

The social perspective on island energy transitions: Evidence from the Aegean archipelago*

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Abstract

Multiple (inter)national networks and research consortia attempt to capitalise on their emerging experience of integrated smart and green energy solutions by contributing towards the sustainable energy transition of non-interconnected island communities. However, past research at an international level suggests that local opposition might undermine otherwise promising transition plans. In order to minimise the problems of technological transfers, it is, thus, imperative to embark on an early-stage exploration of public attitudes towards such innovations. In light, however, of the routine exclusion of social issues in island energy studies, we present timely data from the first-ever questionnaire survey conducted across the islands of the Aegean Sea. In doing so, we uncover the widespread acceptability of green energy solutions developed as part of the internationally acclaimed TILOS (“Technology Innovation for the Local Scale, Optimum Integration of Battery Energy Storage”) Horizon 2020 project. Simultaneously, though, we draw on the outputs of our unique end-user segmentation analyses and argue that only certain islanders are likely to accept the full replication of the TILOS energy model in their communities. Numerous personal/demographic factors influence the likelihood of accepting specific sustainable energy technologies and, subsequently, only a group of individuals who are young, male, knowledgeable and concerned about the environment are expected to support the proposed technological transition. In turn, we argue that these findings should inform future interventions and research with the ultimate aim of supporting efforts to “green” the Aegean archipelago and other non-interconnected islands at an international level.

Keywords: *public attitude; social acceptance; smart grids; renewable energy; islands; TILOS*

Highlights

- Islanders are, in principle, supportive of a sustainable energy transition.
- Solutions necessitating active acceptance are only supported by 21.6% of islanders.
- Personal/demographic factors influence attitudes towards island energy transitions.
- Three distinct energy-user typologies implicated in island energy transitions.
- Green prosumers are typically male, young and concerned about the environment.

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1 Introduction

While renewable and smart grid technologies have existed for decades, they have gained increasing attention over the last years, with multiple (inter)national authorities undertaking initiatives to roll out smart grid and renewable energy infrastructures at an aggressive pace [1]. Inter alia, the European Commission has recently put forth a set of comprehensive proposals for the effective governance of an ambitious transition to a carbon-neutral Europe by 2050 [2]. Non-interconnected island territories figure prominently in such ambitious plans; the rapidly emerging concepts of the ‘green’ or ‘smart’ island provide new ways of looking at the role energy plays in everyday life and at the evolving relationship between energy utilities and consumers, and their emergence may create further opportunities for a sustainable energy transition [3,4]. Indicatively, the *‘Political Declaration on Clean Energy for EU Islands’* moves beyond stultifying accounts focusing on the environmental, economic and supply problems encountered in isolated energy systems [5,6]. In doing so, it asserts that: *‘inhabited EU islands are often well placed to employ innovative solutions and attract energy investments that integrate local renewable production, storage facilities and demand response in order to achieve interoperable, economic, environmentally friendly and sustainable energy systems’* [7].

In particular, many real-world implementations exist that exemplify different transition pathways and allow insight into the pursuit of smart energy solutions on islands. Although attention has customarily been placed on the optimum sizing of centralised RES plants (e.g. Kaldellis et al. [8]; Papaefthymiou and Papathanassiou [9]), innovative and smart grid interventions are currently on the rise in remote island territories across the globe [4,10]. This shift is exemplified by the internationally acclaimed TILOS (“Technology Innovation for the Local Scale, Optimum Integration of Battery Energy Storage”) prototype energy model. This currently comprises of a 800 kW wind turbine, a 160 kW photovoltaic park, an advanced 2.4 MWh/800 kW NaNiCl₂ FIAMM battery for energy storage, and a smart micro-grid coordinating the operation of the system and offering the possibility of future distributed micro-generation [11].

The practical challenges of such innovative energy transitions are predominantly addressed in small and large-scale modelling research (e.g. Malekpoor et al. [12]; Mendoza-Vizcaino et al. [13]). Multiple econometric, energy equilibrium and optimization analytical and modelling tools have aided this smart energy transition within isolated electricity systems, including HOMER, DER-CAM, and PLEXOS [13,14]. Different aspects studied include capacity expansion investments and improving system-level decision-making (e.g. grid balancing and energy policy analysis). For example, Weisser [15] examined the main economic and technological obstacles for incorporating renewables within small island systems, while Pina, Silva and Ferrão [16] and Ilic, Xie and Liu [17] studied test-bed systems for electricity grid balancing and unit commitment optimisation within remote grid systems.

According to the International Renewable Energy Agency (IRENA) [10], such developments create a blueprint that can be replicated in other isolated communities and, possibly, on other larger systems. Hence, whilst most research and interventions in the field focus on specific islands, there is also a concerted effort to share

experiences beyond the narrow geographic realms of extant project sites. For instance, whilst the TILOS-Horizon 2020 project principally engages the islands of Tilos (Greece), La Graciosa (Spain) and Corsica (France), it also aims ‘*to create a special platform that will enable technological know-how transfer between islands*’ [11]. Moreover, several (inter)national networks and research consortia are currently at the forefront of capitalising on emerging knowledge in an attempt to stimulate further sustainable energy transitions for non-interconnected islands. These include, amongst others: the Dafni Network of Sustainable Greek Islands, the Smart Islands Initiative, the Global Sustainable Energy Islands Initiative, and the Global Renewable Islands Network (see Spataru [4] for an overview).

Against a backdrop of growing interest in island energy transitions – and especially in the introduction of hybrid power plants in insular non-interconnected power systems [18,19], this paper focuses on the public acceptance of the innovative TILOS-Horizon 2020 energy model. Given that the project forms part of a wider pool of research within the societal challenges BRIDGE program having a strong focus on consumer engagement [20], a fundamental concept informing this research is that the implementation of novel energy technologies does not simply depend on technological optimisation and economic feasibility [21]. As energy supply is understood to constitute a fundamental prerequisite for the functioning of modern society [21,22], we draw on a people-centric assertion that energy systems are complex *socio-technical* entities deeply embedded within the fabric of society [22]. Indeed, many scholars working in the field of energy research and policy agree that energy transitions must be led by transdisciplinary consortiums guided by social science concerns around the human dimensions of energy [23].

As indicatively noted by Upham [24], public acceptability can help bridge the gap between research and the development/ implementation of novel energy technologies and, subsequently, is has become ‘*a matter of importance for governments, the energy industry and academics*’. Similarly, Nejad et al. [25] are keen to highlight how close examination of public attitudes is one of the most popular techniques for predicting the diffusion of novel products, services or infrastructures. Finally, this assertion is further reflected in recent trends in global research policy and anticipatory governance (e.g. Responsible Research and Innovation (RR1) and Open Innovation European strategies informing the Horizon 2020 EU programme) advocating for research and innovations driven by social considerations [2,26]. This involves aligning technological developments with the values, needs, preferences and expectations of the society and, subsequently, searching for socially acceptable and desirable futures [26].

Subsequently, given the TILOS-Horizon 2020 research consortium’s interest in transferring the innovative energy model of Tilos to other non-interconnected islands [11], the ultimate aim of this research is to provide timely insights into whether Greek islanders are likely to accept such sustainable energy innovations in their localities. We address the following two key research questions:

Q1: What are the preferences of different publics with respect to the energy future of the Aegean Sea islands?

Q2: What are the characteristics of potential supporters (and opposers) of a sustainable energy transition for the region?

In addressing these research aims and questions, this paper proceeds as follows:

- i. [Section 2](#) anchors this research by providing an overview of past scholarship on energy publics. In doing so, it emphasises the pivotal significance of public acceptability to the successful implementation of sustainable energy transitions, introduces multiple factors that have previously been found to influence levels of support and opposition to sustainable energy solutions at an (inter)national level, and details multiple gaps in knowledge we aim to fill.
- ii. [Section 3](#) moves on to outline the unique methodological starting points informing the first-ever ‘upstream’ exploration of public acceptability of hybrid energy solutions across the Aegean archipelago. This involved, amongst others, an end-user segmentation analysis to help develop distinct energy user profiles who are more or less likely to support a green energy transition for the region in light of their different personal characteristics.
- iii. [Section 4](#) subsequently proceeds to present the empirical findings of this research, highlighting that whilst several islanders are in favour of green energy transitions, on the one hand, we cannot turn a blind eye to those segments of society opposing such developments on the other – and especially to the fact that personal/demographic factors influence recorded attitudes.
- iv. Finally, [Section 5](#) explores the scholarly and governance implications of this research, and focuses especially on how this research is only a starting point when discussing the potential transferability of the TILOS energy model.

2 Literature review: The social dimensions of (island) energy transitions

Public acceptability of green energy solutions involves ‘*a favourable or positive response (including attitude, intention, behaviour and – where appropriate – use) relating to proposed or in situ technology or social-technical systems by members of a social unit (country or region, community or town, and household or organisation*’ [24]. It consists of four distinct components: a) the general opinion of key stakeholders as well as the political framework conditions (i.e. *political acceptance*); b) the general opinion of the public with respect to green energy solutions (i.e. *social acceptability*); c) practical acceptance of specific projects or site selections within the affected communities (i.e. *community acceptance*); and d) the acceptance of renewable power production by consumers and investors in the energy market (i.e. *market acceptance*) [27]. Given, however, the complex financial and industrial arrangements that have built-up around sustainable energy technologies and the centrality of such innovations to the achievement of ambitious climate change and emissions targets at the (inter)national level [28,29], we do not currently regard *market* and *political acceptance* as key limiting factors.

Nonetheless, we assert that *social/community acceptance* of sustainable energy innovations is not simply a “nice-to-have” factor that facilitates project development. Technological developments across the Aegean Sea – and elsewhere – are contingent upon wider social factors and, otherwise, promising technologies, may fail or thrive

as a result of the ‘interactive complexity’ [22] of societies. Subsequently, the transfer of best practice experience from the TILOS-Horizon 2020 across multiple non-interconnected islands should not be taken for granted; islanders need innovative green energy technologies, but technologies also need islanders. In particular, community opposition constitutes one of the main challenges that hinder the adoption of otherwise promising novel energy technologies in multiple communities and/or individual households. The gap between national goals for a green energy transition and community acceptance has been discussed by several researchers, who have concluded that social disapproval can function as a restricting factor in achieving ambitious objectives [27,30–33]. For instance, whilst wind power is widely identified with the most favourable social impacts when compared to alternative energy production technologies [34], an International Energy Agency (IEA) study identifies a ‘*democratic deficit*’. Multiple wind energy projects were either significantly delayed or cancelled altogether due to public opposition, even when this originated from a small, unrepresentative number of opponents dominating the decision-making process [35].

A representative regional example that highlights how a local community can undermine the promotion of RES technologies is the case of a Greek island, Euboea, where almost 200MW of wind farms were installed between 1998 and 2001. However, during this considerable introduction of wind energy installations, developers assumed community acceptance “*fait accompli*” and failed to consult with interested parties – leading to ever-increasing local opposition (from environmentalists, cultural clubs, some municipal authorities, part of the local population, etc.) and, ultimately, to a virtual stand-still of any further wind farm developments across southern Euboea [36]. The case of geothermal energy is even more telling of the detrimental impact public attitudes might have on sustainable energy transitions within *and beyond* specific host communities. While Greece is a country with high geothermal energy potential, its utilisation is exceptionally limited – being solely exploited through direct thermal uses. This absence of power production through geothermal energy largely comes down to extensive public opposition throughout the country in the aftermath of the trial operation of the deficient Milos Island pilot power plant where significant hydrogen sulphide leaks were recorded (1970s-1980s) [37]. Until recently, most attempts made for the exploitation of geothermal fields are characterised by the lack of local community’s awareness, involvement, engagement and/or support [37].

