Smart-BEEjS

Human-Centric Energy Districts: Smart Value Generation by Building Efficiency and Energy Justice for Sustainable Living

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Business Models and Consumers' Value Proposition for PEDs

Value Generation Systems for PEDs: Archetypes for a Networked Europe, 2040: Foresight Report

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Executive Summary

The development of Positive Energy Districts (PEDs) requires an inclusive and just, user-driven market. In this report, we identify the vision for the energy system in Europe by 2040 and possible pathways to achieve it and hence facilitate PED development based on scenario-based foresight interviews that were conducted in 8 EU regions with the participation of local stakeholders.

In particular, this report consists of 8 regional reports. For each region, we first discuss the context and its unique characteristics. Secondly, we present the analysis of the current energy system based on the interview data across four themes (collaboration and participation, techno-economic development, business models, equity and energy poverty), presenting the challenges and drivers of the current energy system to reflect the baseline from which the energy transition will start. We then focus on the desired future energy system based on the interviewees vision addressing the same four themes and identify priorities. After comparing the current baseline situation with the desired future, we present a desired pathway, with possible pathway actions for each theme. We conclude each regional report with a discussion section.

1 Foreword and Introductory Remarks

Stathopoulou, Eleni; Derkenbaeva, Erkinai; Heinz, Helen; Galanakis, Kostas

The EU's Strategic Energy Technology Plan (SET-Plan) has set out a vision to create 100 Positive Energy Districts (PEDs) in Europe by 2025 [1] expecting further progress by 2040. The PED concept stands out as a tool for achieving decarbonisation through local energy transition towards an energy-efficient, flexible, and self-sufficient system based on renewable energy sources.

This supports the pledge that many countries have made to become 'net-zero', i.e., carbon neutral, by 2050. Albeit this clear vision, it remains uncertain how to achieve it and what changes are needed. The goal requires not only the adoption of renewable energy sources, but also support for the 'local' energy transition [2]. This implies finding just and place-based solutions [3] and engaging citizens in the energy transition process with new roles in the future. Yet, the way the energy transition will take place in each region will remain context-dependent [4] and while learning from different country, region, and city level is beneficial, the pathway to 'net-zero' will be region-specific.

This deliverable (D6.4) presents the findings from foresight interviews conducted across Europe and aims to provide possible scenarios to facilitate PED development exploring the need for subsidies and with the reinforcing power of an inclusive and just, user-driven market. In particular, we produce base and vision scenarios that reflect the current and the future energy system in 8 EU regions along with the possible pathways to achieve the energy transition.

1.1 Approach

This foresight report is based on deliverable D6.3; it collates, codifies, and analyses the scenario-based foresight series of interviews in the 8 regions of the Smart-BEEjS project with the participation of local stakeholders and with a horizon of 2040. The regions where interviews have been conducted include Switzerland and Italy for a country-wide perspective; the Canary Islands (Spain), Lisbon metropolitan region (Portugal), Nottingham (United Kingdom), and Ruhr region (Germany) for a regional perspective; and Amsterdam (the Netherlands) and Vienna (Austria) for a city perspective. The foresight interviews were conducted in a semi-structured manner in two rounds. The first round of interviews focused on understanding the barriers and drivers of the current energy system, while the second round aimed at identifying the overall vision and salient priorities of the stakeholders for their desired future local energy system (Figure 1.1).

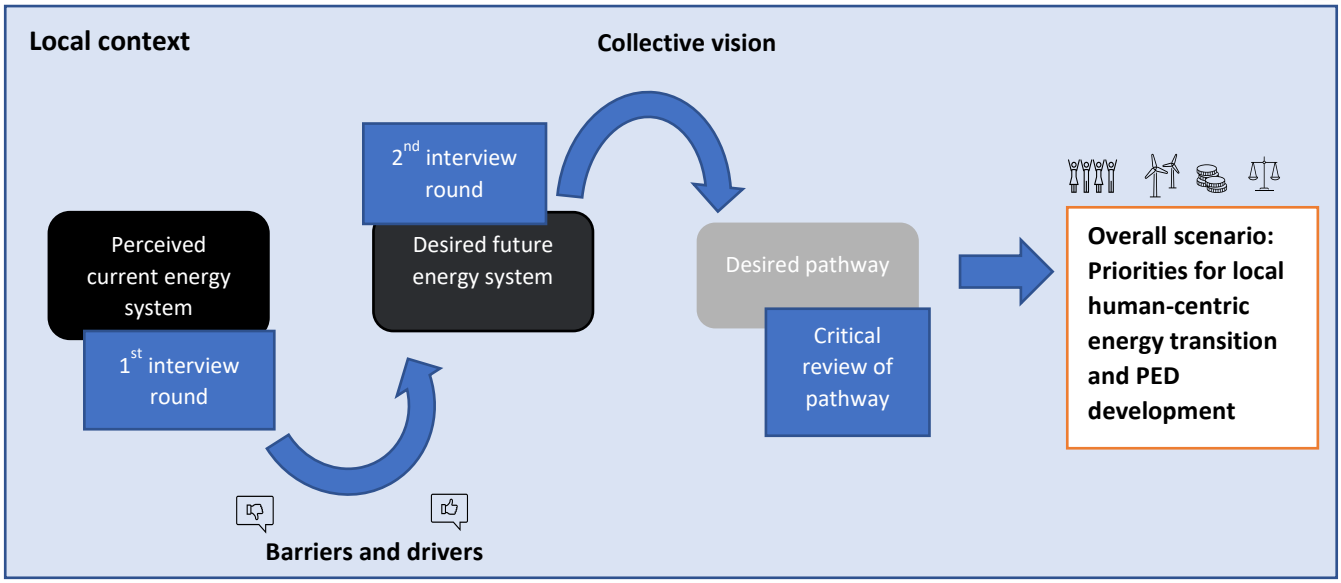

Figure 1.1 Steps in identifying pathways for a collective vision in a local context

The main groups of stakeholders that have been targeted are:

- Policymakers (including regulators and representatives from local authorities),
- Business experts/ industry representatives (including financers and intermediary organisations)
- Technology experts (including researchers and consultants),
- Environmental NGO's/ citizen representatives (including energy cooperatives, sustainable housing cooperative, and energy justice networks).

These stakeholder groups were chosen due to their relevance in local energy systems [5] and more specifically in the chosen themes that are similar to the storyline dimensions of analysis [6]. These themes, which also align with the different aspects explored in the Smart BEEjS project, include the following:

- Techno-economic development
- Business models
- Participation and collaboration
- Equity and energy poverty

The 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. The interviews were conducted using the Delphi technique which is widely applied as a valuable foresight tool [7]. The Delphi method is an iterative process to elicit judgments or other subjective opinions in relation to the future [8]. 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 [9]. Therefore, this method has been chosen to understand not only the current situation, but also the vision of the future energy system to identify possible pathways for a successful energy transition. The outcome of the 59 interviews (deliverable D6.3) has informed this foresight report.

The 8 EU regions are described at different scales, while some are at a larger – regional or country/national scale, others are at a smaller – city scale. The difference in the scale of analysis is justified by the differences in the contextual features of the EU regions. Contextual features include their geographical, climate, regulatory, development, cultural and other characteristics that have to be considered when analysing and understanding possible scenarios of the energy transition. With this foresight exercise, we do not aim at comparing the energy transition pathways of these regions, but rather identifying how overall scenarios for the transition and transformation could possibly look like at different scales and contexts.

In order to estimate the advancement of the current and the future energy system with regard to the four themes, we developed a scale from '1' to '5'. Figure 1.3 elaborates on the estimates of the scale. This scale enables comparing the distance/gap between the current and the desired future energy system advancement. We graphically presented this comparison in a Radar diagram for each region (Figure 1.2).

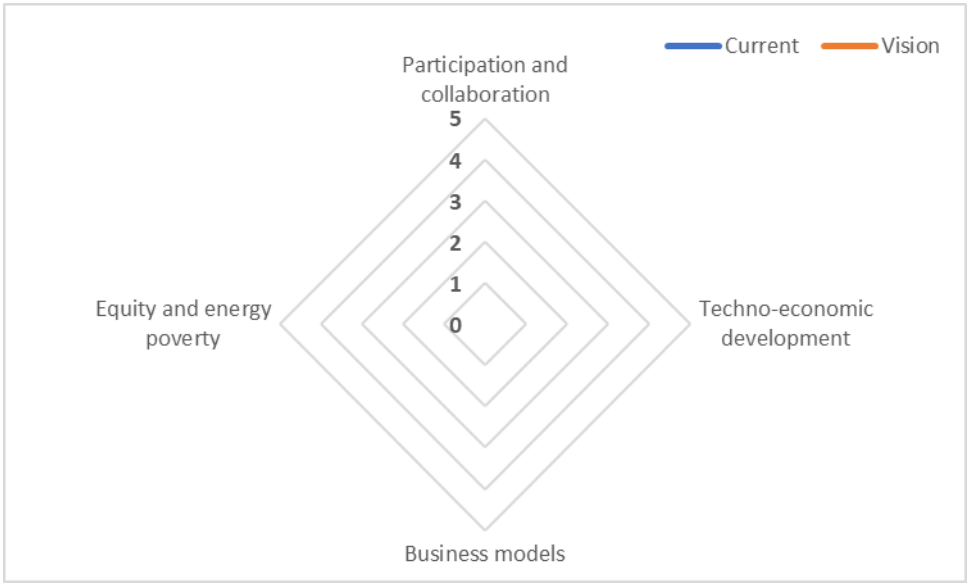

Figure 1.2 Radar diagram template to compare current and envisioned state with regard to the four themes of analysis.

THEMES \ LEVELS	VERY LOW (1)	LOW (2)	MODERATE (3)	HIGH (4)	VERY HIGH (5)
Participation and collaboration	The different stakeholder groups do not collaborate if not for their interest. There is strong silo-thinking and monopolies with no or very low effort to engage citizens. Lack of awareness and knowledge limit participation and engagement all groups of citizens.	Some stakeholder groups collaborate, while with others it is more difficult. There is still silo-thinking and monopolies. Some first efforts to engage citizens have been made already. Lack of awareness and knowledge limit participation and engagement all groups of citizens.	Some stakeholder groups collaborate, while with others it is more difficult. There is less silo-thinking and monopolies. Citizens engagement and participation is important and efforts are being made. Some lack of awareness and knowledge limit participation and engagement of most groups of citizens.	Most stakeholder groups collaborate for a common interest through different means. Citizens engage and participate. Efforts are being made to increase this by including them from the beginning of e.g. projects. Increased awareness and knowledge support participation and engagement of most groups of citizens.	All stakeholder groups collaborate for a common interest through different means. Citizens engage and participate in a democratic way. Citizens are the centre of participation and collaboration. Awareness and knowledge support participation and engagement of all groups of citizens.
Techno-economic development	There is still a very high dependence on fossil fuels both in the energy and transportation sector. The building stock efficiency is very low and no technology solutions are implemented to reduce energy consumption. Innovations are not feasible or profitable.	Fossil fuels dominate energy and transportation sector with some renewables being implemented. First approaches are there to tackle building stock efficiency and reduce energy consumption. Innovations are not feasible or profitable.	While fossil fuels dominate energy and transportation sector, there is a moderate share of renewables with implementations even at local level. Approaches and innovations are there to tackle building stock efficiency and reduce energy consumption.	While renewables dominate energy and transportation sector, fossil fuels become less important. There are technology solutions and implementations at local level. Similarly, increased building stock efficiency and reduced energy consumption.	Renewables enable self-sufficiency for energy and transportation sector. Profitable technology solutions and innovations at all levels are implemented, combined, and controlled. Solutions are there for efficient building stock and energy consumption.
Business models	Business-as-usual models that create mistrust and exclusion of the vulnerable part of the society. Lack of social value and profit-oriented Business models (BMs) as well as lack of subsidies and investments. Immense regulatory limitations to implement sustainability-oriented and innovative BMs.	Mostly business-as-usual models, but increasing public awareness and activity initiates first energy cooperatives. Still, lack of social value and profit-oriented Business models (BMs) as well as lack of subsidies and investments. Regulatory limitations to implement sustainability-oriented and innovative BMs.	Thinking evolves away from business-as-usual models with increasing public awareness, local energy initiatives and cooperatives. Availability of investments and subsidies. Awareness that policies on emission prevention or tax incentives could increase for sustainable and socially responsible investments. Still, there are regulatory limitations but some incentives.	Innovative Business models (BMs) and local energy initiatives and cooperatives. Also BMs with private companies and consumers. Increased availability of investments, and subsidies. Policies on emission prevention or tax incentives support sustainable and socially responsible investments. Collaborative, regulatory advancements and incentives for energy efficiency and innovative BMs.	Locally-driven innovative and inclusive Business models (BMs) with high consideration of social and environmental value (energy cost reduction and profit from own production contributes to self-sufficient). High sustainable and socially responsible investments and subsidies contributing to quality of life for vulnerable part of the society. All enabled through regulations and incentives.
Equity and energy poverty	There is high injustice and energy poverty that especially affect the vulnerable population groups. Non-inclusive policies do not allow the access to financial resources and technological opportunities. Inequality is prevailing based on gender, age, status. All, contributing to poverty in general and non-accessibility and affordability of energy.	There is injustice and energy poverty that affects the vulnerable population groups. Mostly non-inclusive policies, inequality, and inequity contribute to poverty in general, and non-accessibility and affordability of energy. Still, there are minor initiatives to support the vulnerable get access to financial resources and technological opportunities.	Low injustice and energy poverty with a goal for energy accessibility and affordability for all parts of the society. First strategies/regulations to tackle energy poverty and promote equity. However, some non-inclusive policies still affect the vulnerable population or excludes them from financial resources or technological opportunities.	There are strategies/regulations to tackle energy poverty and promote equity. Financial incentives, social housing, inclusive policies, fair distribution of resources contribute to high importance and consideration of equity and energy poverty. Financial resources or technological opportunities for all parts of the society.	Injustice and energy poverty should not be present. Tackling remaining energy poverty and ensuring energy affordability is of primary importance of all stakeholders. There are strong long-term regulations to promote equity, financial incentives, social housing, inclusive policies, and fair distribution of resources contribute to equal resources and opportunities, and high quality of life.

Figure 1.3 Scale for estimation of the current and future energy system development

Lastly, we discuss the overall scenario of all regions, bringing together the key findings of the perceived current energy system, the desired future energy system, and the desired pathway. Figure 1.4 is the template for this overview, which has been used to visually present the overall scenarios and pathway actions for each region.

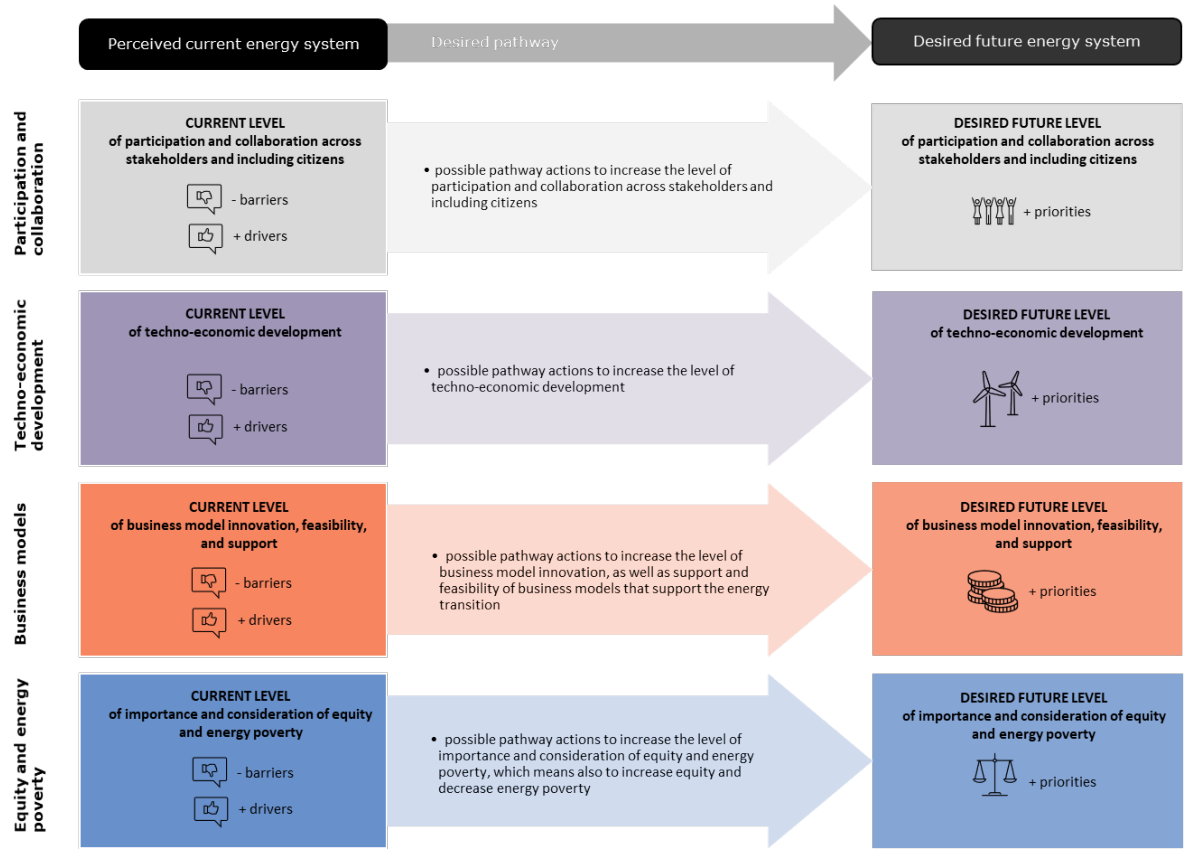

Figure 1.4 Template of overview of the current and desired energy system, and possible pathways for achieving the vision as a summary of overall scenario for the energy transition and system transformation.

1.2 Structure

The next chapters present the 8 regional reports where the structure is as follows. First, we introduce the context of each region including the location, climate, the level of development, the energy system overview, and the energy goals and challenges. Second, we provide the analysis of the current energy system based on the interview data across the four themes. In this subsection, we discuss the challenges and the drivers the current system experiences in the area that provide the overview of the baseline from which the transformation will start. Third, we focus on the future energy system addressing the same four themes and identify the desired energy system based on the interviewees collaborative vision towards the direction they wish to follow. Fourth, we present possible pathway actions with respect to each dimension. We conclude each regional report with a discussion subsection, where we present the overall scenario for the transformation of the 'local' energy system revealing priorities that can support a human-centric energy system and foster PED development. We

end this foresight report with concluding remarks for the pathway actions to achieve the energy transition.

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2 Switzerland

Derkenbaeva, Erkinai; Stathopoulou, Eleni; Heinz, Helen; Mihailova, Darja; Hearn, Adam

2.1 Context

Switzerland is a federal republic composed of 26 cantons, with the federal authorities based in Bern. It is a landlocked country and geographically divided among the Swiss Plateau, the Alps, and the Jura, with a generally temperate climate. The majority of the Swiss population is concentrated on the plateau.

Switzerland has the lowest carbon intensity among all IEA countries, as the main source of Swiss electricity is hydropower (~57%), followed by nuclear power (~35%) [1]. However, following the 2017 decision of the Swiss people as part of a vote on the government's energy strategy to gradually phase out nuclear power [8], Switzerland's energy sector is now undergoing a considerable transition. Electricity production from non-hydropower renewables has been steadily increasing with photovoltaics making the largest contribution [2].

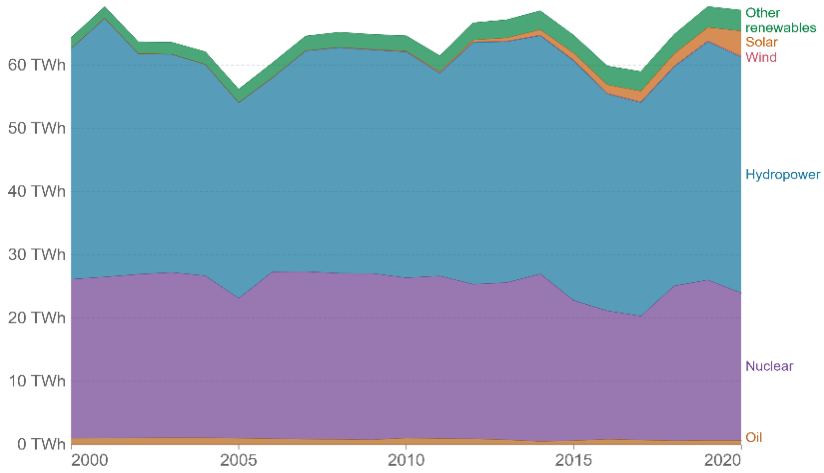

Figure 2.1 Energy production by source in Switzerland, 2000-2020
Source: IEA (2018). Energy Policies of IEA Countries – Switzerland, Review 2018
Note: 'Other renewables' includes biomass and waste, geothermal, wave and tidal

The guiding energy strategy in Switzerland is the Federal Energy Act, commonly referred to as 'Energy Strategy 2050' [8]. This energy policy is founded in four main pillars: improving energy efficiency of energy in buildings, transport, and electrical appliances; promoting the use of renewable energy such as solar, biomass, wind, geothermal, and hydropower; withdrawal from dependence on nuclear energy; and development of the electricity power grid [2]. According to the Act, for real estate, specifically, newly constructed buildings may not generate CO_2 emissions and existing buildings will face stricter CO_2 emissions allowances when replacing heating systems.

