Aalborg Universitet

Policy strategy recommendations

Smart Island Energy Systems - H2020 Project SMILE Deliverable 8.5

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Smart Island Energy Systems

Deliverable D8.5

Policy strategy recommendations

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Keywords, Acronyms

AAU	Aalborg University
BESS	Battery Energy Storage System
BMS	Battery Management System
CES	Community Energy Scotland
CETA	Clean Energy Transition Agendas
CFSR	Climate Forecast System Reanalysis (Weather data)
CHP	Combined Heat and Power plant
D8.X	Deliverable X from WP 8
DH	District Heating
DSM	Demand Side Management
DSO	Demand Side Operator
EEM	Electricity Company of Madeira (Empresa De Electricidade Da Madeira S.a.)
EMS	Energy Management System
ERSE	Energy Services Regulatory Authority
ETS	Emissions Trading System
EV	Electric Vehicle
GHG	Greenhouse Gases
ICEV	Internal Combustion Engine Vehicle
JP	Jet Petrol
LPG	Liquefied Petroleum Gas
Li-on	Lithium-ion
MERRA	Modern-Era Retrospective analysis for Research and Applications (Weather data)
PES	Primary Energy Supply
PP	Power Plant
PV	Photovoltaic
RES	Renewable Energy Source
RAM	Região Autónoma da Madeira
SECAP	Sustainable Energy and Climate Action Plans
V2G	Vehicle To Grid
VDP	User Datagram Protocol
WP	Work Package

1 Introduction

SMILE combines a number of partners to investigate the project pilot islands Samsø in Denmark, Orkney in the United Kingdom and Madeira in Portugal and their ways of becoming carbon neutral through renewable energy (RE) and smart technology demonstration. While local conditions on these islands differ widely, the investigation covers similar technical and non-technical solutions, such as demand response, smart grid functionalities, storage and energy system integration. The demonstration includes – in line with the transition to high-RE shares – the so-called smart technologies, such as battery electricity storage systems (BESS), power-to-heat, power-to-fuel, electric vehicles (EVs), electricity stored on board of boats, aggregator approach to demand side management (DSM) and predictive algorithms.

In this report, we present the outcome of *Task 8.5: Policy strategies to support the transition to high-RE systems in Orkney, Samsø and Madeira Island*. The task and the corresponding deliverable are part of work package (WP) 8 of the Smart Island Energy System (SMILE) project.

The present report concludes Task 8.5 and thereby WP8 by drawing on the previous tasks and deliverable and by elaborating on policy strategies for the SMILE demonstration. Chapter 2 reviews WP8 with its objectives and deliverables to set the context for D8.5. Chapter 3 presents the insights from the demonstrations islands and the resulting policy recommendations, EU emissions framework and replication opportunities in other target locations. Chapter 4 summarizes the presented evaluation and concludes the report, before final remarks conclude the overall WP8.

2 Clarifications

This Chapter presents clarifications that are necessary for a full understanding of this report. Therefore, a short review of WP8 with its objectives, tasks and deliverables is performed, including a review of relevant aspects in relation to D8.5, before going into detail with the approaches taken for its achievement. Further information can be found in the preceding deliverables described below. Chapter 3 follows with the resulting policy strategies to support the transition to high-RE systems.

2.1 Review for policy strategy task

For the understanding and alignment with the previous tasks and the overall goal of WP8 in the SMILE project, the following presents the relation to the other tasks, before addressing the policy design approach for this report in Section 2.2. The policy approach includes cooperation with the SMILE project partners, a literature study and resulting questionnaires to draw conclusions for policy strategies from.

2.1.1 Review of Work Package 8 (WP8)

Within the Framework of the SMILE project, the main goal of WP8 is to analyse and present the pilot islands' energy systems and the impacts, strategies and market designs associated with the project. The main objective of WP8 is to investigate potential development pathways towards high RE for the three pilot islands taking into consideration the energy systems impacts of the demonstration projects and their role in such high-RE scenarios. For this, the technical solutions demonstrated – from production, over conversion and storage, to demand – are taken into account. Besides these technical energy system analyses, the WP investigates the energy market structures and policy strategies that impact and are impacted by the transition process in the three pilot islands.

The objectives of WP8 are achieved through meeting the following Tasks:

- 8.1: Establishment of reference energy systems simulations models of the three pilot islands (Deliverable submitted January 2018 [1])
- 8.2: Establishment of medium term (10-15 years) high RE scenarios for the three pilot islands (Deliverable submitted December 2018 [2])
- 8.3: Power loss management of minutes-based energy outages in the distribution grid of the three islands, with simulation tools (Deliverable submitted April 2021)
- 8.4: Establishment of recommendations for market design structures to support the transition to high-RE systems in the three pilot islands (Deliverable submitted April 2021)
- 8.5: Establishment of policy strategies to support the transition to high-RE systems in the three pilot islands (this report, submitted April 2021)

Further information and related documents of WP8 can be found on the SMILE website [3]: www.h2020smile.eu/press-downloads/ and on The Community Research and Development Information Service (CORDIS) website [4]: https://cordis.europa.eu/project/id/731249/results.

Where Task 8.1, 8.2 and 8.3 covered the technical aspects, and Task 8.4 focused on the energy market structure to support the transitions to high-RE energy systems, the here presented task looks more broadly at policy implications. These include both present policies influencing the design of the energy systems and what potential policies are needed for supporting the transition to high-RE energy systems on the islands in the future. Therefore Task 8.5 relies on the preceding tasks and input from the SMILE demonstration islands. However, this task is not split up into separate tasks for the three pilot islands, rather, recommendations are sought that transcend the different circumstances given by the three pilot project islands, with a view to providing replication opportunities towards other markets.

2.1.2 Review of Deliverables

Task 8.5 and D8.5 are built upon the preceding tasks in WP8, especially D8.4, but also the foregoing energy system modelling in D8.1 and D8.2. These are briefly reviewed in the following, while details can be found in the corresponding deliverables. In general, the impact analyses from WP8 are split into technical and institutional analyses, where D8.1 and D8.2 are part of the first and D8.4 and D8.5 are part of the latter. All are however holistic analyses where all energy sectors are included: electricity, heating, transport.

D8.1 and D8.2 present the reference energy systems (2014/2015) and the future energy system scenarios of 2022 and 2030 for the three demonstration islands Samsø, Orkney and Madeira. Besides including all sectors, also the supply, conversion and demand sides are included and presented through the hour-based modelling tool EnergyPLAN [5]. The models include local characteristics, not just regarding the availability of wind and solar radiation, but also technologies and fuels most suitable and employed in each island.

Despite the local differences, each island is modelled to increase its RE share by around 20%-points from the current to the 2030 system models through the employment of SMILE technologies as well as additional RE capacity. While D8.1 presents the islands in their 'current' (2017) situation with their potentials and weaknesses, it also indicates the need for better integration of locally produced energy to supply electricity, heating and transport sustainably. Next to the evaluation of smart SMILE technologies for the future model in D8.2, further technological advances and changes in the system are included to ensure the transition of each island to high RE shares in the long run.

This energy transition is aiming at the transformation of the energy systems toward a 100% RE share, through various technologies requiring balance, sector integration, and optimized biomass utilization [6]. Furthermore, for islands, this transition is also characterized by increased self-sufficiency, however, this entails a better integration of local resources, technologies and demands. With increased electricity demand in the heating and transport sector, additional RE capacity is required, but also optimal utilization, which has been addressed through the energy market perspectives in D8.4.

D8.4 discusses the need to align the technical energy system analyses with market analyses, where local options and barriers are discussed for each demonstration island, as well as recommendations made based on these. Finally, support mechanisms and an evaluation of the specific needs for islands are presented to provide the best opportunities for islands in transitions to high RE shares.

While Task 8.4 investigates how this transition may be supported by present energy market structures, Task 8.5 relates to the corresponding policy implications and strategies to support the transition for the demonstration islands and beyond. Hence, D8.5 relates to both the technical models and the energy market structures suggested and concludes the WP8 with transcendent recommendation for the different circumstances found across SMILE islands and other markets.

To support Task 8.5, references to related research are made, which was carried out during the preceding tasks. An evaluation of BESS set-ups on Samsø contributes to the discussion [7], as well as a comparison made between BESS and TES in combination with heat pumps for Samsø and Orkney [8]. Additional aspects of transitioning all SMILE islands to high RE share [9] supports the issues already introduced in D8.4. Especially the analysis made on the required alignment of technical and market analysis for Madeira [10] adds to the influencing material for D8.5. Finally, the work in relation to the PhD thesis on ‘Modelling renewable energy islands’ [11], which was supported by the SMILE project, influences the approach to the policy design, as is described in Section 3.1.

2.2 Energy policy approach

As presented in the previous work – both deliverables and related research – islands have a larger need for self-sufficiency than well-embedded energy systems, not just technically but also institutionally. The integration of fluctuating RE, such as wind and solar energy, is difficult to match with the demand, especially on islands, including the SMILE demonstration islands. However, SMILE demonstrates options that address this problem through demand response, smart technologies and integration of electricity in other sectors. These technical and non-technical possibilities need to be implemented correctly to allow for balance and flexibility. This benefits not only the consumers, but also the energy providers, and allows the future modelled energy system to become reality. Hence, not only alignment with the energy market and potentially new energy market design structures are required, but also policy analysis and strategies to support these.

Besides the discussion of the previous tasks in WP8, the following approaches are taken to recapitulate the island-specific aspects for Samsø, Orkney and Madeira to point out problems and potentials in regard to policy design. This is aligned with existing research to find transcending solutions. These approaches are explained in further detail below, resulting in Chapter 3.

- Scientific literature review
- Questionnaires for input from each island
- Recommendations for policy strategies
- Framework for EU islands
- Analysis of replication opportunities

Figure 1 presents the design of the overall methodology applied. While the literature review represents stage 1, the questionnaires represent stage 2 and stage 3, resulting in the policy recommendations including strategies, framework and replication opportunities, as further explained in the following.

