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Decarbonisation pathways: a foresight exercise in the Canary Islands

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Abstract: The Canary Islands are heavily dependent on fossil fuels which intensifies the need for a decarbonisation pathway by 2050. Our study provides a comprehensive approach to identify possible energy transition pathways in line with different stakeholder perspectives. We conducted two rounds of 16 foresight interviews in the region with stakeholders representing different groups. The first round focused on understanding the current challenges and opportunities of the energy system, while the second round aimed at identifying the overall vision of the stakeholders for their local energy system. We have found that there are still significant regulatory difficulties that hinder implementation of technologies and innovative business models. However, the main challenges highlighted were achieving a transition without energy justice and the lack of collaboration between stakeholders. Different pathways have been identified but all interviewees emphasised that the future energy system needs to be human-centred and support citizen participation, prosumers, and energy communities.

Keywords: Decarbonisation; Human-centric; Energy Transition; Pathways; Foresight; Stakeholder perspectives; Canary Islands.

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1 Introduction

While the vision of decarbonisation by 2050 is clear, the pathway and strategy to achieve this vision remains a challenge and can differ depending on the context (Heaslip & Fahy, 2018). Therefore, 'local' energy transitions (Akhatova et al., 2020; Dobravec et al., 2021) require place-based solutions and actions to achieve 2050 decarbonisation goals (Powell et al., 2021). This research aims to demonstrate how the local context can directly or indirectly influence energy transition pathways either by creating barriers or accelerating it. Therefore, this study seeks to identify how the regional context creates the conditions to achieve local decarbonisation or influence the path-dependence of the required actions. At the same time, the aim of this study is to highlight priorities for achieving a human-centred energy transition. One of these priorities is justice and inclusiveness of the energy transition with the focus of enabling citizens to take a more active role in the future energy system. Local energy transitions and the facilitation of this changing role of citizens requires participation and collaboration of all stakeholders in and outside the energy value chain that play an important role in energy transition. Therefore, this research also contributes to promoting a bottom-up approach in the decarbonisation pathway that supports initiative, collaboration, and partnership of different energy stakeholders.

2 Literature review

As transition to a carbon-free energy system is receiving increasing attention, the literature on this topic has been growing for the past decade. There is a wide variety of approaches that have been used to analyse pathways towards future carbon-free energy systems. Research on energy transition pathways (Chen et al., 2019) can involve and combine quantitative scenarios or qualitative narratives of storylines (Auer et al., 2019). Additionally, energy transition pathways are expected to be distinct in different areas where contextual aspects differ in their spatial, techno-economic, social, and environmental features (Derkenbaeva et al., 2022).

Indeed, different local contexts can directly or indirectly influence energy transition pathways either by creating barriers or accelerating it, causing the local energy transitions to be path-dependent (Judson et al., 2020). This is in line with research on socio-technical transition pathways, which recognise that transitions are context-dependent and unfold very differently under various circumstances (Foxon, 2013; Geels and Schot, 2007; Smith et al., 2005). In this sense, context (e.g., stakeholder governance) can also influence the fairness of the energy transition (Heiskanen et al. 2021). For instance, the FLEXCoop project analysed the current situation and pathways regarding regulatory, market, socio-economic, and ethical context in different countries such as The Netherlands and Spain (FlexCoop, 2020). In this way, they were able to demonstrate that some priorities might be similar, while others are different, for example, due to cultural differences.

The most applied approach to study this phenomenon is a quantitative analysis that mostly integrates techno-economic optimisation methods and modelling frameworks (Hof et al. (2020), Barney et al. (2021), Hainsch et al. (2021)). The studies based on quantitative methods mainly focus on techno-economic analysis of the energy systems and are conducted for different area scales (i.e., a country, a region).

A study held by Hainsch et al. (2021) is conducted on a regional scale and analyses possible decarbonisation pathways, using varying assumptions for carbon constraints and distributions among some model regions. The authors apply a linear optimisation model approach to compute low carbon scenarios for 17 European countries. Similarly, Barney et al. (2021) in their study also conduct techno-economic analysis including development of energy scenarios and economic assessment on a broader scale. The authors implement the energy planning decarbonisation platform on eight islands within the EU. The platform is tested with different scenario generation methods and proven to be suitable for different islands, regardless of location and size. In the contrary, Hof et al. (2020) argue that the decarbonisation transition strategy largely depends on the narrative and the scale. The authors develop low-carbon narrative-based scenarios to explore the consequences of different pathways on the electricity system from the global to national scale that is neglected in cost-optimal solutions. They apply two integrated assessment models and one detailed European electricity system model.

Evidently, there are multiple advantages of quantitative methods, however, due to the nature of quantitative model-based approaches, some aspects of the real world can only be included in a simplified way overlooking some important social/human aspects. Quantitative methods that include equilibrium or optimisation models tend to oversimplify their depiction of societal and institutional aspects (Li and Strachan (2019)). This makes it challenging to use them for developing and implementing energy transition-related scenarios or pathways.