Additionally, the 2000-Watt society was founded on the notion that 2000 watts of continuous power are available on average to each citizen of our world. Reducing energy consumption by 43% by 2035 is one of the Swiss energy strategy goals [7]. It is seen as a necessity in order for all to have the potential of a high quality of life [4]. The goals are to be met between 2050 and 2100, and the society

has 39 certified areas throughout Switzerland, and is a part of the Energie Schweiz sustainability programme.

2.2 Results

This section presents the findings from the foresight interviews conducted in Switzerland. It includes an overview of the current state of the energy system of Switzerland, the desired future energy system, and a possible pathway to achieve this desired future starting from the baseline. The results are based on two interview rounds including 7 participants that represented the following stakeholder groups: policymakers, business experts/ industry representatives, technology experts, and environmental NGO's/ citizen group representatives. The interviewees were asked about Switzerland in general, but they all originate from the northern, German-speaking, part of Switzerland (Bern, Basel, Zurich, and Winterthur).

2.2.1 Current state of the local energy system

The analysis of the current energy system in Switzerland reflects on the current barriers and drivers in the system across four themes: participation and collaboration, techno-economic development, business models, equity and energy poverty. The overview of the current energy system from the perspective of different stakeholders contributes to a complete picture of a baseline from which the energy transition in Switzerland will take off or further continue.

Participation and collaboration
Collaboration between different stakeholders in the energy system of Switzerland takes various shapes. In particular, the interviewees view collaboration with real estate companies as a good opportunity for renewables deployment and energy efficiency as they are motivated in creating an appealing image. On the other hand, interviewees mention that working with municipalities in renewable energy deployment is challenging as they are constrained by knowledge and financing. Often, the energy department in a municipality might consist of only a few individuals. Based on these circumstances, negotiations between municipalities and other stakeholders can take a long time. This can be seen as an opportunity for intermediary companies. These companies are able to lend their expertise to municipalities wishing to expand their renewable energy capacity. Finally, while describing collaboration with utilities, large companies, and small and medium-sized enterprises (SMEs), the interviewees reported that working with utilities in Switzerland can be not easy given their traditional business models, however, they have enough funds to experiment. SMEs can be easier to work with than large companies as the board structure and decision-making processes in large companies can mirror the complications of working with municipalities.

While the collaboration between some stakeholders is considered low/moderate (e.g., some municipalities, large companies) and strong among other stakeholders (e.g., intermediary companies, SMEs), the citizens participation in the local energy transition is considered as strong. Citizens show their engagement through initiating the local energy communities and participating in different innovative energy transition related projects. Overall, the participation and collaboration can be evaluated as 'moderate' for the context of Switzerland.

Techno-economic development
In Switzerland, electricity is largely generated through renewables like hydropower. However, the heating sector is still based on fossil fuels and requires the most transformation, e.g., moving to district heating. The interviewees stated that the level at which the energy transition happens is the level of rooftops and basements. This means public and private building owners make the decision to outfit

their buildings with PV or retrofit the space to be more energy efficient. This can be driven through regulation, especially at the cantonal level. In Switzerland, the federal government creates laws but it is up to the cantons to interpret and implement them. This leads to a plurality of interpretations of the same law, e.g., different subsidy schemes for installing heat pumps. Complicated regulation also leads to the problem that building owners wait for clarity around the investments they might receive for updating their heating systems – an estimated third of all heating systems in Switzerland are already too old or need to be replaced. Switzerland has the added challenge that the energy strategy involves phasing out nuclear energy while simultaneously putting in play decarbonisation measures. Overall, the techno-economic development can be evaluated as 'moderate' in Switzerland as the country is relatively developed in its renewable technologies, while there are still some abovementioned regulatory barriers to be improved for achieving the vision.

Business models

Businesses in the current energy system are driven by both regulation and investment. Switzerland's Energy Strategy 2050 pushes companies in the energy sector to move into the renewable technology space. Additional forthcoming federal legislation around the carbon tax and energy efficiency measures add more regulatory pressure for companies to switch to renewables. There has also been a lot of investment in the energy transition in Switzerland as it is seen as a steady and impactful long-term investment opportunity. The renewable energy sector is seen as a big business opportunity as demand for solar electricity is expected to grow in the next years. Another motivation is image. Municipalities and companies may want to project an image of 'green' stakeholders. For municipalities, this may mean installing PV in places where it can be publicly seen in order to demonstrate that they are an 'Energy City' (Energie Stadt label in Switzerland), while real estate companies may want to offer investment opportunities for clients that pursue 'greener investment'. Motivation for citizens to participate in the energy transition lies in complying with regulation, desiring a good image, and independence from the energy grid. Cooperatives also show that citizens are motivated by social and environmental aspects of the energy transition as the economic benefit (i.e., profitability) of participating in an energy cooperative is perceived to be low. There is a misconception that private citizens participation (i.e., citizens' investments) in energy transition is not financially viable. This misconception is caused by a lack of knowledge of the citizens that is a barrier to their participation. Overall, the business models in the current energy system can be considered at their 'moderate' state with the stakeholders being highly motivated in achieving the 'green' image and seeing long-term opportunities of investments in renewables.

Equity and energy poverty

Energy poverty is not perceived as a significant problem in Switzerland, rather it is seen as part of a social problem. It is hard to differentiate who is in energy poverty or in poverty in general. Similarly, energy affordability in Switzerland was not a concern for the interviewees. The grid price is regulated and electricity cannot be sold at a higher price than the grid price. Renovation of buildings can drive the rents up (e.g., new floors, new walls, new kitchens), but energy is not the main cost. As the interviewees recognise low injustice and energy poverty in Switzerland, this domain of the current energy system can be evaluated as 'moderate' in Switzerland.

2.2.2 Vision for the desired future energy system

This subsection will focus on the desired future energy system in Switzerland. The analysis of the vision reflects on the future energy system across the same themes as in previous subsection: participation and collaboration, techno-economic development, business models, equity and energy poverty. The

collaborative vision of different stakeholders contributes to proposal of desirable features according to these themes of the future system, towards which Switzerland would like to transit.

Participation and collaboration

Stakeholders that should collaborate in reaching the future energy system are citizens, academia, financial institutions, architects, real estate and construction companies, and the oil and gas sector, with citizens playing a predominant role. Start-ups and innovative projects play a role in demonstrating new technologies and pursuing financial institutions' attention (e.g., in terms of lending money). Financial institutions such as banks are key to providing loans for building stock renovations and new projects, as well as in controlling where money currently flows and where it can go in the future. Collaboration with architects is important as part of demonstrating that energy efficient installations and renewable energy technologies do not have to look ugly or disruptive, but can be elegantly integrated with the environment. It is noted that collaborating with multinational companies in the oil and gas sector is important as they are the current dominant players in the energy market. Working hand-in-hand with these companies may be more effective in guiding where money flows and convincing them of an alternative green future. Most interviewees mentioned the importance of working with multi-stakeholder groups in the future energy system to build a common understanding of needs, sharing knowledge, and financing innovation. Overall, the participation and collaboration in the future energy system in Switzerland is envisioned as 'very high'.

Techno-economic development

Among all, the most important stakeholder group to work with is the building owners as they are responsible for efficiency renovations in buildings. Tenants have less incentive to renovate. The national Swiss government intends to make energy efficient renovations mandatory, as well as incentivise installation of heat pumps to meet heating-related emissions thresholds. However, once energy efficiency in buildings has been achieved, consumption behaviour of tenants is next important. Mobility is considered a significant channel to achieving net zero emissions and electric mobility is a commonly cited solution, though it may not be as effective in rural environments. One of the interviewees noted that the technology that will guide our energy future is yet to be discovered. The policymaker representative mentioned that energy storage was not currently in the future plans due to its high costs, while the technology expert believes that it will likely become cheaper in the future. It is mentioned that there are projects for making battery storage a local function that could build community identity in Switzerland. Overall, the desired state of the techno-economic development in the future energy system in Switzerland is envisioned as 'very high' with multiple plans and ambitions to achieve the vision and with some steps towards it being already taken.

Business models

In the future energy system, subsidies are envisioned to be very important to promote the energy transition and should be considered as a tool not only in financing energy efficient renovations, but also funding climate change research. Non-subsidy ways of incentivising change towards carbon neutrality require more risk-taking and innovation. For instance, risk-taking on the part of real estate and construction companies in terms of trying new ideas, or risk-taking on the part of banks as the business case for loans may not always be clear, and more innovation and start-up projects that demonstrate the viability of different solutions. Regulation is a powerful tool to incentivise change, as it regulates the allowed CO_2 emissions from building stock and makes stipulations for electric mobility. Thus, fossil fuels may become more expensive and less preferred. Overall, the business models in Switzerland are envisioned to achieve the 'high' level in the future energy system as the stakeholders are already highly motivated in contributing to the energy transition and the current business models are seemed as quite effective.

Equity and energy poverty

It is envisioned that in the future energy system, there are strategies and financial resources for vulnerable groups that face difficulties such as old houses, high energy bills, and high investments needed for renovation. The inclusivity of such vulnerable groups is central in the future energy system. Overall, as this domain of the energy transition in Switzerland is at its relatively average level, in the future energy system it is envisioned to scale-up for at least one step and achieve the 'high' level of performance of equity and (energy) poverty reduction.

2.2.3 The current and envisioned performance of the energy system in Switzerland

This section demonstrates the performance of the current energy system and its desired performance in the future. Overall, the domains of the current energy system are evaluated as 'moderate' as the country already shows substantial progress in its energy system transformation. At the same time, the future energy system is envisioned to achieve its highly advanced state according to the experts' visions and the goals of the Energy Strategy. The comparative analysis of the current performance of the energy system domains and the envisioned performance of the future energy system 2040 in Switzerland is shown in Figure 2.2.

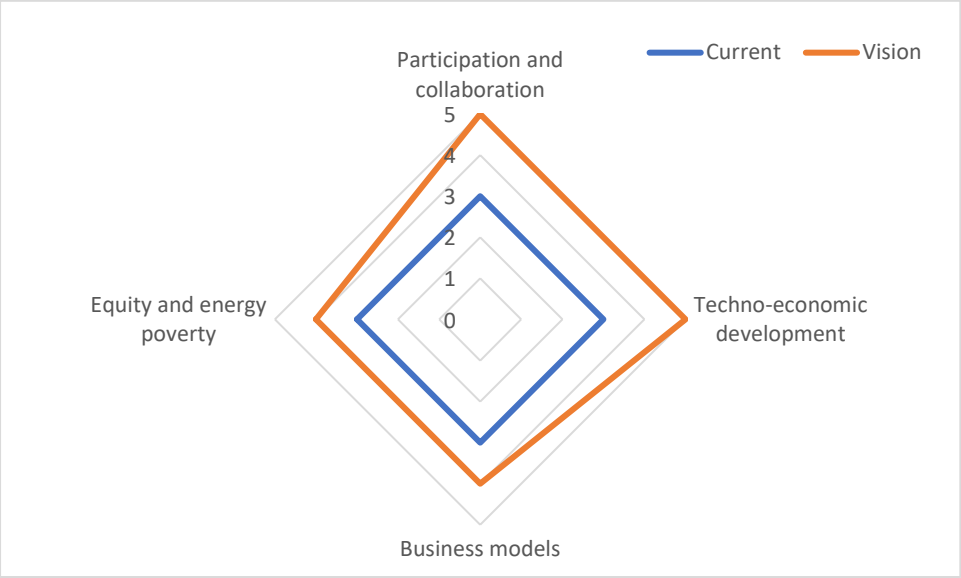

Figure 2.2 The current and envisioned performance of the energy system in Switzerland.

Comparing the vision of the interviewees and the goals of the Energy Strategy, it is clear that they align with each other to some extent. Both the vision of the interviewees and the goals of the strategy target improvements of the energy efficiency in the buildings, the use of renewables, and reduction of energy consumption. However, the interviewees also highlight the importance of participation and collaboration of the stakeholders as well as support of the vulnerable groups in the country energy system transformation. They recognise that increasing the awareness of citizens, supporting tenants and the vulnerable groups (e.g., elderly), and stronger collaboration of all stakeholders will be central on the Swiss pathway towards decarbonisation.

2.2.4 Desired energy transition pathway to achieve the vision

Considering the current level of performance of the current energy system, its drivers, barriers, and the local context, changes and action are required in order to achieve the previously elaborated vision for the future energy system. The interviews allowed to identify possible actions that support the local

energy transition pathway towards the desired future energy system. Hence, this section describes the desired energy transition pathway and the individual actions respectively for each theme of the analysis.

Participation and collaboration

According to the opinion of all interviewees, the energy transition is a common goal and all energy stakeholders must come together to achieve it. Every stakeholder brings their own expertise and role in the transformation. Knowledge creation and dissemination, inclusive regulations and policies, financial support, and technological innovations, all contribute to the pathway of the energy transition in Switzerland. Among all stakeholders, the municipality should take the leading role in organising this process and overcoming the barriers that hinder the transition.

Techno-economic development

Phasing out nuclear energy while putting decarbonisation measures into play is a difficult task. Technological changes and economic incentives are key to the decarbonisation pathway in Switzerland. While energy efficient renovations are becoming mandatory, building owners will take a key role and responsibility in this part of transformation, whereas the consumption behaviour of tenants afterwards is most important. It is important to overcome complicated regulations that cause different misinterpretations from place to place in Switzerland, but also allow more flexibility for the stakeholders in order to accelerate the energy transition. It is also important to develop inclusive policies and regulations that will not leave the vulnerable groups out. Subsidies and financial incentives are mentioned as key pillars on the pathway towards decarbonisation in Switzerland. Subsidies can enable a greater number of innovative projects and support citizens in the local transition. Mobility is also considered an important topic to achieving net zero emissions and electric mobility is a commonly cited solution.

Business models

The renewable energy sector is seen as a big business opportunity in Switzerland. To make the transition to renewables successful, business models need to change from traditional to more innovative. New start-up projects are taking the lead in this transformation of the existing business models and are able to demonstrate the viability of different solutions. There is an increasing importance of demo projects and experiments in achieving the energy system 2040. Such demo projects showcase the value in trying new innovations, demonstrating possibilities, disseminating awareness and knowledge, and assuring different stakeholders, such as citizens and financial institutions, that an alternative future is possible. Therefore, funding for new research in academia is of utmost importance in order to find new ways of mitigating climate change and achieving energy efficiency.

Equity and energy poverty

While energy is not the main cost for the citizens, the government needs to focus on subsidising and investing more in the building renovations. Supporting the vulnerable groups and creating more inclusive conditions will be one of the key components on the decarbonisation pathway in Switzerland. In fact, the energy transition can make energy more affordable after the initial installation costs – technologies like heat pumps lower operation costs relative to other systems. With a PV plant, electricity can be sold directly to the tenants and the bill may be lower compared to electricity from a utility company.

2.2.5 Discussion of the overall scenario

The transition in Switzerland has already started with multiple energy efficient and sufficient projects being demonstrated in various districts. Nevertheless, there is still a long way to achieve the goal 2040. There are several barriers and drivers in the current energy system in Switzerland. As barriers, the interviewees highlight the limited sources on the part of municipalities, the heating system being still highly dependent on fossil fuels, fragmented adoption of regulations, and a lack of knowledge of citizens on financial opportunities. However, as the Swiss energy system is relatively developed, the number of drivers exceeds the number of barriers. The drivers include availability of funds for the energy transition, attractive collaboration with real estate companies, the electricity sector is already largely based on renewables, high motivations of stakeholders in participation in the transition, and low energy poverty.

However, moving to 100% renewable energy is seen as a part of the process but is not seen as the end. Overall, the general direction of the vision is grounded on reducing energy demand through both energy efficiency measures and behaviour change, and renovation of the buildings. Additionally, the envisioned future energy system is characterised as a system combining strong stakeholder's collaboration, start-ups and innovative projects, electric mobility and increased battery storage, more subsidies available for the research and support of vulnerable groups.

Based on the analysis of the current state and the vision of 2040 of the energy system, it is identified that the priorities of the energy transition in Switzerland are reducing energy consumption and increasing energy efficiency. It is determined that increasing awareness and disseminating knowledge is important in achieving the energy transition priorities of Switzerland. Citizens do not only need to move to renewables, but also change their consumption behaviours and create more energy efficiency. The government, in turn, is expected to create supportive conditions in this transformation by offering subsidies and developing more inclusive and clear regulations that would not allow different misinterpretations. Innovative start-up projects are important not only in demonstrating the future energy system, but also expanding the transformation towards the vision 2040 in Switzerland.

There are several important contextual features of Switzerland that contribute to its energy transition pathway and distinguish the country from other regions. First, Switzerland is one the most developed countries and therefore, the addressed domains are also relatively more developed than in other case studies (e.g., the country has very low or no energy poverty and poverty in general). Second, in Switzerland, the federal government creates laws but it is up to the cantons to interpret and implement them. This leads to a plurality of interpretations of the same law, e.g., different subsidy schemes for installing heat pumps. This is an important factor that contributes to the development of the possible energy transition pathway in terms of the policies. Third, adherence of the citizens to the Swiss Energy Act 2050 that, in turn, contributes to active participation of the stakeholders in the energy transition.

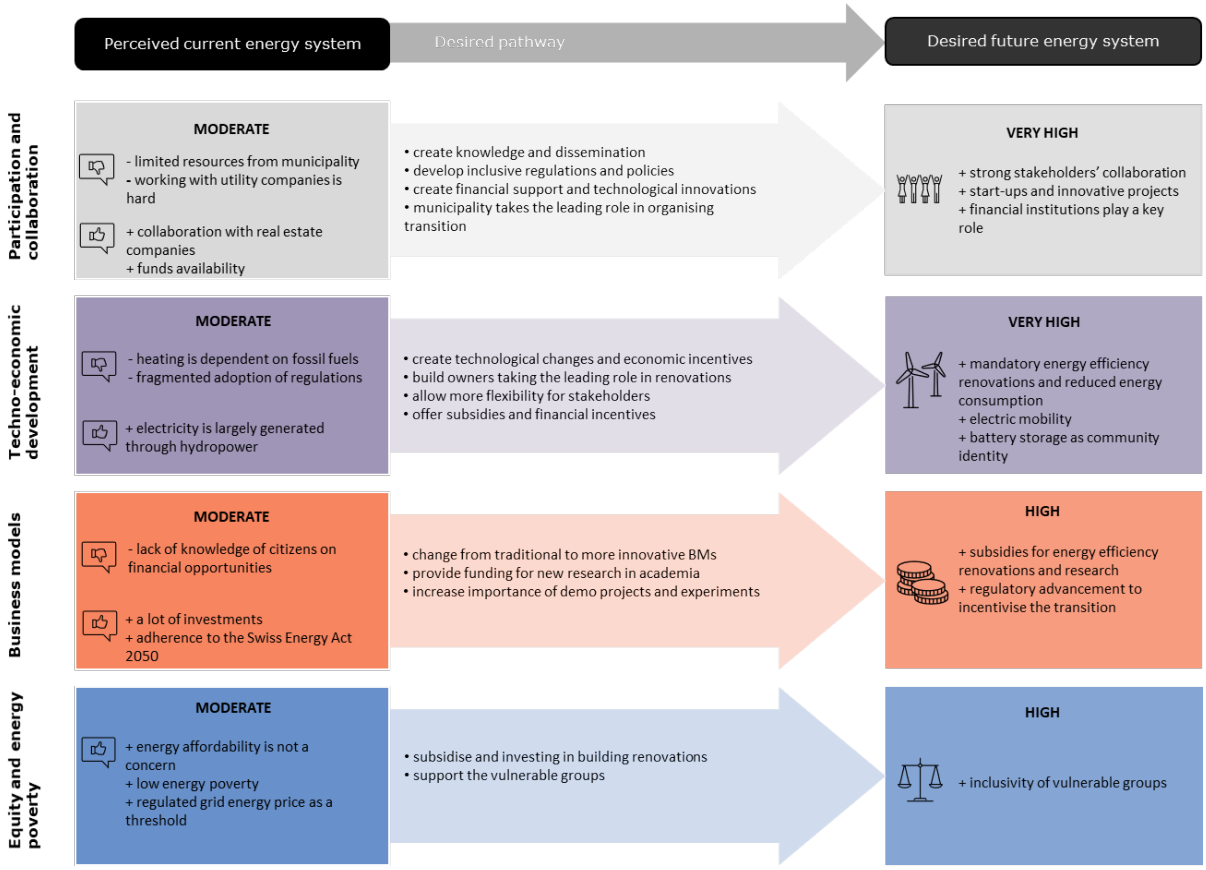

Figure 2.3 Key elements summarising the barriers and drivers of the current energy system, overall vision of the future energy system, and a possible pathway to achieve this vision in Switzerland.