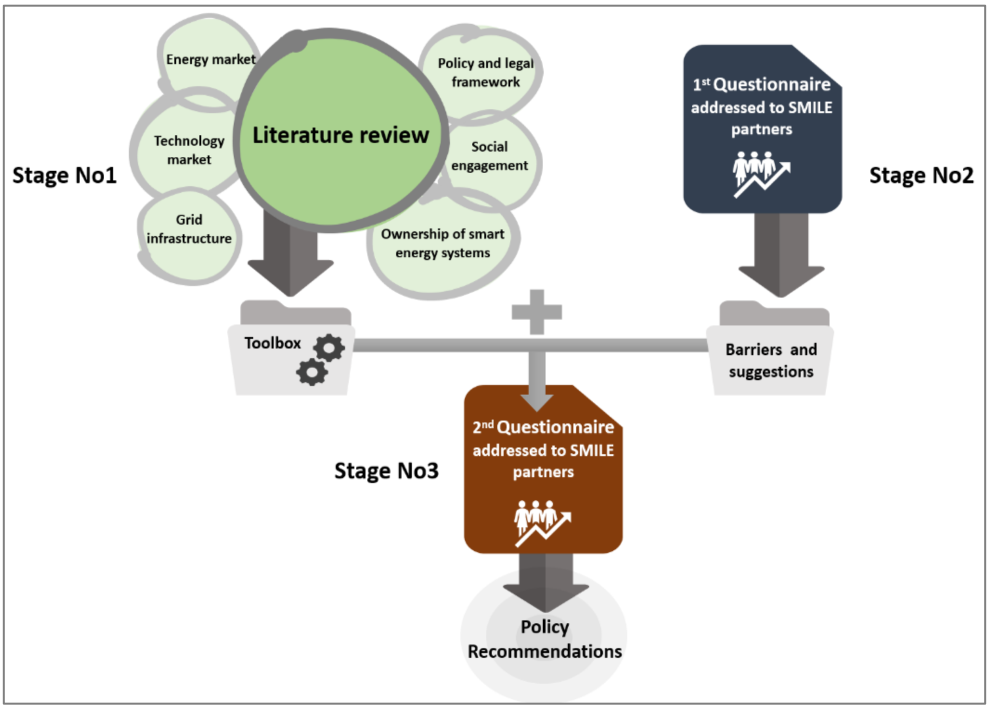

Figure 1: Design of the methodology

2.2.1 Literature review

In order to place SMILE and the demonstration potential into the political analysis framework, an initial literature review is conducted by AAU and DAFNI with a focus on energy system analysis and policies. The aim it to summarise policy suggestions within a number of themes relevant for the impact analysis of SMILE and for the creation of a subsequent questionnaire. The themes identified for this are presented in Figure 2 and form the first stage of the methodology presented in Figure 1. While some themes overlap with the work done in D8.4, where relevant aspects are introduced in regard to markets, the following six themes are further discussed in D8.5, as markets and policies can be intertwined.

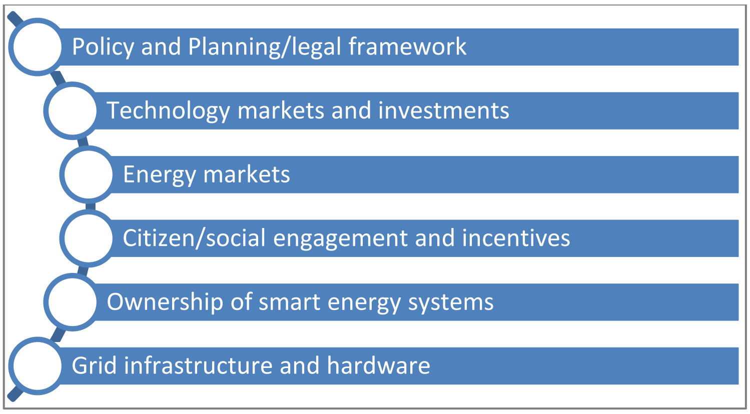

Figure 2: Structure for policy identification

The overview of the literature review, as well as the responses from the SMILE demonstration representatives across the demonstration islands, can be found in the Appendix, though details are supporting already to analysis in Chapter 3, as well as influence the following questionnaire to the SMILE demonstration islands and representative partners.

2.2.2 Questionnaires

As presented in Figure 1, the questionnaires form Stages 2 and 3 of the policy analysis methodology as they are interlinked with the literature review in Stage 1. These questionnaires are intended to establish, first, an overview of barriers and potential policy suggestions as experienced or perceived by SMILE partners representing the three SMILE islands. This first part of the questionnaire is an open questionnaire seeking general inputs within the six identified themes. And, secondly, in combination with the literature review and inputs gathered, the same SMILE partners are asked to assess the relevance of the identified barriers and suggestions, thereby, providing mutual inspiration between the SMILE islands. This second part presents an assessment and island-transcending alignment of identified barriers and suggestions.

All questions refer to the context of the transition to a smart energy system in general – based on the SMILE technologies, as well as other general scenario elements described in D8.2 and summarized in Table 1.

Table 1: Energy system impact analysis

	Madeira	**Orkney**	**Samsø**
SMILE Technologies and current issues	PV (and RE) integration Increase self-consumption Improve grid restrains Residential and communal BESS EVs with smart charging Grid stability	Wind integration Smart heat pumps Thermal storage BESS EVs, smart charging Electrolyser, smart control	Integration of local RE New PV and BESS at marina Sale of locally produced power to boat owners Heat pumps Optimising local production, sales and consumption
Other technologies considered for further transition to high RE shares	Additional RE capacity Balancing options including electrolysers and V2G, Hydrogen production and demand	Additional EVs Potential V2G Additional heat pumps DH in Kirkwall	Additional DH heat pumps Biogas production Additional EVs

Based on Table 1, the SMILE partners were asked to assess the following questions in regard to the SMILE technologies relevant to their islands. Barriers and suggestions did not need to be matched one-to-one; and thus barriers might be identified without concrete policy suggestions. The aim was to share inputs and insights from both successful and unsuccessful implementations – i.e. needs to overcome a barrier and approaches, ideas and failures to address them in a certain way. In the resulting Table 2, the text in *green italic* is an example as inspiration to the shape of the required input given to each partner.

Table 2: Questions to each demonstration island for later comparison and assessment

1) Which barriers exist within the **general policy-making and planning framework** and what suggestions may be made?
[Response]

Example: It is a problem that the municipality and local authorities do not have any formal planning competence within district cooling – but I don't have any good suggestion on what to do about it.
2) Which barriers exist within **Technology markets, investment and financing** and what suggestions may be made? Technology markets are to be interpreted as the market for gaining access to the physical equipment e.g. PV panels, heat pumps.
[Response] *Example: EVs are still very expensive compared to compatible vehicles. Excessive financial incentives or novel business models such as car sharing are needed to be promoted.*
3) Which barriers exist within **energy markets** and what suggestions may be made? Energy markets are to be interpreted as the market for dealing with flows of electricity, heating, cooling, gasses and similar.
[Response] *Example: A lack of a remuneration scheme for Demand Response services discourages users from accepting to use remotely controlled smart devices.*
4) Which barriers exist within **Citizen engagement and incentives** and what suggestions may be made? If this engagement is not considered, explain why.
[Response] *Example: Citizen are dubious towards technologies that could possibly harm their comfort conditions (DR, V2G). Clear incentives and easy-to-understand framework are needed.*
5) Which barriers exist within **Ownership of smart energy systems** and what suggestions may be made? (i.e. who should own what to advance the transition and foster optimal operation of energy systems – e.g. minimum allocation of share of wind turbines to local residents to improve acceptance)
[Response] *Example: People do not wish to bear the noise/visual burden of other peoples' investments in wind turbines. A certain share should be allocated to neighbours of the installation*
6) Which barriers exist within **infrastructures, grids, and hardware** (additional to the technologies already addressed and outline above) and what policy suggestions may be made based on this?
[Response] *Example: A complex legal framework of charging stations installation and their connection to the distribution grid.*

After the first round of questionnaire with each island independently, the second round includes the responses from each island to be assessed by the other islands in terms of relevance and appropriateness. This is leading to Chapter 3, where a resulting summary and the consequential policy strategies are presented. Details to the individual island responses in regard to the literature and themes can be found in the Appendix.

2.2.3 Policy recommendations, framework and replication approach

Chapter 3 is split into four sections, with the first presenting insights from the demonstration islands Samsø, Orkney and Madeira and the following sections each addressing the results on policy recommendations (Section 3.2), framework compliance (Section 3.3) and replication opportunities (Section 3.4).

Input from the islands and policy recommendations are based on the questionnaire, having the focus on the SMILE islands, while the framework compliance targets EU islands in general, and the replication opportunities aim at certain other target locations, based on the previous assessments. The framework for EU islands is based on a review of existing schemes and options within the field of environmental standards with resulting proposed schemes in Section 3.3. In Section 3.4, the replication potentials are assessed for the application on Greek islands in particular, though parallels to other locations can be found. The replication section addresses the different suggestions made in Section 3.2, as well as the literature statements, found in the Appendix. Both are evaluated in a ranking scale from 1-5 for replication on Greek islands, where a higher value refers to wide applicability and suitability for Greek islands as a whole. This section is supported by the experiences with Greek islands through DAFNI – the Network of Sustainable Greek Islands.

3 Policy strategies to support the transition to high-RE systems

In order to align the policy strategies with the SMILE project and demonstration islands, the following chapter is split into four parts: First, the individual insights and perspectives from the demonstration islands are presented individually, before presenting overall policy recommendations based on individual and transcending perspectives. This is based on the literature review and questionnaires. Afterwards, the framework potentials on environmental standards are analysed for the context of all EU islands, and finally, replication opportunities are assessed and evaluated for other target locations.