Qualitative methods are less commonly used in the past energy transition research but are gaining more attention (Abbasi et al. (2021), Li and Strachan (2019), Auer et al. (2019)). Abbasi et al. (2021) present an overview of the heat decarbonisation practices through heat pumps technologies across Europe. They adopt an evidence-based approach synthesizing experiences from the best practices with the aim to identify key issues and challenges that emerge from the heat decarbonisation. However, the authors recognise that besides technical, economic, and environmental considerations, it is also important to evaluate the social context and consequences. This transformation directly affects people’s wellbeing and decision-making and future research in this direction is imperative (Abbasi et.al., 2021). At the same time, supporting the goal of a future human-centric energy system (European Commission, 2018), it is necessary to consider energy justice for just and inclusive pathways towards a low carbon energy system (Chapman et al., 2018).

Li and Strachan (2019) in their study utilise a socio-technical energy transition model of the UK’s energy system to capture elements of heterogeneity, consistency, and co-evolution of societal and political drivers. The authors focus on exploring government-led and societally-led energy transitions and their differences in decarbonisation pathways. The findings of this study show that even though both energy transition scenarios hold the potential to extensively decarbonise the energy system, the most successful scenario appears to be top-down where the governmental body initiates decarbonisation though regulatory leverages while holding the regulatory power. However, the study fails to capture the interactions between different stakeholders, while social influence and collective actions are considered to be imperative in transformations (Li and Strachan, 2019).

Some qualitative studies also focused on various energy transition scenarios and salient pathways. In their research, Auer et al. (2019) emphasise that both visions and storylines of possible pathways to achieve the vision should only be considered as ideas and narratives that demonstrate possible developments and priorities. There can be different energy transition pathways that might depend on adopted business models, maturity of thinking and engagement of stakeholders (Derkenbaeva et al., 2020) and strategies due to technical capacities, policy, and political contexts (Broekhoff et al., 2018).

Based on this review, we identify two major gaps in the literature. First, qualitative studies that focus on societal aspects to analyse varying social and institutional contexts, heterogeneity of stakeholders, their interaction in the energy system, and possible decarbonisation pathways based on a human-centric way are scarce. Developing just and inclusive pathways towards a low carbon energy system is central in decarbonisation mission (Chapman et al., 2018). Second, as there are large differences in energy transitions between global, regional, and country levels (Hof et al., 2020), it is important to analyse how local context can directly or indirectly influence energy transition pathways either by creating barriers or accelerating it. Therefore, in this study we aim to demonstrate an energy transition pathway for a geographical island and its path-dependence as an example of a human-centred place-based decarbonisation scenario.

The literature on islands energy system planning has been mostly focusing on techno-economic evaluations, while overlooking social and human aspects and failing to provide a complete picture (Barney et al., 2021). The energy transition pathway of an island is unique, due to more specific and varying combination of challenges and drivers that are defined e.g., by their geography and climate, seasonal changes of energy production and demand, and (electric) isolation from the mainland (Bunker et al., 2015). These distinct circumstances that influence island energy systems require place-based approaches and priorities on their pathways to achieve their local energy transition. The variety of energy transition pathways on islands (Eurelectric, 2017) demonstrate this need.

3 Context

The Canary Islands are an autonomous region of Spain, belonging to the outermost regions of Europe. The archipelago consists of 7 islands, namely Tenerife, Fuerteventura, Gran Canaria, Lanzarote, La Palma, La Gomera, El Hierro (Figure 1). The islands are situated in the middle of the Atlantic Ocean, off the coast of Morocco. The location close to the equator and the trade winds enable mild climates on the islands, rich of wind and solar energy (Calero & Carta, 2004; Meschede et al., 2018). The islands differ in their climate, geographical features (topology, size), population density, energy resources, and social and economic circumstances, which creates unique contexts for their local energy transitions.

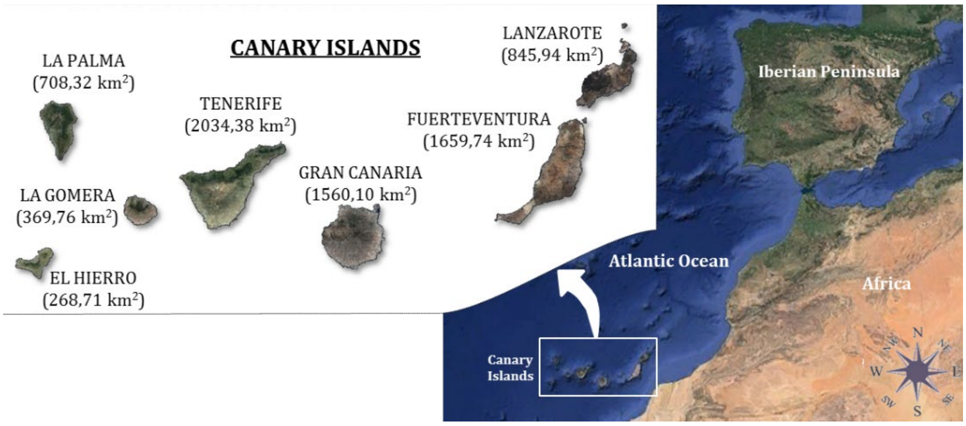

Figure 1. The location of the Canary Islands (Lanzarote, Fuerteventura, Gran Canaria, Tenerife, La Palma, La Gomera and El Hierro).