In sharp contrast, emerging research suggests that public attitudes do not presently undermine sustainable energy transitions. At an EU level, Eurobarometer data [38] point to exceptionally high levels of public support for sustainable energy supply, and especially for renewable energy solutions. Similar are the trends recorded by multiple research programmes at a regional level across Greece. For instance, and albeit recording low levels of awareness of renewable energy technologies, Kaldellis [36] points to the fact that islanders are especially supportive of local wind turbine installations – envisioning them as partial solutions to omnipresent energy supply problems faced in the summer months. Similarly, research by Tsoutsos et al. [39] exploring local acceptability of wind parks uncovers how the vast majority of islanders from Crete are supportive of local developments. Furthermore, econometric analyses conducted by Zografakis et al. [40] on the island of Crete suggest that islanders are: a) concerned by the environmental impacts of fossil fuel overexploitation, and b) far

more willing to pay for local renewable installations than for upgrades to conventional local power plants. Finally, recent data from the island of Skyros suggests that the majority of locals support the implementation of renewable-based, small-scale projects corresponding to local energy autonomy scenarios [41].

Unfortunately, and against such promising developments, research across Europe consistently highlights an attitudinal paradox: a social gap between generally favourable attitudes towards sustainable energy and acceptance of specific energy-related infrastructures by individuals who are directly affected by developments [42,43]. Indeed, Johansson and Laike [44] and Sauter and Watson [45] warn us that attitudes toward green energy in general and attitudes toward specific projects will understandably differ, as they are different attitude objects. Each carries a different set of associations in the minds of community members: where people may consider issues such as energy security and environmental quality when thinking about green energy in general, they think about specific localised impacts and are influenced by subjective norms and perceptions when such developments are actually proposed in or near their community [46,47]. Subsequently, researchers focusing on public acceptance of novel energy technologies have, amongst others, warned practitioners in the energy field to differentiate between ‘acceptability’ as a broad, evaluative attitude towards green energy technologies and consumer ‘acceptance’, as an actual and/or anticipated behavioural response towards specific technological interventions [48]. These insights, thus, suggest that in order to minimise the problems and maximise the expected results of technological interventions – and prior to the strategic plans being drawn-up and governmental decisions taken – it is imperative to research public opinion. In this way, the possibility of failed decisions and interventions is minimised [49].

Given the critical importance of local public support for green energy infrastructures, social scientists have developed a multitude of conceptual frameworks explaining public attitudes vis-à-vis energy transitions. For instance, the ‘NIMBY’ (Not in My Backyard) hypothesis posits that although people, according to some opinion polls, tend to support RES projects in general, they are likely to oppose specific project plans in their local area for self-interest and particularistic reasons (see Devine-Wright [32] for an overview). They want to enjoy the benefits of clean, carbon-neutral energy, but not in their own ‘backyards’ where the plants are feared to be noisy, to disturb the landscape and perhaps even harm the health of affected neighbours [50]. Furthermore, scholars in the field have moved significantly beyond the ‘NIMBY’ hypothesis which stigmatises objectors as egoistic, short-sighted, ill-informed, and ignorant to the greater good [42,46,51]. Instead, academics have put forth a multitude of additional explanations for public responses to local energy infrastructure developments. As summarised in [Fig.1](#), researchers in the field have conceptualised and empirically validated how *personal*, *socio-psychological* [31,46,52], *contextual* [53,54] and *spatial factors* [31,55,56] shape local public acceptance of energy-related interventions.

Focusing on the Greek context, five key factors appear to undermine the public’s willingness to accept green energy solutions (either at the regional or at the household level). First, there is a notable lack of (accessible) information on novel energy technologies and their economic, environmental and social benefits/costs – as

reflected in the reluctance of locals for new energy supply programs [36,57,58]. Second, there is an enduring public fear that local renewable energy installations can degrade landscapes. For instance, both academics and the mass media outline how some locals oppose RES installations on their islands in fear that they negatively impact picturesque land/seascapes which constitute the main touristic selling points of the islands of the Aegean Sea [57–59]. Third, local communities occasionally are presented with proposals for large-scale renewable installations in their near vicinity that do not account for local eco-geographical idiosyncrasies [60]. Fourth, local communities often adopt a protectionist stance in light of their distrust of non-local, and allegedly corrupt and/or self-interested, developers and stakeholders who might be involved in “clientelistic” relationships [61]. Fifth, and finally, there are multiple barriers to prosumption including, inter alias, significant recent feed-in-tariff cuts [61], the ongoing dire economic circumstances that have greatly reduced public willingness to invest in micro-generation technologies [61,62], and the current inability of the economy to empower prosumers [63].

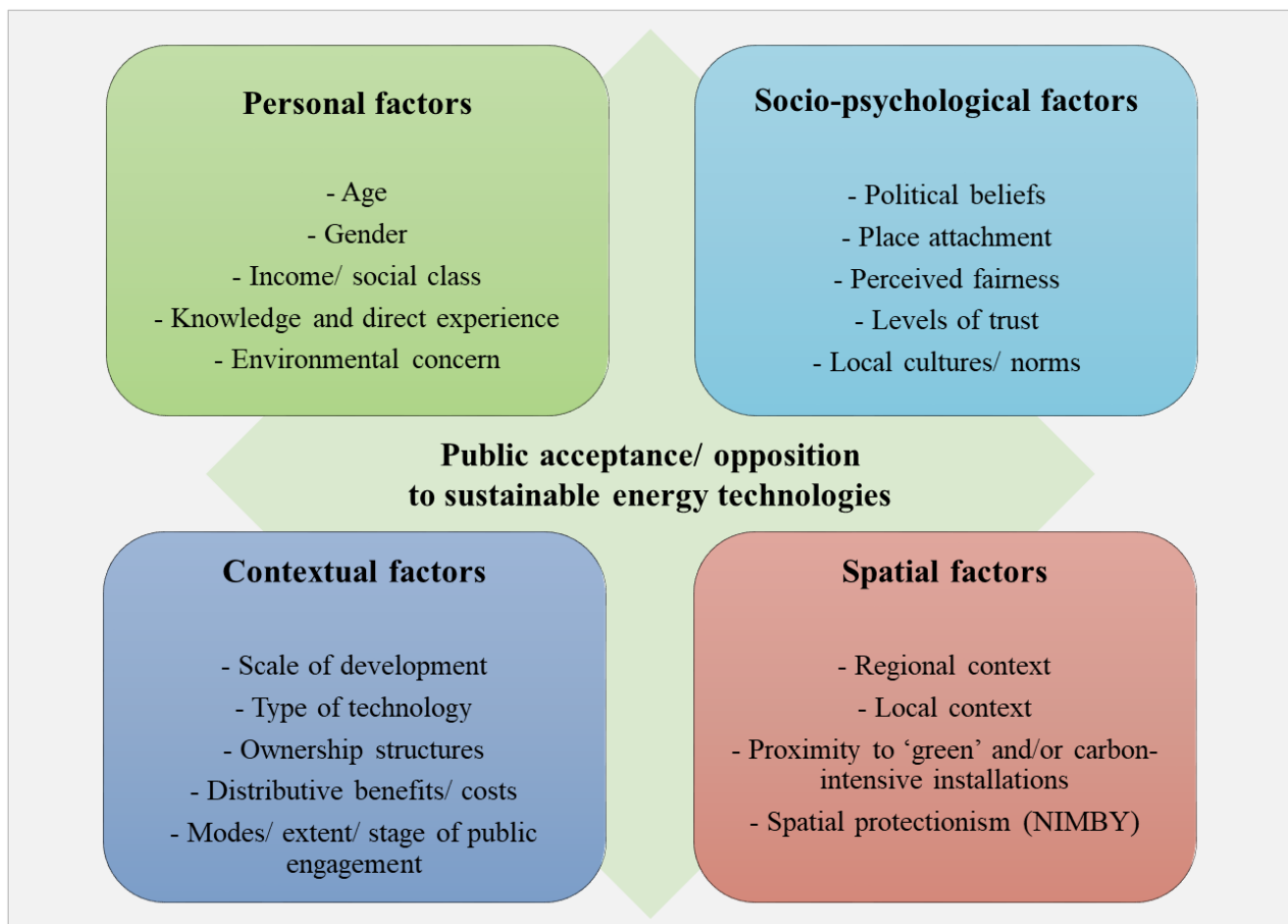


Figure 1: Factors influencing public acceptance/ opposition to sustainable energy technologies (following Devine-Wright’s [31,32] cross-paradigmatic framework of public acceptance).

In this study, and alongside recording general attitudinal trends towards novel smart and green energy solutions for non-interconnected islands, we focus on *personal factors* that might influence levels of public acceptance/opposition to such solutions. Such factors include the demographic characteristics of islanders (namely age, gender and income/social class), their prior knowledge and/or direct experience of different energy

systems, and their levels of environmental concern (see [Fig.1](#)). An extensive body of literature has examined personal/demographic correlates of pro-environmental attitudes and, because of the assumed connection between energy and the environment, these factors are also expected to be relevant to attitudes about sustainable energy [31,32]. As Gröger et al. [64] assert and validate empirically, a typical green energy consumer or prosumer is male, high-income, young, educated and concerned about the environment.

2.1. Rationale for the study

As Devine-Wright et al. note, the study of social acceptance of novel energy solutions '*has blossomed over the last decade*' [65] (also see Rohrer et al. [66]). Indeed, Gaede and Rowlands' [67] recent bibliometric review identifies over 857 research articles published in leading journals such as *Applied Energy*, *Energy Policy* and *Renewable Energy*. These articles explore public attitudes towards a wide range of energy infrastructures – including, for instance, smart grid technologies [68], on/off-shore wind farms [59,69], distributed generation [70], and energy storage solutions [65]. Nonetheless, and despite the meteoric growth of academic and non-academic interest in public attitudes towards energy infrastructures, three persistent shortcomings plague our understanding of the societal dimensions of energy systems.

First, we are especially interested in the *personal/demographic* determinants of attitudes in light of an ongoing debate on whether such factors matter. On the one hand, multiple surveys have empirically validated the hypothesis that there is a positive correlation between income/social class and levels of support for both renewable energy and other smart technologies (see Devine-Wright [31,32] for a review). Especially with respect to attitudes towards domestic RES-based micro-generation in Greece, Sardianou and Genoudi [53] assert that income influenced adoption (or intention to adopt) positively. Similarly, multiple empirical studies corroborate the argument that levels of environmental concern influence expressed public attitudes. For example, Poortinga et al. [71] identified high levels of public support for energy policy-making to be driven by the goal of environmental protection, with 77% of a representative national sample of 1462 individuals preferring the increased deployment of renewable energy technologies over fossil-fuel stations. Furthermore, Warren, Lumsden, O'Dowd, and Birnie [72] note that social conflict over proposed renewable energy developments can be characterised by action motivated by environmental concern on both sides of the conflict: supportive individuals may be principally concerned about the impacts of climate change at the global scale, whilst opposers are primarily concerned for the local impacts of such technologies.

On the other hand, there is inconclusive evidence with respect to the hypothesis that age, gender, and prior knowledge/experience also matter. For instance, regional surveys on the role of age have found both higher levels of awareness and opposition towards renewable energy amongst older respondents. In contrast, national studies in the UK have found levels of opposition to be lower in younger and older cohorts in comparison to middle-aged respondents (see Devine-Wright [31,32] for a review). Studies exploring gender differences have produced equally contradictory results, depending upon the focus. For example, while several surveys have indicated weaker support for new renewable energy development by women than by men [31,32], a UK-based

survey identified higher levels of awareness of renewables amongst men but lower levels of support for development in the locality when compared against women [73]. Finally, although studies of public acceptance have been driven by assumed negative implications of deficits in public understanding, there is limited evidence that more informed individuals are more accepting of sustainable energy technologies. Whilst some studies in Greece [74] and the UK identify correlations between knowledge and acceptance of micro or macro-scale renewables [71,72], others note that levels of support were independent of levels of awareness (see Devine-Wright [31,32]). Subsequently, leading scholars in the field – including Devine-Wright [46], Huijts [48] and Wolsink [75] – have led an ongoing scholarly debate on whether it is now time to abandon the elusive quest of developing an internationally generalizable demographic profile of sustainable energy supporters/opposers and focus on exploring other, context-specific factors (see Fig.1) such as ‘place-technology fit’ [46] instead.