3.1 Input from pilot islands

The following sub-sections present the individual views from the SMILE demonstration islands Samsø, Orkney and Madeira in regard to identifying policy barriers and potentials. Afterwards, a combination and comparison are done in Section 3.2, recommending transcendent solutions. While some things are individual to the three demonstrations islands, also similarities can be found between Orkney and Samsø – often due to similar energy system characteristics – but also similarities with Madeira. Since the answers to the questionnaire represent the perspective from the SMILE representatives in early 2021, they might reflect only a limited area of focus, however, parallels can be expected and comparisons drawn between the individual island responses with caution nonetheless. Therefore, the following presents specific views, which might overlap with the general discussion of themes and questions in the resulting transcendent recommendations' section.

Policy design is an important part in the energy transition process. As presented in Figure 3, the inputs from islands can contribute to the design and development of support mechanisms and recommendations for the transition towards higher RE shares as part of energy planning. While Figure 3 points to the role of island perspectives for policy design strategies through inclusion of modelling experiences of, on, from, and most importantly *with* islands, Figure 4 indicates the relation of islands in policy design as part of energy planning, where both perspectives are to be balanced to achieve successful energy transitions. To develop policy strategies through the modelling of islands as done in D8.1 and D8.2, the perspectives and integration of opportunities with islands are to be included here in D8.5, especially through the island inputs, but also for the replication and EU framework design.

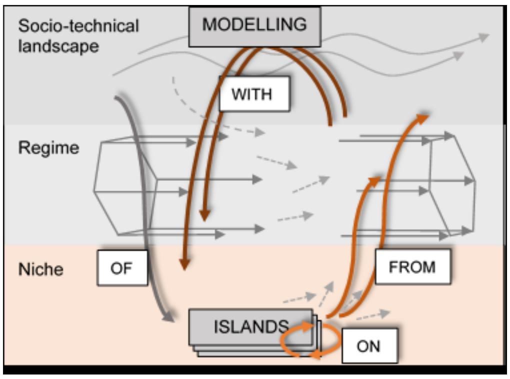

Figure 3: Strategic policy perspectives of islands for the transition to high RE shares [11]

Detailed information on how the modelling *of* islands, the perspectives *on* islands and the insights *from* them influences the design of policies *with* islands, can be found in the work on 'Modelling renewable energy islands' [11], which is a parallel work done in relation to the SMILE project[11].

Figure 4: Recommendation for policy strategy design (as part of energy planning) in relation to islands, here shown through a photo of Orkney [11]

3.1.1 Input from Samsø

In the case of Samsø, the identification of barriers and condition are closely related to the specific SMILE demonstration project, which is the development of a smart harbour at the Ballen Marina, including new PV panels, electricity storage and various flexible consumption technologies and customers. Besides those, Samsø's energy system is characterised by high amounts of wind power production, which is currently exported to a large extent, further influencing the resulting barrier identification and policy design.

Samsø already has a special demonstrator position within the Danish energy system development and research, presenting opportunities to the island, but some barriers still exist. An opportunity is the existing handling of local energy balances, since Samsø has an agreement to use two slightly different ones, depending on the current needs and aims. In one, the wind power production from the offshore wind farm is considered fully integrated and part of the Samsø energy system, in the other it is not, since the production outside the island can be considered external, influencing also the local responsibilities in that regard. Samsø is otherwise well integrated into the Danish energy system via its two transmission lines and exchange otherwise via the two (soon to be three) ferry connections. Therefore, Samsø is to follow Danish regulations and policy making, as further elaborated in SMILE D7.1 [12].

On the contrary to its integration, Samsø also has an experimental and demonstration status within Denmark, allowing certain exceptions to otherwise national rules. Existing barriers on Samsø within the national system, however, also exist, include mostly limits to the infrastructure with capacity limits in the transmission lines and the need for better local integration, though with an identified lack in support for it. Due to its island status, Samsø has introduced various bottom-up initiatives, where compliance with municipal and national regulations are still to be followed.

Within SMILE, Samsø demonstrates a specific solution for the integration of locally produced electricity for consumption within the same parcel, the Ballen Marina. It is comparable to other smaller or household-size island solutions, yet a roll out to larger size is suggested, e.g., to integrate the locally produced wind power in a smart way as well. However, ownership structures are named as a potential barrier on Samsø, as they are constantly changing towards more complex and external structures, instead of clear, local ownership. Further discussion of Samsø's demonstration project and implications on barriers and recommendations is presented in Section 3.2 after presenting all islands individually.

3.1.2 Input from Orkney

Also Orkney is evaluated in regard to their demonstration project within SMILE, which evolves around smart heating and transport solutions for the better integration of local wind power production. In order to identify barriers and recommendations, these are therefore discussed in the Orkney context, before relating them to the other islands. Specific to Orkney, besides the local wind production, is the complexity of the electricity grid, which encompasses the transmission line to the mainland as well as many small and large production sites around the circular distribution grid across the 20 islands.

The increase in grid and energy system complexity is mentioned as a limiting factor in regard to engaging and supporting the local stakeholders appropriately to their, as well as the overall islands', benefit. The main concern is the conflict of interest of local users with the national providers of electricity, as well as to fit technical solutions, including the SMILE ones, into the overall system and plans. Therefore, while national regulation prevail, local flexibility and education is needed for better alignment of national with local strategies and policies.

Similarities can also be found with Samsø and potentially other places, as ownership structures of local production and conversion technologies shifts and uncertainty in regard to the future develops with the energy transition to high RE shares. For example, the 'smartness' of technologies is mentioned, as collaboration between consumers and providers requires actual interaction with people's home and privacy for a future smart energy system. For that, community capacity-building schemes and strategies are proposed to align the overlap of private properties with communal goals and strategies. Especially new technologies, like electric storages for smart heat production requires understanding of future heating opportunities and limits. With economic barriers often existing in remote areas, the ownership of power production as well as flexible consumption, including the heat installs and EVs as part of SMILE, needs further discussion.

While the inputs from Orkney are further discussed in Section 3.2, similarities of the individual experiences across all SMILE islands can be found. Most importantly, the alignment of local development on islands, however, with (Scottish, British and) EU strategies is needed, as suggested in Figure 3, as the demonstration projects also have the potential for influence on policy design on larger scale.

3.1.3 Input from Madeira

The input from Madeira in regard to local regulatory barriers and suggestions presents some similarities with the other demonstration islands, however, due to Madeira's autonomy in the energy system as well as to a certain extent also institutionally, differences to mainland-connected islands can be expected. Changes in the energy system in relation to the SMILE demonstration, however, and thereby their relevance for policy design, are similar to Samsø and Orkney, as local electricity production and balance is the main concern in this regard.

Madeira's location in one of the EU's outermost regions results in a legal exemption in relation to the electricity market with EEM, the 100% Madeira Regional Government-owned company, operating and developing the local system, while the Portuguese national energy regulatory authority's (ERSE) outreach extends to the island. Hence, 'energy systems policy-making is undiminished by the local authorities', though due to Madeira's electrical grid constraints, it is harder to implement certain national law requirements and regional laws must be created.

While any technological changes on Madeira are met with regulatory obstacles, also time perspectives and economic feasibility have a more direct impact on the changes needed for the energy transition due to the island's isolation and limited options in that regard. Issues are mentioned in regard to investments, as technologies are too expensive in the short-term, but too difficult to plan in the long-term. Hence, the need for appropriate economic incentives are discussed to support the fragile energy system on Madeira, as well as in other remote locations.

As Madeira already demonstrates a certain need for flexibility and freedom through its autonomy, further alignment of technological advances with policies to support this is highlighted. By further exploration of exemptions for demonstration or due to its isolated state. The SMILE demonstration on Madeira addresses this need for better flexibility in their isolated electricity grid by investigating better PV power integration and balancing, as well as exploring opportunities within the electrified transport sector. Much of the Madeira pilot projects are addressing specific needs and solutions for Madeira, though a better regulation for PV and EV installations and exploring balancing options is needed for the transition to high RE shares in general and also in other places.

More specific details and suggestions are following in the next section, though general alignment of technical changes with institutional opportunities can already be highlighted. While Madeira presents a specific energy system set-up, the use of demonstration potentials and exploration of loopholes could be replicated also elsewhere.

3.2 Policy recommendation transcending SMILE islands

The following is structured according to the six themes and identified questions to highlight barriers within those themes for the demonstration islands with specific examples. A comparison and combination of the different insights, as well as resulting suggestions follow. Additionally, the Appendix includes the full overview of reflections from the literature review from all three demonstration islands and concluding comments, which supports the recommendations in this section.

3.2.1 General policymaking and planning framework

Based on the answers provided by Samsø, Madeira and Orkney representatives, a lack of integration between the energy local plans and the electricity network planning has been outlined, since both are operated at different scales and periods. More specifically, the electricity network investment plans are scheduled at a fixed period (every two years with perspective for investment for 5-10 years for the case of the UK [13] (Art. 32)); thus, new interventions (e.g., new local energy plans) during this period are not taken into consideration, apart from some rare cases. In parallel, together with the electricity network investment, the associated price control policy is settled. Consequently, the price range is fixed while significant changes are difficult to be achieved.

Another barrier that was mentioned, is the lack of engaging stakeholders in the effort to modernize the electricity system into a dynamic smart distribution network, in which a wide range of players will provide grid services through their participation. In addition, there are inexistent or inefficient incentives from central governments to promote and create communities (e.g., consumers, local businesses, and institutions) that will contribute to the design and development of smart flexibility services on local distribution networks. Regarding the latter, the island of Samsø is slightly different as local citizens are engaged by following a series of formal events (e.g., public meetings, hearings, political committee decisions, etc.).