The Canary Islands are electrically isolated from the European or African mainland and even between themselves. Only La Gomera and Tenerife, and Fuerteventura and Lanzarote are connected via 66kV undersea cables. The electrical isolation made the Canary Islands highly dependent on fossil fuels (see Figure 2) because the integration of renewable energy sources challenges the local grid stability and is limited due to the geographical boundaries of the islands. Only El Hierro could achieve an energy mix dominated by renewable energy, due to wind-pumped hydro power plant 'Gorona del Viento'[1]. Of the energy consumption of all islands, however, 75% can be associated to transport sector, while commercial, residential, industrial, and agricultural sectors only account for 12%, 9%, 3% and 1%, respectively (Gobierno de Canarias, 2020).

The Canary Islands' government aims to publish an Energy Transition Plan by the end of year 2021 to identify strategies for full decarbonisation of the whole archipelago by 2040 (Gobierno de Canarias, n.d.a). The local government, alongside the European Union, is implementing a regulatory environment for energy communities and self-consumption[2]. Different stakeholders are involved to push this movement and support citizen-led and industry-led energy communities and their business models. Furthermore, the Canary Island Institute of Technology[3] is involved in many projects that support the islands' energy transition in cooperation with the public and private sector. For instance, the development of 'Gorona del Viento' in El Hierro, was a public-private partnership and involved different stakeholders with different capabilities and resources. Citizen engagement was noticed as increasingly important (Pellegrini-Masini et al., 2019). The project also demonstrates how business models can provide environmental, social, and economic value for the citizens, which is why it is often used as a best-practice example of the island energy transition. However, it the local energy cooperative's La Palma Renovable[4] and SomEnergia[5] help to promote the human-centric energy transition.

[1] More information on https://www.goronadelviento.es/en/
[2] See Royal Decree 244/2019 to support renewable energy self-consumption.
[3] More information on https://www.itccanarias.org/web/es/areas/energias-renovables
[4] More information on https://lapalmarenovable.es/en/
[5] More information on https://blog.somenergia.coop/grupos-locales/canarias/

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Additionally, the Canary Islands energy market has special regulations (Uche-Soria & Rodríguez-Monroy, 2018) to maintain price levels similar to the customers in the Spanish mainland. In June 2021, a new tariff has been introduced based on the Royal Decree 12/2021, which changed the energy tariff to a time-of-use tariff of three bands. The new energy tariffs should drive the installations of roof-top solar PV and the shift of energy consumption to off-peak hours; however, they affect all consumers independently of their flexibility capital (Powells & Fell, 2019). While there is almost no need for heating on the islands, many households need air conditioning, and many suffer from low incomes. Therefore, evaluation of energy poverty in the Canary Islands should be considered in the local planning of energy transition pathways (Uche-Soria & Rodríguez-Monroy, 2020) and strategies for a just energy transition (Gobierno de Canarias, n.d.b).

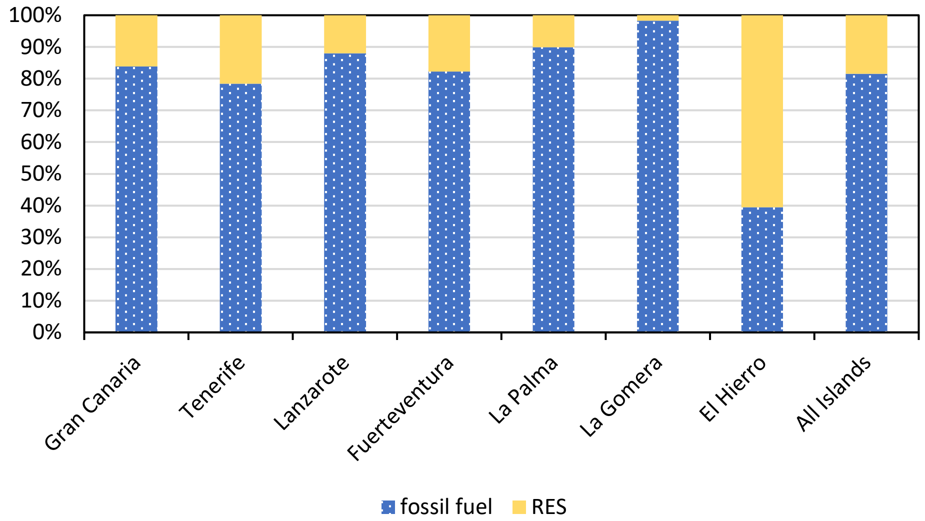

Figure 2. Comparison between technology baseline for energy generation in the 7 Canary Islands with share of fossil fuel vs. RES (renewable energy sources) based generation. Most of the islands still depend on fossil fuels.