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3 Italy

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3.1 Context

Italy is a republic in the southern Europe with extensive coasts along the Mediterranean Sea. Italy consists of 21 regions, two of which are islands. Additionally, it is separated from neighbouring countries by the Alps.

Italian government has set an ambitious target in terms of reducing greenhouse gas (GHG) emissions and aims at reaching 30% in total energy consumption and 55% in electricity generation from renewable energy sources [1]. With regard to the energy production, Italy's energy system has been based mainly on renewable energy sources (Figure 3.1). Even though the progress has been made in terms of market liberalization and infrastructure development, the development of the gas sector has been slower than expected [2]. While the energy supply in Italy is mainly based on oil and natural gas, the supply of renewables (wind, solar, biofuel, and waste) has constantly increased since early 2000s [2].

Italy has developed the 'Integrated National Plan for Energy and Climate' for the years 2021-2030 that is aligned with the objectives of the Green Deal. The Integrated National Plan aims at reducing emissions, a 43% reduction in primary energy consumption against the EU target of 32.5%, increasing the share of energy from renewable sources. In order to achieve these goals, the government introduced the National Plan for Recovery and Resilience (PNRR) that will provide 2.2 billion euros to effectively transform the current energy system towards decarbonisation [2].

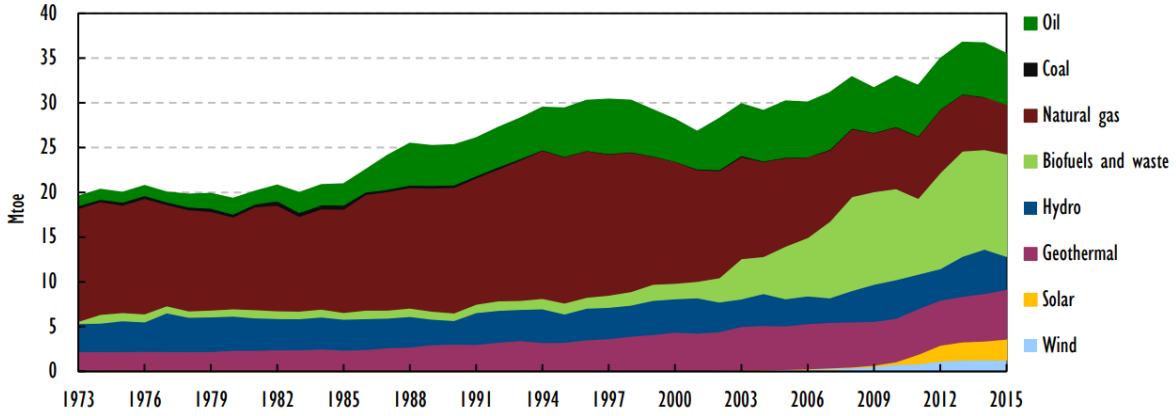

Figure 3.1 Energy production by source in Italy, 1973-2015
Source: IEA (2016). Energy Policies of IEA Countries – Italy, Review 2016

3.2 Results

This section presents the findings from the foresight interviews conducted in Italy. It includes an overview of the current state of the energy system of Italy, the desired future energy system, and a possible pathway to achieve this desired future starting from the baseline. The results are based on two interview rounds with a total of 7 interviews, with participants that represented the following

stakeholder groups: policymakers, business experts/ industry representatives, technology experts, and environmental NGO's/ citizen group representatives. The interviewees were asked about Italy in general, but they all originate from the northern Italy.

3.2.1 Perceived current state of the local energy system

The analysis of the current energy system in Italy reflects on the current barriers and drivers in the system across four themes: participation and collaboration, techno-economic development, business models, equity and energy poverty. The overview of the current energy system from the perspective of different stakeholders contributes to a complete picture of the baseline from which the energy transition in Italy will take off or further continue.

Participation and collaboration
In relation to strategies for stakeholders' engagement, the interviewees rejected the idea that any one stakeholder could be identified as posing the most barriers. In Italy, for example, citizens' engagement in the energy transition is considered relatively high, while the barriers lay mostly in rigid institutional and governance structures. However, there is still limited involvement of all citizens' groups in the local energy transition because of the lack of awareness and knowledge about possible benefits that can be obtained thanks to the energy transition. The limited involvement of some groups of people can also be because of the cultural feature that people need to be obliged in order to make them take actions. The current energy system also suffers from the fact that the real needs of people are not considered. Overall, the participation and collaboration domain can be estimated as still 'low' for the context of Italy as there is still a gap in engagement of all groups of citizens in the current energy system transformation.

Techno-economic development
In terms of techno-economic aspects, the participants highlight the substantial investment that is being made at the Italian country level to the technological aspects of the energy transition. However, there are still numerous challenges that include low energy efficiency of the buildings (especially, condominiums), lack of agreement between public and private bodies, and high energy costs. The main driver of the current energy system is research. As such, newly developed technological solutions for the energy transition are demonstrated by the recent research work, including the work of the Italian Observatory on Energy Poverty (OIPE); that is the network of researchers, public and private entities and institutions interested in the energy transition, and energy poverty in particular. The OIPE's work includes studies on the best cost-effective technological solutions to generate energy savings with the focus on the most vulnerable population groups. The research supports policymakers in designing the policies on reducing dependence on fossil fuels and disparities in access and affordability of energy. Therefore, it is considered as the main pillar for the transformation of the current energy system. Overall, the techno-economic development can be evaluated as still relatively 'low' in Italy with significant regional differences which means that the state of the energy system in each district/region is unalike.

Business models
The interviewees highlight the 'one-stop shop' business model as an effective approach for the energy transition that showed the high engagement of citizens. The interviewees stated that the community cooperative model in Italy is still not very common, but growing thanks to the transposition of EU directives into Italian law. Another key aspect that was highlighted by majority of the interviewees was how current business models were still heavily subsidised. One interviewee in particular saw these subsidies as essential to finance the energy transition given the high and increasing cost of raw materials for the transition (construction materials primarily) in light of the pandemic which has had

inflationary pressures. Also, increasing cost of raw materials (construction materials primarily) in light of the pandemic which has had inflationary pressures support the need of subsidies and investments. Overall, the state of the current business models can be estimates as 'moderate'.

Equity and energy poverty

It appears that there is energy poverty and energy injustice in the current energy system in Italy, and Italy in general. Aspects related to energy poverty and equity are highly linked to the topic of business models. In fact, all the interviewees agreed that the current system based on subsidies most of the times does not consider the more vulnerable and poor groups of people. It was mentioned that the policies for the energy transition are regressive and a lot of funding for the energy efficiency comes directly from taxation schemes that are disproportionately impacting the most vulnerable population groups. Moreover, the information and delivery of the 'right' or tailored message to its recipients is highlighted to be foremost in the energy transition. Additionally, it was recognised that the current energy system entails gender inequality in the context of Italy, and that is it important to pay more attention to women in the energy transition as they are considered busier than men while being responsible for the house/family (part of the culture). However, the interviewees highlight that the government officials are receptive to working on energy poverty, which is important as they are the ones who lead the energy transition via regulations. Overall, there is a 'very low' level of the domain of equity and energy poverty in the current energy system of Italy.

3.2.2. Vision for the desired future energy system

This subsection will focus on the desired future energy system in Italy. The analysis of the vision reflects on the future energy system across the same themes as in previous subsection: participation and collaboration, techno-economic development, business models, equity and energy poverty. The collaborative vision of different stakeholders contributes to proposal of desirable features according to these themes of the future system, towards which Italy would like to transit.

Participation and collaboration

The future energy system in Italy is envisioned as a system where participation of all stakeholders and their collaboration will be key. The energy communities are seen as one of the important actors for the system transformation as they are envisioned to help exploiting (in a more efficient way) the potential of localised renewable energy sources coupling them with efficient technologies and optimisation and building simulation tools. It is seen that citizens will play the most important role in the future energy system and it is essential that each person changes their behaviour/habits in their energy consumption. However, it will only be possible with the support from the policymakers. The policymakers will also play a major role with regard to the uptake of renewable energy technologies as they have a good overview of the needs at the local level and can design tailored policies for those needs. Major utility companies will also be important in the future energy system if they adapt to a new system and offer what meets the needs of citizens. To bring all these stakeholders together for collaboration, a tailored communication channel is needed. Overall, the participation and collaboration in the future energy system in Italy is estimated to achieve 'very high' level.

Techno-economic development

In terms of techno-economic aspects, the interviewees envision the future energy system with a technological advancement with improved Heating, Ventilation, and Air Conditioning (HVAC) system. To make HVAC system more efficient, building envelop refurbishment will be imperative. To refurbish the building stock, it will also be important to solve the owner-tenant dilemma with regard to the techno-economic decisions. Additionally, to make these technological advancements possible, subsidies will play a key role in the future energy system. However, the interviewees believe that

subsidies will not be as important as strategic and organised policy interventions. Hence, the desired state of the techno-economic development in the future energy system is envisioned as 'very high' as the energy system is expected to transform to the envisioned set-up.

Business models

In the future energy system, the business models should function without subsidies. At the household-level, fiscal incentives such as the 'super bonus' are seen as crucial in achieving the transition by the interviewees, but the interviewees also mention that such funding schemes are regressive and may not be suitable for an equitable energy system in the long-term. In fact, it was voiced that at the end this 'super bonus' is used only by people that already have money at their disposal to invest into building renovation. Therefore, the interviewees highlight the importance of the equal distribution of subsidies in the future energy system in order to include people who do not have high economic viability. For the energy transition towards the envisioned system in Italy, it is important to have equality in transformation that can be achieved through the business models majorly based on private investments and partially on subsidies offered only for the vulnerable ones. At the same time, business models in the envisioned energy system in Italy are seen more as people-led rather than the governmental. Regulations shall be in place that will allow sharing the locally produced energy (selling/buying) among prosumers. The business models in the future energy system in Italy are envisioned to achieve 'high' level.

Equity and energy poverty

The interviewees highlight the importance of developing a transition plan that addresses different groups of people targeting their distinct issues. The interviewees envision the future energy system that will be developed in terms of legislation that will allow establishing energy communities and sharing the energy, which will reduce energy costs and allow for increased energy affordability and fair distribution of resources. The state of the future energy system with regard to equity and reducing the energy poverty in Italy is estimates as achieving 'high' level.

3.2.3 The current and envisioned performance of the energy system in Italy

This section demonstrates the performance of the current energy system and its desired performance in the future. Overall, the domains of the current energy system are at relatively 'low' state except the business models dimension that is at a 'moderate' level of development. The future energy system is envisioned to achieve its highly advanced state according to the experts' visions and the goals of the Integrated national plan. The comparative analysis of the current performance of the energy system domains and the envisioned performance of the future energy system 2040 in Italy is shown in Figure 3.2.

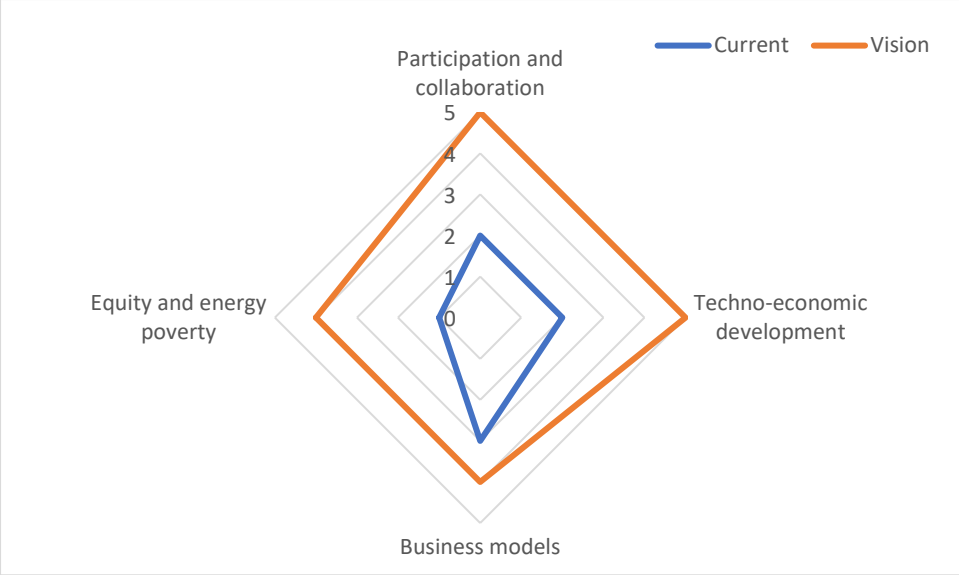

Figure 3.2 The current and envisioned performance of the energy system in Italy.

Comparing the vision of the interviewees and the goals of the Integrated national plan, it is clear that they align with each other in terms of technical aspects. Both the vision of the interviewees and the goals of the national plan target improvements of the energy efficiency in the buildings, the use of renewables, technological advancement, and reduction of energy consumption as well as GHG emissions. However, the interviewees also highlight the importance of participation and collaboration of the stakeholders and the need for increased consideration of equity and equality for the country's energy system transformation.

3.2.4 Desired energy transition pathway to achieve the vision

Considering the current level of performance of the current energy system, its drivers, barriers, and the local context, changes and action are required in order to achieve the previously elaborated vision for the future energy system. The interviews allowed to identify possible actions that support the local energy transition pathway towards the desired future energy system. Hence, this section describes the desired energy transition pathway and the individual actions respectively for each theme of the analysis.

Participation and collaboration

According to the opinion of the interviewees, in order to engage all population groups, there is the need for information campaigns to increase their awareness. These campaigns are important to disseminate the knowledge on possible benefits from the energy transition. However, it is important that the information transmitted is tailored to specific groups differently taking into account their needs (e.g., elderly may need different information and approach compared to younger population groups). It is believed that this approach will increase participation of all population groups in the energy transition. At the same time, obligations for the energy transition should also be introduced to make citizens think of their actions and take responsibility for their energy consumption behaviour.

Techno-economic development

The major issue of the current energy system is inefficiency of buildings. Therefore, the interviewees agree that the initial step towards the future energy system should be increasing energy efficiency of the buildings. Increasing building efficiency should happen twofold: by implementing retrofitting and

reducing energy consumption. This will not only save the energy costs, but also make a monetary benefit for those who adopt energy generation technologies. This is especially challenging in the condominiums. Therefore, the agreement and collaboration between the policymakers and private companies (i.e., the owners of condominiums) will be essential. Another important direction of the transformation is optimisation of the storage system to make the system not only energy efficient, but also self-sufficient and more flexible.

Business models
In terms of business models, all interviewees agreed that the system should move away from the subsidy method. However, they also noted how this should be gradual in order to be able to achieve a more sustainable (also economically) transition. One of the most important factors to achieve the energy transition, as identified by multiple interviewees, is the need to move from a heavily subsidised public investments-led model to a more private investments-dominated model as the public investments cause a lot of inequalities. Many interviewees noted that this is still difficult given the current economic conditions including the cost of materials and insufficient incentives. Additionally, the emergence of new community cooperatives was identified as crucial, to not only bring about the energy transition, but to do so in an equitable way that is mindful of the needs of different community stakeholders.

Equity and energy poverty
Because of the current regressive policies with regard to the energy transition in Italy, the issue of equity and energy poverty remains a concern. Energy efficiency funding that comes directly from taxation schemes are disproportionally affecting the most vulnerable population groups. In order to overcome this issue, targeted policies will be important. They should be designed in a way that supports the vulnerable groups in the energy transition and creates inclusive opportunities for them. Additionally, it was highlighted that more attention should be paid to women who have more responsibilities (i.e., in house) and are often excluded from the process of the energy system transformation. In order to diminish gender inequalities in the future energy system, it is imperative to engage women in the transition process more.

3.2.5 Discussion of the overall scenario

The current energy system in Italy is still experiencing quite low levels of development. The system is heavily dependent on subsidies that, in turn, are unequally distributed among the population. Technologically, the system is not yet advanced and the building stock needs renovation. Non-inclusive policies and rigid institutional structures hinder the (vulnerable) groups of people to participate in the transition. Despite this, the citizens are significantly active and engage in community cooperatives. The collaboration of the policymakers and the research contributes to finding the possible ways towards decarbonisation and designing the policies. Business models are operating relatively effectively, however, there is still high injustice and (gender) inequality in the current system.

The vision that is set by both the government and the interviewees is not an easy goal to achieve. The future energy system is envisioned as a system with strong energy communities, tailored communication channels to disseminate knowledge on energy transition, fair distribution of resources, technological advancement, and support of the vulnerable groups. The desired energy system requires an increase in energy efficiency of the buildings, active engagement of citizens and cooperation with the government and private companies. What is utmost for the envisioned energy system is inclusive targeted policies that allow engagement of all groups of citizens, prosumerism, and increase in energy communities. Equity and equality are highlighted to be also key factors for the transition. Figure 3.3 summarises the key findings of each interview themes.

The desired pathway towards the future energy system in Italy focuses on a people-led energy transition. It is desired to promote and support more community-driven energy cooperatives and the citizens needs to be prioritised and addressed. Inclusiveness of the vulnerable population groups is also central for the energy transition in Italy. These groups refer to more poor population groups, tenants in condominiums, as well as women. Due to the contextual feature of the Italian culture, women are often excluded from the process of the energy system transformation as they tend to be busier and account more for the household responsibilities, which creates gender inequality in the energy system. On the other hand, the limited involvement of some groups of people can also be because of the cultural feature that people need to be obliged in order to make them take actions.

This desired pathway is the energy transition scenario for Italy as a country, however, it is important to highlight that the regions within Italy differ significantly (some (in the North) are more developed than others (in the South)) and these differences need to be considered accordingly.

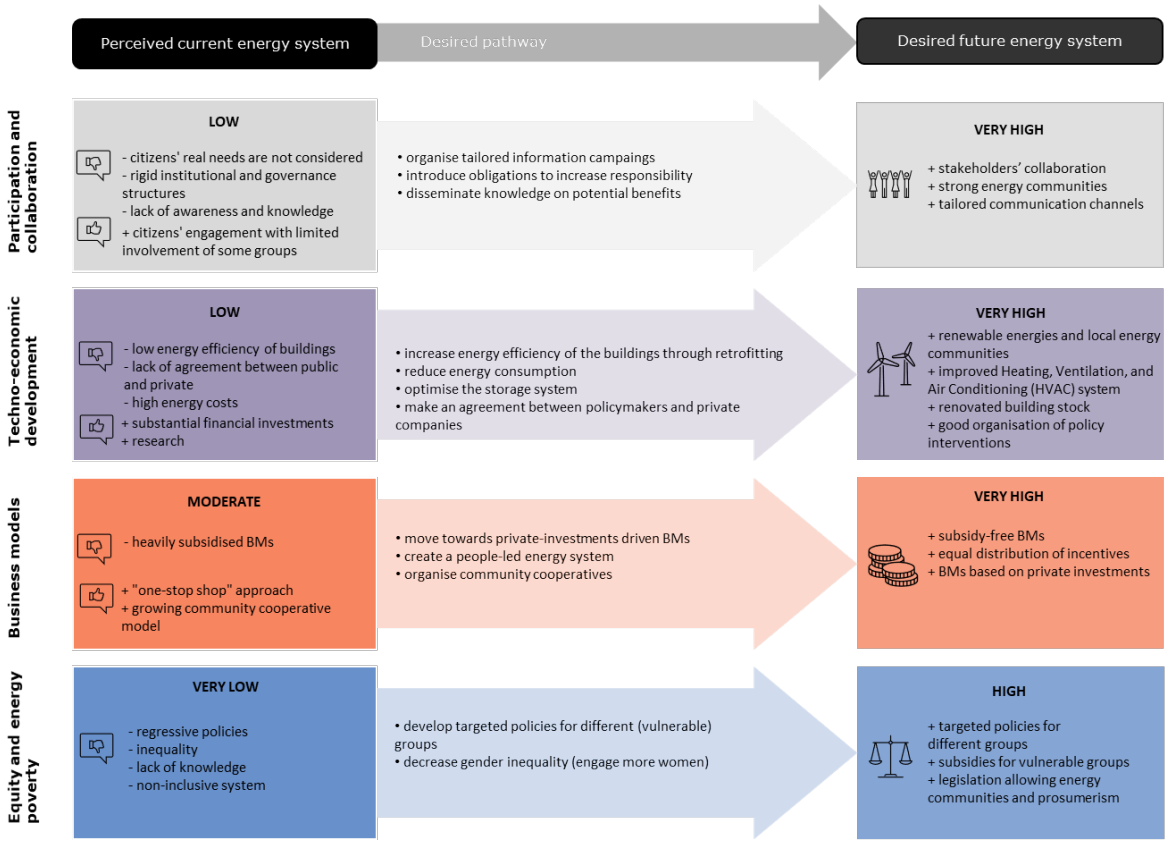

Figure 3.3 Key elements summarising the barriers and drivers of the current energy system, overall vision of the future energy system, and a possible pathway to achieve this vision in Italy.