In Samsø and Orkney, split metering is not permitted; thus, consumers are obligated to receive electricity only from one supplier, which usually excludes local electricity suppliers to the benefit of large national ones – or at least excludes the direct supply from a local producer. The 2019 electricity market directive [13], however, introduces the option for consumers to conclude an aggregation contract with any actor without the consent of the supplier, enabling to buy and sell energy services to aggregators (art. 13).

It should be noted, that while split metering is an approach that may further local exploitation of renewable energy sources, it also comes with issues. As analysed in [7], while local optimisation can be a good solution for some parts of the energy system, it can also come at the expense of wider system optimisation. Though in general, in RES-based electricity systems, optimising local systems will cause sub-optimisation in the wider energy system. On the other hand, of course, if the surrounding system is not RES based, then there is a certain option for local optimisation.

Current regulation may in certain cases limit the penetration of new local renewable energy suppliers, who could contribute supplementary in increasing the DSOs' capabilities. An example are the citizens energy communities which have been recently integrated into Danish law (cf. D7.3, Section 3.4.2 [14]), but with a barrier to split metering could be an issue to these structures. Similarly, there are other regulations governing the supply of electricity that require energy suppliers to address high costs. As a result, local and small energy suppliers are unable to participate on even terms in the supply market.

Suggestion (1):

- A solution, provided by the responses, could be the enabling of split metering, since it could possibly increase the penetration of local renewable energy supplies.

Finally, as a generic barrier, the electricity sector exclusiveness was acknowledged by all representatives. In specific, the highly technical and complex framework that often surround this sector adversely affects citizens engagement, limiting public participation. An overview of the barriers identified and their relevance on the SMILE islands is presented in Table 3.

Table 3: List of barriers within general policymaking and relevance for islands

List of barriers	Madeira	Samsø	Orkney
Lack of integration of energy planning and electricity network planning	X	X	X
Lack of engagement resources	X	X	X
Lack of localized process to engage community groups	X		X
Lack of split metering permission		X	X
Difficulty for local suppliers to participate in the supply market		X	X
Electricity sector exclusiveness	X	X	X

3.2.2 Technology markets, investment, and financing

Technology markets are to be interpreted as the market for gaining access to the physical equipment e.g., PV panels, heat pumps.

It is a common belief among the regional island demonstrators that the performance of the energy systems and the energy-saving achievements depend significantly on consumer behaviour. Thus, the lack of consumers' education and awareness limits the effectiveness of innovative energy solutions (e.g., heat pumps, energy storage systems). It has been observed in many cases that prerequisite measures may have been set but they are not always implemented, and as a result, owners could not achieve energy savings or decrease their energy costs.

Suggestion (2):

- A suggested solution was to raise awareness regarding the energy system operation, and also to adopt typologies-practices, such as load-shifting to take advantage of solar PV production and/or to purchase 'smart' appliances that can be set to start during peak-production, in order to ensure the optimal use of the applicable technologies.

All the island representatives support that smart technologies remain relatively expensive with the return on investment on technology markets being quite long, and thus also some entrepreneurs have difficulties meeting return expectations. Especially in remote and peripheral areas, where few suppliers operate and long supply chains are observed, the maintenance or repair services' economic sustainability is under question. At the same time, local owners continue selling their wind turbines to large external companies, while the monopoly of supply continue to drive consumers to the national electric grid supplier.

Suggestion (3):

- A suggested solution is that central governments should support more locally led financing models, applicable for smart technologies, which drive down the capital costs, through collective/bulk purchase of equipment and installation services. For example, in the case of EVs, different types of incentives should be promoted to support EV adoption:
    a) special household energy tariffs for EVs,
    b) promote "green cities" encouraging sustainable mobility (e.g., banning ICEVs from cities' main roads, offering free parking lots for EVs, promote car sharing, electrify the public transportation sector, promote bike-sharing, etc.).

Table 4: List of barriers within technology markets and investments and relevance for islands

List of barriers	Madeira	Samsø	Orkney
Lack of consumer knowledge results in lower performance of the energy systems	X	X	X
Smart technologies are expensive with long and low return on investment	X	X	X

3.2.3 Energy markets

Energy markets are to be interpreted as the market for dealing with flows of electricity, heating, cooling, gasses, and similar.

At Samsø and Orkney, there is an incentive scheme only suitable for large-scale developers which is designed to guarantee renewable energy participation via specific auctions. There is no respective or similar scheme for small scale energy producers limiting the potential of further renewable energy development. There was no doubt that the electricity supply sector is heavily regulated, and the conditions of the market are demanding for new entrants. Even at the option of providing flexibility services to the electricity grid, large-scale energy generation is often required. Further elaborated in D7.3 [14], the minimum bid size is 1 MW for balancing services markets, higher for some other services, and markets are non-existent for local services that can be offered by small producers/flexibility owners (such as voltage regulation). An alternative could be large scale aggregation of many small loads, but it is at an immature level and no incentives are available. While the electricity directive, art. 32, addresses this, the local flexibility markets set up by the DSO are often still non-existent [13]. Thus, the energy supply market is not currently designed to facilitate small and local energy suppliers, even though this option is now part of the Danish law.

Concerning Madeira, which is an EU outermost region and has a legal exemption in relation to the energy market operation, the transportation, distribution, and commercialization of electricity is operated by a single entity (100% Madeira Regional Government owned). Every activity at the local electricity market is regulated by a Portuguese legal person governed by public law (Energy Services Regulatory Authority), with competences on implementing topics of regulatory, supervisory, advisory, sanctioning, and arbitrating nature. Since the start of the year 2021, it is now possible to create renewable energy communities on Madeira, but specific regulations are still needed to implement it.

Suggestion (4):

- A solution could be the promotion of alternative business models (e.g., the creation of energy communities accompanied by special benefits) and new energy schemes (e.g., Demand Response) in order to foster a more active participation of energy consumers/prosumers in the energy market.

Table 5: List of barriers within energy markets and relevance for islands

List of barriers	Madeira	Samsø	Orkney
Lack of incentives schemes for small local energy supply		X	X
Lack of local flexibility markets open to small providers.	X	X	X

3.2.4 Citizen engagement and incentives

It has been noticed that there is no statutory procedure for participatory energy planning at any of the three islands. Thus, key players (e.g., DSOs) are not required to exchange opinions with locals, which discourages potential citizen engagement actions. According to the law, the energy planning procedure follows an absolute top-down approach. On the other hand, bottom-up initiatives from citizens which do not have a basis for specific legislation are often impracticable, because they have to comply with municipal and national planning. Samsø applies a combination of the two approaches (bottom-up and top-down) in an effort to keep engagement and realism aligned, besides the lack of legislation.

Suggestion (5):

- Even if the development of democratically based local energy plans is at a very early stage, sufficient investment could roll them out in parallel with the setting of relevant legislation.

Another barrier is the lack of awareness in terms of smart technologies, distributed energy generation and energy efficiency due to misinformation or lack of interest. Therefore, the engagement process becomes even harder for local citizens and communities. On top of that, there are neither organized community schemes nor laid down guidelines on how energy communities could engage and develop, besides the above-mentioned options for citizen energy communities in Denmark and renewable energy communities in Portugal with the current lack of practice and detailed rules for implementation.

Suggestion (6):

- Information sessions and Q&A with specialists could be a solution to overcome these obstacles. Citizens and communities could benefit from the development of strategies and information tools to raise awareness on energy relevant topics.

Table 6: List of barriers within citizen engagement and relevance for islands

List of barriers	Madeira	Samsø	Orkney
Lack of legislation for participatory energy plans	X	X	X
Lack of citizens awareness tackles their engagement	X	X	X

3.2.5 Ownership of smart energy systems

I.e., who should own what to advance the transition and foster optimal operation of energy systems – e.g., minimum allocation of share of wind turbines to local residents to improve acceptance.

A lack of financial and regulatory support for private and community ownership of smart energy systems is identified in all three islands. More specifically, there is a lack of reliability in terms of commitment in the case of smart energy systems ownership, when the equipment needs to be located on personal properties. For instance, the residential installations of a project need to be protected from unexpected disengagement of the homeowner in order to avoid a potential business failure. This is the case when for example a battery, that requires years of operation to benefit the project and meet business model funding, is fitted to a property. From another point of view, the technologies that are being installed should principally meet the home's requirements and effectively operate with regard to the household characteristics.

Suggestion (7):

- Adapted regulations need to be drafted for recovering the financial damage in the event of a homeowner leaving the project.

A barrier of similar importance regarding smart energy systems is the current capital and operating costs compared to the return on investments since neither the operators nor the homeowners would likely be able to stack enough income streams in order to cover the cost of the equipment. However, smart energy systems provide a variety of benefits to the relevant stakeholders (e.g., DSO, homeowner etc.).

Suggestion (8):

- A solution could be to foster shared or community ownership of smart energy technologies and co-finance the expenditure costs. Meanwhile, technology manufacturers are already imbedding control mechanisms within smart energy systems. For example, an operator of a cloud-based aggregator platform would be able to incorporate these technologies reducing overheads to the operator. Another paradigm is the UK government's grant mechanism on EV chargers which for now supports only the purchase of those enabled for control over an internet connection. Consequently, this leads to the creation of a charging network that could be monitored and/or controlled for the interest of homeowners too, reducing their mobility costs while reinforcing the value of shared assets. This could also be a solution for non-interconnected islands, like Madeira, facing difficulty to foster optimal operation of energy systems (from the prosumers' perspective), as their management requires coordination by the grid operator.

Another barrier for smart energy systems which is identified only at Orkney is that large-scale energy systems (e.g., wind turbines) have complicated levels of acceptance. There must be enough head room on the grid for DNOs, sufficient business models for the operators, and adequate buy-in by the local residence. For instance, there is no doubt that ensuring the wind turbine function under "smart" mechanisms (with external control) will assist the DNO by verifying that the local grid is not overloaded while generating times and revenue are maximized; however, there is no observed benefit for the local residents.