Source: (Gobierno de Canarias, 2020)

4 Methodological approach

Our analysis is based on a comprehensive approach commonly used in foresight studies (Popper, 2008) and includes two rounds of foresight interviews with experts from five representative groups of stakeholders in the region of the Canary Islands (Figure 3). The foresight interviews were conducted in a semi-structured manner in two rounds. The first round of interviews focused on understanding the challenges and opportunities of the current energy system, while the second round aimed at identifying the overall vision of the stakeholders for their future local energy system.

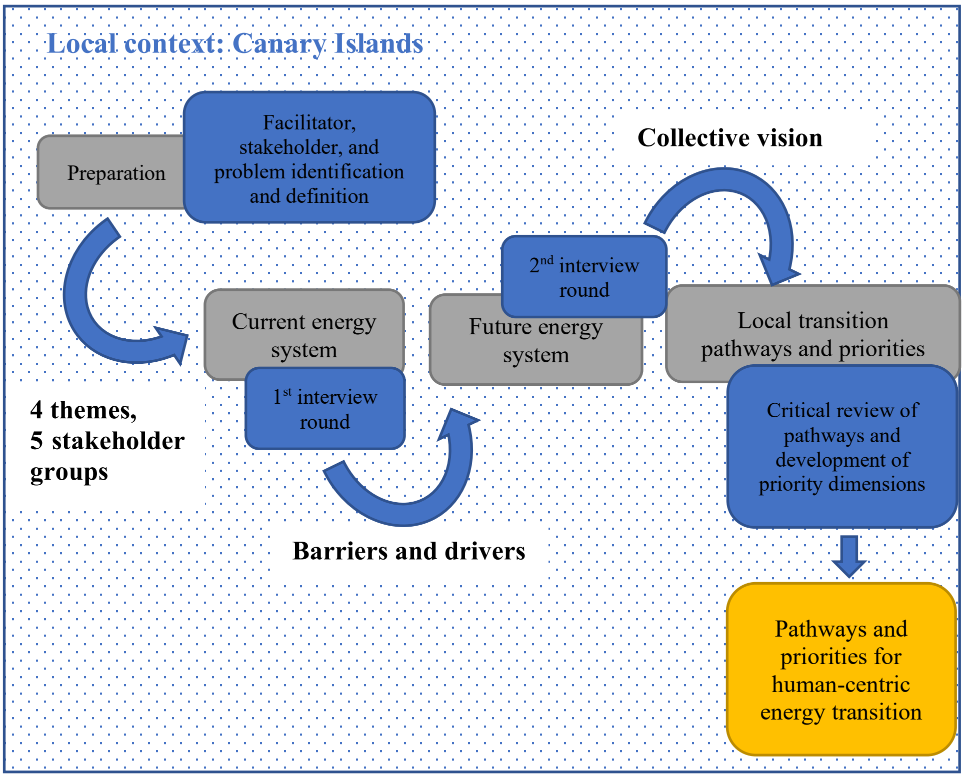

Figure 3. Steps in identifying pathways for a collective vision for a local context, here Canary Islands.

The interviews were conducted using the Delphi technique which is widely applied as a valuable foresight tool (Czaplicka-Kolarz et al., 2009). The Delphi method is an iterative process to elicit judgments or other subjective opinions in relation to the future (Linstone and Turoff, 1975). This method is considered suitable for exploring and examining specific issues, identifying areas of agreement and disagreement, and developing decisions based on consensus among interviewees (Hsu and Sanford, 2007). Therefore, this method has been chosen to understand not only the current situation, but also the vision of the future energy system to identify the possible pathways for a successful energy transition.

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The main groups of stakeholders that have been targeted are local authorities, business actors/ financers, technical experts/ researchers, citizens' groups (including environmental NGOs and energy justice networks). These stakeholder groups were chosen due to their relevance in local energy systems (Walker et al., 2021) and more specifically in the chosen themes that are similar to the storyline dimensions of analysis by Auer et al. (2019). These themes include the following:

- Participation and collaboration;
- Techno-economic obstacles and drivers;
- Business models in current and future energy system;
- Equity, energy poverty, fair energy transition.

These themes aim to grasp the complexity of the energy transition and decarbonisation pathways focusing on their barriers and drivers. The interview questions were developed according to the identified themes.

A total of 16 interviews were conducted. In both interview rounds, all stakeholder groups had at least one representative (Table 1).

Table 1. Number of participants for both interview rounds

Stakeholder group	*Number of participants*	
	1st round	2nd round
Local authorities	3	1
Business actors/financers	2	1
Technical experts/researchers	3	2
Citizen groups	2	2

Source: Own work

The interviews were analysed according to the themes based on the overall stakeholder thinking. Furthermore, the interviews were critically reviewed to identify the understanding of possible energy transition pathways of the stakeholders and the salient priorities. While the pathways were identified as the way from current situation, including barriers and drivers, to achieve the vision, the priorities are based on three proposed dimensions. These dimensions were derived in a circular way from literature, wider trends, and local understanding (vision) under the consideration of the interview themes and context. Produced word clouds with *NVivo 12 Pro* of each round, were used as an indicator for the magnitude of each dimension along with the analysis and the results of the findings. Words 'noise' had been filtered out in an intuitive way to present sensible word clouds that can be used for justification. The list of "stop" words can be found in the Appendix.