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4 Canary Islands, Spain

Heinz, Helen; Stathopoulou, Eleni; Derkenbaeva, Erkinai; Bruck, Axel

4.1 Context

The Canary Islands are an autonomous region of Spain, belonging to the outermost regions of Europe. The archipelago consists of 8 islands, namely Tenerife, Fuerteventura, Gran Canaria, Lanzarote, La Palma, La Gomera, El Hierro, and La Graciosa. 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 [1]. 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.

Spain is still heavily dependent on nuclear energy, however 54% of the total energy production came from renewables and waste (see Figure) [2]. Also, the Canary Islands are still heavily dependent on fossil fuels due to their electrical isolation 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. Therefore, 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 the wind-pumped hydro power plant 'Gorona del Viento'. Looking at 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 [3].

The Canary Islands' government published an Energy Transition Plan[1] in February 2022 including strategies and investment needs for full decarbonisation of the whole archipelago by 2040 [4]. Furthermore, the Canary Island Institute of Technology 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 [5]. At the same time, the two local energy cooperative's La Palma Renovable and SomEnergia help to promote the human-centric energy transition.

Additionally, the Canary Islands energy market has special regulations [6] to maintain price levels equal 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. The new energy tariffs should drive the installations of roof-top solar PV and the shift of energy consumption to off-peak hours. 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 [6].

[1] Full document available here: https://drive.google.com/file/d/1azMZVmPyVpy0zBTYPATf7WmMziZITjfr/view

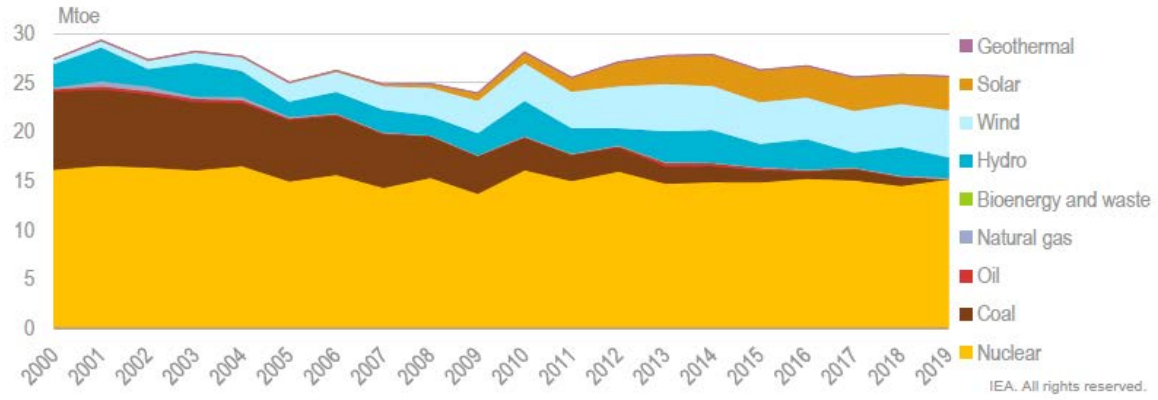

Figure 4.1. Energy production by source in Spain, 2000-2019.
Source: [1] IEA 2020, IEA World Energy Statistics and Balances (database)
Note: Mtoe = million tonnes of oil equivalent

4.2 Results

This section presents the findings from the foresight interviews conducted in the Canary Islands. It includes an overview of the current state of the energy system of the Canary Islands, the desired future energy system, and a possible pathway to achieve this desired future starting from the baseline. The results are based on two interview rounds including 16 participants that represented the following stakeholder groups: policymakers, business experts/ industry representatives, technology experts, and environmental NGO's/ citizen group representatives.

4.2.1 Perceived current state of the local energy system

The analysis of the Canary Island's current energy system reflects on the current barriers and drivers in the system across four themes: participation and collaboration, techno-economic development, business models, equity, and energy poverty. The overview of the current energy system from the perspective of different stakeholders contributes to a complete picture of the baseline from which the energy transition in the Canary Islands will take off or further continue.

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 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 to collaborate with. Citizens who do not lack of knowledge and trust are very willing to participate, however, they lack the means. 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. There are ongoing projects which demonstrate participation and collaboration between stakeholders, also the Institute of Technology Canary Islands supporting it, still, based on the above discussion, current participation and collaboration is assessed as still 'low'.

Techno-economic development

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 and all citizen's energy consumption is primarily electric (household electronic devices, kitchen appliances, electric water heater). The islands further need electricity to produce water, while the mobility sector is still heavily dependent on fossil fuels. 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 or other measures could create energy savings, but at the same time heating and cooling are not seen as very relevant by the interviewees. Nonetheless, the various projects and general stakeholder awareness demonstrates the current techno-economic solutions on the islands to be at a 'moderate' level already.

Business models

The interviewees note that the participation in any business models that support the energy transition is still economically driven, but that there are more businesses active in the renewable energy sector. However, the interviewees also note an increasing environmental awareness, which can further drive and influence local 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, according to the interviewees' experience, the decision to act still depends on the 'sense for the environment' and financial possibilities of the islanders. 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. Therefore, more emphasis is needed for opening up innovative business models, as the current level for business aspects and business model innovation can been assessed as 'low', even though the technologies are very profitable in the islands.

Equity and energy poverty

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 also often not aware how they could change their behaviour to save energy and costs. 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 in the current energy system are more concerned about having access to energy in general rather than having cheaper or green energy in the long-term. In conclusion, there have been projects supporting social coherence, but this is still very far from being a major aspect of the considerations for a fair energy transition, ranking this theme to be 'low' according to the local understanding.

4.2.2 Vision for the future energy system

This section will focus on the desired future energy system in the Canary Islands. The analysis of the vision reflects on the future energy system across the themes of analysis: participation and collaboration, techno-economic development, business models, equity and energy poverty. The analysis of the interviews with different stakeholders across the four themes contributes to understanding of their collaborative vision and proposals of desirable features according to these themes for the Canary Island's future energy system.

Participation and collaboration

In the desired 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 in the future energy system of the Canary Islands. 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. This means, the future energy system requires a 'very high' participation and collaborations between different stakeholders including citizens.

Techno-economic development

Technology-wise, the envisioned 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 interviewees wish for a future energy system that will consist of a mix of technological solutions for energy production, management, and storage for the self-sufficiency of all islands. The interviewees mention that a diverse mix of both established and innovative technologies, and centralised or decentralised solutions would enable unique configurations for all islands, solving local grid-constraints. For instance, more offshore wind energy would be in place due to increased environmental concerns and limitations of land. In their vision, citizens will be involved through decentralised energy production and self-consumption individually or within concepts such as microgrids or Positive Energy Districts [7]. Overall, technology solutions are the first thing that all interviewees discuss when talking about the future energy system, wherefore the level of importance for techno-economic solutions can be assessed as 'very high'.

Business models

The interviewees imagine an energy system in the future that does not require subsidies. Instead, there would be an increased number of markets and several new companies that are involved in, for example, implementation of PV installations. In the vision of the participants, the success of the Canary Islands future energy system, would enable the islands to serve as the lighthouse islands for the energy transition and technological solutions. However, the context of the islands will still not allow for standardised solutions even in the future. Therefore, it will be important for companies who are willing to invest to understand this issue. Additionally, a citizen representative states that it will be preferable if business actors, financers, and investors would be local islanders who know the context instead of external stakeholders from abroad. This would be a supportive factor for a fair, sustainable, and human-centric energy system. In the future scenarios, the industrial sector will play a predominant and leading role regarding self-consumption and energy communities. Furthermore, innovative business models will be important to include citizens that could not afford participation. For instance, they will be able to produce energy without the need to have direct ownership of the

batteries. As such, innovative business models and business actors will be needed in the future, but the public sector will still have an important role to support with enabling regulations and incentives and to ensure inclusiveness. Therefore, this theme has been assessed to be 'very high' in the future.

Equity and energy poverty

The interviewees project the energy prices to fall in the future as a result of the decarbonisation of the electricity sector and the reduced dependency of fossil-fuels. In fact, several interviewees think that the current subsidy on energy prices will not be necessary in the future as the energy prices will be even lower. Hence, the interviewees envision that this money could be used for other incentives for energy vulnerable households in the future energy system. These incentives could, for instance, support vulnerable households to implement rooftop solar PV, increase energy efficiency of electric devices or building stock, or buy energy cooperative's 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. Generally, the interviewees demonstrate a vision and awareness of the need for a fair energy transition and an inclusive future energy system, which involves 'very high' level of justice and social equity and addressing energy poverty when needed.

4.2.3 The current and envisioned performance of the energy system

This section demonstrates the performance of the current energy system and its desired performance in the future. Overall, the domains of the current energy system are at 'very low'/ 'low' state except the technology development dimension that is at a 'moderate' level of development. The Canary Islands represent a unique context which already drove their energy transition regarding techno-economic solutions. Nonetheless, there is still a long way to go in order to reach the levels of desired performance with regard to participation, business models, and equity. Figure demonstrates the performance levels of the current energy system and how it has been envisioned for the future. Considerations of equity and energy poverty and innovative business models will be important in the future, but to have a human-centric energy system in the future it requires very high levels of participation and socially coherent techno-economic development under the context of the Canary Islands.

Comparing the vision of the interviewees and the goals of the Canary Islands Energy Transition Plan, it is clear that they align with each other. Both the vision of the interviewees and the goals of the strategy target improvements of the energy efficiency and increase of renewables in an energy just and participatory way. In fact, similarly to the interviewees, the Energy Transition Plan envisions a very high level of citizen participation and a socially just energy transition, considering technology implementation for the public benefit, and supporting the building of more than 100 energy communities to tackle energy poverty. At the same time, while the Canary Islands' Energy Transition is planned to be primarily supported by immense public investments, new business models (like energy community business models) should support the energy transition and the participation of citizens according to the Energy Transition Plan.

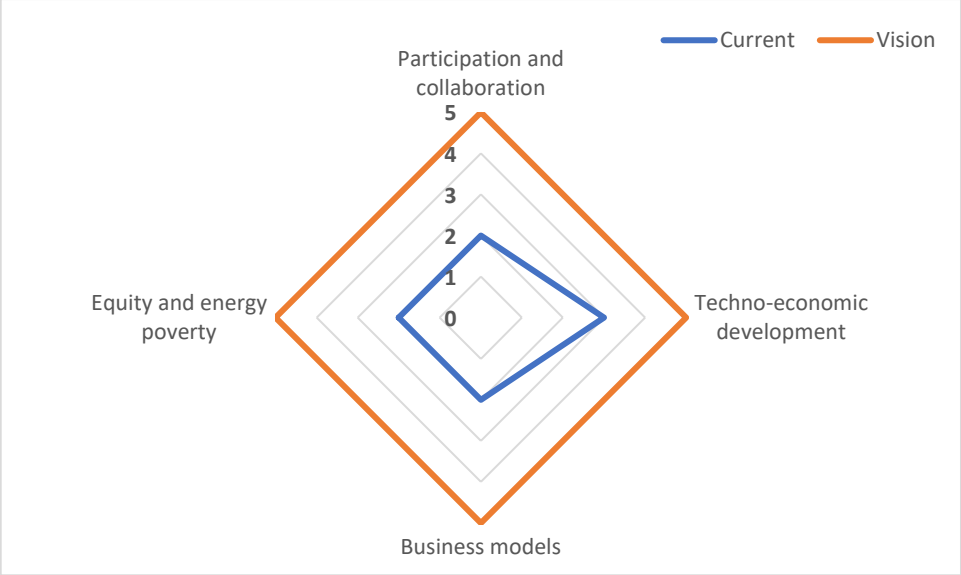

Figure 4.2. The current and envisioned performance of the energy system in the Canary Islands.

4.2.4 Desired energy transition pathway to achieve the vision

Considering the current level of performance of the current energy system, its drivers, barriers, and the local context, changes and action are required in order to achieve the previously elaborated vision for the future energy system. The interviews allowed to identify possible actions that support the local energy transition pathway towards the desired future energy system. Hence, this section describes the desired energy transition pathway and the individual actions respectively for each theme of the analysis.

Participation and collaboration

The stakeholders are convinced that achieving the appropriate level of collaboration and changing the roles require 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 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 the 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 development

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

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, which therefore needs to change. Existing investors are increasingly aware of the importance of environmental and social value of investments and recognise the benefits of innovation of their business models towards sustainability. For instance, 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 and energy poverty

Energy poverty and social benefits are topics that need to be further addressed for a fair and inclusive energy transition pathway. Therefore, all interviewees are convinced that energy affordability and accessibility should be a priority action in political agenda to guide a fair energy transition. 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.

4.2.5 Discussion of overall scenario

Figure summarises the key findings of each interview theme. That is, how possible pathway actions can contribute to the change from the current energy system to the envisioned future energy system, given the key aspects of both.

The analysis of the Canary Islands' current situation demonstrates that while an energy transition is progressing, it is still no human-centric energy transition. Citizens are still far away from being the center of the energy system or being enabled to take an active part in the transition. Interviewees noticed that citizens are willing to collaborate, have increased environmental awareness and happy to get engaged. However, citizens are confronted by high levels of bureaucracy, lack financial resources and lack trust into local policies. Nonetheless, the current energy system is changing towards a more sustainable system. There is an active implementation of renewable energies in the

Canary Islands. Even though big companies fear to lose their market share, all stakeholder groups are actively working together to achieve decarbonisation targets, along with the support of the EU commission. Additionally, favourable weather conditions drive the economic profitability. This is an important factor that could possibly leverage the limited funding that the local authorities recognise. Still, in order to fully decarbonise, the grid-constraints are a major issue which needs to be solved in order to implement further renewable energy potential.

The desired future energy system is envisioned to be fully renewable and self-sufficent, which would be in-line with the local governments energy transition plans. The interviewees envision a future energy system with a full mix of technology solutions to address current the different local contexts of the islands, but also an energy system which puts citizens into its center through decentralised energy production and self-consumption as part of energy communities. The vision of all interview themes circles around achieving a human-centric energy transition and implementation of innovative technology and business solutions for full decarbonisation by 2040.

The analysis of the interviews showed that to achieve this ambitious vision in a fair and inclusive way, awareness and engagement of all stakeholders are as important as inclusive incentives, subsidies, and stable policies that all together form an attractive and participatory environment for all stakeholder groups. Regulatory changes such as inclusive policies targeting especially vulnerable groups of citizens (i.e., in terms of financial incentives) are needed in the desired pathway to promote the active role of citizens and energy communities in the energy market.

The interviewees recognised that technology alone is not enough to cover the 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 can also cause barriers in decarbonisation. Based on these findings, it is evident that decarbonisation will require different pathway actions for each of the eight Canary Islands considering their contextual features and constraints, while there is one desired pathway for the whole Archipealago.

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 can contribute to an inclusive energy transition and to the implementation and development of PEDs. The regulatory framework takes a leading role in facilitating the process of engagement and collaboration and increased implementation of technologies. With the increasing focus on energy communities and microgrids and the existing awareness across all stakeholder groups about a 'fair' energy transition, the importance of social and environmental value, and the evolving role of citizens, the Canary Islands could provide the needed baseline and context for the development of PEDs. PEDs could be developed through innovative business models and with subsidies only for financially limited/vulnerable citizens.

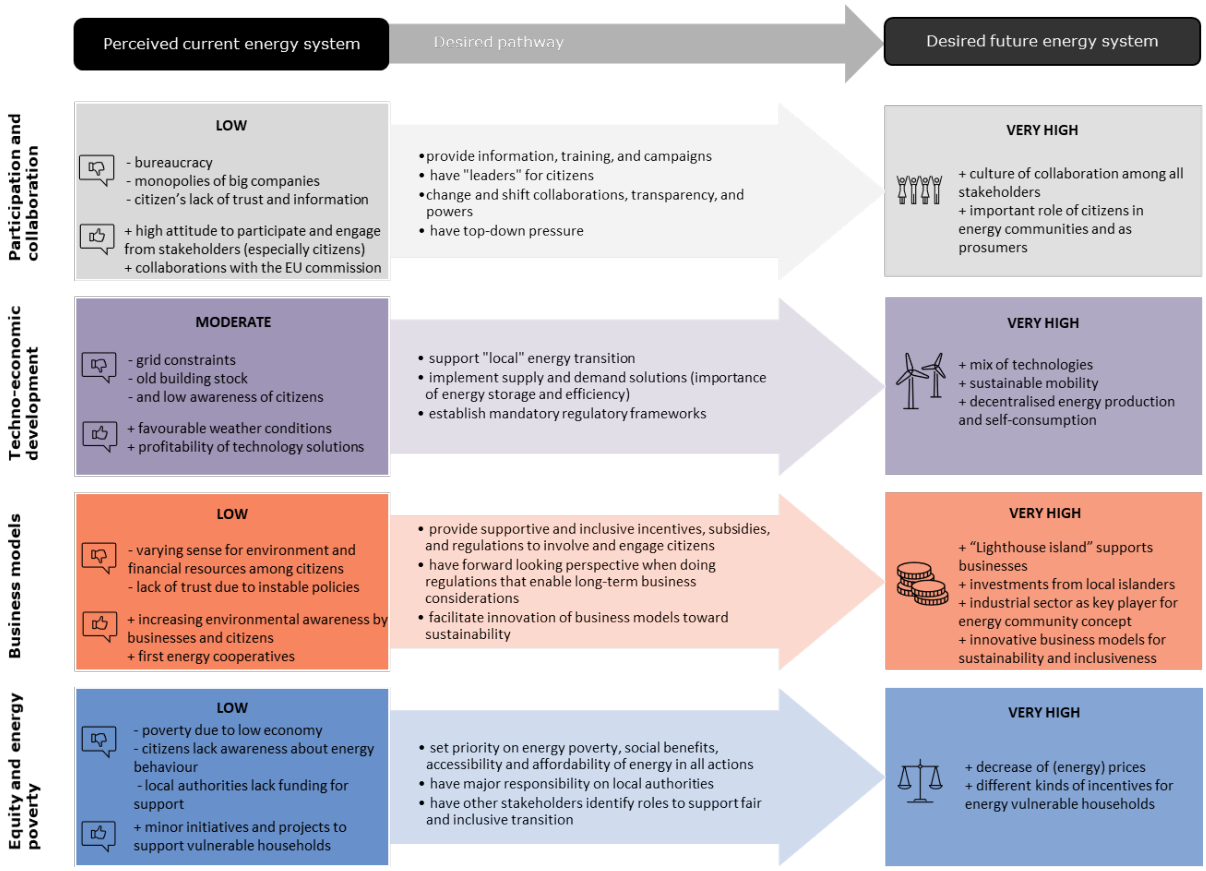

Figure 4.3. Key elements summarising the barriers and drivers of the current energy system, overall vision of the future energy system, and the possible pathway actions to achieve this vision in the Canary Islands.

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5 Lisbon metropolitan region, Portugal

Heinz, Helen; Stathopoulou, Eleni; Derkenbaeva, Erkinai; Lamonaca, Luca; Nguyen, Minh Thu

5.1 Context

Portugal was one of the first countries to set the goals for its 2050 carbon neutrality and is actively working on the energy transition [1]. In 2019, almost 30% of renewable energy production come from wind and solar PV. However, its energy system is still highly dependent on fossil fuels, mostly natural gas and coal, with 47% of energy supply in 2019. The two main renewable energy sources are hydro and wind (Figure). Hydrogen is an emerging technology that will support Portugal's energy transition in the long-term [1].

The Lisbon metropolitan area includes 18 municipalities with Lisbon, the capital of Portugal and largest city of the country, at its heart. It is the largest urban area in the country with a population of more than 2,8 million in an area of roughly 3,015 km². Next to the Atlantic, the area is located on the south-west coast of Portugal. Throughout the year the weather is mild and Mediterranean.

The solar potential is twofold. On the one hand, it can facilitate the energy transition and e.g., Lisbon's solar strategy [2]. On the other hand, climate change increasingly brings heatwaves and droughts to the region, which the city of Lisbon aims to tackle through its resilience action plan [3] and the wider region through its Lisbon Metropolitan Area climate change adaptation plan[2] [4]. Hence, the energy strategy in the Lisbon metropolitan area follows the 'Lisbon Metropolitan Area climate change adaptation plan'. This strategy builds upon the Portuguese national energy and climate plan 2021-2030 (NECP 2030) from December 2019[3]. In 2018 19,4% of the Portuguese population was under energy poverty [1]. Hence, the Portuguese NECP 2030 includes objectives to tackle energy poverty to ensure a fair energy transition. These objectives are closely connected to the need to improve the building stock energy efficiency [6].

Nonetheless, these plans focus not only on energy and energy efficiency, but also on agriculture, biodiversity, economy, human health, water resources, security of people and goods, coastal zones and ocean, and transport and communication[4]. The plans demonstrate awareness and encourage cooperation and collaboration across the various sectors and its stakeholders [4]. The transition is dependent on regional and urban planning, management, and governance, which foresees increased citizen participation. This also includes circular economy and the avoidance of food waste, where the LISBOA ZERO digital platform demonstrates how different stakeholders can come together and develop partnerships [5].