Second, relevant literature has overwhelmingly focused on local opposition to single wind energy projects [76,77], relying heavily on independent local case studies to understand the emergence of opposition to specific interventions at a late stage in the implementation process [76,78]. Consequently, and with some notable exceptions [45,79,80], it has relatively little to say about support or opposition to current smart, green or hybrid energy developments affecting energy publics and their everyday lives directly (cf. Sauter and Watson [45] and Wolsink [55]). In other words, as the development of such innovative energy infrastructures continues to suffer from a mere technological focus [81], multiple proposals that are not necessarily acceptable by local communities have emerged [82].

Third, and finally, we argue that these shortcomings are reflected in research and practice on energy islands. On the one hand, energy users are increasingly re-envisioned as essential components of effective island energy transitions: a) as conscious consumers who accept green energy installations in their backyards and respond to awareness-raising campaigns by using electricity more efficiently [83]; b) as “smart” consumers who use smart energy feedback [82,84]; c) as “flexible” consumers accepting load management systems [84,85]; and d) as energy prosumers [66]. On the other hand, and albeit considerable experience of island energy transitions and a mushrooming body of research on isolated energy communities (see [Section 1](#)), a critical starting point for this research is the acknowledgement that the social dimensions of sustainable energy transitions have been overlooked. Funding is still dominated by techno-economic interests. Indicatively, whilst human-centric concerns have informed the Horizon 2020 programme on energy islands [26], Mikkelsen et al. [20] note that *‘not much room has been given [within the programme] for research into different implementation views and the preferences of end-consumers’*. Indeed, with very few notable exceptions [53,86,87], there is limited interest in exploring whether islanders are *actually willing to accept* green/smart energy technologies and the new roles envisioned for them by energy experts.

We assert that the case of the Greek islands of the Aegean Sea is particularly telling; in spite of extensive international scholarship on public attitudes towards sustainable energy technologies, the region constitutes an exemplary case of overlooking public attitudes. First, while recent studies and interventions move significantly

beyond renewable energy production [11,88], they continue to apply multiple implicit and unfounded assumptions about the willingness of locals to live in and be part of green energy systems in the near future, and solely addresses the practical challenges of island energy transitions through modelling research [14,89,90]. There is, in short, a timely need for an early stage – or ‘upstream’ – exploration of whether islanders from across the Aegean Archipelago are likely to accept micro- or meso-level green and smart energy interventions in the future (following Whitton et al. [80] and Wilsdon and Willis [91]). Second, there is limited yet conflicting data on the energy publics of the Aegean – especially with respect to islands of high touristic importance. Whilst some academics (e.g. Kaldellis [36], Tampakis et al. [49], and Petrakopoulou [41]) highlight widespread public support for such technologies for specific islands, there are numerous reports on national and local newspapers claiming that islanders oppose local renewable energy installations (see Gidas [92] and Deligiannis [93] for an overview). Given the growing interest in turning regions such as the Aegean archipelago into green energy hubs [7,11], it is, thus, crucial to provide timely insights into public attitudes from a large and representative sample of locals from across its islands. Third, and finally, past research on the region largely fails to provide insights on the profiles of local energy publics – presenting instead broad descriptive accounts with very limited insights into the drivers of support and opposition to sustainable energy transitions. Two noteworthy exceptions include the work Sardanou and Genoudi [53] and Dimitropoulos and Kontoleon [59] which, nonetheless, falls short of accounting for all *personal/demographic predictors* of public attitudes put forth in past research on the topic (see [Fig.1](#)).

In addressing these persistent literature gaps, and in an attempt to assist in speeding-up island energy transitions, this study breaks new ground for research on public attitudes to sustainable energy solutions in three key ways:

- i. We respond to calls to better understand island energy users [20] and provide up-to-date information on energy publics from across the Aegean Sea at an ‘upstream’ stage.
- ii. We move beyond merely descriptive explorations of energy users that do not account for the possible determinants of public attitudes – contributing to an ongoing international scholarly debate on whether *personal attributes* influence stated attitudes. In doing so, we also hope to contribute important new research findings – from a previously unstudied region – to an ongoing debate on whether personal/demographic factors influence levels of support/opposition to sustainable energy technologies [31,32]. Understanding the profiles of different energy publics is of crucial importance for a sound sustainable energy policy that would develop distinct ways of targeting both supporters and opposers of sustainable energy developments.
- iii. Finally, this is, to the best of our knowledge, the first-ever study providing insights into the social dimensions of hybrid energy systems – simultaneously accounting for attitudes towards a range of constitutive technologies and, thus, informing timely conclusions on the possible uptake of hybrid energy solutions. The research thus fills a significant void in our understanding of a set of otherwise technologically viable solutions that are especially vulnerable to public opposition – or indifference – as their introduction is dependent on ‘active acceptance’ at three key levels simultaneously: the active interest and support of affected individuals at the general, local *and* at the household level [24,70]. Moreover, given growing interest in transferring the TILOS energy model [11] – and other similar designs [4] – beyond their technological and geographical

niches, our analysis will inform efforts to better integrate such infrastructures within existing energy regimes.

3 Methodology

As part of our work on the TILOS-H2020 research program, a questionnaire survey was used to collect information on public attitudes towards the possible future transfer of the innovative energy model of Tilos to a number of additional non-interconnected islands of the Aegean Sea. A point of particular interest in this study – apart from extending the exceptionally limited research conducted thus far concerning public acceptability of sustainable energy solutions for island territories – is the area under investigation. The wider region of the Aegean Archipelago is of major interest since a) it exemplifies the problematic energy supply status quo of non-interconnected islands [94,95]; b) the region exhibits exceptionally high renewable energy potential [96]; and c) there is ever-growing academic and practitioner interest in local sustainable energy transitions – and especially in the establishment of autonomous smart islands [11,19,97].

The survey was conducted between the 8th and 25th September 2017, employing a computer-assisted telephone interview (CATI) protocol. A phone-based survey was selected among other methods (e.g. personal interviews, postal or door-to-door questionnaires, etc.) since it was considered the most cost-efficient approach for this particular case. Although there are several disadvantages to using CATI surveys (e.g. questionnaire had to be kept short, there is high difficulty in making alterations to or providing considered responses, etc. [98]), the method gave us the opportunity to speedily collect and analyse large amounts of data using standardized descriptive and exploratory statistical techniques.

In addressing the core research aims and questions – and drawing on past academic research [33,99,100] and our own extensive experiences from the island of Tilos – the questionnaire comprised of seven closed-type questions. These explored general public attitudes towards specific renewable and smart grid systems put forth by the TILOS consortium (i.e. meso or macro-scale RES installations, RES-based domestic micro-generation, DSM, smart metering, community energy, etc.). In addition, and given our scholarly interest in exploring which factors affect public support and opposition to regional sustainable energy developments, we included five additional question units capturing key information on *personal/demographic* attributes of our sample – namely: age, gender, annual household income, knowledge/prior experience of green/ smart energy technologies, and levels of environmental concern (see [Table 1](#)).

In delivering this project, virtually all questionnaire design errors were eliminated through a team approach to research and by working in close collaboration with the highly trained personnel and supervisors of a nationwide market research company (MARC A.E.). Following a trial run of the survey which involved 70 islanders, draft questionnaires were reviewed by both the data collectors and the academic team. This involved re-considering question wording, answer categories, question order, and question skip patterns for clarity and correctness. Furthermore, 28.4% of the interviews were subject to random quality control monitoring, whereby supervisors monitored calls and data collation and pointed-out any procedural or linguistic errors for the

interviewer to improve upon. Finally, all collected data went through a comprehensive screening process which: a) involved all data collectors, supervisors and members of the academic team, b) applied a strict missing value protocol, and c) checked for logic, consistency, and congruency in responses.

Table 1: Overview of survey questions and response options.

<i>Question</i>	<i>Response options</i>
<i>Section 1: Capturing general attitudes/perceptions of the sample</i>	
A. Would you prefer using electricity produced by fossil fuel plants, or using renewable energy source?	Fossil fuel plants (1); Renewable energy sources (2); Do not know/ Do not answer (DK/ DA) (3)
B. What is your view of possible local RES installations on your island?	Negative (1); Somewhat negative (2); Neither negative nor positive (3); Somewhat positive (4); Positive (5)
C. Would you be willing to accept the complete decarbonisation of your island, with all electricity supplied using RES and battery storage solutions – even if this involves large local installations?	No (1); Probably no (2); Probably yes (3); Yes (4); DK/DA (5)
D. How important is local disturbance caused by the following energy sources/technologies? (a) fossil fuel plants; (b) wind turbines; (c) photovoltaics; (d) seabed (interconnection) cables; (e) hydroelectric.	Very important (1); Important (2); Neither important nor unimportant (3); Unimportant (4); Very unimportant (5); DK/DA (6)
E. Opposers of RES suggest that local installations spoil the landscape and, subsequently, undermine the tourist industry of areas that are important because of their pristine surroundings. What might be the impact of local RES installations on tourism?	Negative (1); Somewhat negative (2); Neither negative nor positive (3); Somewhat positive (4); Positive (5); DK/DA (6)
F. Would you be interested in becoming an “energy prosumer” (a) by producing electricity for your self-consumption, and (b) by buying shares in and co-managing a local energy cooperative?	No (1); Probably no (2); Probably yes (3); Yes (4); DK/DA (5)
G. Would you be willing to accept smart grid technologies such as (a) Demand-Side Management (DSM), and (b) smart metering?	No (1); Probably no (2); Probably yes (3); Yes (4); DK/DA (5)
<i>Section 2: Capturing information on key personal/demographic factors found to influence public attitudes</i>	
H. How important are the following problems for your island? (a) environmental problems; (b) electricity supply problems; (c) water shortages; (d) health security/cover shortcomings; (e) unemployment; (f) inefficient air/boat connections to the mainland	Very important (1); Important (2); Neither important nor unimportant (3); Unimportant (4); Very unimportant (5); DK/DA (6)
I. Do you have any past experience or knowledge of renewable or smart grid technologies (e.g. domestic PVs, smart meters, electric vehicles, etc.)?	No (none at all) (1); Very limited (2); Limited (3); Reasonable (4); Extensive (5); DK/DA (6)
J. Your age?	18-24 years old (1); 25-34 years old (2); 35-44 years old (3); 45-54 years old (4); 55-64 years old (5); 65+ years old (6); DK/DA (7)
K. Your gender?	Male (1); Female (2); DK/DA (3)
L. Your (estimated) annual household income?	Low (1); Average (2); High (3)

The findings presented in this paper draw on primary data collected from fifteen islands from across the Aegean Sea (see [Fig.2](#)). These islands were purposely included in the research because they share one or more common characteristics with the island of Tilos (e.g. in terms of size, geographical position, renewable energy potential, etc.) that render the transferability of the TILOS-Horizon 2020 energy model technically and economically feasible. Our analyses draw on 1001 fully screened questionnaires, revealing the attitudes of a representative sample of individuals in the region who responded to at least 80% of our questions. This sample is considered adequate to provide a statistically-significant view of public perceptions of sustainable energy technologies, with

a statistical error margin of $\pm 3\%$ (see for example the “sample-to-population” ratio adopted in other similar studies [99,100]).