5 Results

5.1. Barriers and drivers

Participation and collaboration

The experience of the participants reveals that collaboration between stakeholders can be very challenging. The most significant challenge is perceived to be the administrative/political sector's bureaucracy as it remains a main barrier for collaborations and the energy transition. Also, big companies such as the local energy provider, are challenging collaborators and even a barrier for the energy transition by themselves, as they are afraid to lose their monopoly and market share. More specifically, regarding energy communities, a technology expert raises concerns that information, trust, values, and communication can be a major barrier among citizens. Even though citizens and small private companies are generally perceived as easy as once they participate, they are very willing to collaborate and drive the transition. At the same time, collaborations with the European Commission have been considered as beneficial for the islands, as they help in that the islands are not overlooked in the global/Spanish energy transition.

Techno-economic drivers and obstacles

The techno-economic conditions in the Canary Islands appear to be straightforward among all stakeholder groups: the favourable weather conditions drive implementation of renewable energies, heating and cooling are not seen as very relevant, all energy consumption will be electrified, which also includes water production and mobility and allows for sector coupling. All the existing technologies are seen as very economically profitable, however, not all solutions fit all islands, underlining the importance of the island context and size. Grid-constraints are the main barrier for further implementation of renewable energy technologies and their profitability, as they can be curtailed. Further reduction of battery prices can drive their adoption and contribute to the local energy transition. Furthermore, the existing building stock in the Canary Islands is very old. There is low awareness of citizens that increased building efficiency can create energy savings.

Business models in current and future energy system

Participation in any business models that support the energy transition is economically driven. However, the interviewees highlight an increasing environmental awareness, which can further drive and influence businesses. Social benefits are not actively considered by business actors but emerge indirectly to the citizens. On the contrary, a representative of the citizen group emphasises that if citizens participate in energy transition business models such as energy cooperatives, they are more likely to be motivated by the environmental and social value of it than the economic one. Nonetheless, the decision to act still depends on the 'sense for the environment' and financial possibilities of the citizens. Also, past experiences with instable policies and incentives leaves business actors just as citizens with a strong sense of doubt, which remains a major barrier for energy transition business models.

Equity, energy poverty, fair energy transition

Energy poverty is not a topic that is widely discussed on the islands. As people do not need to spend money on heating, and energy prices are subsidised, the consensus of the interviewees is that people are rather poor in general due to the low economy. People are

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also often not aware how they could change their behaviour to save energy and costs. Therefore, all interviewees are convinced that energy affordability and accessibility should be a priority action in political agenda to guide a fair energy transition. Interviewees from local authorities also state that they engage in energy projects such as social housings or energy vulnerable communities, but are often confronted with limited funding, which remains a main barrier for a larger impact. According to the interviewees, more actions are required for a human-centric energy transition as energy vulnerable families are more concerned about having access to energy in general rather than having cheaper or green energy in the long-term.

Overall

There are several drivers and barriers for a human-centric energy transition in the Canary Islands. While there is willingness to collaborate are increased environmental awareness and engagement, there are high levels of bureaucracy and lack of trust which counteract each other. Figure 4 summarises the drivers and barriers hold in the current energy system of the Canary Islands.

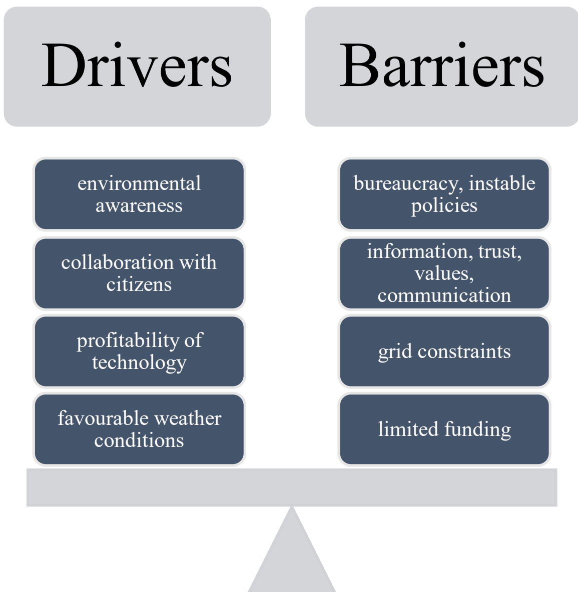

Figure 4. Key drivers and barriers that the different stakeholder perspectives revealed in the interviews.

5.2. Vision

Participation and collaboration

In the future energy system, collaboration between all stakeholders will be very important. The vision is that there will be a 'culture of collaboration' instead of a 'culture of competition' with no monopolies. Energy communities will be key in the future energy system, which requires collaboration between all kinds of different actors such as energy market players, energy cooperatives, public administrations, and town councils, to provide local energy services. At the same time, the role of citizens will be crucial within energy communities. Interviewees are convinced that citizens will have a more active role in the future energy market through being prosumers or being involved in energy communities or energy cooperatives.