Suggestion (9):

- There is a common method used by wind turbine operators/planners to provide financial shares to a local community organization in order to reduce the risk of objections. To promote support for smart wind turbines there would be some incentives for the homeowners to benefit from such mechanisms. For example, a platform to pair the operation of the wind turbine with domestic or community level energy systems. The first step has been achieved, since energy suppliers are required to provide electricity tariffs that benefit homeowners/communities which are willing to displace their time of electricity consumption to match the renewable energy generation. Whilst the complexity of such mechanisms is not met by a financial scheme to benefit all parties, external funding would be critical.

It must be noted, that on all the islands, but mostly on those connected to a mainland, a shift from local ownership to external, corporate ownership takes place. There are legal grounds for offering partial local ownership of a renewable energy project, up to a certain point. In general (at least for the SMILE islands), the municipality cannot require that a developer establishes a common monetary fund, but it can recommend establishing one in order to gain public acceptance. In order for local people to take part in establishing acceptance and receiving benefits, energy communities can also be mentioned.

Table 7: List of barriers within ownership and relevance for islands

List of barriers	Madeira	Samsø	Orkney
Lack of reliability and commitment within the household participants	X	X	X
High costs of the smart energy systems for all the involved parties	X	X	X
Large-scale energy systems integrated by smart control provide limited benefits for the locals.			X

3.2.6 Infrastructures, grids, and hardware

This refers to technologies additional to the ones already addressed and outline above.

Technical limitations regarding the quality of electricity that can be exported to the national grid was commonly identified by all three islands. The voltage must be kept within a narrow band, and transformers should not be overloaded. Moreover, submarine cables to the mainland had to operate close to their carrying capacity.

Suggestion (10):

- A partial solution is to consume the excess electricity on the island, near the production site, for example by promoting (start-up) companies to increase the local power consumption and demand side management, like integrating the fluctuations into the heating or transport sector, either privately or in large-scale, e.g. in district heating. Alternatively, the integration of energy surplus on the public grid could be achieved by the re-sizing of the grid's components (lines/cables, transformers, etc.).

Another barrier that was reported by the representatives of the three islands is the lack of potential reliable communication between the consumers and the smart grid operator. Especially in places where broadband or 4G mobile coverage is limited or non-existent the possibilities of developing smart energy systems are limited. More specifically, such systems require a reliable 24-hour connection. For instance, if a property has low bandwidth on their communication lines, there is no mechanism to prioritize the energy system over other technologies connected to the same line; it is in the property owners' greater interest to disconnect the system and allow it to operate as an "island".

Suggestion (11):

- Some incentives would need to be created (e.g., financial reward) for the property owner to ensure good communications. Government and industry would need to develop a mechanism for supporting rural communities to ensure that they are not disadvantaged over urban areas that would typically have greater connectivity and potential benefits.

Madeira was aligned to Orkney's views regarding the lack of back-up system which will be required to cover the periods when the control mechanisms fail. A smart system can manage grid overloads, but reinforcements might also be needed. This implies large-scale investments which, if passed to final consumers, makes the energy systems more expensive. Furthermore, even though they are regulated, grid operators operate as monopolies in their regions. Thus, this state of play does not accelerate network connection upgrades to support electrical energy systems.

Suggestion (12):

- A solution to the above could be the promotion of further market liberalization including full ownership unbundling, since the costs to manage and reinforce the grid would be covered by the stakeholders that are directly integrated into the system (including prosumers). This might be most relevant to Samsø and Orkney.
- A solution could also be to change the revenue methodologies for DSOs, giving more weight to efficient investments in smartening the grid for the energy transition to take place. Of course, these investments should not lead to a disproportionate electricity price increase for final consumers.

An additional barrier to the supporting infrastructure of smart energy systems is the local experience in deploying and maintaining the equipment. Generally, there is an increased level of complexity with these systems and constant human intervention is often required. This can go even further, as large-scale smart energy systems could require the mass adoption of electric vehicles. If local garages maintain their vehicles, then it is unlikely to assume the appropriate incentive for the greater population in order to implement this transition. On the other hand, the scarcity of publicly available charging spots increases the difficulty of mass EV adoption.

Suggestion (13):

- With the development of such technologies, the companies working in that area should evolve and educate their staff, in order to retain their businesses. Local learning sessions could be organized where the expertise on installation and operation of the equipment takes place. Supplementary, proactive incentives from the government including training programs could support this solution.

A similarly important issue according to all the island representatives is the buildings' unsuitability for smart energy systems due to their existing situation (e.g., age and insulation level). Under these circumstances, the homeowner's interest will be to continue paying manageable oil prices than to invest in insulations and draft exclusion measures, prior to the covering of heating system costs. Additionally, difficulties in the deployment of smart energy systems are met also in the case of EV charging points, due to the old electrical infrastructures.

Suggestion (14):

- Large-scale adoption of cleaner technologies requires ongoing and increased levels of support which could be bridged with support mechanisms.

Table 8: List of barriers within infrastructure and relevance for islands

List of barriers	Madeira	Samsø	Orkney
Limitation on the exported electricity	X	X	X
Lack of reliable communication between consumers and smart grid operator	X	X	X
Lack of reinforcement mechanism to support the function of smart grid	X		X
Lack of technical experience on smart grid systems	X	X	X
The unsuitability of buildings with smart energy systems	X	X	X

The overall presentation of barriers and suggestion both for the demonstration islands individually, as well as commonly, identifies the recommendations to be made within policy design for the transition to high RE shares on islands. While the themes all identify options for changes in different areas, a combined approach transcends not only the islands, but also the relevance aspects of the energy system transition.

3.2.7 Summary

To summarize, the suggestions from the previous sub-sections are listed below. While some of them address technical barriers, others suggest institutional support or re-organization of local structures or stakeholders. Overall, a strengthening of the local and/or island institutions and involved participants is aimed for, in alignment with the technological development of the energy system.

Suggestions:

- raise awareness regarding the energy system operation
- adopt typologies-practices, such as load-shifting and/or to purchase 'smart' appliances
- central governments should support more locally-led financing models, e.g. tariffs for EVs,
- the promotion of alternative business models and new energy schemes
- sufficient investment to roll out local energy plans with the setting of relevant legislation
- Information sessions and Q&A with specialists to overcome obstacles and raise awareness
- legal rights to be defined for recovering the financial damage
- foster shared ownership of smart energy technologies and co-finance the expenditure costs
- creation of a charging network that could be monitored and controlled for the interest of all
- provide financial shares to a local community organization
- consume the excess electricity on the island, near the production site
- incentives for the property owner to ensure good communications
- develop a mechanism for supporting rural communities to ensure that they are not disadvantaged
- educate their staff, in order to maintain their businesses, organize local learning sessions, training programs
- large-scale adoption of cleaner technologies through increased levels of support
- split metering to increase the penetration of local RE supplies may be considered

These suggestions lead to the overall policy recommendation of better inclusion and alignment of islands in light of their local possibilities as well as limits for the planning and organisation processes in the transitions to higher RE shares on islands. As illustrated in Figure 3, this alignment can improve the technical knowledge from and for islands, as well as their recognition on all institutional levels.

3.3 Framework for EU islands on environmental standards

When considering the possibility of introducing a compliance framework related to environmental standards and specifically to the reduction of GHG emissions of European islands, a relevant reference is the EU Emission Trading System (EU-ETS) that since 2005 has contributed to the implementation of European targets on reduction of GHG emissions.

To briefly recap the characteristics of the EU-ETS system, it is a “cap and trade” system, which on the one hand caps the total amount of GHG emissions for 11,000 sites and airlines that account for approximately 50% of the GHG emissions of the EU and on the other hand foresees trading of emission allowances among covered parties so that total emissions are within the set limits and the most cost-effective actions are implemented. [15]

This is the key aspect of the EU-ETS system: the EU decided to implement this “cap-and-trade” structure in order to meet the overall GHG emissions reduction targets with the lowest total cost to participants and for the economy as a whole, with the participants being free to decide whether the best option for them is to implement actions on own assets, implement emission-saving projects around the world or purchasing emissions allowances on the market. [16]

Being a proven cost-effective solution to reduce GHG emissions at national and international level, the EU-ETS is also a best practice for other countries willing to develop emissions trading schemes [17].

For instance, according to the EU, national or regional similar systems are being evaluated or implemented in several countries including Canada, China, Japan, New Zealand, South Korea, Switzerland, United States.

For the above-mentioned reasons, the present paragraph focuses on the proposal of a system implementing some features of the EU-ETS to support the decarbonization of EU islands. Indeed, as mentioned also in SMILE D8.4, it is widely acknowledged that energy transition of islands can be one of the drivers of the EU decarbonization: on the one hand, islands can become early adopters of technical solutions related to smart grids to be subsequently replicated on the mainland; on the other hand, acting on islands has typically a high impact, due to specific local characteristics, e.g. the concrete fossil-based energy mix, potentially weak local grids, the level of energy poverty, and the value of the local ecosystem.

The proposed scheme foresees the following main steps:

- the realization of a baseline GHG emission inventory for EU islands, based on activities carried out through Sustainable Energy and Climate Action Plans (SECAP) signed under the Covenant of Mayors initiative [18] or Clean Energy Transition Agendas (CETA) prepared within the Clean Energy for EU Islands initiative [19];
- the clustering of EU islands with reference to size, geographical area / local climate, level of interconnection with the mainland or with other islands;
- the definition of a year-by-year cap to GHG emissions at EU, island cluster and single island level, based on the analysis of the baseline situation and of specific local features including the potential for renewables and improvement of the level of energy efficiency;
- the creation of a web-based platform for the annual reporting of GHG emissions of each island;
- the annual quantification of GHG emissions for each island, based on widely recognized methodologies and uniform, reliable and updated emission factors; the quantification shall be based on data from the local utilities and validated by third parties before the upload to the monitoring platform;
- the annual determination of “credits” and “debits” for GHG emissions related to the identified caps; the islands having an “emission credit” could then sell the related emission allowances to islands with “emission debits”, thus generating revenues through an auctioning process.