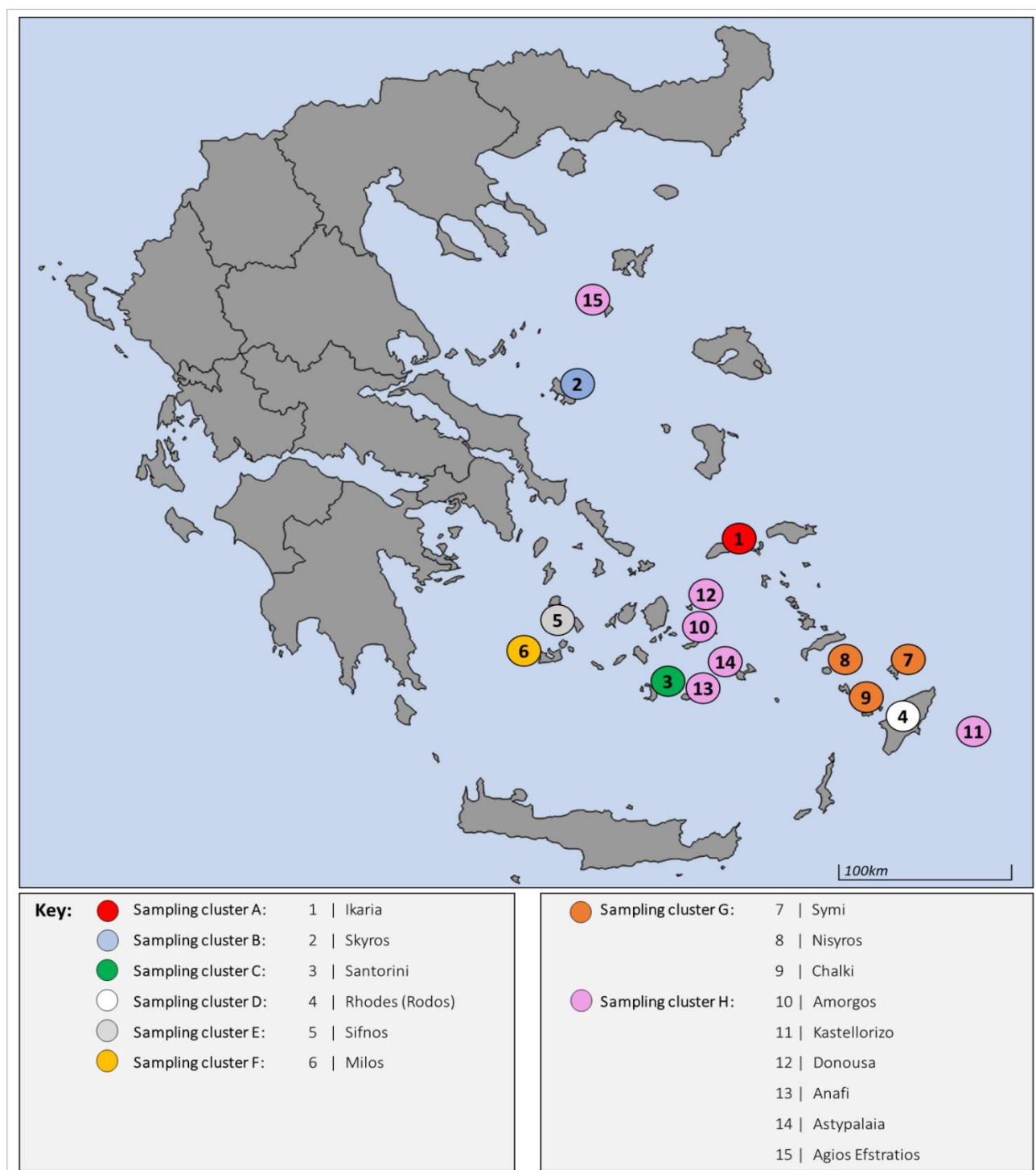


Figure 2: Geographic distribution of study, with individual islands distinguished by number and analytical cluster.

Although the overall response rate was reasonably low (26%; 3850 individual households contacted in total), all necessary steps were taken to eliminate, to the extent possible, nonresponse bias. We compared our emerging demographic data against data obtained from the latest Population and Housing Census of the Hellenic Statistical Authority on the Northern and Southern Aegean Peripheries [101] and adjusted our sampling and analytical

approach to achieve non-statistically significant differences between the sample and the population. Specifically, the researchers involved in primary data collection employed a multi-stage random sampling technique that used a Census-informed quota based on gender, age, educational attainment, income, and geographical distribution to ensure the representativeness of the results from across the islands considered for this study.

Whilst unable to include large enough and representative samples at the level of specific islands, statistical representativeness was achieved by dividing our sample into eight sampling clusters (see [Fig.2](#)) sharing similar characteristics: a) amongst themselves, and b) with the regional population. Sampling clusters include: a) the island of Ikaria; b) the island of Skyros; c) the island of Santorini; d) the island of Rhodes; e) the island of Sifnos; f) the island of Milos; g) the islands of Symi, Nisyros and Chalki; and h) the islands of Agios Eustratios, Astypalaia, Anafi, Donoussa, Kastellorizo, and Amorgos. 13.6% of respondents were from sampling cluster ‘A’; 11.0% from sampling cluster ‘B’; 17.7% from sampling cluster ‘C’; 17.3% from sampling cluster ‘D’; 10.1% from sampling cluster ‘E’; 11.9% from sampling cluster ‘F’; 10.1% from sampling cluster ‘G’; and 8.3% from sampling cluster ‘H’. The demographic composition of the sample is summarized in [Table 2](#).

Table 2: Demographic characteristics of the sample.

Sex	Male (M)	Female (F)					
	46%	54%					
Age	18-24	25-34	35-44	45-54	55-64	65 or older	DK/DA
	3.3%	12.0%	13.9%	21.8%	18.7%	29.4%	0.9%
	(1.3% M; 2% F)	(6% M; 6% F)	(6.8% M; 7.1% F)	(10.8% M; 11% F)	(8.7% M; 10% F)	(12.4% M; 17% F)	(0% M; 0.9% F)
Annual income	Low	Average	High	DK/DA			
	29.3%	24.3%	6.4%	40%			

Following data collection, the survey outputs were analysed using standardised statistical analyses techniques in the IMB SPSS Statistics suite (version 25). First, several *chi-squared tests* were performed to assert whether recorded attitudinal differences between various sample sub-groups (e.g. male/female; young/old; etc.) were statistically significant. Second, and given that most of our dependent and independent variables were nominal, several *multinomial logistic regression* analyses were performed to test the effects of the influencing *personal/demographic factors* on the stated acceptance/opposition of multiple green/smart energy technologies. Finally, in responding to recent calls to classify or segment energy end-customers in a manner that goes beyond the identification of basic attitudinal trends [20], an analytical novelty of this research is the application of a *two-step cluster analysis* described in Hair et al. [102]. This data-driven post-hoc segmentation technique that has recently informed our understanding of attitudes to bioenergy production [103], community financing of renewable energy projects [104], and energy-user behaviour at the household level [105], and incorporates the principles of hierarchical and partitioning clustering methods to identify distinct sample profiles that were not known a-priori. In light of our interest in providing broader conclusions on whether islanders are in favour or against sustainable energy transitions, this explorative data-driven technique took into account responses to all

of our question units to help arrive at an overall judgement of the sample population. Following multiple analyses involving different cluster numbers, we identified the optimal number of clusters (i.e. three) based on the measure of cohesion and separation that guarantees that our clusters are statistically significant and conceptually meaningful.

4 Results

Given our aim to explore the potential transferability of the TILOS-Horizon 2020 energy model to other non-interconnected islands prior to the development of specific plans, the primary data collected and presented as part of this research project relate to the second key dimension of social acceptance (following Upham, Oltra and Boso [24]) – namely the general opinion of the lay public vis-à-vis the proposed green energy solutions (i.e. *social acceptability*). We present general public attitudes towards specific technologies and systems put forth by the TILOS-Horizon 2020 research consortium, as well as provisional evidence with respect to the determinants of these attitudes – detailing the relative influence of multiple *personal/demographic factors* on levels of public support or opposition. In doing so, we put forth a narrative that is only partially optimistic; whilst [Section 4.1](#) documents generally favourable attitudes towards the TILOS energy model, [Section 4.2](#) draws on outputs of our *chi-squared, multinomial logistic regression and two-step cluster analyses*, and discusses how such an energy transition would only be accepted by individuals with certain personal/demographic characteristics.

4.1. Public acceptance/ opposition to a sustainable energy transition for the Aegean

In line with the overall trends recorded in multiple regional studies that only explored attitudes to meso/macro level renewables (e.g. Kaldellis [36], Tampakis et al. [49], Petrakopoulou [41] Sardianou and Genoudi [53], and Dimitropoulos and Kontoleon [59]), our survey results suggest that locals from across the Aegean are also likely to support hybrid expert-led visions [11,19,97] for the green/smart energy transition of the region. It is indicative that when asked to choose between energy supply from fossil fuel-based stations or hybrid RES and storage systems, preference for RES is overwhelming – especially on islands such as Rhodes where existing fossil fuel power stations have been expanded without prior public consultation [100]. Specifically, a statistically significant majority of islanders (73.7%) prefer covering their everyday needs for electricity by using the energy produced through RES technologies. Conversely, only 11.8% cite their preference for electricity supply through fossil fuel power stations (see [Fig.3a](#)). In certain cases, such as the island of Rhodes, support for a RES-based energy mix is almost universal, with 81% siding in favour of a RES-based system, and only 8.2% siding in favour of maintaining the energy supply status quo (see [Fig.3b](#)). Multiple respondents from Rhodes even qualify their preference for RES technologies by providing unprompted corroboration to the scholarly claim that communities which neighbour conventional power stations overwhelmingly welcome green infrastructures as they see their arrival as a symbol of development and progress [106,107].

Promisingly, our research also documents how the general public of the Aegean Archipelago gives its provisional support to the complete decarbonisation of electricity production in the region through the use of renewable

energy and battery storage technologies – even if this involves large local installations. Most research informants (78.6%) are strongly or probably in favour of a complete energy transition to renewables, against a mere 9.5% of respondents who oppose such a radical change in energy supply and production (see [Fig.4a](#)). The example of Rhodes is indicative, with only 5.4% of survey respondents opposing this transition and, thus, providing their de facto support to the maintenance and expansion of existing fossil fuel power plants (see [Fig.4b](#)).

Q: Would you prefer using electricity produced by fossil fuel plants, or using renewable energy sources?

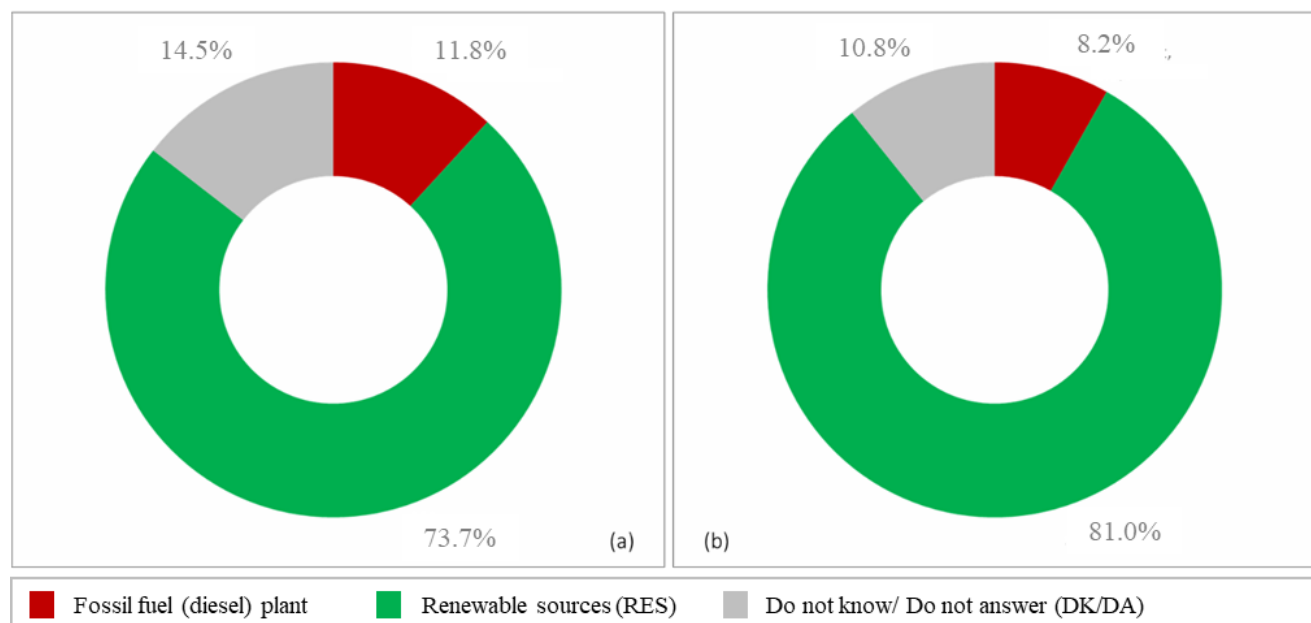


Figure 3: Stated preference for electricity produced using either fossil fuels or renewables sources for (a) all islands included in the study, and (b) for the island of Rhodes.