Techno-economic drivers and obstacles

Technology-wise, the vision of the future energy system is similar among all stakeholder groups: *"The electricity and mobility sector should be decarbonised, and energy demand should be reduced by 2040"*. Decarbonisation of the Canary Islands will also involve sustainable mobility with innovative solutions for roads, water, and air transport. The future energy system will consist of a mix of technological solutions for energy production, management, and storage. The interviewees mention that a diverse mix of both established and innovative technologies, and centralised or decentralised solutions will enable unique configurations for all islands. For instance, more offshore wind energy will be in place due to increased environmental concerns and the geographical boundaries. Citizens will be involved through decentralised energy production and self-consumption individually or within concepts such as microgrids or positive energy districts.

Business models in current and future energy system

The future energy system will need no subsidies. There will be an increased number of markets and several new companies that are involved in, for example, implementation of PV installations. The Canary Islands can serve as lighthouse islands for the energy transition and technological solutions. However, the context of the islands, which will still not allow for standardised solutions, is important to be understood by companies that want to invest. Additionally, a citizen representative states that it will be preferable if business actors, financers, and investors are local islanders who knows the context instead of external stakeholders from abroad, in order to ensure a fair, sustainable, and human-centric energy system. The industrial sector will play a predominant and leading role regarding self-consumption and energy communities. Furthermore, innovative business models can play a significant role to include citizens that could not afford participation, while they will be able to produce energy without the need to have direct ownership of batteries.

Equity, energy poverty, fair energy transition

As the decarbonisation of the electricity sector will reduce the dependency of fossil-fuels, the interviewees project the energy prices to fall down in the future. In fact, several interviewees think that the subsidy on energy prices will not be necessary as the prices will be even lower and can be used for other incentives for energy vulnerable households. These incentives can, for instance, support these households to implement rooftop solar PV, increase energy efficiency of electric devices or building stock, or buy energy cooperative's

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shares. The interviewees agree that the future energy system should not have dynamic tariffs that discriminate consumers who are not flexible in their energy consumption, which most likely are the energy vulnerable households. Instead of citizens needing to change their behaviour, policies and incentives should be in place to support energy efficiency measures.

Overall

Figure 5 summarises the key elements that need to come together to create a holistic and human-centric energy system in the future. These elements derived from the different stakeholder perspective on all interview themes.

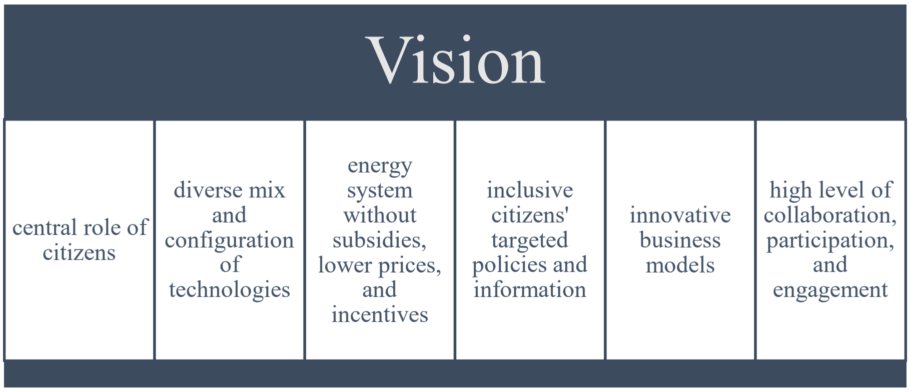

Figure 5. Key elements summarising the overall vision of the future energy system in the Canary Islands.

5.3. Pathways

Participation and collaboration

The stakeholders are convinced that achieving the appropriate level of collaboration and changing roles requires more information, dissemination, training, and campaigns. For that, institutions of higher education and professional training need to be involved to support this pathway. Additionally, new sources and means of collaboration will be valuable for human-centred energy transition. Local authorities or other individuals with higher social status are seen as crucial for the engagement of citizens and the promotion of their future role. Similarly, the interviewees state the importance of the local and national government to act as role models and to transmit clear and consistent messages to citizens. Furthermore, changing collaborations, transparency, and a shift in powers should be facilitated as these can help to dissolve monopolies and enable citizens’ roles. Otherwise, top-down pressure from Europe is needed to force local authorities and big companies to allow the future human-centric energy system to emerge.

Techno-economic drivers and obstacles

While the global perspective of the energy transition can support price reduction for new technologies, the interviewees envision a 'local' energy transition. That is, the energy transition starts at local/island level with a mix of decentralised and centralised solutions, but at all means, with storage technologies. Due to the islands' isolation and different challenges, storage technologies are crucial for the techno-economic feasibility of the future energy system. Still, the interviewees agree that both energy supply and demand need to be transformed. Additionally, energy efficiency will play an important role in decarbonisation. This can be achieved through measures such as the increase of energy efficiency through implementation of LEDs or the replacement of electric water heaters, as well as more expensive measures, which affect the building stock efficiency through mandatory requirements of adapting passive housing and bioconstruction. These mandatory regulatory frameworks could also be in place for other technical building codes of new housing, such as direct implementation of rooftop solar PV.

