy generation.

Finally, a further barrier to consider regarding readiness for the SG and DR would be people's everyday lifestyles and practices, and how far these interventions can succeed in changing people's energy consumption patterns and behaviours. Studies on energy consumption informed by perspectives from the social sciences have shown that, in general, people do not often think about or calculate how much electricity they use until they see their energy bill [91], as people use their electrical appliances to conduct normal everyday activities, including cooking and eating, leisure, as well as convenience and cleanliness [92,93]. As such, electricity consumption is largely inconspicuousness, and different energy consuming behaviours become habitual [94]. In contrast, energy related practices are expected to change—in their timing as well as in their constituent elements (the different technologies and artefacts that shape them)—if the SG and the uptake of associated DR technologies is to be achieved. Further challenges related to the uptake of DR include the nature of some everyday practices. An examination of user experiences with DR has shown where many of those activities can be inflexible [95,96]. In this way, participating in the smart grid can be perceived as an inconvenience, particularly when the economic incentives are unable to overcome these issues [97]. A family's convenience is dependent on schedules and the simultaneous timing of different events and activities that include using different appliances. Family structures influence uptake, where single-person households and childless couples are more flexible than families with children or pets [82,98,99]. For families with children, the morning routine would be too busy a time to insert those activities into [82]. Therefore, designer expectations on how much flexibility can be obtained from users in DR interventions such as REACT should take into consideration barriers that pertain to normal everyday practices, and the extent of shifting action and flexibility is therefore bounded by household variables. Hence the type of households that are most suited to interventions like REACT could be further limited. Therefore, providing householders with the option of opting out of certain DR requests during certain hours of the day or over different times of the year will help circumvent those difficulties and encourage householders to participate in DR programmes.

To build on the economic and environmental motivations emerging from the analysis, efforts are needed to improve knowledge and understanding of the technologies of the SG and the implications these have on people's homes, their everyday lives and communities. The current low levels of adoption of DR and SG technologies forces us to think about the different barriers for the diffusion of innovation in societies, from becoming aware of an innovation, deciding whether to accept or reject it, to adopting and using it [100,101]. From this perspective, users who adopt an innovation before others are considered "early adopters", who as individuals might be more open to change and "earlier in adopting new ideas than other members of a system" [100] (p. 267). These individuals are typically younger in age, enjoy a higher social status, and are more educated. As such, they can see the benefits of adopting new technologies earlier than others. Similarly, in a study on the likelihood of accepting sustainable energy technologies, Stephanides et al. [9] found that the group more supportive of change were male, knowledgeable and concerned about the environment. This in turn suggests that to instigate the diffusion of DR technologies and the SG, efforts should aim at increasing knowledge about these technologies in island communities. This is especially important given the overall low familiarity reported from the survey results.

The implications for DR technologies such as the REACT solution are discussed on the basis of five factors, as developed by Garling and Thogersen [102], namely relative advantage, compatibility with existing context, complexity, trialability and observability. Relative advantage pertains to how much is an innovation perceived to be better than existing ideas or solutions. Compatibility concerns the innovations is suitable and fitting with the lifestyle, needs, values and experiences of potential users. Complexity refers to how relatively difficult or challenging to understand or use the innovation is, whereas trialability refers to how easy it is to demonstrate or experiment with the innovation. Finally, observability pertains to how visible the outcome of the innovation would be to potential users. The relevance of these implication to DR technologies and the case of the REACT solution is outlined in Table 3.

Table 3. Dimensions of technology adoption for the REACT solution.

Dimension for Adoption	Dimension of Adoption for the REACT Solution
Relative advantage	The advantages of DR are well known; however, knowledge of the principles and technologies of SG is low overall.
Compatibility	Previous research indicates that the flexibility that SG requires might not be easy to implement. The reluctance of respondents for adopting SG technologies suggests that perceived compatibility is low.
Complexity	The low levels of understanding of SG concepts and technologies is likely to be a result of the complexity of the concept and its application.
Trialability	The possibility to trial the REACT solution is an advantage here, particularly given the high costs if the REACT solution was to be available in an open market.
Observability	Financial benefits to households can be observed via lower electricity bills. The wider outcomes of SG technologies are not directly visible as these pertain to efficiencies to the grid, lower CO_2 emissions and lower costs for the islands.

The findings from our survey show the limited knowledge that residents in the three islands have of DR concepts and the SG. As such, demonstrations and trials are necessary for engaging communities with energy demand management, including DR and other technologies of the SG. In this context, the ability to trial DR projects like REACT can be an advantage. However, the complexity involved in the operation of various technological components and in being able to understand the principles underpinning the SG is a challenge. Direct lower electricity bills might be an observable outcome of the REACT project, which is advantageous. However, the inability to observe wider effects on the island will mean that other non-economic and community benefits can lose their significance. Therefore, to increase the observability of REACT and make it more visible in the communities, the demonstration of its solutions in community and public buildings should be an opportunity to showcase the benefits to the island residents. In turn, these will have to be communicated effectively to members of the community and households, using local networks that are trusted and that are embedded in the respective communities. As examples from other energy projects have shown, partnering with local community organisations and institutions [103], as well as engaging with the islanders with transparency in order to build trust [23] are crucial for the success of interventions for DR. Earlier research has also shown that if the designers of technologies intended to reduce or shift energy consumption are not sensitive to how people live and work in buildings, a gap occurs between the expected and actual performance of those technologies [104,105]. Therefore, it is essential to the success of SG interventions on islands that they are designed in ways which are sensitive to island residents' expectations.