Q: Would you be willing to accept the complete decarbonisation of your island, with all electricity supplied using renewable energy and battery storage solutions – even if this involves large local installations?

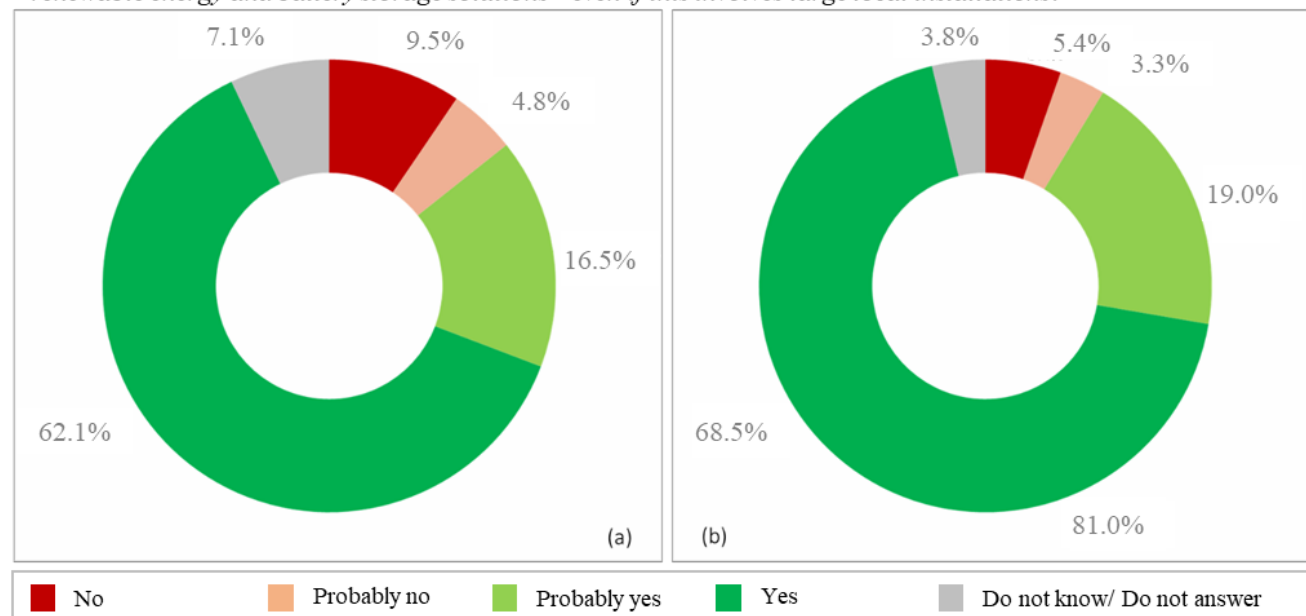


Figure 4: Stated preference for complete electricity supply decarbonisation for (a) all islands included in the study, and (b) for the island of Rhodes.

Moreover, in line with past academic research focusing on isolated cases of Greek islands [36,40,49], the survey debunks the myth that islanders are particularly worried by the prospect of RES infrastructures in their proximity [57,92,93] – and, subsequently, contributes further empirical validation to emerging criticisms [31,51,56] of the much-cited ‘NIMBY’ hypothesis as a whole. Specifically, when asked to provide their views on the possibility of developing RES installations (such as PV parks and wind turbines) in their localities, a statistically significant majority of islanders (62.1%) responded positively – with a further 14.6% of survey participants indicating that this was a somewhat positive prospect. Conversely, only 12.8% of respondents felt that this prospect was either negative or somewhat negative (see [Fig.5a](#)).

Q: What is your view of possible local RES installations on your island?

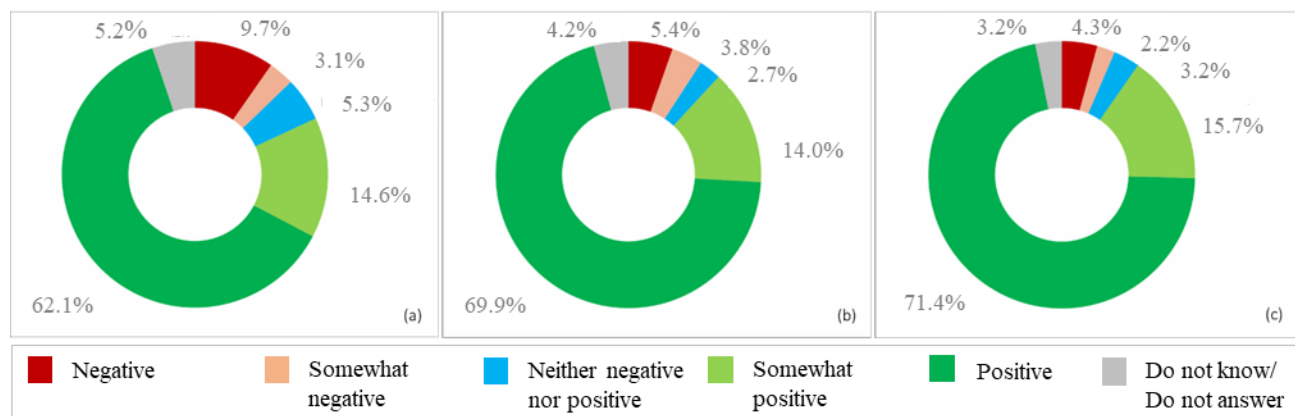


Figure 5: Public acceptability of local RES installations (a) for all islands included in the study, (b) for the island of Santorini, and (c) for the island of Rhodes.

Our assertion that Greek islanders support, at least in principle, RES developments in their proximity is further validated through closer consideration of survey findings from specific island clusters. While past research around public acceptability of RES installations documents considerable opposition in areas of touristic importance [59,92,93], our findings suggest that the public would support a sustainable energy transition even in emblematic tourist destinations. Specifically, based on the findings of the public survey, there appears to be evidence of an apparent inverse ‘NIMBY’ – or ‘YIMBY’ (Yes in my backyard) – effect [56,108], as locals are more supportive of local renewable infrastructures than expected under a ‘NIMBY’ scenario. Indicatively, [Fig.5b](#) and [Fig.5c](#) exemplify how islanders from Santorini and Rhodes – two of the top five tourist destinations in Greece [109] – are more supportive of local RES installations than the survey sample as a whole (refer to [Fig.5a](#)). Up to 69.9% of islanders from Santorini and 71.4% of respondents from Rhodes are strongly supportive of such developments. Moreover, we recorded the lowest levels of public opposition to renewables in these two localities, with 5.4% and 4.3% of respondents from Santorini and Rhodes respectively sharing their negative attitudes towards possible local RES installations.

These high levels of public acceptability for regional sustainable energy developments are far from surprising. In line with well-documented assertions that public acceptance is contingent upon anticipated positive local impacts of particular developments [110,111], our survey also recorded widespread anticipation that such local

infrastructures – and especially RES installations – would benefit local societies. Indicatively, there is general agreement that RES installations cause significantly less disturbance to local communities when compared against existing fossil fuel power stations in operation in the region (see [Fig.6](#)).

Q: How important is local disturbance caused by the following energy sources?

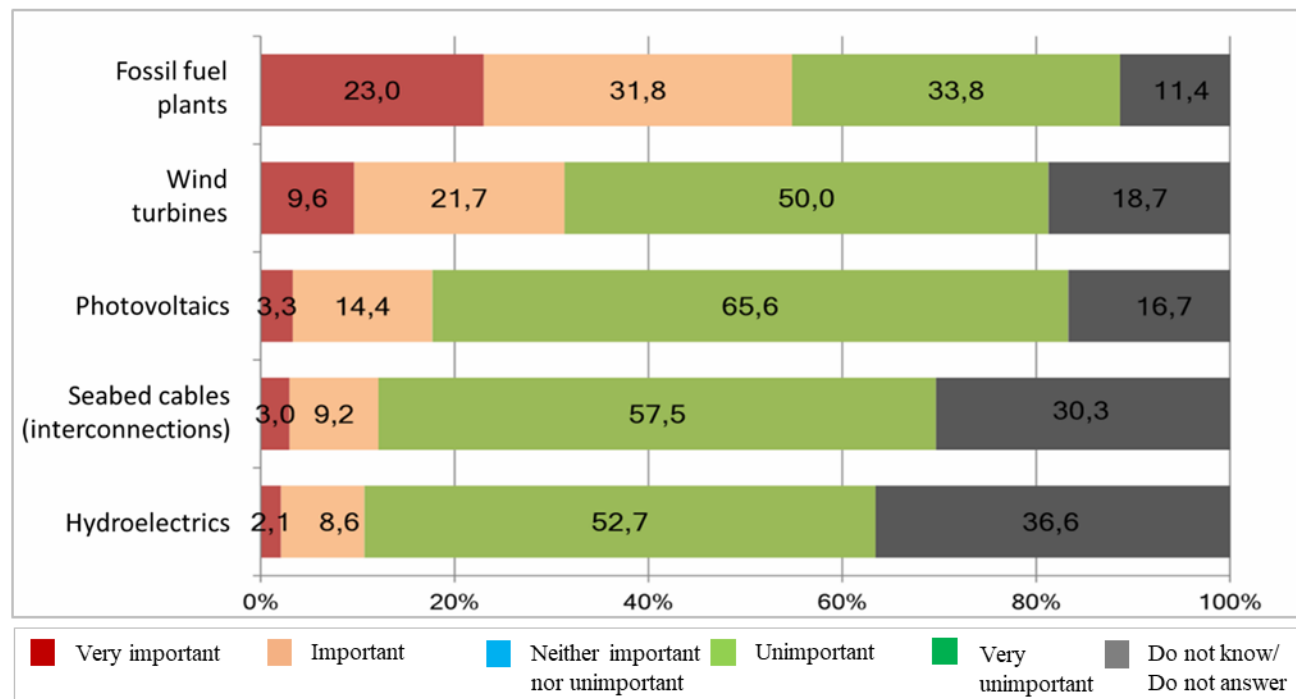


Figure 6: Subjective evaluation of local disturbance caused by a selection of energy sources.

For instance, against a backdrop of scholarship focusing on the negative visual impacts of wind turbines [44,99], only 9.6% of respondents believe that their disturbance is significant. Moreover, all renewable-based solutions consistently perform better when compared against either fossil fuels plants or plans for continental interconnections via seabed cables – with PV solutions manifesting themselves as the most favoured forms of energy supply (a statistically significant 65.6% of respondents believe that disturbance from PV installations is negligible) (see [Fig.6](#)). In keeping with these overall trends, the island of Rhodes manifests itself as an indicative case-study; most local respondents believe that disturbance caused by such plants is significantly more important than disturbance caused by RES infrastructures. In particular, the majority of locals (65.6%) believe that disturbance caused by fossil fuel plants is (very) significant. Conversely, a statistically significant majority (66.3%) of respondents believe that local disturbance caused by PV installations is insignificant.