[2] Consult the Lisbon Metropolitan Area climate change adaption plan here: https://www.lisboa.pt/fileadmin/atualidade/noticias/user_upload/plano_metropolitano_de_adaptacao_as_alteracoes_climaticas.pdf

[3] Consult the NECP 2030 of Portugal here: https://ec.europa.eu/energy/sites/ener/files/documents/es_final_necp_main_en.pdf

[4] See: https://www.youtube.com/watch?v=itjlqIZfxxE

The energy transition pathways and policies of the whole Lisbon metropolitan region will need to consider the variety of contexts of the different municipalities. For instance, regarding transportation, the widespread geography of Torres Vedras impacts private transportation choice [7].

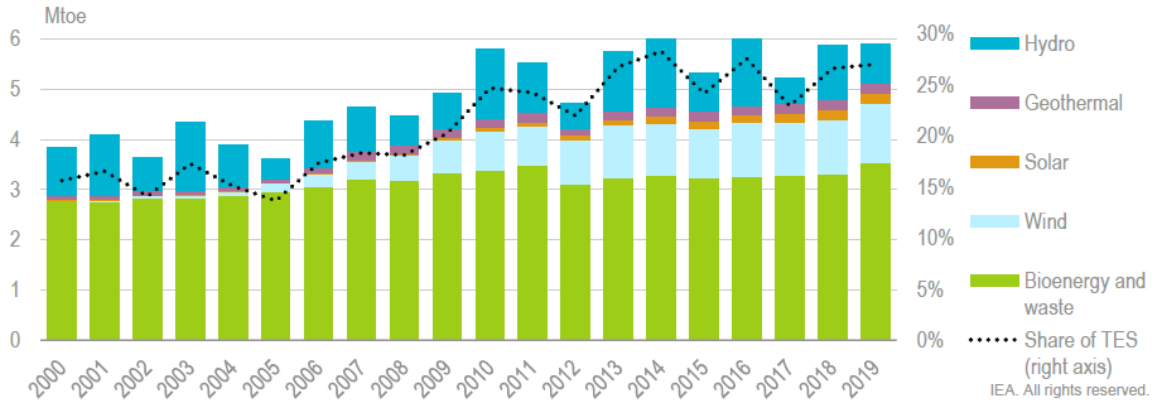

Figure 5.1. Energy production by source in Portugal, 2000-2019
Source: IEA (2020). IEA World Energy Statistics and Balances (database)
Note: Mtoe = million tonnes of oil equivalent. TES = total energy supply.

5.2 Results

This section presents the findings from the foresight interviews conducted in the Lisbon metropolitan region. It includes an overview of the current state of the energy system of the Lisbon metropolitan region, the desired future energy system, and a possible pathway to achieve this desired future starting from the baseline. The results are based on two interview rounds with a total of 7 interviews, with participants that represented the following stakeholder groups: policymakers, business experts/ industry representatives, technology experts, and environmental NGO's/citizen group representatives.

5.2.1 Perceived current state of the local energy system

The analysis of the current energy system in the Lisbon metropolitan region reflects on the current barriers and drivers in the system across four themes: participation and collaboration, techno-economic development, business models, equity and energy poverty. The overview of the current energy system from the perspective of different stakeholders contributes to a complete picture of the baseline from which the energy transition in the Lisbon metropolitan region will take off or further continue.

Participation and collaboration
The local stakeholders identified municipalities, Juntas de Freguesia (a municipal sub division), the national government, and citizens as the main stakeholders in the energy transition. The representative of the citizen group divides the business sector into two categories, the companies being easy to work with as they have the same interests and goals or the big companies of the energy sector which are rather a 'closed' community. Coopérnico is the only energy cooperative in Portugal, with 85% of their members being citizens. The interviewees' experiences and perceptions are that the Portuguese society has changed significantly towards being more environmentally active. Specifically, experiences of a project in the district of Alfama, Lisbon, demonstrated the easier engagement with citizens than with municipalities. However, the stakeholders highlight that this is very context-dependent. At the same time, it can be challenging that the government changes every four years, or

that citizens have vast sets of different interests and priorities also given that some are more vulnerable than others. It is important to be aware of the diversity of the stakeholders. Hence, local projects already map stakeholders, and engage them through workshops and other activities in order to identify problems and impactful solutions respectively. Nonetheless, a citizen representative is convinced that the government is still not listening enough to people working with communities and citizens themselves to fully understand local issues. That is, the government does not sufficiently seek to understand the problems of the citizens. Overall, the level of participation and collaboration can be assessed as 'moderate'.

Techno-economic development

The country is already undergoing a change to full electrification and implementation of renewable energies. Especially, solar energy is of use in the Lisbon metropolitan area. Also, wind and wave energy are being further developed. In fact, wind energy does not require special subsidies or feed-in-tariffs anymore. The interviewees recognise the increasing discussions about 'local energy communities', however, perceive it as being more a trendy term without real implementation plans. For instance, although there is law supporting local renewable energy communities, the municipalities have not set one up, which demonstrates the current gap between the idea and its actual implementation. A similar gap exists regarding energy storage solutions. At the same time, all interviewees raise the point of the energy inefficient building stock, which requires renovation and retrofitting. A technical expert states that without changing the priorities of the current techno-economic solutions 'in 2040 we even might have a solar panel, but I still have my poorly insulated house'. Therefore, this theme has been assessed as 'low'.

Business models

In the current energy system, direct investments into solar energy are more attractive. The energy cooperative 'Coopérnico' is considered as successful as it is more straight-forward. Members of Coopérnico seek diverse benefits; economic, social, and environmental. Older generation members are more attracted to social values and cooperation, while younger generation members are motivated by the environment, whereas some members are only interested in making economic profit. Overall, the interviewees agree that the financial aspect of the current business models is still dominant but the environmental awareness increases. Additionally, the economic returns are as important to businesses as to citizens. Although the local government is considered to face funding challenges, according to the interviewees, Lisbon does not face a funding challenge but rather has wrong priorities. A citizen representative raises the point that the energy transition is a profit game, with established stakeholders, i.e., big energy companies, deterring other players, as this implies less power or returns. In the current energy system, there is no democratic, open space for discussions between stakeholders 'to make business' and find solutions, which is a problem for bringing innovative business models forward. At the same time, there are no market and no business models that support energy efficiency retrofitting. Currently, there are not enough investments into local production and self-consumption. While some projects, such as the Alfama SUSHI project[5], investigate sustainable retrofitting in the urban context of Lisbon, there is no long-term strategy and business model behind it on how to fund the measures for other houses. According to the technical expert, this happens because the different owners and communities make retrofitting complex and difficult, due to their different goals and priorities and different sorts of funding to which they can apply. He also states that business models for retrofitting go beyond the economic benefit but support thermal comfort, indoor

[5] See more: https://sustainablehistoriccitydistricts.wordpress.com/

air quality and health, which should be further supported. The description of the business models in the current energy system leads to the assessment of 'low'.

Equity and energy poverty

The interviewees demonstrate significant awareness on energy poverty, which is more related to the increased costs during winter than for cooling during summer. In fact, all interviewees agree that the major issue for energy poverty is the energy inefficiency of the old existing building stock. The secretary of State of Energy had undertaken a public consultation for the long-term national strategy regarding energy poverty. The cooperative Coopérnico, universities, and other energy agencies collaboratively produced a paper with recommendations for this strategy, which according to the interviewees remained unheard. Currently, the approach misses monitoring measures that would keep track of the proposed strategy. Also, the citizen representative is convinced that this cannot only be the work of politicians but requires greater participation of different stakeholder groups. The current proposed concept of granting vouchers to energy vulnerable households does not even closely cover the required expenses, in fact they are considered 'peanuts' by the citizen representative. Other researchers have developed local maps to identify and characterise energy poor households. Generally, the interviewees stated that they inform themselves about energy poverty through participation in webinars and seminars, learning from across Europe. Still, while the awareness is there, the solutions are missing and injustice is still present. Therefore, the current energy system has been assessed as 'low' with their considerations towards energy poverty.

5.2.2 Vision for the desired future energy system

This section will focus on the desired future energy system in the Lisbon metropolitan region. The analysis of the vision reflects on the future energy system across the themes of analysis: participation and collaboration, techno-economic development, business models, equity and energy poverty. The analysis of the interviews with different stakeholders across the four themes contributes to the understanding of their collaborative vision and proposals of desirable features and actions for the Lisbon metropolitan region's future energy system.

Participation and collaboration

The interviewees envision a future system, where all stakeholders from both the transport and energy sectors will work together. This will include collaborations and partnerships between local authorities, universities, energy producers and retailers, but also transport operators and the whole automobile industry. The vision also includes a 'stakeholder observatory' or 'plenary meetings', where politicians listen and which can be seen as safe spaces for the different stakeholders to discuss openly, identifying problems and solutions to tackle them to achieve common goals. This concept would also support the development of new projects and inclusion of new stakeholders. Overall, the interviewees envision a democratised energy system that supports bottom-up approaches from citizens. The interviewed member of the local authority is convinced that the future energy system will include many renewable energy communities, which further emphasises the important role of citizens in the future energy system, but also of the municipalities as enablers. In fact, the future energy system should demonstrate strong political commitment. The vision of the participants demonstrates strong bounds and high levels of participation and collaboration between various stakeholder groups; hence, it has been assessed as 'very high'.

Techno-economic development

Technologically, the future energy system is envisioned to be fully electrified and have the potential to be electrically independent. Renewable energy will be produced from the sun, sea, and wind. Additionally, the interviewees are conscious about the energy resources and state that energy

efficiency is an important factor especially for the building stock as well as for electrical devices, and energy production. Technologies, energy production and consumption will be connected and managed through smart grid technology and the Internet of Things. Life cycle assessments and wider supply chain assessments will be part of the future energy value chain. The future energy system will have decentralised energy production, which can include energy communities, for instance, in form of Positive Energy Districts [8]. In fact, the interviewed technology expert emphasises the importance of 'small units' of decentralised energy production, as this includes local energy production from solar panels on private and public buildings. Furthermore, surplus energy is fed into energy storage systems and then made available to the community at cheap rates, possibly also connected to electric vehicle charging stations in the front of buildings. The technology expert also envisions the transport system to change its paradigm and adjust to the actual needs of the people by also offering on-demand busses serving smaller localities. Public transport and logistics, consisting of heavy-duty vehicles, will use hydrogen as alternative fuel. According to all interviewees the various concepts are needed under the context of e.g., urban Lisbon or its smaller municipalities such as Torres Vedras as the space is limited. Instead of occupying forests or agriculture lands, the future energy system will consider innovative technologies or use the built environment to install solar panels, according to the technology expert. Also, the interviewed policymaker envisions the future Lisbon to be greener and more natural not only in terms of energy, but also through actual reforestation. Combining the different aspects to an overall vision demands a 'very high' level of techno-economic development.

Business models

The future energy system is envisioned to demonstrate an effective combination of public and private financing sources. It is desired that there will be a market for retrofitting interventions and personnel with skills. Business models on retrofitting and renovating houses could be implemented through solar PV installations for local energy production. Economic returns would still be important; therefore, some initiatives might need to be mandatory standards to encourage building owners to act. The community will be more active with regard to financing their technologies and taking on ownership; hence community driven innovative funding schemes would need to be in place or crowdfunding initiatives could be the solution in some situations. Some subsidies are considered to still be needed not only to support citizens' engagement and energy efficiency measures, but also for e.g., the transport system that highly relies on it. The overall vision can be described by a 'high' level of business model innovation and importance.

Equity and energy poverty

The vision of the interviewees of the future energy system circles around enabling technologies, renovation of buildings, and stakeholder engagement, where the consciousness about equity and energy poverty is always present. In fact, the policy maker representative states that while the energy efficiency of the cities will highly increase, the future generation should not forget about humanity and health. Through incentives and inclusion into relevant projects and energy communities rather than just behavioural changes, citizens will be included in local, decentralised energy production and self-consumption supporting the social coherence of the future energy system. As the participants demonstrate high awareness and levels of considerations about energy poverty through their vision this can be translated to a 'very high' level of importance for the future energy system.

5.2.3 The current and envisioned performance of the energy system

This section demonstrates the performance of the current energy system and its desired performance in the future. The domains of the current energy system are evaluated as varying from 'very low' to 'moderate' which means that there are many efforts and changes needed to support and accelerate

the energy system transformation. It is especially important, as the future energy system is envisioned to achieve a desirably high state of performance, according to the experts' visions. Figure shows both thresholds, demonstrating the changes that have to be made under the local energy transition pathways, with most changes required with regard to the techno-economic development.

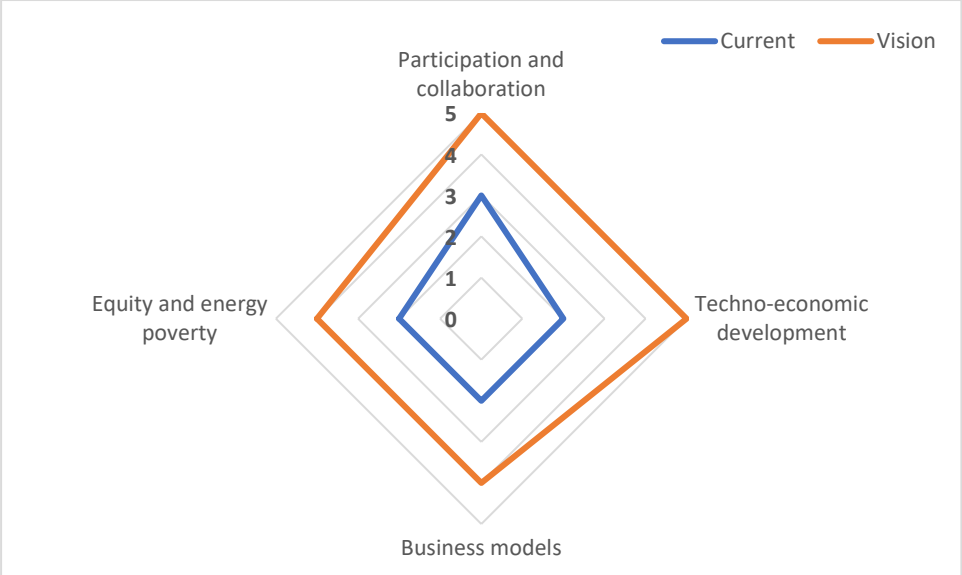

Figure 5.2. The current and envisioned performance of the energy system in Lisbon metropolitan region.

It is positive that the comparison of the vision of the interviewees and the local context and ambitions demonstrates significant alignment. The local energy transition is starting with different initiatives in partnerships and collaborations, technology development, tackling energy poverty and overall increased citizen engagement. Nonetheless, the participants seem to specifically focus on the need to increase the energy efficiency of the current building stock, which requires effective coordination of all discussed themes. Furthermore, the interviewees stated that the political commitment and plans are still not enough for a feasible just energy transition, which demonstrates the pressure on the government in the Lisbon metropolitan area.

5.2.4 Desired energy transition pathway to achieve the vision

Considering the current level of performance of the current energy system, its drivers, barriers, and the local context, changes and action are required in order to achieve the previously elaborated vision for the future energy system. The interviews allowed to identify possible actions that support the local energy transition pathway towards the desired future energy system. Hence, this section describes the desired energy transition pathway and the individual actions respectively for each theme of the analysis.

Participation and collaboration

To achieve the level of participation and collaboration between the different stakeholders and especially the citizens, the interviewees highlight the importance of the role of the local authorities and the national government. Also, it is necessary to start engaging citizens and providing them with mechanisms that enable their participation. Both policymakers and citizens representatives state the need for more commitment from the politicians and willingness for compromises between the parties to develop and achieve common goals. At the same time, the national government plays an important role to transmit the energy transition goals to the different municipalities, supporting the collaboration and acceleration of the process. Both government levels will need to develop policies and financial schemes, for instance, for renovation of buildings, that target different levels such as

district, household, and individual level to engage different people. Nonetheless, all actors could seek to integrate citizens from the early beginning in projects by developing urban living labs and innovation hubs to accelerate their acceptance and willingness to participate. The different stakeholders, which not only include the government, but also researchers and companies, could learn from experiences and best practices from all over Europe. Similarly, energy companies will need to learn from what is happening and accept their changing role, to participate and collaborate in the energy transition pathway.

Techno-economic development

The integration of renewable energy technologies at the building and community level are important to achieve the vision. However, to achieve decentralised energy production solutions, it requires a clear vision from the government first, as they will need to set off against the current centralised energy production companies. Experiences and learnt lessons from European projects will help to move from ideas to implementation solutions as e.g., for energy communities. While energy consumption patterns and dual energy tariffs might be relevant at the beginning of the pathway, they will reduce in relevance with the increasing level of implemented techno-economic solutions. At the same time, the interviewees mention that the focus should not primarily be on technologies, mobility, or 'fancy gadgets', but rather on increasing the energy efficiency of the existing building stock to not dismiss the energy vulnerable part of the society. Indeed, all interviewees identify renovation of the current building stock as very important, as the current renovation rate is far too low to achieve the vision. The interviewees propose renovations at a district and local level with condominium companies to connect with the communities.

Business models

Considering the developments of the past, the interviewees are sure that the installation of large-scale renewable energies does not need subsides. However, subsidies at all levels will be needed on this pathway to accelerate the energy transition. The focus should rather be on incentivising local change by targeted incentives for renovation of buildings than enabling citizens to install renewables. This could also be combined through innovative business models or financing packages for buildings that include e.g., new windows, insulation, and solar PV, from which the citizens will be able to receive economic benefit in the long term. Also, the industry will benefit from supporting schemes to push innovative technologies, such as for hydrogen. Then, these investments and the transition will happen gradually, for instance, the uptake electric or hydrogen vehicles. Even though most of the money will need to come from public funds, the private sector will also have a high stake. The combination of public and private funds will be important to allow all parts of the society to invest into the local energy transition pathway. Innovative financing solutions will be needed to make the investments even more attractive for citizens. As such, expensive bank loans should be avoided, instead energy agencies and municipalities should work together to enable financing at low costs for the citizens.

Equity and energy poverty

Addressing energy poverty and fair energy transition starts at designing both national and local policies accordingly. That means, the policies should not only be shaped around the needs of the general public, but also of the vulnerable part of the society. To achieve this, it will be needed to go from 'door to door' to learn about concerns and connect with the people as newsletters and websites might not be enough. Local decentralised energy production and self-consumption, and the possible decrease of taxes on energy prices could help to tackle energy poverty. Still, the interviewees agree that the major aspect that needs to be tackled is the inefficient building stock to increase energy efficiency and thermal comfort. By retrofitting proactively at a district level, this would include low-income households. More data (of energy consumption, production, management etc.) and

accessibility to data would support these schemes and the active role of the citizens. To bring this forward, the interviewees see local energy agencies and municipalities taking the leading role in action.

5.2.5 Discussion of overall scenario

The interviews demonstrate that within the current energy system of the Lisbon metropolitan area there is great awareness of local drivers and barriers for the energy transition across all analysed themes, and through specific pathway actions a desired energy system can be achieved by 2040 (Figure 5.3). While the energy cooperative Coopérnico is an example of the engagement and environmental awareness of the citizens, most citizens are still left with limited possibilities and incentives for participation. Established renewable energy technologies are being implemented, funds are available, and investments are made into local solar energy, nonetheless, lack of equity and existing energy poverty are the issues that recognised by all stakeholder groups. The interviewees emphasised that the government sets the wrong funding priorities and lacks long-term solutions and strategies throughout the four themes, as discussed above.

Nonetheless, the desired vision of the future energy system is ambitious with a fully renewable, smart, decentralised, electrified energy system that could be completely energy independent. The interviewees envision this to be possible on the one hand through strong collaboration between sectors and continuous communication among stakeholders, and on the other hand through effective financing and innovative business models that combine energy efficiency and solar PV installations. At all times, energy poverty is desired to be a key priority in the future energy system, being tackled through incentives for and inclusion of vulnerable citizens.

This study has also revealed several pathway actions that are desired by the interviewees. These actions demonstrate the need for increased collaboration and engagement between all stakeholders, to learn and create partnerships, in order to develop innovative solutions and pursue a common goal. According to the interviewees, there are more actions required and a more specific and 'common' vision is needed to achieve the future envisioned energy system as currently planned and provided by the government. The government should provide enabling policies, subsidies, and incentives to support the development of the analysed themes. More focus is needed on tackling energy poverty with measures beyond 'vouchers' and clear guidelines on data ownership.

The interviewees' thinking is in line with the local 'Lisbon Metropolitan Area Climate Change Adaptation Plan' and the 'National Energy and Climate Plan'. There is emphasise on projects that do not only focus on renewable energy but also on other sectors and solutions such as energy efficiency and retrofitting, effective use of built environment, transportation, and creation of a 'greener' city through plants. The interviews demonstrated that the stakeholders are recognise the value and need for a human-centric energy transition which requires to listen to communities and tackle energy poverty. Furthermore, the different stakeholder perspectives allowed to showcase that a common vision for a future human-centric energy system is possible and can be achieved through further, aligned political commitment. The rural and urban contexts of the Lisbon metropolitan area can be considered as opportunities for different technology solutions and partnerships.