This proposed scheme could be implemented in subsequent phases, similar to the initial implementation of the EU-ETS system; for instance, in the first years of implementation, the allocation of a significant share of GHG emissions allowances could be free, in order to only create an incentive for best performing islands and progressively become a full market-based system. Clearly, installations on islands that are already under the EU-ETS system should be excluded from the island GHG emissions quantification and reporting to avoid double-counting.

Additionally, the annual allowances will have to reduce each year, as goes for the EU ETS. This will create rising costs for the islands that do not manage to decarbonize enough. This may be because of a lack of local revenue to actually invest in solutions, in islands that are already plagued with energy poverty. This only works if this is fair and if we avoid adding further burdens to populations that are already in general poorer conditions than on the mainland. If islands are to be labs for the transition, their own transition must be fair [20]. They must benefit from funding schemes as proposed in D8.4. Plus, it can be considered unfair if such a scheme only applies to islands and not to the mainland. A final point of argument is that there are other ways of pricing carbon, such as a carbon tax. The final choice certainly lies within the competence of EU institutions and member states but in any case, the solution adopted should apply to all the national territory in order to avoid creating unfair situations.

3.4 Replication opportunities towards other target locations: Identification of applicable suggestions for Greek islands

In this section, the identification of applicable suggestions on policy strategies to Greek Islands, outlined by SMILE islands demonstrators and the relevant literature, is presented. Every suggestion can find some application depending on the type and status of each Greek island. Thus, an evaluation format of the application intensity of every suggestion is adopted in the following tables for the Greek islands as a whole. The format used hereby is in a ranked scale from 1 to 5, with a suggestion evaluated as a 5 being one which can find application in each of the Greek islands or makes much more sense than the others to adopt and vice versa for a suggestion evaluated as a 1.

In short, it seems that policies and recommendations that promote public and local active participation in clean energy projects can find significant application in Greek islands. Those policies can help alleviate social acceptance issues and further benefit the local economy. Raising social awareness could be the first step towards a locally-led energy transition and the provision of an enabling framework for small and local stakeholders could be beneficial in the effective implementation of clean energy technologies in an island-wide context. Policies that require technological developments or legal and regulatory provisions, such as demand response mechanisms or even microgrids, may have a positive application to Greek islands, but they could require many steps to consider prior to their effective implementation. Finally, policies related to district heating/cooling systems or heating and gas networks in general, although beneficial in their conception, cannot be applied in the Greek islands, since such systems do not exist.

The first of the following tables shows the identification and evaluation of the replication of the SMILE islands demonstrators' suggestions, while the second depicts the same information regarding the literature recommendations accumulated for the purposes of WP8.

Table 9: Analysis of potential applicability of suggestions from SMILE demonstrators to Greek Islands

SMILE demo suggestions	Greek Islands [Rank: 1-5]	Additional comments
Suggestion (1) from Sub-section [3.2.1]	3	In Greek mainland and island energy systems, split metering is not permitted either; thus, this limits the penetration of new local and/or small-scale energy suppliers in Greek Islands too. In the same sense, small-scale energy suppliers are usually unable to participate on even terms in the supply market. This finds application to every Greek island in order to increase the penetration of local renewable energy supplies.
Suggestion (2) from Sub-section [3.2.2]	4	In Greek island energy systems, practices such as load-shifting or the purchase of 'smart' appliances are more or less absent. Some adjustments have to be implemented both in the electricity network codes and in the operation of those systems, but the suggested solution can find fruitful application in Greek Islands.
Suggestion (3) from Sub-section [3.2.2]	2	The suggested solution can of course find application in every Greek island and help each of them towards the decarbonization of their transportation sector. However, this should not be limited only to locally-led financing models, but to such models that enable in general local engagement. Furthermore, some suggested measures, such as ICEVs banning seem quite extreme for implementation. Finally, the suggested solution should be complemented with even-scale RES deployment, especially in non-interconnected island systems.

Suggestion (4) from Sub-section [3.2.3]	4	Energy communities are explicitly described in the Greek energy legislation. The promotion of relevant business models can indeed foster a more active local participation in the Greek island energy systems. However specific incentives have to be provided and new enabling legislation have to be laid down in order to enable the facilitation of small and local energy suppliers.
Suggestion (5) from Sub-section [3.2.4]	4	Most Greek islands lack concrete local energy planning. Sufficient investment and even technical support from national or regional level can accommodate their effective roll out in each one of them. This suggestion needs to be more specific in terms of investment sources. Additionally, local energy planning should be incorporated I the national legislation as obligatory for local authorities, which should be consulted for private energy investments in their region.
Suggestion (6) from Sub-section [3.2.4]	4	The suggested measures can benefit every Greek island community in terms of engaging them in their local energy plans. Specific attention has to be paid on every different island type, for Greek island may share some common characteristics, but in general they differ in a lot of aspects (population, size, economy, tourism activity, interconnectivity status, etc.)
Suggestion (7) from Sub-section [3.2.5]	3	It is true that large scale development of smart and clean energy projects will eventually involve some residential installations. It is in the homeowner's and project developer's best interest to define legal rights and obligations, ensuring smooth operation of the foreseen project. Thus, this suggestion should also protect island homeowners.
Suggestion (8) from Sub-section [3.2.5]	5	This could find fruitful application in every Greek island incorporating services related to e-mobility and demand response.
Suggestion (9) from Sub-section [3.2.5]	4	This suggestion can increase the relatively low acceptance levels of large wind turbine projects in Greek islands. Although, some relevant mechanisms have to arise in order to successfully pair the operation of wind turbines with the domestic community energy systems. Some local engagement activities (local sessions, meetings with municipalities and local energy communities) might have to be a prerequisite from the project developer's side.
Suggestion (10) from Sub-section [3.2.6]	2	The first suggestion can find application in every Greek island; albeit it seems that the local companies' loads have to be aggregated in order to meet the increasing demand. The second suggestion finds application only in Greek interconnected islands, though a re-sizing of the grid's components often is a complicated and costly procedure.
Suggestion (11) from Sub-section [3.2.6]	1	Smart communication between the consumers and the grid operator needs first to be established in Greek islands. Then, depending on how it will develop some incentives will definitely need to be created to ensure good communications in all areas of every Greek Island.
Suggestion (12) from Sub-section [3.2.6]	2	Market liberalization of the grid operation can accelerate network connection upgrades to support electrical energy systems, but this should be done with an enabling framework and with careful handling, with local DSOs under centrally organized control.
Suggestion (13) from Sub-section [3.2.6]	3	This could find application in every Greek island; though its impacts largely depend on the nature of each local island community and the quality of the local training sessions. The need however to train local personnel is significant since it is very difficult to attract highly specialized personnel to the islands.
Suggestion (14) from Sub-section [3.2.6]	1	Although true in its conception, this suggestion will have to be more specific and provide the right support mechanisms for businesses and homeowners to adopt clean energy technologies and contribute in large scale clean developments.

Table 10: Analysis of potential applicability of suggestions from literature recommendation to Greek Islands

[Literature number, see literature review in Appendix]		
A. Policy and Planning framework	**Greek Islands [Rank: 1-5]**	**Additional comments**
Statement from literature [1]	2	The Samsø representatives' response is applicable to Greek islands, stating that the simulation model should be designed depending on the time frame. More specifically, for short-term planning the optimization with quantitative goals is ideal, while for long-term planning scenario simulations are better.
Statement from literature [2]	4	In Greek islands wind projects face difficulties due to environmental, spatial concerns and local opposition. In the case of citizens engaging early and actively in the decision-making processes (e.g., through ownership by local EC) such investments will be better facilitated.
Statement from literature [3]	4	This is a necessary step but demands wide support to alleviate the Greek island municipalities lack of experience in handling and owning energy projects. Therefore, more effort will be needed, for instance hiring experts with a background on energy planning and project development particularly on islands. Ideally, the experts should be related to the island (e.g. through origin)
Statement from literature [4 - 5]	2	NGOs could support the islands in the early stages of energy planning (e.g. introducing climate change, necessity for long-term energy planning, influencing people on accepting renewable projects). However, if local stakeholders and representatives of the technologies are not involved as well their role and power will be limited and not adequate for the islands' energy transition.
Statement from literature [6]	5	The Madeira representatives' view is applicable to Greek islands, supporting that public discussions are the ideal way to increase transparency in energy planning.
Statement from literature [7]	4	In Greek islands spatial planning should be communicated at an earlier stage. Specific framework envisaging the public consultation processes would be helpful but the adoption could be proved problematic for the energy development in case of delayed actions.
Statement from literature [8]	1	Although this recommendation might be beneficial in general, at the moment no experience exists on district heating in Greek islands. Only one pilot hybrid station (solar PV, wind, battery) including district heating solution is under development in Agios Efstratios. This recommendation should be further examined.
Statement from literature [9]	4	Depending on the size of intervention this recommendation would be fruitful. For small and private interventions (e.g., solar panels in the property of a hotel) community engagement wouldn't be that necessary. However, for larger projects (or the preparation of islands' long-term agenda) with an impact on local's life their early engagement should be mandatory.
Statement from literature [10 - 11]	2	Spatial characteristics are indeed core to the energy planning. However, to be fair, social energy policies need to ensure that public state support is prioritized to vulnerable households, providing alternatives in case of "unsuitable" spatial characteristics.
Statement from literature [12]	3	Greek islands are numerous and although they share a common high wind and solar potential, in relation to the other RES they may differ. Thus, such a policy would make sense. Local communities should be aware of the pros and cons of each technology.
Statement from literature [13]	5	Greek islands need a more supportive framework as they face difficulties in energy transitions despite being often ideal areas to test new technologies. Logistic costs are higher while economies of scale cannot be applied. Islands often include large areas of protected nature which should be respected in