In agreement with past academic work on the island of Naxos documenting how locals perceive that nearby wind turbines are unlikely to influence tourism [59], the majority (41%) of survey respondents even believe that the installation of RES infrastructures (e.g. wind turbines) will definitely or likely have a positive impact on their local touristic activities (see [Fig.7a](#)). Multiple participants qualify their response by: a) confirming past claims that RES infrastructures might act as touristic attractions [112,113] as wind turbines are, allegedly, appealing to tourists as they represent symbols of green development and enhance the visual interest of landscapes/seascapes,

and b) asserting that, at the very least, such local installations would increase energy security and, subsequently, the experienced satisfaction of tourists who are not used to either blackouts or voltage fluctuations. Furthermore, up to 31.2% of respondents believe that the landscape interference of such installations will have neither a positive nor a negative impact on tourism. This holds true even in emblematic tourist destinations, such as Santorini, where up to a statistically significant 52.2% of survey respondents believe that RES installations will benefit, or probably benefit, the tourist industry, compared to a mere 11.8% of locals who are fully or partially concerned about potential negative effects on tourism (Fig.7b).

Q: Opposers of renewable energy suggest that local installations spoil the landscape and, subsequently, undermine the tourist industry of areas that are important because of their pristine surroundings. What might be the impact of local RES installations on tourism?

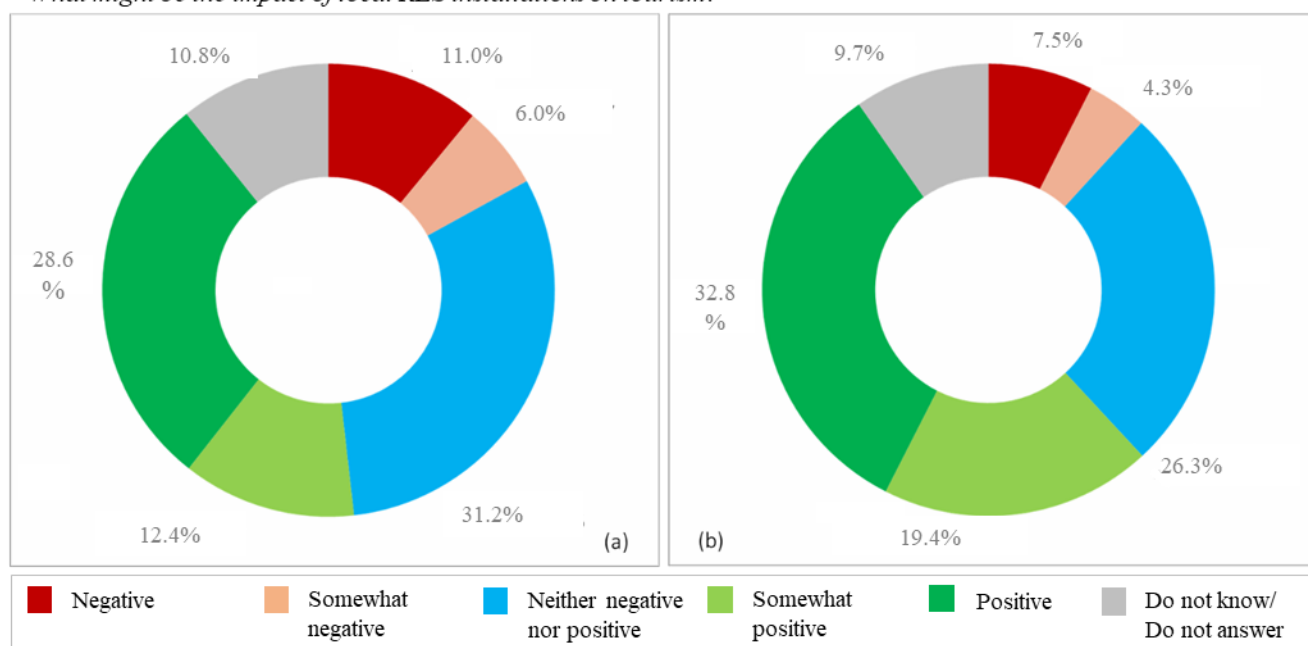


Figure 7: Anticipated impacts of RES infrastructures on tourism for (a) all islands included in the study, and (b) for the island of Santorini.

Simultaneously, though, the survey empirically validates the need to distinguish between ‘acceptability’ as a broad, evaluative attitude towards green energy technologies and consumer ‘acceptance’, as an actual and/or anticipated behavioural response towards specific technological interventions [48]. With our questionnaire survey also uncovering widespread public opposition to specific smart or green energy solutions that form an integral part of the TILOS energy model and affect the end-user directly, we are reminded of the timely need to discuss social acceptance in all its forms: attitudes, behaviours and – importantly – actual or possible investments [48]. Specifically, with novel technological interventions such as those put forth by the TILOS consortium demanding far more than passive consent for implementation, the fact that many respondents are not willing to accept plans that affect them directly raises concerns. For instance, whilst a statistically significant majority (42%) of respondents from across the 15 islands studied who would probably, or definitely, be interested in producing their electricity through domestic PV panels, generally positive attitudes towards renewables do not translate into behavioural intention to invest in micro-RES units (see Fig.8a). Around half of the respondents citing their preference for a RES-based energy system (see Fig.3a) are interested in RES micro-generation

practices. Moreover, whilst state-of-the-art research on energy publics demonstrates how early-stage community engagement increases acceptance of sustainable energy technologies, especially in the context of local energy cooperatives [4,70,114] our survey findings suggest there is limited scope for such participatory practices. A statistically significant majority (51.2%) of survey informants from across the Aegean would not or probably not be willing to buy shares and co-manage a RES-based local energy cooperative (see [Fig.8b](#)).

Q: Would you be interested in becoming an energy prosumer (a) by producing electricity for self-consumption, and (b) by buying shares in and co-managing a local energy cooperative?

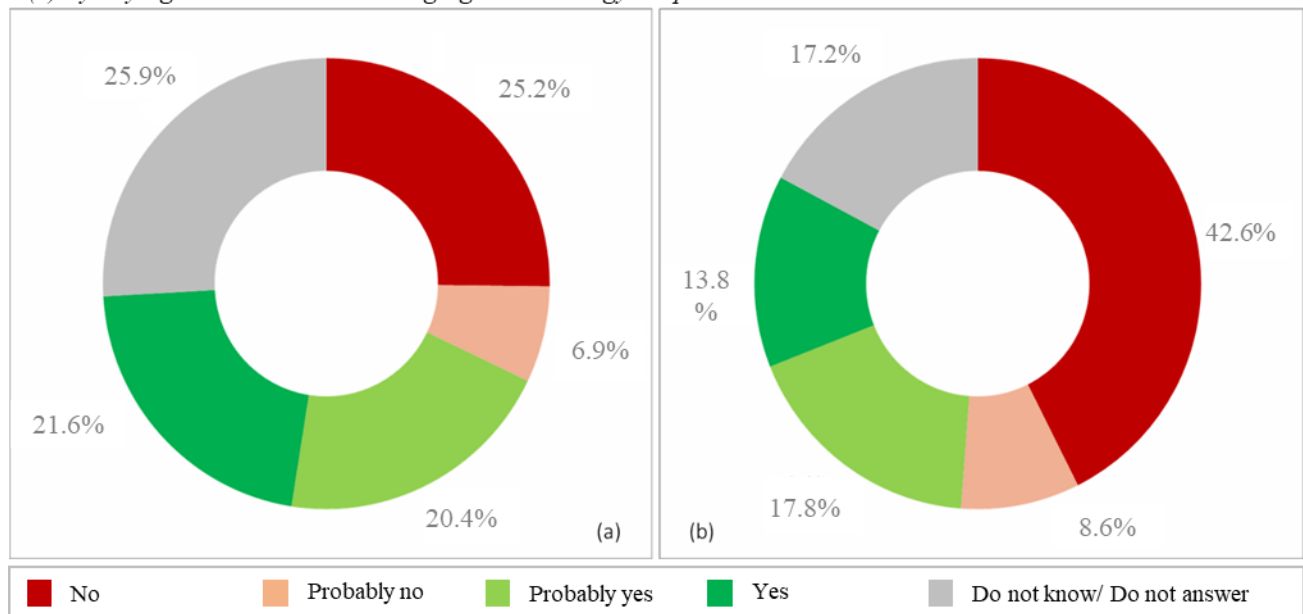


Figure 8: Public willingness to adopt prosumption practices.

Q: Would you be willing to accept key smart grid technologies such as (a) Demand-Side Management, and (b) smart metering?

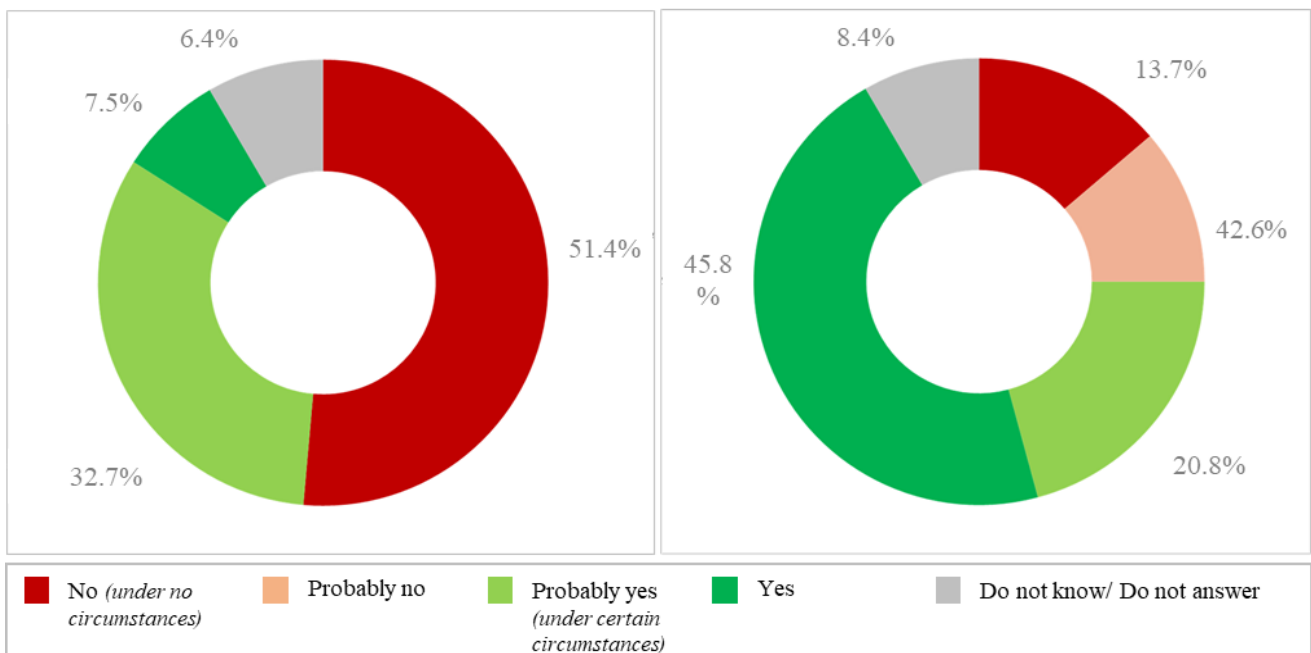


Figure 9: Public willingness to accept smart grid technologies.

Similarly, and as suggested by [Fig.9](#), many islanders would not accept any smart grid technologies whatsoever:

- i. A statistically significant majority of respondents (51.4%) would under no circumstances accept external DSM, believing that it would act out to the detriment of their energy use experience; and
- ii. Up to a quarter of those few (n=156) survey respondents who know what a smart meter is, would not or probably not accept the free installation of a smart meter in their house or business premises.