Based on the analysis of the current energy system and the transformation towards the future energy system of the Lisbon Metropolitan region, it can be concluded that PEDs can be possible in towards the end of the transformation. The set-ups of the PEDs might differ according to the contexts in the region. However, the overall thinking of integrating not only community engagement and renewable energy technology but also other aspects such as waste and water management is already present in the Lisbon Metropolitan Area Climate Change Adaptation Plan. PEDs could be community driven and

financed through crowdfunding and other innovative funding schemes. A PED in the context of the Lisbon metropolitan region would be inclusive and if needed there were subsidies to include the vulnerable part of the society.

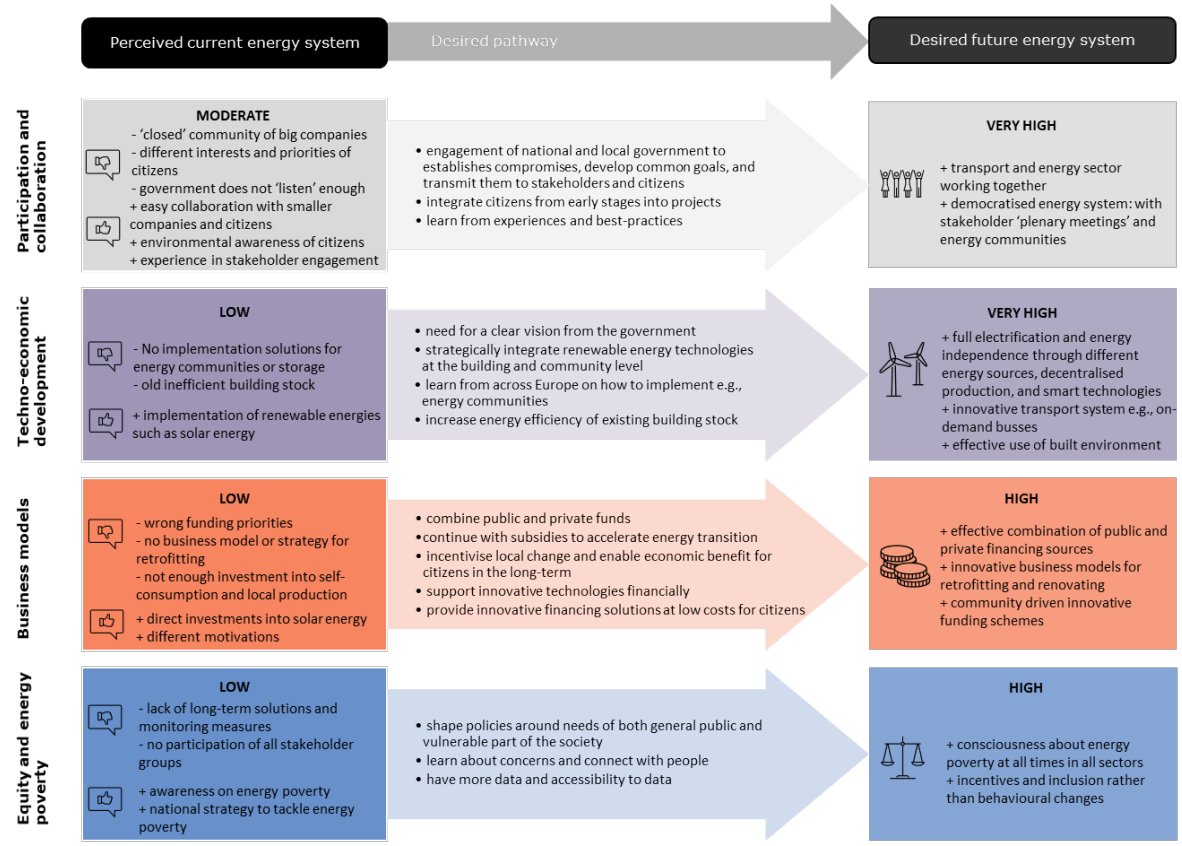

Figure 5.3. Key elements summarising the barriers and drivers of the current energy system, overall vision of the future energy system, and a possible pathway to achieve this vision in the Lisbon metropolitan region.

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6 Ruhr region, Germany

Derkenbaeva, Erkinai; Stathopoulou, Eleni; Heinz, Helen; Marggraf, Clemens

6.1 Context

Covering an area of around 2,700 km², the Ruhr region is located in the German state of North Rhine-Westphalia. The region has an oceanic climate despite its inland position, with winds from Atlantic travelling over the lowlands to moderate temperature extremes as a consequence for cloudy and wet climate with low sunshine hours.

The Ruhr region consists of 53 cities that were dependent on coal mining when it reached industrial scale in the 1800s. At their peak in the 1950s, the mines employed around 600,000 workers and tied the region's identity to coal [1]. Energy in Germany is still sourced predominantly by fossil fuels including coal, nuclear, oil and natural gas, however, in the decade of 2008-2018, production of fossil fuels declined by a third with nuclear production being halved (Figure 6.1.) [2]. However, on the supply side, Germany highly depends on energy (including nuclear power) that comes from other neighbouring countries.

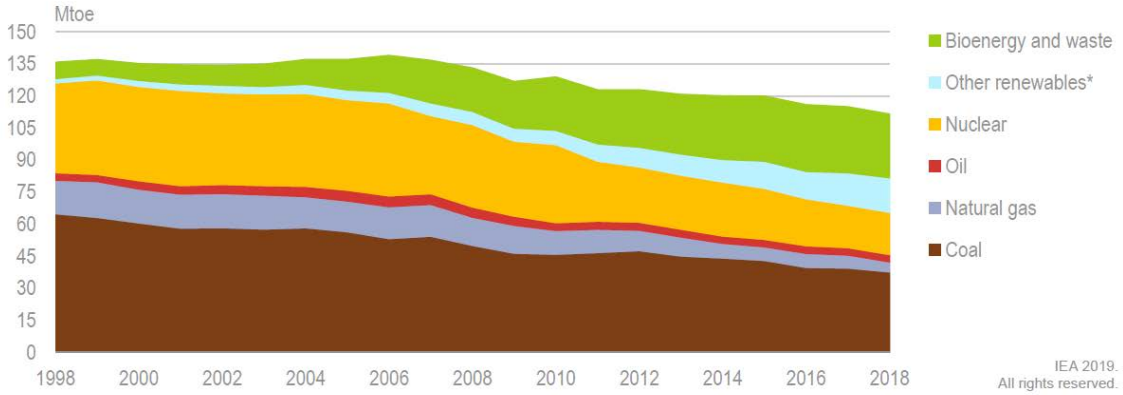

Figure 6.1. Energy production by source in Germany, 1998-2018.
Source: IEA (2019), World Energy Balances
*Note: *Other renewables includes electricity from wind, solar and hydro (and a minor share geothermal).*

These declines were largely offset by increased production of energy from renewables and waste that accounted for 41% of the total domestic production in 2018 [2]. The guiding energy transition plan in Germany, the 'Energiewende', was introduced nearly a decade ago and became a defining feature of Germany's energy system with the goal to transform towards a more efficient and renewables-driven system. Even though the Energiewende showcases its feasibility in renewables-based electricity production, it still faces notable challenges in transport and heating [2]. As part of the Energiewende, Germany's Climate Action Plan 2050 adopted in 2016 includes the goals to achieve at least 40% reduction of greenhouse gas emissions by 2020, 55% by 2030, 70% by 2040 and 80-95% by 2050, compared with the base year of 1990 [3]. As of 2018, Germany had reduced its emissions by around 31% compared to 1990, meaning that the country still remains far off its 2020 emissions target [2].

To foster emissions reduction and phase out coal, the Ruhr region is working on the framework to implement the energy transition of the area. The spatial unity of energy sources (coal), energy supply,

and energy-intensive industry led to a correspondingly integrated economy and a specific infrastructure design. This heritage is still reproduced today in certain path dependencies and power structures [4]. In this context, the focus of the framework lies on structural, political, cultural, and institutional conditions as well as problems and solution strategies for the local energy transition from coal.

6.2 Results

This section presents the findings from the foresight interviews conducted in the Ruhr region. It includes an overview of the current state of the energy system of the Ruhr region, the desired future energy system, and a possible pathway to achieve this desired future starting from the baseline. The results are based on two interview rounds with a total of 9 interviews, with participants that represented the following stakeholder groups: policymakers, business experts/ industry representatives, technology experts, and environmental NGO's/ citizen group representatives.

6.2.1 Perceived current state of the local energy system

The analysis of the current energy system in the Ruhr region reflects on the current barriers and drivers in the system across four themes: participation and collaboration, techno-economic development, business models, equity and energy poverty. The overview of the current energy system from the perspective of different stakeholders contributes to a complete picture of the baseline from which the energy transition in the Ruhr region will take off or further continue.

Participation and collaboration
Within the theme on collaboration in the energy transition, the interviewees were asked about the participation process, inclusiveness and solidarity, networks in the Ruhr area. The interviewees stress that it is still challenging to fully engage certain stakeholders in the energy transition due to the unfair financial distribution of profits. It is acknowledged that Germany's entire energy system is strongly geared towards larger companies. As a result, individual citizens are often neglected in terms of financial benefits from the energy transition. The citizens are willing to invest only in case a greater share of profits from investments into renewable energy technologies (e.g., solar panels, wind turbines, etc.) is given. Besides the existing monetary barriers, there is also lack of awareness in the population. In terms of the transition for companies, it is mentioned that the local authorities (in this case, in the city of Essen) focus their support more on larger energy providers such as E.ON, while smaller companies are often being overlooked. Consequently, this makes the transition challenging and unfair for individual stakeholders. With multiple challenges of the current energy system in the Ruhr area, the participation and collaboration domain is estimated as still 'very low'.

Techno-economic development
In terms of techno-economic aspects, the interviewees were asked about the decentralisation of the energy system, priority of sectors and respective technologies. It is recognised that it is not an easy task to transform the current energy system in Germany to a fully renewables-based system. The biggest challenge is that the transportation sector still heavily depends on fossil fuels. The interviewees highlight that the local scale is important for the energy transition due to its huge potential. There is a large number of roofs of buildings such as supermarkets and business offices that have a great capacity for renewable energy technologies installation, which remains unused. However, it is also highlighted that it can be possible only if the companies are 'forced' by the government to adapt their infrastructure and take actions towards the energy transition. The current energy system faces technological limitations while being dependent on the existing laws and regulations that are

implemented at the state level. Overall, the current state of techno-economic development in the Ruhr is still at its 'low' state.

Business models

In the discussion on business models for energy transition, the interviewees highlight multiple factors that play a role for energy consumers to participate in business opportunities which would boost the energy transition. One of the factors is financial incentives. city of Essen in the Ruhr region is one of the examples where a fair distribution of funding and especially support of low-income households are in place. Another important driver for participation in the energy transition-related business models is legislation. There is a limited number of policies on prevention of high emissions generated by large private companies, and at the same time no policies on tax incentives or other economic benefits for them to invest into environmentally friendly infrastructure. Another factor that is central for the transformation of the current energy system is social. Recent popular movements such as the 'Fridays for Future' accelerate the change in the mindset of citizens towards the 'green' future, but also put pressure on private companies and politicians to be more positive towards the transition. Technological change is also included as an important driver. There is a positive change in this regard in the last decade. Nowadays, the efficiency of renewable energy technology together with the energy cost reduction make the investments in renewables more attractive than investments into fossil fuels. Finally, an additional important factor mentioned is the context, more specifically, the topography of the area and its geographical location. As the Ruhr region is not a windy area, it becomes more beneficial to invest in solar panels rather than wind turbines, which is also being considered as part of the current local energy transition. Overall, the business models in the Ruhr area are estimated as 'moderate' as there are already multiple drivers in the current energy system.

Equity and energy poverty

The interviewees agree that energy should not be a luxury good, rather it should be accessible and affordable for everyone. Energy poverty is still an acute problem for the region. Recently, energy poverty became more magnified to vulnerable population groups due to the current situation caused by COVID-19, putting an additional financial burden (e.g., higher energy bills). However, with energy poverty being mainly related to the housing sector (e.g., heating, cooling, etc.), its relation to mobility is often overlooked. It is recognised that there is still a lack of infrastructure for mobility transition. While the citizens are asked to transit to the electric vehicles, there is often a lack of charging points in close proximity. However, it is also highlighted that addressing energy poverty is not merely a responsibility of the government or polluters/producers, but also consumers themselves. The energy consumers are responsible for their energy-related behaviour. Overall, equity in the current energy system of the Ruhr region is considered relatively 'low' with a risk of increasing energy poverty, especially during the recent crisis (i.e., the pandemic caused by COVID-19).

6.2.2 Vision for the desired future energy system

This section will focus on the desired future energy system in the Ruhr region. The analysis of the vision reflects on the future energy system across the themes of analysis: participation and collaboration, techno-economic development, business models, equity and energy poverty. The analysis of the interviews with different stakeholders across the four themes contributes to understanding of their collaborative vision and proposals of desirable features according to these themes for the Ruhr region's future energy system.

Participation and collaboration

Collaboration among all stakeholders is recognised to be central for the future energy system. The interviewees agree that citizens, the local authorities including policymakers, and private companies

are the most important stakeholders. Increasing citizens involvement is key in maintaining the future renewables-driven system. The local authorities are interested in making the cities in the region attractive, so that citizens would wish to come, live, and work there, as well as companies would be attracted in operating in the region. Being part of production, private companies are expected to take a key role in the future energy system as well, due to established society pressure. Overall, the participation and collaboration of the abovementioned stakeholders is envisioned to achieve the 'very high' level in the future energy system in Ruhr.

Techno-economic development

The future energy system in the Ruhr area, and Germany in general, is envisioned to be more decentralized, smart, and flexible. Energy efficiency in the buildings is seen as a result of a mix of technological solutions including thermal insulation, installed heat pumps and solar panels. Separate regulations for new and old buildings are crucial and are part of the transition as they require a different approach, for example, new buildings are required to be built based on energy efficiency standards, while the old buildings should undergo retrofitting. Flexibility of energy consumption is also an important feature of the future renewables-driven energy system. The interviewees highlight that the flexible energy system integrated in houses is environmentally beneficial and reduces the energy costs for households. Flexibility is seen as part of an automatised energy system where many processes will be automatically controlled and managed. Overall, the techno-economic development is expected to achieve a 'very high' level in the future system in the Ruhr area.

Business models

Economically sustainable business models are becoming a milestone for the future energy system. Most interviewees agree that subsidies might not be needed anymore in the future energy system because the market will further regulate or is already regulating the energy transition in Germany since the prices for the renewable energy technologies have diminished. It is expected to have own local energy production at a cheaper price than the energy from the grid. However, subsidies will still play a key role for the vulnerable groups of population as well as for some companies that need support for their transition towards becoming 'greener' and competitive in the market. It is also mentioned that companies are actively developing and integrating new business models that would be more sustainable, while their ultimate goal still remains making a profit. The state of the business models' domain in the future Ruhr energy system is estimated as 'high'.

Equity and energy poverty

Change of people's mindset regarding energy behaviour is highlighted to be central for the future energy system. More environmentally responsible behaviour will be important not only for emission reduction, but also for achieving energy efficiency. However, it was also stated that the tax system will play a key role in regulating the fairness of the energy transition and the future energy system, while keeping the financial burden of the transition equal for everyone, while at the same time not to burden the vulnerable ones even more than they are already. As such, the regulatory system and its direction in the dimension of equity and energy poverty is upmost for all stakeholders. In this regard, the government will take the leading role and is envisioned to be responsible for providing financial incentives not only for big companies but most importantly for the poorer ones so that they can afford sufficient energy in their homes, let alone the energy transition. The NGO representative believes that: 'if the government is able to support 'Lufthansa' with substantial financial help during the COVID-19, it should be definitely able to support the vulnerable ones'. This fairness is desired to be achieved in order to successfully operate in the future energy system that would be just for all stakeholders. Overall, it is envisioned to achieve 'very high' level in the domain of equity and overcome energy poverty in the future Ruhr energy system.

6.2.3 The current and envisioned performance of the energy system in the Ruhr region

This section demonstrates the performance of the current energy system and its desired performance in the future. Overall, the domains of the current energy system are evaluated as relatively 'low' as the region, as well as the country, are still facing a lot of challenges in the energy transition. It is especially difficult for the Ruhr region as it is still experiencing the path dependencies from the past coal-led energy system. On the other hand, the transformation to the future renewables-based energy system is considered feasible and is planned to achieve its mostly 'very high' development state. The comparative analysis of the current performance of the energy system domains and the envisioned performance of the future energy system 2040 in Ruhr is shown in Figure 6.2.

Comparing the vision of the interviewees and the goals of the Energiewende, it is clear that they align with each other to a large extent. Both the vision of the interviewees and the goals of the strategy target improvements of the energy efficiency in the buildings, the full transition to renewable sources, and reduction of emissions. However, the interviewees also highlight the importance of participation and collaboration of the stakeholders in the energy system transformation as well as increase in equity and inclusivity. These aspects are also recognised and supported by the local initiatives in the Ruhr area [5], however, they have not been addressed in the governmental strategy yet.

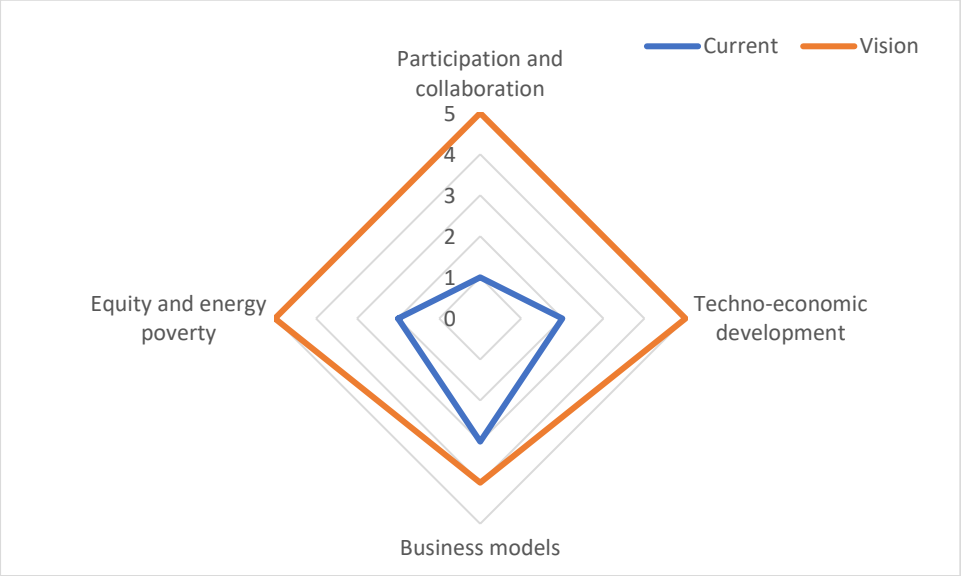

Figure 6.2. The current and envisioned performance of the energy system in the Ruhr region.

6.2.4 Desired energy transition pathway to achieve the vision

Considering the current level of performance of the current energy system, its drivers, barriers, and the local context, changes and action are required in order to achieve the previously elaborated vision for the future energy system. The interviews allowed to identify possible actions that support the local energy transition pathway towards the desired future energy system. Hence, this section describes the desired energy transition pathway and the individual actions respectively for each theme of the analysis.

Participation and collaboration

In order to increase participation and collaboration of different stakeholder groups, it is important to create financial opportunities for them. According to the interviewees, financial incentives for small

companies will allow them to actively participate in the energy transition and avoid exclusion in the competition with the larger companies. At the same time, financial incentives for the citizens might help them to stay engaged and motivated to adopt renewable energy technologies if they see the monetary benefit from them and support at the early stages of their transition. Another important factor that can strengthen participation and collaboration is information. The interviewees agree that it is upmost to create different communication channels (e.g., informational campaigns) for the citizens (and not limited to them) about the importance of the emissions reduction and potential benefits from the energy transition. Besides the informational campaigns to increase the awareness of the adult population, it is also imperative to target the younger generations starting from the kindergartens and schools, and design educational programmes that help them to learn how to live their (future) lives sustainably (e.g., separating garbage, saving the energy when possible, reuse unnecessary items, etc.).

Techno-economic development

There is no simple solution for transforming from fossil fuels to renewables as the system is complex and requires applying a holistic approach in the transition. The interviewees highlighted several aspects that are important to consider and implement on the way towards the vision. Firstly, electric vehicles (EVs) are viewed as one of the solutions that can effectively facilitate the future energy transition. However, EVs are limited in their types of individual cars and public vehicles (i.e., buses), while long-distance transportation means such as airplanes remain a concern. To solve the problem with emissions generated by the air transportation, the interviewees agree on a twofold solution: first, to reduce the number of flights, the interviewees suggest to increase prices for airplane tickets; second, to make people use more land-based transportation instead of airplanes for long-distance trips, it is important to invest in railway network and infrastructure. Secondly, every-day use of smart appliances is also considered as an important step towards reduction of energy consumption and control of the energy generation and storage. For example, the smart appliances may include mobile applications that allow controlling energy demand, generation, and available storage capacity, or automatising the process of charging the EVs with a certain condition such as charging only when the energy price is the lowest during the day. Generally, it is important that the energy transition happens simultaneously at all scales (i.e., national, regional, and local). To make it possible, regulation will play a key role by also targeting different stakeholder groups as well as differentiating between old and new building and offering a distinct approach (e.g., obligations, subsidies) for helping them become energy efficient.