6. Conclusions

In this paper, we introduced the H2020 REACT project that is being piloted in the three European islands: La Graciosa, Carloforte and Inis Mór. We outlined the main objectives of the project and presented the findings from a survey we conducted with a sample of households on the three islands. Conducting the survey presented us with a unique opportunity to assess the readiness levels for the SG among island dwellers and to measure familiarity and knowledge of the SG concept and DR technologies among island dwellers by employing a quantitative approach. Our results show that high levels of economic and environmental motivation and a willingness to change electricity consuming behaviours indicate households in those communities are ready to participate in the SG and adopt DR technologies. However, other variables suggest that more efforts are needed to succeed in engaging with communities with technological solutions such as REACT. Insofar as people's experience and familiarity with DR technologies is concerned and their lack of familiarity with the concept of the SG, coupled with the very low levels of current adoption of such technologies, these island communities might not be as receptive as expected.

This has implications for the design and development of interventions in DR and the future of smart grids. Firstly, more effort should be devoted to building awareness and knowledge of the SG by effectively utilising local networks and partnering with community-based organisations and, where possible, to demonstrate these technologies in community buildings. The design of the user interface should also take into consideration the different factors that motivate people to take part in DR programmes. For example, tailoring interventions based on people's stated preferences and motivations based on conducting consumer surveys will improve the roll-out of these solutions. Finally, the ability to opt-out of DR requests should be a built-in feature of any DR intervention to overcome the reticence of households who are concerned about how shifting their consumption patterns might affect their routines and the smooth running of their homes. Considering the processes required for the successful diffusion of innovation [102], the demonstration of technological interventions such as REACT represents a crucial phase in their development. Sufficient attention to make these projects effective models of innovation and engagement is therefore imperative to success in transitioning islands to greener and more sustainable futures. Our study indicates that the readiness of island dwellers for the SG should not be assumed, while careful social indicators in relation to knowledge, familiarity and motivations should be assessed when planning smart solutions for islands.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the questionnaire study.

Data Availability Statement: Not applicable.

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Appendix A

The survey questions are described in Table A1 below. The questions on energy attitudes, familiarity with SG and DR technologies and motivating factors were adapted from the work of Li et al. [76]. Questions on demographics, households, building characteristics, heating and cooling technologies and behaviours, as well as willingness to invest in RET and SG enabling technologies were developed by the authors.

Table A1. Questions in the survey.

Aspects	Survey Questions
Demographic, household and building characteristics	Age; gender; household size; age of household members; education level (primary, secondary, technical training/education, university, postgraduate); employment (student, part-time work, full-time work, self-employed, unemployed, retired); type of dwelling (detached, semi-detached, row house, apartment in building, shared house); number of bedrooms.
Energy consumption and impact on household	impact of energy bill on household budget (very high impact, high impact, medium impact, low impact, no impact, Don't know), average household energy bill (€50 or less, €50–€100, €100–€150, €150–€200, €200 or more, I don't know), heating and air-conditioning systems: type (central, individual units, both, Don't know); rooms heated; method of use (always on at constant temperature, always on at varied temperatures, turned on when someone is at home at constant temperature, turned on only when someone is at home in varied temperatures, Not often used); thermostat availability).
Energy attitudes	Importance of energy saving (very important, important, slightly important, not important, not important at all); having RETs (very important, important, slightly important, not important, not important at all)
Familiarity with SG and DR	How familiar are you with the SG concept before contact by REACT? (never heard of it, heard a little of it but don't understand the concept, heard a lot of it but don't understand the concept, know a little about the concept, know a lot about the concept); How familiar are you with the following SG technologies and appliances? (smart washing machine, smart tumble dryer, smart dishwasher, smart refrigerator/freezer, smart heat pump, hot water storage tank with smart charging and discharging, battery with smart charging and discharging, electric vehicle, pv, micro co-generation (micro combined heat and power), smart meter, home energy management system, home energy display. Possible answers: never heard of it, heard of it but do not understand the concept, know a little about the concept, know a lot about the concept, I own one.
Willingness to adopt SG technologies	Which of the following would you like to use in your house? Smart washing machine, smart tumble dryer, smart dishwasher, smart refrigerator/freezer, smart heat pump, hot water storage tank with smart charging and discharging, battery with smart charging and discharging, electric vehicle, pv, micro co-generation (micro combined heat and power), smart meter, home energy management system, home energy display
Motivating factors	Which of the following measures can motivate you to accept smart grids and use smart appliances?—Giving your house a more sustainable character, making your house high-tech, comparing your energy consumption to other households, sharing your results on social media, reducing your energy bill, contributing to the reliability of the grid, receiving acknowledgement for efforts, seeing the effects of your actions, reducing your CO_2 levels—(strongly motivating, motivating, slightly motivating, not motivating, I don't care).
Willingness to pay for SG technologies	How much would you be willing to invest for installing RETs or SG enabling technologies?—(€99 or less, €100–€499, €500–€999, €1000–€4999, €5000 or more, Don't know, I'm not willing to invest any money)

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