4.2. Personal/demographic determinants of public acceptance/opposition

Given the lack of complete support to key sustainable energy solutions of the TILOS- Horizon 2020 model, and in addressing the second key question of this research, this sub-section contributes to ongoing debates on the importance of *personal/demographic factors* in explaining differing public attitudes. In doing so, it uncovers how the replication of the TILOS model might only be accepted by individuals with certain personal/demographic characteristics.

First, *chi-squared analyses* demonstrate how observed differences in levels of support/opposition to a spectrum of sustainable energy solutions between men and women are unlikely to be by chance. Small yet statistically significant differences recorded in the responses provided by men and women suggest that women are more likely to challenge a hoped-for energy transition than men. Indicatively:

- i. Men appear more supportive of local RES developments than women, with 13.4% more men than women having a positive attitude towards such possible future developments (χ^2 : 29.456; df: 5; sf: .000).
- ii. Men are more supportive of a complete transition to a RES-based energy system with battery storage capabilities than women. For instance, while 69.9% of men are completely in favour of such a transition, a significantly smaller majority of women (56.4%) are thoroughly supportive of this future energy supply scenario (χ^2 : 31.576; df: 4; sf: .000).
- iii. While islanders are generally reluctant to partake in a local energy cooperative, men are more willing than women to become involved in such schemes (χ^2 : 18.076; df: 4; sf: .001). For instance, while only 10.4% of women would be wholeheartedly willing to partake in an energy cooperative, up to 18.5% of men appear willing to invest time and money in a locally owned energy system.
- iv. More men than women believe that the tourism/hospitality industry will benefit from local RES installations (χ^2 : 19.451; df: 5; sf: .002). Indicatively, while 31.7% of men believe that RES technologies will benefit tourism, only 26.3% of women share a similar belief.
- v. Many more men than women are interested in investing in prosumption (e.g. by installing domestic PV panels) (χ^2 : 10.661; df: 4; sf: .031). For example, 10.2% more men than women have indicated their possible interest in such innovative technologies.

Second, there is considerable evidence to suggest that, as a rule of thumb, older individuals are slightly more wary of a sustainable energy transition for the region than younger islanders. Particularly, in line with past academic research at an international level documenting the demographic determinants of public acceptability for energy innovation [64] – and against regional-level data of Sardianou and Genoudi [53], we assert that:

- i. Individuals between 18-54 years old are, generally speaking, more supportive of a complete transition to a RES-based energy system than individuals who are 55 years old or older. For example, while an overwhelming majority (66.9%) of individuals aged between 18-54 years old is supportive of such a transition, a significantly smaller majority (57.2%) of islanders who are 55 years old and older is unequivocally supportive (χ^2 value: 43.171; df: 24; sf: .010).
- ii. Younger people (between 18-54 years old) are, across all islands studied, less concerned that PV installations will cause any local disturbance when compared against older individuals (55 years old or above). For instance, 13.3% more individuals aged between 18-54 years old believe that disturbance caused by PV installations is insignificant when compared against the 55+ years old demographic group.
- iii. Older individuals (55 years old or older) tend to be more reluctant with respect to becoming active energy prosumers when compared against younger individuals (χ^2 : 93.188; df: 24; sf: .000). Indicatively, the statistically significant majority of research informants who are 55 years old or older are against prosumption practices (34.3%). Conversely, only 16.8% of the 18-54 years old demographic is against such practices.

The assertion that support or opposition to sustainable energy technologies relates to differences in the demographic profiles of the research informants is further supported by multiple *multinomial regression analyses* performed on the sample – comparing data on the personal characteristics of our sample with levels of stated support to such technologies. [Table 3](#) demonstrates the *logistic regression coefficients (B)* and the *odds ratios (Ex(B))* for the independent variables for the six key dependent variables. These include: a) acceptance of local RES installations; b) acceptance of a complete transition to a RES-based energy system; c) willingness to invest in domestic micro-generation; d) interest in participating in community energy projects; e) willing to accept DSM; and f) willingness to accept installation of smart meters.

Specifically, the first case explored uncovers how all but one personal factors included in the study are significant in predicting full support to local RES installations. Older individuals (55 years old and above) are 1.473 times less likely than younger individuals (18-54 years old) to fully accept such developments. Men are 1.196 times more likely than women to express their complete support for local installations. Finally, experience of RES and higher levels of environmental concern are also important predicting factors. Individuals with experience of such technologies are 1.377 times more likely to support rather than oppose local RES installations than individuals with no such experience. Likewise, individuals who believe that environmental issues are locally significant are 1.187 times more likely to support rather than oppose such installations on their respective islands. Similar results are recorded with respect to support towards a complete electricity supply decarbonisation and more extensive end-user engagement around sustainable energy, with the results confirming that men, younger individuals and locals with environmental concerns and experience of RES systems are more likely to support such smart and green energy transitions than their counterparts. Indicatively, the probability of women being wholeheartedly interested in participating in a local energy cooperative is 0.437 times lower when compared against their male counterparts.

Table 3: Impact of personal variables on willingness to fully accept different sustainable energy solutions.

<i>Dependent variables</i>	<i>Acceptance of local RES</i>	<i>Acceptance of complete RES transition</i>	<i>Willingness to invest in micro-generation</i>	<i>Interest in community energy</i>	<i>Willingness to accept DSM</i>	<i>Willingness to accept smart meters</i>
Age	B: -0.388 Ex(B): 1.473**	B= -0.442 Ex(B)= 0.643***	B: -0.828 Ex(B): 0.437***	B: -0.270 Ex(B): 0.763**	B: -0.200 Ex(B):0.819**	B: -0.203 Ex(B): 0.817
Gender	B: 0.179 Ex(B): 1.196**	B= 0.119 Ex(B)= 0.888*	B: 0.270 Ex(B): 0.763**	B: 0.828 Ex(B): 0.437***	B: 0.107 Ex(B): 1.113*	B: 0.908 Ex(B): 0.403**
Income	B: 0.320 Ex(B)= 1.377	B= 0.320 Ex(B)= 1.377	B: 0.064 Ex(B): 1.066***	B: 0.187 Ex(B): 0.341	B: -0.064 Ex(B): 0.938	B: 0.361 Ex(B): 1.435
Past RES knowledge/ experience	B: 0.320 Ex(B): 1.377*	B= 0.554 Ex(B)= 0.576**	B: 0.151 Ex(B): 0.860*	B: 0.151 Ex(B): 0.860*	B: 0.297 Ex(B): 0.743*	B: 1.822 Ex(B): 0.162**
Env. concern	B: 0.830 Ex(B): 1.187*	B= 4.72 Ex(B)= 0.624***	B: 0.442 Ex(B): 0.643***	B: 0.422 Ex(B): 0.643**	B: 0.479 Ex(B): 0.619***	B: 0.999 Ex(B): 0.368***
Pseudo R ²	0.14	0.17	0.26	0.26	0.17	0.14
Correct predictions	62.4%	66.0%	70.4%	55.7%	61.0%	92.2%

***Statistically significant at the 0.01 level.

**Statistically significant at the 0.05 level.

* Statistically significant at the 0.1 level.

Case 3, namely willingness to invest in RES micro-generation at the household level, is also in line with past research in Greece [53] and beyond [31,32] – documenting a positive association between annual household income/social class and acceptance of sustainable energy technologies and RES-based domestic micro-generation. All personal factors – including stated household income – predict high levels of interest in micro-generation. For example, individuals in the higher income range are 1.066 times more likely to be willing to invest in micro-generation than other islanders.

Finally, in considering the whole corpus of survey data through the application of a *two-step clustering* technique, we uncover three distinct respondent clusters – with all but one of our personal/demographic factors acting as statistically significant predictors in our model (see [Table 4](#)). These three respondent clusters include Potential Opposers (25.2% of the sample), Potential Green Consumers (53.2% of the sample) and a minority of Potential Green Prosumers (21.6% of the sample).

Specifically, willingness to partake in an energy cooperative, perceived disturbance caused by fossil fuel plants, level of acceptance of RES installations with storage capabilities, willingness to install domestic PVs and/or domestic storage batteries, and acceptance of RES installations with storage in place of fossil fuel plants, are the five primary predictors of cluster participation. Indicatively, the more concerned an individual is by the burning of fossil fuels for electricity generation, the more likely (s)he is to support active energy user engagement in a potential green energy transition. Notably, and in line with past research in this field [31,32,53], there is considerable ground for suggesting that key socio-demographic attributes influence acceptability of green

energy technologies in a consistently significant manner. On the one hand, our findings provide further empirical support to Gröger et al's [64] assertion that a typical green energy consumer or prosumer is male, young, concerned about the environment and with relevant experience/knowledge – and, subsequently to a number of studies identifying similar patterns (see [Section 2](#)). On the other hand, our analyses challenge the contextual resonance of past studies noting that levels of support are independent of levels of awareness [31,32].

Table 4: Two-step cluster analysis of findings (Silhouette measure of cohesion/ separation: Good = 82% of cases belonging in clusters).

Cluster	Green Consumers (53.2%)	Green Prosumers (21.6%)	Opposers (25.2%)
Willingness to partake in an energy cooperative	Importance= 1.00 Most frequent category: DK/ DA (100%)	Importance= 1.00 Most frequent category: Yes (100%)	Importance= 1.00 Most frequent category: No (100%)
Perceived disturbance by fossil fuel plants	Importance= 0.80 Most frequent category: Significant (59.8%)	Importance= 0.80 Most frequent category: Very significant (100%)	Importance= 0.80 Most frequent category: Insignificant (100%)
Acceptance of complete RES transition	Importance= 0.80 Most frequent category: Yes (100%)	Importance= 0.80 Most frequent category: Probably yes (100%)	Importance= 0.80 Most frequent category: DK/ DA (51.5%)
Willingness to install domestic PVs	Importance= 0.75 Most frequent category: DK/ DA (48.7%)	Importance= 0.70 Most frequent category: Yes (100%)	Importance= 0.60 Most frequent category: No (100%)
Willingness to install domestic storage batteries	Importance= 0.70 Most frequent category: Probably yes (48.7%)	Importance= 0.60 Most frequent category: Yes (100%)	Importance= 0.50 Most frequent category: DK/ DA (100%)
Acceptance of RES installations/ storage in place of oil-based plants	Importance= 0.65 Most frequent category: Yes (100%)	Importance= 0.60 Most frequent category: Yes (94.5%)	Importance= 0.50 Most frequent category: Fossil fuels (46.8%)
Perceived disturbance caused by wind turbines	Importance= 0.60 Most frequent category: Insignificant (90%)	Importance= 0.55 Most frequent category: Insignificant (82.4%)	Importance= 0.47 Most frequent category: Significant (57.1%)
View of potential local RES installations	Importance= 0.55 Most frequent category: Positive (80%)	Importance= 0.50 Most frequent category: Positive (90.5%)	Importance= 0.45 Most frequent category: Negative (39.5%)
Perceived impact of RES installations on tourism	Importance= 0.55 Most frequent category: Neither positive nor negative (58.6%)	Importance= 0.50 Most frequent category: Positive (100%)	Importance= 0.40 Most frequent category: Negative (100%)
Perceived disturbance caused by wind turbines	Importance= 0.50 Most frequent category: Insignificant (53.4%)	Importance= 0.40 Most frequent category: Insignificant (100%)	Importance= 0.40 Most frequent category: Very significant (38.1%)
Concern over environmental problems	Importance= 0.45 Most frequent category: Somewhat significant (53.4%)	Importance= 0.30 Most frequent category: Significant (100%)	Importance= 0.35 Most frequent category: Insignificant (58.4%)
Gender	Importance= 0.20 Most frequent category: Male (54.3%)	Importance= 0.10 Most frequent category: Male (57%)	Importance= 0.20 Most frequent category: Female (58%)
Age	Importance= 0.10 Most frequent category: 18-49 (61.2%)	Importance= 0.10 Most frequent category: 18-49 (67%)	Importance= 0.15 Most frequent category: 50+ (78%)
Environmental concern	Importance= 0.10 Most frequent category: Significant (61.2%)	Importance= 0.10 Most frequent category: Very significant (62.1%)	Importance= 0.10 Most frequent category: Insignificant (54.4%)
Past RES experience/ knowledge	Importance= 0.05 Most frequent category: Somewhat significant (53.4%)	Importance= 0.03 Most frequent category: Significant (53.4%)	Importance= 0.08 Most frequent category: Insignificant (53.4%)

Hence, our three distinct islander clusters can be described as follows:

- i. Potential Green Consumers constitutes a class of individuals who are willing to accept most renewable technologies but are reluctant to adopt or reject prosumption practices. These individuals tend to be men,

aged between 18-49 years old, who believe that environmental problems are locally significant, and with some experience or knowledge of RES/ smart grid technologies.