		energy planning. Even amongst islands special attention have to be paid to smaller and more isolated ones.
B. Energy markets	**Rank: 1-5**	**Additional comment**
Statement from literature [15 - 17]	3	Although heat power markets do not exist in Greek islands, the deployment of smart energy systems integrating different markets and coupling different sectors could be a very beneficial recommendation towards RE projects economic sustainability.
Statement from literature [18 - 19]	3	Greek islands could benefit from this recommendation. However, demand-response incentives are yet not applicable to the Greek islands as they require the installation of residential smart-meters. In many Greek islands would be difficult to apply as the energy demand is highly seasonal due to increased population in the summer and power needs. In the winter it could be more applicable especially with the adoption of electromobility.
Statement from literature [20]	1	Electricity generation in Greek islands is liberalized; albeit, still, large-scale generation on islands is owned solely by the Public Power Company. However, due to the planned interconnections and the free access for private renewable energy producers to the respective grids, Greek islands could not benefit further from this recommendation.
Statement from literature [21]	1	Generation in Greek islands is still highly depended on fossil fuels; therefore, such a policy would be very aggressive, especially for smaller islands, and would result in even higher electricity bills. At the same time, islands face difficulties in the acceleration of the energy transition due to persisting high investment costs, lack of financial and technical support. Therefore, the facilitation of RES investment is still an issue in Greek islands which should be resolved.
Statement from literature [22]	4	Recommendation applicable to Greek islands, but have to be more specific.
C. Technology markets and investments	**Rank: 1-5**	**Additional comment**
Statement from literature [23 -25]	2	Economic welfare is directly related to society, meaning that citizens cannot pay taxes forever to fund subsidies. State support is often necessary to proceed to capital intensive investments, but pay-back benefits should be able to justify this. In conclusion, the two aspects are quite related and cannot be easily isolated.
Statement from literature [27]	4	Demand response can be challenging in Greek islands, especially in areas exhibiting seasonality in electricity demand. Therefore, it is in the Greek islands best interest to have significant changes taking place at market structure elements, aggregation, and technical modalities to further exploit the benefits of "consumer demand response”.
Statement from literature [11]	5	This recommendation would be very useful for the Greek islands, since it a difficulty of access in such investments is often observed.
D. Citizen engagement and incentives	**Rank: 1-5**	**Additional comment**
Statement from literature [28]	1	This recommendation seems beneficial, but it is not applicable to Greek islands, as no renewable or conventional centralized heat units operate in them or are planned to do so, with the exception of Agios Efstratios pilot project.
Statement from literature [29]	4	The view from Madeira is also applicable to Greek islands. It depends on the situation; spatial characteristics, location, size of the system, use (commercial or residential) etc. In general, the turn in decentralized smart energy systems will be beneficial for toughening the weak island grids and for ensuring lower energy costs.

Statement from literature [30]	3	The concept of this recommendation is on a good basis and could benefit Greek islands, but it would serve better if targeted renewable energy systems are promoted one-off and not compensated for 20 or 25 years with a tariff policy that might not be topical at a later period.
Statement from literature [31]	5	The rise of employment should be accounted as a positive factor as it contributes to overall social welfare. But, most importantly, in the context of just energy transition, the employees of soon-to-be decommissioned fossil fuel plants must be taken care of.
E. Ownership of smart energy systems	**Rank: 1-5**	**Additional comment**
Statement from literature [32]	5	In Greek islands citizen ownership could help the acceleration of decentralized projects as external investors face often local opposition.
Statement from literature [4 & 6]	5	As stated above citizen ownership could help the acceleration of decentralized projects in every Greek island, so investment priority to locals for clean energy technologies will be largely beneficial for Greek island communities.
Statement from literature [33]	2	In Greek islands the energy prices are not different from the mainland. To see any effect on energy prices consumer ownership must increase nationally.
F. Grid infrastructure	**Rank: 1-5**	**Additional comment**
Statement from literature [35 -36]	2	This could be a useful recommendation, but microgrids are not yet described in Greek legislation. However, this might need to be considered when drafting the relevant Greek legislation on microgrids.

4 Conclusions

In order to support the transition to high RE shares on the SMILE islands, as well as islands and regions elsewhere, policy strategies, framework conditions and replication opportunities are presented. This represents the final part of the energy system analysis and implementation issues that SMILE WP8 deals with, where both the technological demonstration projects are analysed in three island energy systems in the short- and medium-term perspectives, as well as the requirements for market and policy alignment evaluated. Together, these steps support the implementation of the necessary steps in the transition to high RE shares from both technical and institutional perspectives.

In this task, relevant literature for policy alignment requirements and suggestions were reviewed, SMILE partners questioned based on it, and inputs from Samsø, Orkney and Madeira compared and analysed. While the three demonstration islands have many differences, similar observations and experiences were observed across Samsø, Orkney and Madeira in regards to current barriers and potential solutions. However, Samsø applies Danish national regulations, Orkney follows both Scottish and national/UK law and Madeira has its own regime, differing to an extent from the national framework. The literature and questionnaires, from which the policy recommendations evolve, encompass six thematical areas, which are addressed separately, though overlaps also exist, including with the SMILE report D8.4 focusing on markets aspects. The themes are: Policy and Planning framework, Technology markets and investments, Energy markets, Citizen engagement and incentives, Ownership of smart energy systems, and Grid infrastructure.

Based on this, the recommendations for a better alignment in the transition to higher RE shares include: better integration of technologies, simplifying their implementation in both private and public areas, allowing establishment of local initiatives, such as bottom-up planning, simplify the integration of more RE, local and alternative approaches to local issues with more freedom, better schemes, better structure and information, shifts of legal rights and ownership with better local inclusion, local support mechanism for infrastructure, technologies, local flexibility markets for small actors, etc. The result is an overall policy recommendation of better inclusion and alignment of islands in light of their local possibilities as well as limits for the planning and organisation processes in the transitions to higher RE shares on islands.

Further reflecting on this, framework conditions for EU islands in general in regard to environmental standards are formulated, pointing at the importance of the ETS, as well as proposed schemes for GHG reductions on islands and generally. Finally, the replication opportunities for Greek islands is addressed in a step-by-step analysis of previous suggestions and literature statements, pointing to limits in replicability, but overall alignment of policy statements with the SMILE demonstration islands.

Concluding, the transition to higher RE on the demonstration islands, as well as elsewhere, is supported by previous technical analyses in SMILE reports D8.1, D8.2 ad D8.3 and the institutional alignment with markets in D8.4 and, finally, policies here in D8.5. Thereby, WP 8 covers the different steps necessary to implement the transition by investigating the potential development pathways and solutions. Therefore, the specific technological solutions that are demonstrated on the three SMILE islands are taken into consideration, as well as their energy systems, markets and policies.

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6 Appendix: Literature review and island responses in questionnaire 2

The literature review across the identified themes, the responses from SMILE representatives across Samsø, Madeira and Orkney demonstrators, documented in early 2021, as well as additional comment are presented here.

The following symbol are applied: (✓)– Agreement, (✓-) – Partial agreement, (N/A) – Not applicable or not relevant, (?) – Unknown

Responses from regional demonstrators to literature recommendations				
A. Policy and Planning framework				
Literature Recommendations	**Samsø**	**Madeira**	**Orkney**	**Additional comments**
The modeling simulation process should not be designed based on the optimal quantitative goals but according to a transparent process that demonstrates the different consequences of potential pathways. [1]	✓ -	✓-	✓	Samsø's representatives commented that the simulation model should be designed depending on the time frame. More specifically, for short-term planning the optimization with quantitative goals is ideal, while for long-term planning scenario simulations are better. Madeira's representatives commented that not all the modeling simulations can be tested in real-world conditions, since this would imply that the system owners would change their contracted power tariffs. For the case of the Madeira demonstrator, they followed the optimal economic feasibility approach.
Challenges on wind power development will be faced by setting a) stable conditions for project developers (e.g., feed-in-tariffs), b) clear distribution of competence with authorities on wind power projects spatial planning, and c) incentives or requirements for full or partial local ownership. [2]	✓	*N/A*	✓-	Madeira's representatives stated that the conditions are different in their case, since an energy market does not exist, while there are available feed-in-tariffs. Additionally, they commented that the RES installations depend significantly on the reliable function of the electrical system due to the non-interconnectivity of the island. Orkney's representatives expressed their doubts about this policy suggestion with focus on how the incentives of local ownership would increase the RES development.
The state should provide municipalities with planning instruments and establish a corresponding planning framework in order for the municipalities to function as energy planning authorities. [3]	✓	✓	✓	Madeira's representatives commented further that by using central planning institutions the municipalities' different needs are not addressed. Thus, the decision power of local institutions could be increased by integrating local issues at energy planning.
The insert of new renewable energy technologies should require the participation of NGOs such as local stakeholders and representatives of the technologies even if they do not exert much influence upon the energy system. [4 - 5]	✓-	✓	✓	Samsø's representatives stated that there are NGOs that participate in open discussions about energy planning. However, it has been noticed that they do not affect the energy system.