Business models in current and future energy system

According to a business expert, the overall vision is achievable in a subsidy-free way for high-impact renewable energy installations. However, all interviewees agree that incentives are still needed to involve citizens for the human-centric energy transition. On the one hand, subsidies and other supportive regulatory frameworks can be used to awake interest and accelerate the energy transition. On the other hand, they need to be planned consciously and for the long-term, and only be removed progressively. A business actor claims that the government needs to start planning and making policies for the future and not for the past. Many laws are based on thinking and knowledge from the last 5-10 years, while a forward-looking perspective is required to achieve the energy transition by 2040. Subsidies are needed to support citizens who have financial limitations to ensure a just energy transition. Interviewees perceive current subsidies still to majorly benefit those who already have the money for investments. Existing investors are increasingly aware of the importance of environmental and social value of investments. While local businesses such as hotels use the changing environment for branding and making business of sustainable tourism, in the long-term revenues from renewable energy projects could be re-directed to feed back into the community.

Equity, energy poverty, fair energy transition

Energy poverty and social benefits are topics that need to be further addressed for a fair and inclusive energy transition pathway. Policy actions are necessary to support energy vulnerable households not to be left behind in the energy transition. For instance, mandatory policies such as the installation of rooftop solar PVs can address environmental concerns, while at the same time they fail to address social aspects. The interviewees emphasise the role of local authorities to take responsibility for their communities through supportive financial and action-driven measures and initiatives. For supporting energy affordability and accessibility, the business actors identify their responsibility in terms of increasing sustainable investments, while the technical experts and researchers – in terms of acting as advisors and helping to share information and knowledge. Additionally, the citizen groups aim to further raise awareness and education towards a more inclusive and sustainable agenda.

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Overall

The local government has started its energy transition pathway and further develops strategies for achieving its goals by 2040. While some stakeholders consider this vision ambitious and the pathway being unclear, the analysis of the different themes revealed some key aspects that the different stakeholders consider for a successful and inclusive transition toward decarbonised Canary Islands. These elements include awareness, engagement, energy efficiency, incentives, and further inclusive and stable policies that all together form an attractive and participatory environment for all stakeholder groups to achieve the energy transition (Figure 6).

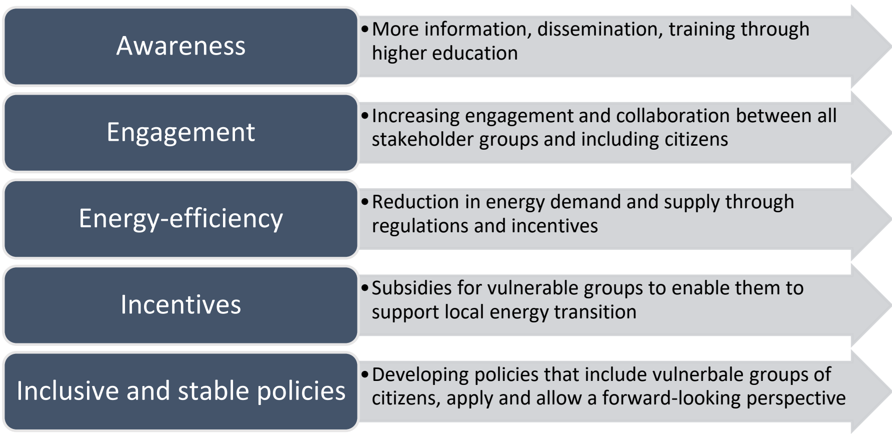

Figure 6. Key elements for human-centric pathway for the local energy transition in the Canary Islands based on different stakeholders' views.

5.4. Priorities

Priorities for the local energy transition under the context of the Canary Islands revolve around the idea of a human-centric (people-oriented) energy transition. Based on the analysis of the themes from the current barriers and drivers along with the vision of the local future energy system, three dimensions that reflect the priorities have been identified. These dimensions are:

- Penetration of energy technology and efficient energy consumption,
- Incentives and inclusiveness,
- Awareness and engagement.

These dimensions are developed based on the findings. The key words presented in the Figure 7 demonstrate the priorities in a human-centric decarbonisation pathway.

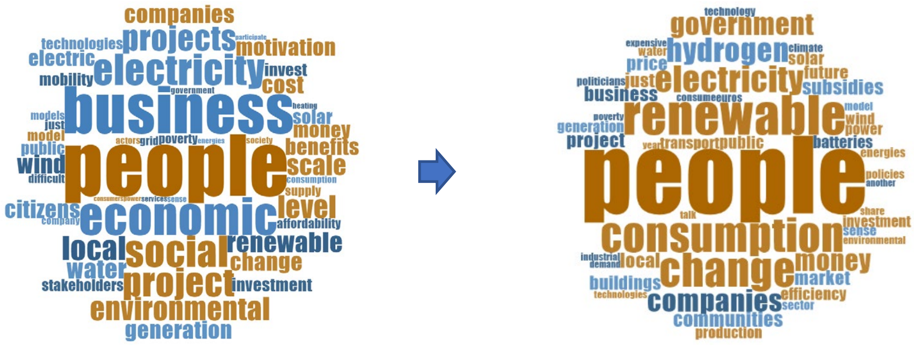

Figure 7. Word cloud of first round interview (current state) - left, and second round interview (vision) - right.