Business models

The interviewees are convinced that subsidies will be essential at the early stage of the transition but then it will be important to attract investments (private and public) as the transition will require substantial funds. It is agreed that the business models of the future energy system should focus on fair distribution of finances in order to allow everyone to participate and benefit from the changes towards renewables. However, business models should be different for each stakeholder group. As such, the business model for retired people can be designed in such a way that allows them to invest some part of their wages while they are employed in renewable energy technologies (e.g., solar panels), while when they retire these investments will be saved and will bring some dividends. On the other hand, business models for private companies are seen as more requiring or binding leverages. The interviewees agree that the government should introduce the regulations that will fine companies for the high emission rates or, on the contrary, offer conditions such as tax incentives to stimulate them to invest in environmentally friendly business. However, not to create unfairness among big and small companies, while the former have more opportunities to transform with less losses and the latter are vulnerable and face more challenges, the regulations and policies should be tailored.

Equity and energy poverty

The interviewees highlight the increase in energy poverty due to the climate change and the need for an urgent transition to the renewables. Collaboration among different stakeholders is highlighted as a key driver to overcome the energy poverty. Citizens play a major role in combating energy poverty by rethinking their energy-related behaviour (e.g., decreasing meat consumption, switching off the lights and heating when not using, etc.), while research is also important for finding the ways to overcome this issue. Additionally, sector coupling is mentioned as one of the solutions to accelerate the energy transition. Overall, to make these processes effective, the government should take the lead role in distributing the resources fairly, but also in creating opportunities for the vulnerable groups such as free public transport.

6.2.5 Discussion of the overall scenario

The vision that is set by both the government and the interviewees is not an easy goal to achieve, the complete scenario is given in Figure 6.3. It requires a collaborative approach to transform to the new future energy system successfully. There are several barriers in the current system that hinders the development towards renewables. These barriers include a lack of awareness, unfair distribution of financial incentives gearing towards large companies, the transportation system lagging behind among others.

The Ruhr region set up a high bar for the future energy system that will be renewables-based with the active participation of all stakeholders and collaboration in the system. The future system is also seen as a smart system that is highly flexible and decentralised with automatised control available for not only the government and private companies, but also the citizens. Economically sustainable business models as well as subsidies for vulnerable groups and smaller companies are considered as important elements to be present in the new system. Above all, increasing awareness and changing the mindset of people are foremost aspects that will be central in the future system.

The desired pathway to transform to the desired future energy system focuses on human-centric approach where the citizens' needs are given the priorities in the energy transition. Creating financial opportunities for the citizens, increasing their awareness through the educational programmes and informational campaigns, as well as designing tailored regulations will contribute to the human-centric energy transition. Additionally, the vulnerable population groups are envisioned to be supported by subsidies and the inclusive policies. The desired pathway also includes the technological improvements in terms of the infrastructure for the (electric) mobility and long-distance land-based transportation. The flexible energy system integrated in houses is considered as environmentally beneficial and reduces the energy costs for households. Sector-coupling is also seen as an important element of the energy transition.

All these abovementioned aspects can be similar to some extent to other regions, however, it is important to take into account the contextual differences of this region when approaching its energy system. The contextual features of the Ruhr area include the topography of the area and its geographical location. As the Ruhr region is not a windy area, it becomes more beneficial to invest in solar panels rather than wind turbines. Another regional contextual feature that is observed is the national regulations that still target and benefit larger companies in the energy system. As such, the current energy system is still highly dependent on fossil fuels and is lagging behind from other relatively similar, in terms of the development, countries. Therefore, the Ruhr region and Germany in general still face numerous issues to solve with regard to the energy transition.

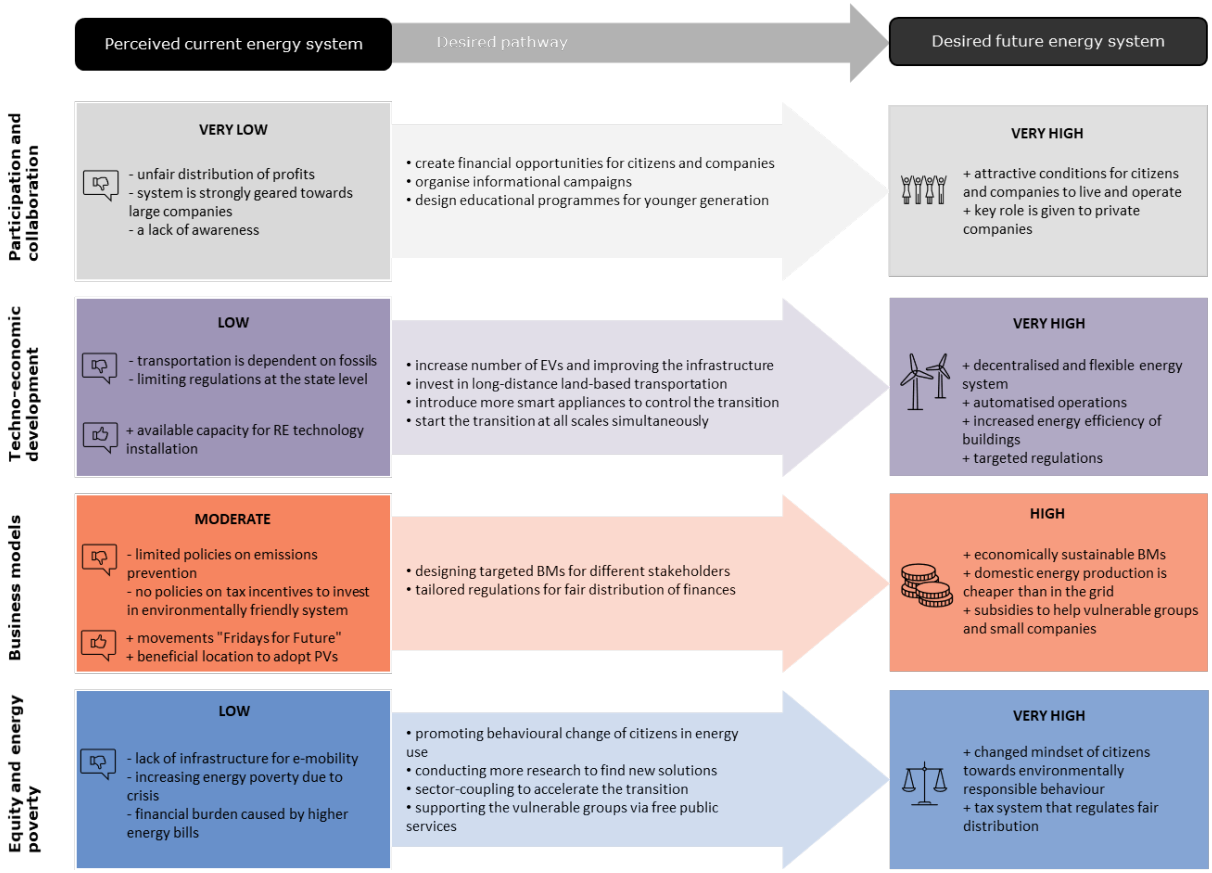

Figure 6.3. Key elements summarising the barriers and drivers of the current energy system, overall vision of the future energy system, and a possible pathway to achieve this vision in the Ruhr region.

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7 Amsterdam, Netherlands

Derkenbaeva, Erkinai; Stathopoulou, Eleni; Heinz, Helen; Yoo, Han Kyul

7.1 Context

Found within the province of North Holland, Amsterdam is the capital and most populous city of the Netherlands, and known for its vast number of canals and the port. The city is connected to the North Sea and therefore has an oceanic climate with prevailing westerly winds. Due to its geographical location, Amsterdam has become the leading centre for finance, trade, and culture.

The energy system of the Netherlands heavily depends on fossil fuels (Figure) [1]. The country is still one of the largest gas producers in Europe; however, domestic gas supply is rapidly declining as production from Groningen is being phased out. In Amsterdam, natural gas heats roughly 90% of all homes and businesses, and therefore, it is a major source of carbon emissions in the city [2]. In 2017, sustainably produced energy made up only 6% of the energy used in Amsterdam. Three-quarters of this energy, electricity, and heat, is generated by waste incineration, while a quarter – by solar panels and wind turbines. In 2019, installed capacity of renewable energy generation in Amsterdam equalled to 73 MW generated by solar panels, and 66 MW by wind turbines, while the ambition for 2050 is 550 MW and 127 MW respectively [3].

As the city of Amsterdam intends to accelerate the process of making the capital more sustainable, it set up a long-term vision for 2050 with the goal to arrive at its desirable CO_2 reduction by 95% compared to 1990, which was introduced in the Roadmap for a Climate-neutral Amsterdam in 2050[3]. This vision incorporates four major themes for reducing emissions: built environment (i.e., the stock of existing buildings), mobility, electricity, port and industry. Heating in a built environment and electricity are considered the biggest contributors to the CO_2 emissions annually accounting for 25% and 39% of total emissions, respectively [3]. Mobility, and port and industry have also a significant contribution to the CO_2 emissions with 18% each.

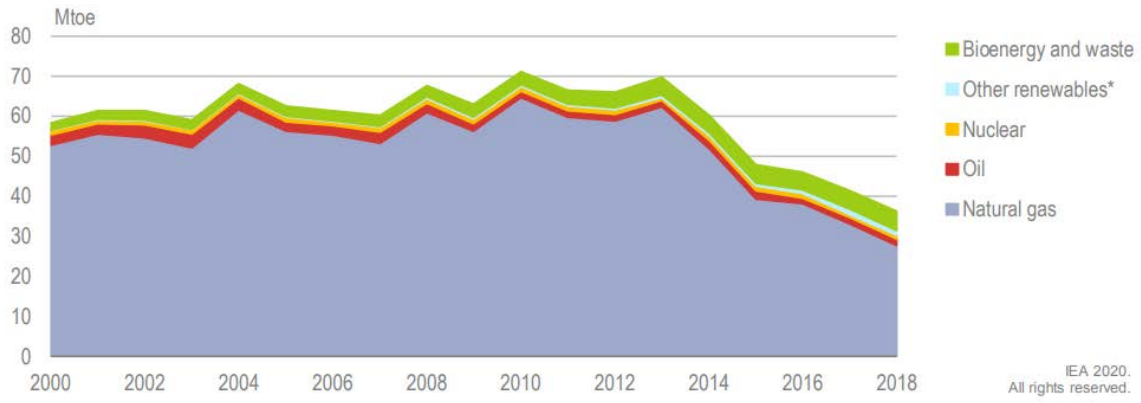

Figure 7.1. Energy production by source in the Netherlands, 2000-2018
Source: IEA (2020). Energy Policies of IEA Countries – Netherlands, Review 2020 [1]
*Note: * Other renewables include solar, wind, hydro and geothermal.*

Addressing Amsterdam's energy transition ambition in all sectors will be challenging. The new energy system will require a substantially larger area/space than the current fossil-based system where different systems/sectors (e.g., transport sector, IT, etc.) will co-exist [4]. As the city is a highly populated urban area, it experiences space scarcity, which will make the integration of renewable energies a difficult task. Having a lot of multi-family buildings that are prevalent in urban areas, the city faces a huge task in energy transition of such buildings where there are multiple owners and limited space for energy technologies. Additionally, the city has historical buildings (in the city centre) that create a lot of obstacles and limitations in terms of solutions on insulation and energy efficiency due to the importance of preserving the archetype of the historical buildings. Therefore, the local government is aware that they need specific targeted technological solutions that address these issues to increase building stock efficiency and transform the energy system to a (more) sustainable system [3].

7.2 Results

This section presents the findings from the foresight interviews conducted in Amsterdam. It includes an overview of the current state of the energy system of Amsterdam, the desired future energy system, and a possible pathway to achieve this desired future starting from the baseline. The results are based on two interview rounds with a total of 8 interviews, with participants that represented the following stakeholder groups: policymakers, business experts/ industry representatives, technology experts, and environmental NGO's/ citizen group representatives.

7.2.1 Perceived current state of the local energy system

The analysis of the current energy system in Amsterdam reflects on the current barriers and drivers in the system across four themes: participation and collaboration, techno-economic development, business models, equity and energy poverty. The overview of the current energy system from the perspective of different stakeholders contributes to a complete picture of the baseline from which the energy transition in Amsterdam will take off or further continue.

Participation and collaboration

Within the theme on collaboration in energy transition, the interviewees were asked about the participation process, inclusiveness and solidarity, networks in Amsterdam. Currently, there is a lack of personal contacts, structural funding, personal funding, financial incentives, and time, which, according to the participants, are the main barriers for the collaboration of diverse stakeholders in the energy transition. The participants shared that in their experience the current decision-making processes regarding energy related projects in Amsterdam are relatively fast when they include private companies or a business partner, while much slower when they include residents and local communities. The experience demonstrated that the mobilisation of citizens requires social components, but also reaching out to the 'right people' that help to raise the interest first, and then multiply it throughout the community. Additionally, the high number of multi-owner buildings and renter-occupied buildings is not only a barrier to the integration of renewable energies, but also to current decision-making processes. It has been pointed out that different ownership of houses makes current decision-making process very complex, which will further hinder the energy transition progress. Despite these obstacles, there are several examples of neighbourhoods in Amsterdam that already became energy efficient and self-sufficient. These transformations were implemented effectively at a smaller scale by the local initiatives as the residents who live there know each other and share common facilities and values. Overall, the participation and collaboration can be evaluated as 'low' for the context of Amsterdam as there is still a large gap in cooperation between stakeholders,

however, there is some engagement of citizens resulting in local initiatives in some neighbourhoods in Amsterdam.

Techno-economic development

In terms of techno-economic aspects, the participants highlight that technological solutions (i.e., RE-technologies) and financial streams (i.e., subsidies/loans) are already there in the current energy system. However, there is a number of obstacles that hinders these available solutions to be implemented. One of the challenges is data availability. Currently, a lack of data limits the ability to conduct the proper analysis of the market and the current state of the energy transition. Another challenge is a lack of knowledge/awareness, which is particularly important as the subsidies/loans are most of the times available, while only a small part of the population makes use of it because the majority does not have information about it. Another challenge is the current regulatory framework, which still creates barriers for implementation of technological solutions and local community energy initiatives (including installation of common storage batteries). Overall, the techno-economic development can be evaluated as 'low' in Amsterdam with the abovementioned steps to be taken on the pathway towards the vision.

Business models

In the discussion on business models that support the energy transition, it has been highlighted that all stakeholders in the current energy system have different motivations. While the investors (that could also include the energy consumers) are driven by exceptionally monetary motivation – to earn and save money, the private companies are facing the 'outside' market pressure (e.g., societal pressure) to make the companies to act more environmentally consciously. On the other hand, the energy consumers/citizens are driven by different motivations including *monetary* (money being the reason why people want to do something), *social* (pressure from outside or desire to affiliate with local community) and *environmental* (sustainability morality). However, the experts believe that the attractive business model for the energy transition is the one that is not about profit but about creating a liveable environment for citizens. The interviewees also highlighted that energy consumers derive much value from the social aspects or participating in energy projects, where they can engage with neighbours and also have influence on larger societal decisions such as where the communities' energy comes from. Therefore, a business model that focuses on these values will appeal to energy consumers. It was also highlighted that it takes a lot of time, effort, knowledge and experience to start the transition, therefore, successful examples and business models that are already in place can help in this process. Overall, the business models in the current energy system can be considered at their 'moderate' state with some successful models being used, but with some room for improvement.

Equity and energy poverty

In the current energy system in Amsterdam, energy poverty is not considered as a separate issue but as part of poverty in general, which is why improving energy efficiency is not perceived as a priority. The interviewees highlight that there are still no examples of 'inclusive' policies that would consider all groups of population in energy transition. Most of the existing policies use the similar tax leverage for reducing the emissions (higher tax for gas-based, lower tax for RE-based) for all population groups without considering the differences in their financial conditions. Moreover, with the prevailing number of multi-apartment houses and rental houses, many citizens are unable to benefit from the financial incentives such as subsidies as they do not own the house but rent, while only the owners can get a subsidy for increasing the energy-efficiency of the house. Additionally, there is a lack of funding and subsidies for elderly people (above 75 years old), which leaves them excluded from the energy transition. However, the energy poverty at the current energy system in Amsterdam is

relatively low, while equity remains a concern. Overall, this domain of the system can be evaluated as still 'low' in Amsterdam.

7.2.2 Vision for the desired future energy system

This section will focus on the desired future energy system in Amsterdam. The analysis of the vision reflects on the future energy system across the themes of analysis: participation and collaboration, techno-economic development, business models, equity and energy poverty. The analysis of the interviews with different stakeholders across the four themes contributes to understanding of their collaborative vision and proposals of desirable features according to these themes for the Amsterdam's future energy system.

Participation and collaboration

In the future energy system, there are various stakeholders with specific roles that will be equally important and will need to collaborate. These stakeholders include Distribution System Operators (DSO) (first who face the problems in transition), tech-companies (that provide solutions), and citizens (who appoint community representatives to reach higher levels of participation in energy systems). The role of utility companies is envisioned to change immensely and their importance to decrease by time due to the transformation to a decentralised system. The interviewees believe that if everyone follows and adopts to their (new) roles, this would lead them to achieve their common desired goals in the future energy system. Hence, collaboration among all these stakeholders will be important. It is envisioned that all stakeholders will be able to communicate being in an equal position in terms of information and leverage as the Dutch are more likely to apply the bottom-up approach rather the top-down. It is mentioned that citizens are often left out and may not communicate in an equal position because a big company has more expertise and financial resources than them. The experts envision the future energy system with more engagement in communication and collaboration where the municipality leads the mediation between the two parties to facilitate communication. Due to the Dutch context where citizens prefer more the bottom-up system, the participation and collaboration in the future energy system is envisioned as 'very high'.

Techno-economic development

In terms of techno-economic aspects, the interviewees envision the future energy system as a smart system where a combination of sustainable and decentralised energy generation, flexibility and storage, as well as reduction of consumption are implemented. The combination of these solutions is targeting at reducing energy losses and transition to more sustainable energy source, with the main focus on replacing the heating system. Promotion of electric mobility and shared mobility was also mentioned as an important component of the desired smart energy system. It is highlighted that 'it is old-fashioned to think that everyone has to own a car'. However, for the smart energy system to operate, the foremost factor is information/knowledge regarding available subsidies, technological opportunities, etc. Hence, the desired state of the techno-economic development in the future energy system is envisioned as 'very high' as the energy system is expected to transform drastically in terms of technological advancement and financial sustainability.

Business models

The interviewees envision a system where new business models will offer material support instead of the financial, such as storage batteries donation or collective purchasing instead of monetary incentives. They also mentioned that the standardised smart appliances that are multifunctional (e.g., heat pumps already including metering installed in the factory) would make the new system more attractive and affordable, as this will imply a 10-fold cost saving for residents. While there will always be a demand for energy, and investments towards its production will always be made, either by

companies, the municipalities, or citizens, it is important to identify for what purposes the financial means will be invested. For instance, companies would continue prioritising investments in polluting energy sources such as fossil fuels and less energy efficient technologies, if these are the profitable choices and if consumers do not show a substantial resistance to that. Therefore, communication between the three parties – municipality, companies, and citizens – needs to ensure the investments are made in an agreed direction, in order for the vision to be achieved without subsidies. Nevertheless, subsidies will always be necessary at the piloting stages of projects while the financial incentives are crucial component of the smart system. Overall, the business models in Amsterdam are envisioned to achieve the 'very high' level in the future energy system as they are considered as an important cornerstone for the energy system transformation.

Equity and energy poverty

The interviewees envision the policies to be obligatory in the future energy system as they agree that it would work better than recommendations in the context of Amsterdam. Obligations for complying with the future energy system can include, for example, increasing energy efficiency levels. These 'obligatory' policies should be accompanied with financial costs for not complying, such as fines. From the other hand, being obligatory, the policies are envisioned to be also inclusive allowing a wider part of the population to make energy-related decisions (e.g., investments) and benefit from them. Additionally, inclusive policies are envisioned to support societal equity. Solutions such as car sharing in the future energy system are envisioned to allow accessing electric mobility to those who cannot afford to own one. Overall, as this domain of the energy transition in Amsterdam is at its relatively acceptable level, in the future energy system it is envisioned to scale-up for at least one step and achieve the 'high' level of performance of equity and energy poverty reduction.