Public participation (e.g., discussions) should be regulated especially in the early phases of the decision process for transparency purposes. [6]	✓	✓	✓	Madeira's representatives supported this specific policy, stating that public discussions are the ideal way to increase transparency in energy planning. It provides the opportunity for fruitful local engagement or can even discourage an intervention when needed.
Local action should be within frames prescribed through the national energy system and coordinated in such a way as not to hinder local action elsewhere; albeit this could act as a barrier or even deterrent for local and national innovation. [7]	✓ -	✓	✓	Samsø's representatives highlighted that spatial planning is an important aspect to consider during energy planning. Thus, the large production energy plants should comply with the general objectives set, which the local municipal council should have the right to approve or reject.
The district heating policy should follow the next suggestions. 1. Establish transparency in cost and benefits by systematically assessing them. 2. Build robust national-level tools by encouraging cities to use a single structure for project assessments, since the national government compares projects and learns from other cities' experiences. 3. Develop electricity balancing markets that can confer value to DH and CHP systems. 4. Encourage holistic energy planning across sectors (electricity, heating, and more). [8]	✓	*N/A*	✓ -	Samsø's representatives supported this policy clarifying that in Denmark there is a national price list for comparing district heating plants, establishing transparency through the national effort to replace all biomass-fired district heating with electric heat pumps. Orkney's representatives on the other hand showed doubt about this specific policy.
Community engagement should be the first step in any siting permit plan while any energy local plan should begin with an examination of community energy priorities. [9]	✓	✓	✓	Madeira's representatives advocated the current policy stating that the community representatives should be chosen by locals considering multiple factors (regardless of their political association) making them reliable to ensure public common attitude on energy planning. Samsø's representatives supported the recommended policy stating that the municipality could play a significant role in energy planning. However, it clarified that the municipality cannot operate as a business giving leverage to private companies.
Energy poverty policy should be designed according to spatially characteristics or/and by housing type features, irrespective of household income. [10 - 11]	✓	✓	✓	Madeira's representatives supported the recommended policy commenting that the current subsidies or incentives are not addressed to the citizens who need them.
The optimal way to foster policies in innovative renewable energy technologies is by comparing the alternative options since different technologies require different types of policy instruments [12]	✓	✓	✓ -	Samsø's and Orkney's representatives commented that they both have been demonstrators of innovative technologies, which have been proved challenging because of the local needs that required to be met using the available funding.

Islands require a special regulatory framework that recognizes their specific situation and can be adapted to their needs, as well as provides support to achieve decarbonization goals. [13]	✓	✓	*N/A*	Samsø's representatives supported the suggested policy, stating that islands require a special framework not only in energy planning but in other relevant sectors too. In contrast, Orkney's representatives did not agree with a special framework on islands.
B. Energy markets	**Samsø**	**Madeira**	**Orkney**	**Additional comment**
Green energy compensation prices should provide sufficient incentives for investors in renewable energy. Thus, a good practice would be a transition to smart energy systems which will increase the prices by integrating the heat and power markets. Consequently, green electricity would never be sold at a lower price than the most expensive heat alternative. [15 - 17]	✓	*N/A*	*N/A*	Orkney's representatives commented that RES penetration should not be attached with smart energy systems even if an integration policy could be mutually beneficial. Madeira's representatives mentioned that it is not a relevant issue for the location.
Taxes should not be used to discourage entirely the use of electricity but rather to discourage the use of electricity during certain periods of low production-to-demand ratio. Similarly, taxes should be used to encourage the use of electricity during periods of high production-to-demand ratios. [18 - 19]	✓	✓ -	?	Madeira's representatives commented that time-of-use taxes could function as an incentive for changing consumer behavior, but they cannot influence the timing of heat production in relation to electricity prices. Orkney's representatives expressed that this policy suggestion is no different from the time-of-use tariffs.
The monopolistic power of state-owned utilities (e.g., large-scale generators) should be reduced by ensuring access to the grid from various types of actors in order to increase decentralized and small-scale energy production. [20]	?	✓ -	✓	Madeira's representatives partially agreed with the recommended policy, stating that some sectors of the electricity value chain should be liberalized in OECD countries, while some other must be regulated, in order to prevent crises like market speculations. Samsø's representatives did not identify with this policy recommendation.
A policy that directly prices or restricts carbon emissions (e.g., carbon tax) is considered to be the most cost-efficient option for the energy system, whereas a policy that will facilitate RES investment (e.g., production or tax credits) is expected to be more cost-efficient at encouraging market adoption of specific technologies. [21]	?	*N/A*	✓	Madeira's representatives disagreed with the suggested policy, stating that over-taxing an entity (which has social responsibilities) without the existence of an alternative technical solution, will not ensure the increase of RES development. Orkney's representatives agreed with the suggested policy. Samsø's representatives commented that they are unfamiliar with this policy.
New frameworks should embrace the heterogeneity of island systems offering new opportunities in the electricity market and leading to a cost-effective energy transition. [22]	?	✓	?	Orkney's and Samsø's representatives did not characterize this policy suggestion. Madeira's representatives agreed with the suggested policy.
C. Technology markets and investments	**Samsø**	**Madeira**	**Orkney**	**Additional comment**

A dual-track incentive system is required to establish socio-economically and business-economically incentives for investing in wind power and integration infrastructure between the electricity, heating, and transportation sectors. [23 -25]	✓ -	✓-	N/A	Madeira's and Samsø's representatives stated that this policy recommendation is linked directly to political ideas, consequently, it can vary from person to person. Orkney's representatives did not agree with this policy.
The "end-use demand response" should be able to provide flexibility to the electricity system alongside supply-side option – under appropriate and accommodating conditions. For further exploitation of "consumer demand response" numerous changes should take place at market structure elements, aggregation, and technical modalities. [27]	✓ -	*N/A*	?	Madeira's representatives commented that the entire market structure is not applicable and viable in their area. Samsø's representatives partially agreed, stating that the demand response system should respond to human demand and not the other way around. Orkney's representatives mentioned that they are no familiar with this policy recommendation.
The investments should be open to lower-income households or local communities while the barriers to entry should be also lowered by ensuring access to low-cost capital. [11]	✓-	✓	✓	Orkney's and Madeira's representatives agreed with the suggested policy while Samsø's representatives partially agreed, mentioning that this policy would not be applicable on an island scale.
D. Citizen engagement and incentives	**Samsø**	**Madeira**	**Orkney**	**Additional comment**
The heat tariff scheme should change, improving the financial incentive for heat savings, while also making the system development less vulnerable to fluctuations and shortages in capital markets. [28]	✓ -	*N/A*	✓	Samsø's representatives partially agreed with this policy since there is a conflict of interest between the permanent and nonpermanent citizens, since the fixed cost benefits permanent citizens while the variable cost benefits the nonpermanent ones. Additionally, it clarifies that a variable cost system would challenge heat supply companies due to their dependency of their profit on weather conditions. Madeira's representatives commented that this is not the relevant issue but could be similarly relevant if the specific policy referred to the electricity market since a big part of the cost is fixed. Orkney's representatives agreed with the recommended policy.
Decentralized installations of solar PV panels together with battery storage under a smart energy system could benefit consumers more than a centralized controlled installation. [29]	✓	✓-	✓	Madeira's representatives expressed doubt about this policy recommendation, commenting that energy storage systems at residential level are not always worth it due to physical (e.g., space available for installing PVs) and regulatory (e.g., rules in terms of maximum allowable installed capacity) limitations. Alternatively, other strategies could be equally effective to increase customer involvement - e.g., dynamic tariffs/DR schemes - while bringing more benefits to consumers.

The tariff policy should change in a way that the long-term costs (which reflect the investment) of future renewable energy systems, instead of short-term ones (which reflect the marginal and operational price), reflect on the tariff base. [30]	*N/A*	*N/A*	?	Madeira's representatives expressed its doubts about this policy, stating that it will be a challenge setting up such a system. In terms of costs, it would need a change of mentality for consumers and municipalities in order to adopt the new charging policy. Samsø's representatives commented that the specific policy will not be applicable for the island since the district heating in Denmark is nonprofit. Orkney's representatives were unsure about the policy suggestion.
Employment generation should be factored in when considering an alternative investment or transition strategies. [31]	✓	✓	✓	All the representatives of the islands were positive about this policy recommendation, without further elaboration.
E. Ownership of smart energy systems	**Samsø**	**Madeira**	**Orkney**	**Additional comment**
Citizen ownership should be encouraged in order for relevant investments to take place on decentralized sustainable energy technologies. [32]	✓	✓	✓	Madeira's representatives advocated this policy suggestion, highlighting the importance of decentralized production technologies and citizen engagement.
The policy related to citizen ownership should give investment priority to local investors to ensure that they always have the right to obtain ownership shares, since ownership restrictions have a clear relationship with local acceptance. Besides, the latter fuels the successful deployment of wind power installations. [4 & 6]	✓	*N/A*	✓	Madeira's representatives commented that the recommended policy is not relevant for the island since the investments in non-domestic renewable energy systems are either made by the DSO/TSO which is publicly owned, or by large private companies. Additionally, there is no issue of acceptance in Madeira. Samsø's and Orkney's representatives agreed with the recommended policy.
Consumer ownership model has positive potential both in terms of maintaining low energy prices and securing low coordination transaction costs in smart energy systems. [33]	✓	✓ -	?	Madeira's representatives commented that the ownership of the production and distribution system is not commonly discussed in Madeira. Furthermore, in a small non-interconnected island which the grid is maintained by a public company and parts of the infrastructure are public (if not shared), the concept of ownership of energy systems seems not applicable. Samsø's representatives agreed with the statement. Orkney's representatives were unsure about this policy.
F. Grid infrastructure	**Samsø**	**Madeira**	**Orkney**	**Additional comment**
The regulation should permit microgrids to operate in existing distribution and transmission infrastructures so that large mixed-use developments should be resilient in the face of major storms and grid outages as well as enable greener energy solutions moving toward a net-zero carbon environment in the future. [35 -36]	✓	✓	✓ -	Madeira's representatives supported the policy recommendation, commenting that extended grid sizes facilitate the functionality of a microgrid. Samsø's representatives supported the specific policy recommendation giving for example the microgrid of Ballen marina. Orkney's representatives commented that maybe is a good practice to follow.

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