Figure 8 demonstrates how the current state and the vision come together under the abovementioned dimensions showing the magnitude or an 'estimated' number for each dimension. It indicates the necessary direction in decarbonisation in the Canary Islands.

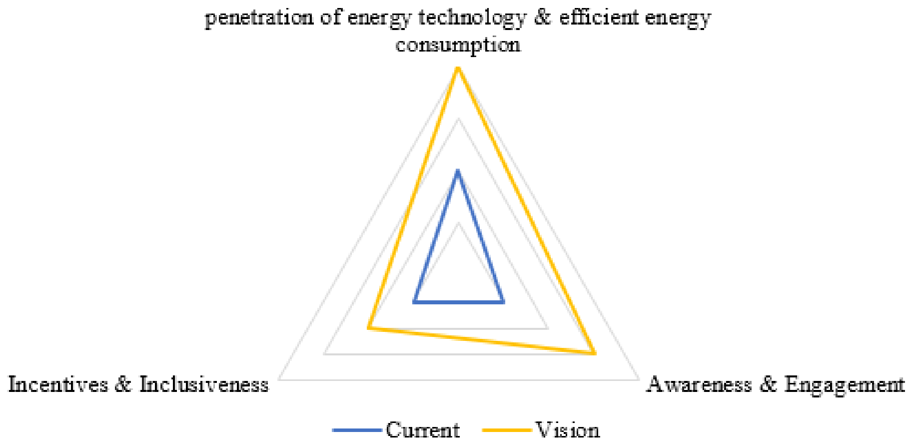

Figure 8. The current state and vision under the priorities for the local energy transition in the Canary Islands.

6 Discussion and Conclusion

All participants share the similar vision that is the future energy system being 100% renewable by 2040. Regulatory changes such as inclusive policies targeting especially vulnerable groups of citizens (i.e. in terms of financial incentives) are to promote the active role of citizens and energy communities in the energy market. Additionally, diverse renewable energy solutions are increasingly seen as mainstream technologies and get implemented. However, the goal to achieve by 2040 is still considered to be ambitious by some stakeholders and the pathway of decarbonisation remains unclear. For instance, the interviews revealed that among all stakeholders, there is a vision of combination of technologies, mainly in electricity generation and mobility. They recognise that technology alone will not be able to cover an islands' energy demand throughout the year due to their unique contexts and the nature of the energy generation. The interviews demonstrate that all stakeholder groups are aware of the uniqueness of their region and different features such as climate conditions, the island's electric isolation, their geographical boundaries/limitations, and being a popular touristic destination. While these features can positively contribute to transition of the energy system, at the same time they also can cause barriers in decarbonisation.

Based on these findings, it is evident that decarbonisation will require different pathways for each of the eight Canary Islands considering their contextual features and constraints. Furthermore, the foresight interviews highlight that a human-centric focus in decarbonisation is of importance as engagement of citizens and collaboration between different stakeholder groups contribute to an inclusive energy transition. The regulatory framework takes a leading role in facilitating the process of engagement and collaboration and increased implementation of technologies.

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Appendix

List of stop words

2040 a able about above after again against all already also am an and any are aren't aren't as at audio based be because been before being below between both but by can can't canaria canary cannot can't come could couldn't couldn't course did didn't didn't different do does doesn't doesn't doing don't done don't down during each eeeh energy esr14 esr5 even every everything example few first for from further give going good gran great had hadn’t hadn't has hasn’t hasn't have haven’t haven't having he he’d he’ll he’s he'd he'll help her here here’s here's hers herself he's him himself his hmmm how how’s how's i i’d i’ll i’m i’ve i'd if i'll i'm important in inaudible int2 int3 int4 int5 interesting into is island islands isn’t isn't it it’s its it's itself i've kind know last less let’s let's like lower main make many maybe me mean more most move much mustn’t mustn't my myself need next no nor not of off okay on once ones only or other ought our ours ourselves out over own part perfect point probably problem question really right said same say says self shall shan’t shan't she she’d she’ll she’s she'd she'll she's should shouldn’t shouldn't small so some something spain spanish speaks such system talking than that that’s that's the their theirs them themselves then there there’s there's these they they’d they’ll they’re they’ve they'd they'll they're they've thing things think this those through time to too topic transition ummm under until up upon us very view vision want was wasn’t wasn't we we’d we’ll we’re we’ve we'd well we'll were we're weren’t weren't we've what what’s what's when when’s when's where where’s where's which while who who’s whom who's whose why why’s why's will with won’t won't work would wouldn’t wouldn't yeah years you you’d you’ll you’re you’ve you'd you'll your you're yours yourself yourselves you've