- ii. Conversely, Potential Green Prosumers accept both large-scale RES technologies and are especially interested in actively supporting a green energy transition – either by partaking in a local energy cooperative or by their interest to invest in micro-generation and battery storage equipment. Prosumers are, once more, a young male-dominated group of individuals who are, nonetheless more concerned about environmental problems and have more experience and a better understanding of RES/ smart grid technologies.
- iii. While both these respondent clusters would, one way or another, support a green energy transition, the third cluster of respondents – what we indicatively label as the Opposers – is expected to pose a significant social barrier to hoped-for energy futures for the region. For they are unconcerned by the use of fossil fuels for electricity generation and, thus, reject all green or smart energy infrastructures. This constitutes an older, female-dominated group of individuals who are not especially concerned by the local significance of environmental problems and have no real understanding of RES/ smart grid technologies.

5 Conclusions

Drawing on a core claim that public opinions make or break sustainable energy transitions [27,30], this research set-out to: a) explore whether islanders from across the Aegean archipelago are likely to support the replication of the TILOS (“Technology Innovation for the Local Scale, Optimum Integration of Battery Energy Storage”) energy model on their islands, and b) determine whether *personal/demographic factors* influence public attitudes. To address these research questions, this exploration started from three original positions. First, we moved significantly beyond current scholarship on public acceptability of green energy infrastructures that overwhelmingly focuses on local opposition to single wind energy projects [47,78,107] – considering, instead, public attitudes to hybrid energy models that combine renewable and smart grid technologies and even attempt to redefine energy end-users as active co-providers or prosumers. In doing so, we moved beyond the use of single case studies focusing on local opposition at a late stage in the implementation process [47,107]. Second, we moved significantly beyond extant research on energy islands which tends to oversee energy publics – thus contributing towards the development of our understanding of a particularly interesting geographic region (in terms of its renewable energy potential, growing commitment to its smart energy transition, and in light of limited yet contradictory evidence on the attitudes of its islanders). Our multi-sited exploration of public attitudes is uniquely situated to help understand energy publics across the Aegean prior to the development of specific plans. Third, and finally, in addressing these persisting knowledge gaps, we explicitly contributed to an incessant debate on the influence of *personal/demographic attributes* on public attitudes.

By addressing our research aims and questions, this paper informs a number of key conclusions with scholarly and transition governance interest. First, our findings challenge past media coverage highlighting that local resistance to green energy solutions – and especially to wind energy – is particularly acute in the context of Greek non-interconnected islands of international touristic significance [92,93]. Specifically, according to the

data obtained through our questionnaire survey, public attitudes towards green energy technologies across the Aegean are generally supportive of interventions such as those made possible through the TILOS project. Most of the survey respondents argue in favour of a transition to an energy system that is completely supplied by RES, and recognise that renewable technologies are likely to improve the local environment when compared against highly disturbing fossil fuel-based power plants.

Second, it is safe to conclude that broad acceptability of such technologies across the Aegean does not equate to universal, unconditional acceptance of all long-term interventions put forth by the TILOS research consortium. As this is the first study to include data from across the Aegean archipelago and to explore public acceptability of hybrid energy systems, the evidence presented in this manuscript also suggests that the replication of the TILOS-Horizon 2020 energy model across the region might not be as smooth sailing as we would have hoped. This holds particularly true for: a) possible interventions beyond centralised renewable installations – such as demand-side management and prosumption, and b) certain types of individuals identified as potential green/smart energy opposers. Specifically, in considering the entire corpus of data collected through the questionnaire survey, we assert that only a fifth of islanders are consistently in favour of all sustainable energy solutions put forth by the TILOS consortium – including, but not limited, to renewable and smart grid technologies, demand-side management and even prosumption from domestic renewable sources. We cannot ignore: a) a majority of respondents who would only accept green energy solutions that do not affect them directly, b) around a quarter of respondents who would thoroughly oppose such developments altogether. With past research in Greece and beyond documenting how public opposition to green energy technologies and infrastructures can bring otherwise promising projects to a virtual stand-still [36,37], we must closely account for diverse public attitudes when envisioning the replication of the TILOS-Horizon 2020 energy model on other islands and plan accordingly.

Third, while this research only explored the relationships between personal/demographic factors and public attitudes, the fact that our *multinomial regression analyses* uncovered matching trends for all different technologies considered suggests that it is highly unlikely to have reached false-positive conclusions. Consequently, against a backdrop of inconclusive evidence on whether *personal/demographic factors* affect public attitudes towards green/smart energy technologies (see Devine-Wright [31,32]), this research confirms the regional transferability of past assertions (e.g. Gröger et al. [64]) that a green energy consumer/prosumer or is typically male, young, knowledgeable/experienced and concerned about the environment. Of course, this does not mean that our findings are a full reflection of past research – especially since past studies have occasionally reached contradictory conclusions. For instance, we did not consistently uncover a statistically significant positive correlation between income/social class and levels of support for both renewable energy and other smart technologies (see Devine-Wright [31,32] for a review). Similarly, while Warren, Lumsden, O’Dowd, and Birnie [72] note that environmentally concerned individuals might occasionally oppose local developments in fear of their local environmental/landscape impacts, environmental concern was, in our case, a consistent predictor of positive attitudes towards sustainable energy technologies.

Admittedly, caution must be taken in drawing too many conclusions from this research. In spite of our best intentions and consideration of public attitudes across different geographical locations, the research inevitably faced several practical constraints. These include inter alia, pragmatic considerations with respect to how many questions to include in the CATI-based questionnaire surveys. Most importantly, the generic framing of the research implicates that generally positive attitudes towards green energy technologies will not necessarily translate into actual support of specific projects on the ground: attitudes toward green energy in general and attitudes toward specific projects will understandably differ, as they are different attitude objects [44,45].

However, setting these limitations aside, it is important to reiterate that this research has provided a radically different insight into sustainable energy transitions in island contexts – moving beyond techno-centric narratives and reconsidering transitions as a socio-technical process [66,115]. Against a backdrop of ambitious energy island transition plans, this is amongst the first studies to suggest that the support of island energy end-users should not be taken for granted – even though they are all equally exposed to the multiple energy security, environmental, economic and energy-supply problems encountered in conventional isolated energy systems [5,116].

As such, the research documented in this paper also lays the groundworks for a future research and policy agenda. Given growing interest in responsible research and innovation processes [26,76], we envision a future research trajectory geared towards better understanding how islanders with distinct profiles view sustainable energy technologies. This would yield important information on how the design of a technology or the way a technology is implemented should be adapted, and how the technological intervention should be communicated, such that acceptance increases and implementation is smoother (e.g. through targeted marketing to specific energy user segments). Bearing in mind that our research program uncovered distinct islander segments, future research in the field should aim to better understand the determinants of public support or opposition and, thus, contribute to ongoing efforts to stimulate island energy transitions from a consumer perspective [20]. In particular, the concept of ‘place-technology fit’ [46] should be used to open up the ways in which diverse potential local energy projects may be represented to ‘fit’, enhance or threaten socially and geographically embedded communities of energy users. All this implies an increased interest in the wider context of local energy development – something which addresses existing calls for more contextualised social psychological research [46,48]. This involves accounting for several additional *socio-psychological*, *contextual* and *spatial factors* influencing public attitudes [31,32,50] and, thus, potentially shaping the three distinct islander classes identified in this paper. These approaches are especially useful in this future research agenda as they have been found [47] to be able to offer powerful conceptual tools for understanding both support and opposition to local energy projects such as those put forth by the TILOS-Horizon 2020 research consortium.

Moreover, from a transition governance perspective, we argue that project developers, policymakers, and other stakeholders should bear in mind that not all members of the public are likely to support their ambitious transition plans and, thus, strategize accordingly. On the one hand, stakeholders cannot change the demographic profiles of islands to increase support for sustainable technologies. On the other hand, however, the knowledge of

different energy-user profiles offers the opportunity for more tailored approaches in project development – e.g. by developing systems that only require the active involvement of a small portion of locals, by developing installations on sites with minimal public opposition, etc.

Most importantly, though, there is a pressing need for information dissemination. Bearing in mind our conclusion that past experience/knowledge of smart grid/RES systems exercises a positive influence on attitudes – as well as past research that correlates opposition to local developments with an information deficit [36,57,58] – prospective developers should also commit to playing-out their part towards enhancing energy literacy in the region. Further development of the three islander clusters and the inclusion of individuals who are currently undecided could prove particularly useful in delivering this programme, with relevant parties developing targeted communication to different audiences in the hope of highlighting issues of specific interest or concern. With respect to the TILOS consortium, this involves: a) the dissemination of accessible and *tailored* information (e.g. on the possible benefits of the system); and b) taking steps towards the ongoing organisation of expert-led site visits to infrastructures on the island of Tilos to help islanders develop a better understanding of the promoted technologies. By clarifying uncertainties and demonstrating the positive impact such interventions have on local populations, such disseminated information is expected to stimulate further support to sustainable energy technologies. This notion that information campaigns or opportunities for public deliberation could increase public support of green energy technologies is relatively common; renewable energy advocates envision attitudes toward projects becoming more positive as the public learns more about the benefits of green energy and misconceptions about impacts are corrected [27,46].

Finally, given the considerable diversity of attitudes towards green energy technologies recorded, we believe there is a pressing need for an (inter)national governance debate on whether governments, developers or other stakeholders should prioritise sustainable energy transitions or energy democracy. Informed by key outputs by multiple European projects (including, inter alia, the TILOS-Horizon 2020 project itself), the European Commission's 'Proposal for a Regulation of the European Parliament and of the Council on the Governance of the Energy Union' [2] assumes that transparent and participatory decision-making can deliver the ambitious plan for a climate-neutral Europe by 2050. On the one hand, and given the attitudinal differences recorded here and elsewhere, there is a strong instrumental rationale for an 'upstream' approach to public participation in place of a 'tokenistic' imposition of the TILOS energy model on other islands in the region. In line with core responsible research and innovation guidelines [26], this entails empowering diverse energy publics and their voices; opening-up wider public discourses and dialogue around what changes are acceptable or desired in a particular place and under which conditions. Specifically, public engagement that is 'upstream' in energy infrastructure decision-making processes may open-up views on the relative acceptability of various local sustainability actions, rather than focusing on single projects that are the result of expert-level discussions establishing the energy-related 'problems' or 'challenges' at hand [56]. Clearly, though, such extensive public engagement might act to the detriment of ambitious energy transition aspirations if, and when, locals oppose specific local interventions or sustainable energy technologies as a whole.

In conclusion, while the transfer of the TILOS-Horizon 2020 energy model to other non-interconnected islands of the Aegean Archipelago appears technically feasible [11], we should not assume that this process will be straightforward. With research and practice on non-interconnected islands at an international level ignoring energy publics (see [Section 2.1](#)), and bearing in mind the significance of public acceptability (see [Section 2](#)), this empirical case study highlights the fact that we can no longer afford to ignore diverse energy publics. Rather, sustainable energy transitions for the region – and beyond – can only ever be achieved by accounting for local publics, their attitudes, values, and sensitivities.

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