7.2.3 The current and envisioned performance of the energy system in Amsterdam

This section demonstrates the performance of the current energy system and its desired performance in the future. Overall, the domains of the current energy system are evaluated as 'low' and 'moderate' as the city already shows some progress in its energy system transformation. At the same time, the future energy system is envisioned to achieve its highly advanced state according to the experts' visions and the goals of the Roadmap. The comparative analysis of the current performance of the energy system domains and the envisioned performance of the future energy system 2040 in Amsterdam is shown in Figure .

Comparing the vision of the interviewees and the goals of the Roadmap, it is clear that they align with each other to some extent. On the one hand, the Roadmap reflects on more general goals targeting the electricity and the heating system transformation with the major focus on technological advancement. On the other hand, the interviewees show a more detailed vision with specific solutions that majorly prioritise citizens in the transition.

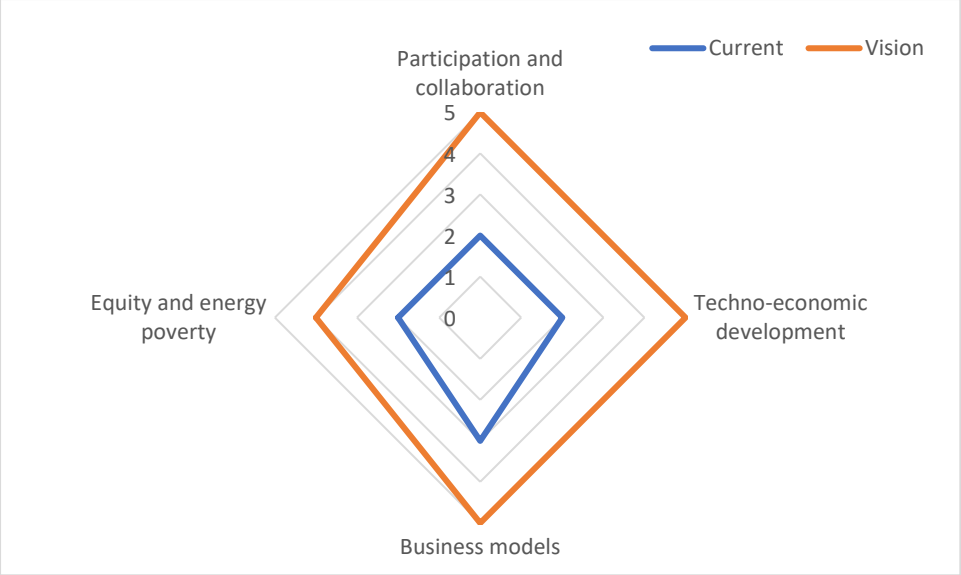

Figure 7.2. The current and envisioned performance of the energy system in Amsterdam.

7.2.4 Desired energy transition pathway to achieve the vision

Considering the current level of performance of the current energy system, its drivers, barriers, and the local context, changes and action are required in order to achieve the previously elaborated vision for the future energy system. The interviews allowed to identify possible actions that support the local energy transition pathway towards the desired future energy system. Hence, this section describes the desired energy transition pathway and the individual actions respectively for each theme of the analysis.

Participation and collaboration

According to the opinion of all participants, building trust between partners and organising citizens within a neighbourhood are central for the desired energy transition pathway in Amsterdam. In order to implement these two objectives, the first step would be building a local network through interacting with local citizens. Both the government and the private sector could play a role in reaching out to community initiatives. Understanding and aligning different goals would allow for scaling up small community initiatives by offering tailored information and regulatory flexibility. Also, educational activities such as trainings and interaction between citizens are suggested as key actions that could help to increase knowledge and awareness of all citizens. Additionally, for the desired pathway in Amsterdam, it will be crucial to also address the homeowners through well-formulated pitches in order to accelerate their participation and collaboration instead of waiting for them to comply with obligatory regulations. Overall, these actions would support trust and the inclusion of citizens in the collaborative pathway that supports the local energy transition.

Techno-economic development

There are three steps towards achieving the goal 2040: Reduce (reduction of energy losses), Reuse (reusing waste as energy source), Produce (producing energy locally from different sources). From the technological point of view, it will be expensive to invest into insulation and technology adoption at the same time. Therefore, transition to a smart system shall start from small steps instead of the ideal set of solutions. These small changes through time are more attractive and can be implemented at a local scale with support from the government in terms of legal aspects. The current regulations and laws that are in place cause different obstacles for local initiatives and local energy communities in

energy transition. In order to enable this small-step approach, inclusive and more flexible regulations and policies are important.

The municipality is responsible for making it interesting and attractive for residents to invest, for example, by providing different subsidies/loans at different levels (local, regional, national) combined with information on available opportunities in terms of technologies and finances. In terms of timing, it has been emphasised that the most suitable and beneficial way for citizens to invest in technology adoption and insulation of their houses is at the time when they purchase a new house. The reason is that they have an opportunity to loan money for increasing energy efficiency in their building as part of their mortgage (received for purchasing a house). Free consultations from the municipality on the best available options to insulate houses and technology adoption are highlighted to be foremost towards the acceleration of energy efficiency.

Business models
The transition will take time as currently it is available mainly for high-income households, while low/middle-income households are still excluded and some remain vulnerable (experience (energy) poverty). Following the small-step approach in the implementation of technological solutions, investments can be made accordingly in several steps involving different parties. Both national and local governments should be responsible for the local energy transition in terms of financial resources. Other key investors that could support the transition pathway include sustainable banks and people volunteering in the energy transition. The interviewees state that unlike current practices, it is imperative to communicate the purposes of investments between the stakeholders to ensure that investments are made in an agreed direction in order to achieve the vision. The overall vision could partially be achieved in a subsidy-free way. However, subsidies for the energy transition in Amsterdam will always be necessary at the piloting stages of the transition projects.

Equity and energy poverty
Changing the mindset of citizens is an important step towards the energy transition. A substantial part of the population is viewed as yet to be convinced to play an active role in the energy transition, such as increasing energy efficiency in their house or investing in solar panels. Awareness campaigns are one of the desired solutions for empowering citizens to make decisions that will benefit them the most, especially the vulnerable groups. Increasing awareness will also help in supporting the energy poor by providing the information how to keep the house energy-efficient (e.g., with different types of appliances). In addition, solutions such as shared mobility can make expensive technology more accessible, such that a wider population can stay up-to-date on the developing technology.

7.2.5 Discussion of the overall scenario

The transition in Amsterdam has already started with multiple energy efficient and self-sufficient districts and neighbourhoods being observed. However, there is still a long way to achieve the goal 2040. There are several drivers and barriers in the current energy system in Amsterdam. It is recognised that the main barriers are a lack of awareness of how to achieve energy efficiency and a lack of knowledge about available funding for this purpose. It is also highlighted that there is a lack of inclusive policies towards the vulnerable groups of citizens, and a complicated bureaucratic process that hinders the local energy initiatives from scaling up. Another barrier is a lack of citizens participation and collaboration among all stakeholders that significantly slows down the energy transition. However, there are some drivers in the current energy system of Amsterdam; they include technological solutions and financial incentives (e.g., loans, subsidies) that are available but not implemented or used yet, local initiatives and relatively low energy poverty.

What the participants envision is that the city of Amsterdam by 2040 achieves an energy system where the citizens are better heard and enabled to set the direction, larger companies align their goals better with consumers, and municipalities bridge the gap between groups with different interests and resources. The vision of the future energy system also includes to raise awareness for the population on how to achieve energy efficiency in their houses with and without investments, as well as upscaled local energy initiatives. It is also envisioned to have more inclusive policies that would allow the vulnerable groups to access the energy and afford their energy needs. Using the driver of the current energy system, it is expected to achieve RE-based technological advancement in an economically feasible way.

In order to transform the current energy system in Amsterdam into the envisioned energy system 2040, one of the possible scenarios of the energy transition focusses on eliminating the abovementioned barriers of the current system and using the drivers to achieve the goal 2040. The key elements of the foresight exercise for Amsterdam are summarised in Figure . The desired pathway to achieve the envisioned future energy system in Amsterdam is highly related to its context. In the city of Amsterdam, there are numerous challenges such as space scarcity, old buildings, and increasing population with many tenants. In order to address these challenges in the energy transition, it is key to use a reduce-reuse-produce approach promoting circularity, as well as increasing energy-efficiency of the buildings. Also, due to the Dutch cultural features, some of the policies (e.g., for increasing the energy efficiency) shall be obligatory rather than recommended, as this works better in the Dutch context. Also, Dutch people prefer the bottom-up approach where they are communicated about the changes and transition at an equal position with other stakeholders. They expect to be able to make decisions and initiate projects where the government will play a supporting role instead of leading.

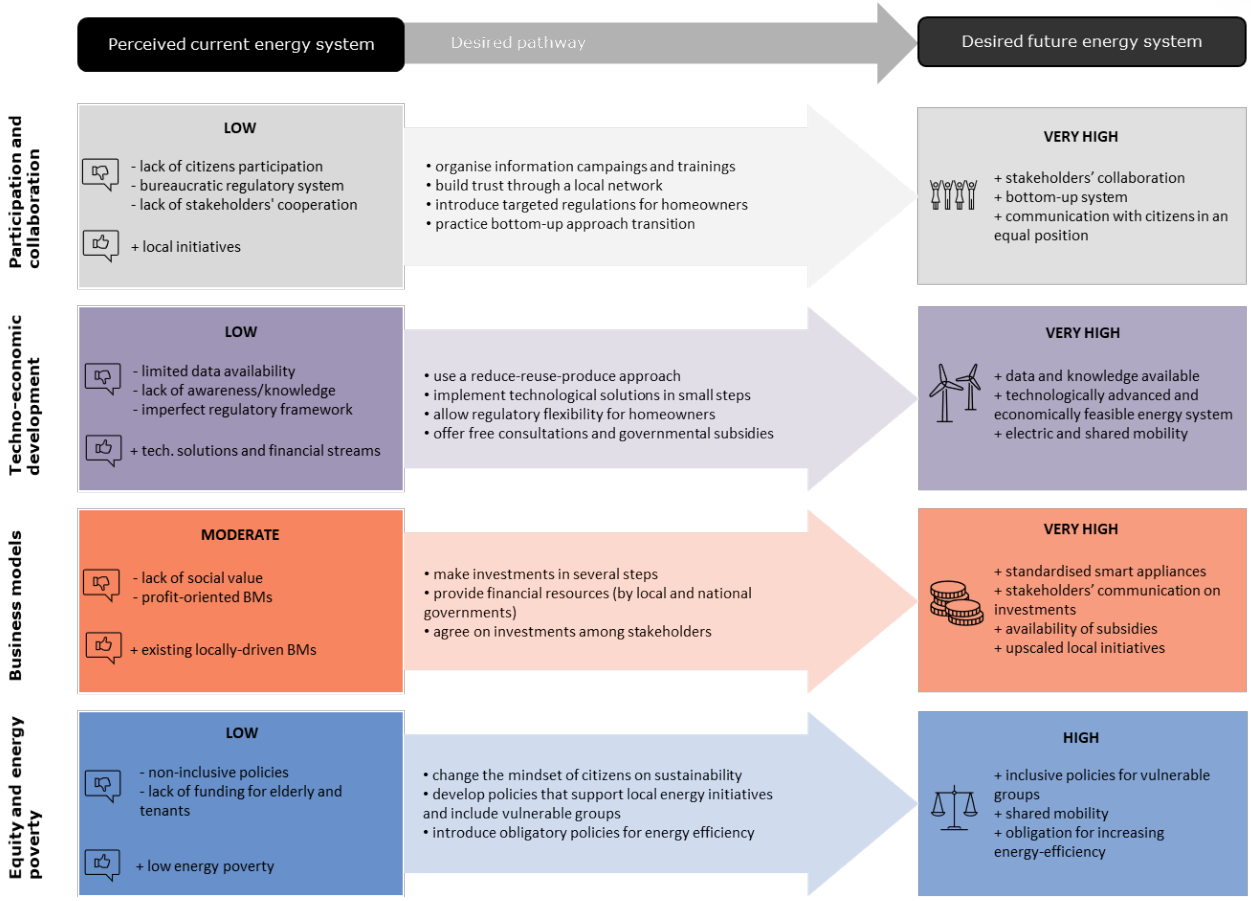

Figure 7.3. Key elements summarising the barriers and drivers of the current energy system, overall vision of the future energy system, and a possible pathway to achieve this vision in Amsterdam.

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8 Nottingham, United Kingdom

Heinz, Helen; Stathopoulou, Eleni; Derkenbaeva, Erkinai; Arslangulova, Botakoz; Lopez Dallara, Maria Lujan

8.1 Context

The UK was the first major economy to create a legally binding target to bring greenhouse gas emissions to net zero by 2050 [1]. This requires many sectors to be net zero carbon by this date including the building stock, heat, power, and transport sector. For instance, in terms of building stock, the Committee on Climate Change forecasts that in the UK 29 million residential buildings will need to be retrofitted to reach the required carbon savings [2] This means that approximately one million homes per year need to be retrofitted during coming 30 years with £1 billion of funding being allocated across several existing government schemes[3] It is estimated that retrofitting to Energy Performance Certificate (EPC) C level could reduce annual energy bills to about £7.5 billion [2]. Figure shows that the UK energy system still depends heavily on fossil fuels and increasingly on nuclear energy with relatively low shares of renewable energies, while coal is supposed to phase out by 2025 [4].

Nottingham is a city in the East Midlands of England with a population of 330,000 [5] covering an area of 75 square kilometres [6]. The population of the city is approximately 29.7 years old, which makes it the youngest place after Oxford in the UK [7]. This high proportion (28%) of 18- to 29-year-olds relates to the two large and growing universities with approximately 60,000 students [8]. Still, Nottingham is a highly deprived area, where the households in the city have the third lowest level of access to a car in England.

Nottingham aims to become a low-carbon city by 2028. Nottingham City Council has a high level of engagement in energy transition, attributable to historical context, political-economy, and political commitment to a local decarbonisation plan [9]. Nottingham has a sizable energy management staff that might influence on proactive engagement in energy transition. The Council is aware that currently, 58.2% of Nottingham's housing stock is below an EPC C level and poses a key challenge [3] Nottingham has a fuel poverty strategy aiming to provide affordable warmth and healthy homes for all citizens [10], searching for energy and cost-efficient solutions for retrofitting the stock [9]. Nottingham City Council and Nottingham City Homes have recently completed an Energiesprong[6] pilot project of retrofitting ten properties to explore ways of preparing homes 2050 ready [9].

[6] Energiesprong is an innovative approach which is a self-financing and viable business model in the Netherlands. Typical interventions include:
– A new thermally efficient wall envelope created with prefabricated panels manufactured offsite,
– PV built into a thermally-insulated roof cassette, also manufactured off-site,
– Air source or ground source heating,
– Removal of gas to create an electricity-only property [9].

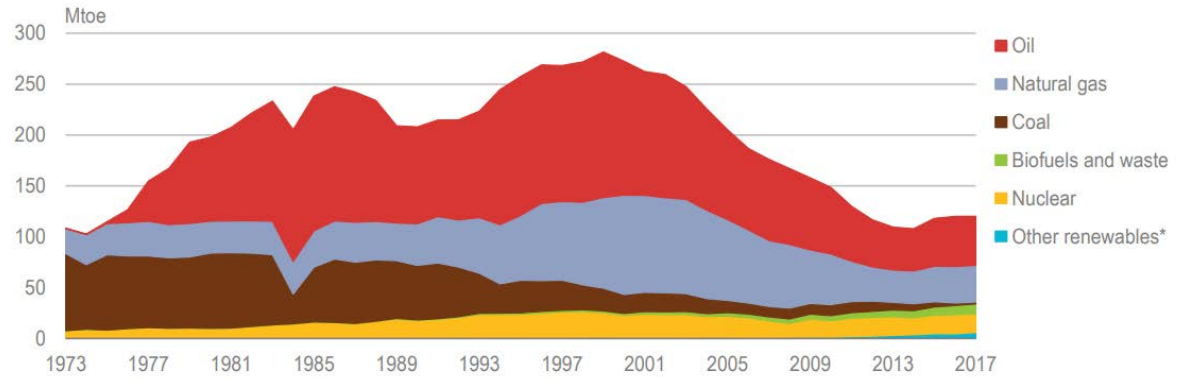

Figure 8.1. Energy production by source in United Kingdom, 1973-2017.
Source: IEA (2019). World Energy Balances 2019 First edition (database) [4]
*Note: *Includes wind, hydro, solar and geothermal.*

8.2 Results

This section presents the findings from the foresight interviews conducted in Nottingham. It includes an overview of the current state of the energy system in Nottingham, the desired future energy system, and a possible pathway to achieve this desired future starting from the baseline. The results are based on two interview rounds with a total of 5 interviews, with participants that represented the following stakeholder groups: business experts/ industry representatives and technology experts.

8.2.1 Perceived current state of the local energy system

The analysis of the current energy system in Nottingham reflects on the current barriers and drivers in the system across four themes: participation and collaboration, techno-economic development, business models, equity and energy poverty. The overview of the current energy system from the perspective of different stakeholders contributes to a complete picture of the baseline from which the energy transition in Nottingham will take off or further continue.

Participation and collaboration

The interviews revealed awareness that collaboration is crucial but that there is potential 'silo thinking' and lack of trust among the many collaborators. The business experts agree that universities and technology companies are relatively easy to collaborate with, while collaboration with bigger companies or developers can be more challenging. This can be because of their governance structure, the pressure for economic value and financial constraints, but also because of uncertainties and changes in level of engagement. Municipalities and their energy contractors typically lack the time, knowledge, and human resources to complete energy transition projects. Also, the level of citizen participation is still limited, which according to the interviewees, is due to a lack of knowledge, but also because the government does not translate their energy transition ambitions in an understandable way to the society. In fact, a business expert states, that even if the citizens would want to engage and establish an energy community that shares electricity, it would not be possible by law. Nonetheless, the interviewees also recognise that the British culture might affect the citizens' attitude towards participation in communal energy sharing and efficient energy consumption, because there is still a lack of understanding of and experiences with these concepts. However, there are already some citizens led initiatives such as the Hockerton Housing Project in Nottingham, where a group of environmentally motivated citizens engage in building low energy houses. Still, for all stakeholders and especially citizens the bureaucracy and laws make proactive engagement into

energy transition difficult. The resources, being time, money, and motivation, which are not enough to overcome this barrier, contribute to an overall 'low' participatory and collaborative energy system.

Techno-economic development

In Nottingham there is a coal fired power plant. Nevertheless, Nottingham is actively supporting with 'will and money' the uptake of renewable energies within but constrained by the existing national legal framework. For instance, they set up 'Robin Hood Energy' a non-for-profit energy company, which unfortunately failed and collapsed in 2020. Regarding transportation, the University of Nottingham also has a Vehicle to Grid trial, investing into innovative solutions supporting electromobility for the city. Furthermore, Nottingham is one of the only cities in the UK with a district heating network. However, the interviewees criticise the users being locked to one energy supplier as this does not make the system completely attractive and energy just. Still, the biggest challenge in Nottingham is the low energy efficiency of the existing building stock, and the often badly constructed new houses, according to the business interviewees. This leads to the fact that heating is often the biggest part of energy costs of the British households. Currently, the construction sector and heating schemes do not tackle this issue sufficiently. The common practice of the government is to do 'what does the law says rather than what's right'. A business representative warns that a change of mind-set to a forward-looking perspective on considerations and technology planning is needed from the government to leave the business-as-usual behaviour. The interviewees agree that this is the major issue that needs to be tackled in their energy system, with technology solutions that need to be affordable because not all consumers can afford them at this point. Therefore, this theme has been assessed with being 'low'.

Business models

Currently there are several policy barriers that block developing or operating potential business models, which could facilitate the energy transition. For example, a small innovative company which builds a small estate of houses with solar panels on roofs and creates a communal energy system with e.g., shared battery supply, will face significant difficulties and complexity in the UK due to current legal framework. In fact, the implementation and investment into renewable energy technologies is not attractive for landlords as there is no tariff system in place. In the past, this tariff system had created an attractive business case, however, in the current energy system, there is not enough payback, rather just costs. There is also the risk, that the people do not use or there is lack of understanding how to use the technology properly, which would increase the costs even further as there would not be any returns. Economic value is needed as an incentive, while environmental and social value are mainly drivers for satisfaction and marketing for individuals and business owners. Few who do participate in energy transition business models need to be highly driven by their values and moral as the business models are not financially beneficial. The interviewees are sure that in the current energy system, lack financial incentives which are needed as otherwise there is no interest in participation. The discussion with the different interviewees therefore results in an evaluation of 'very low' for this category.

Equity and energy poverty

Energy poverty is a well-established concept in the United Kingdom's related policy initiatives. In the UK and particularly in Nottingham, social pressures have increased to address this issue. Nottingham's city council and social housing providers have officials and staff committed to address 'fuel poverty' (this is the prevalent term in UK policy talks). The council owns social houses 'Nottingham City Homes', which consist of old and new building stock, and had put efforts in cooperation with business partners to make the houses more sustainable and energy efficient. Nonetheless, the interviewees state that there could be more consciousness in governmental projects and from the business side about

affordability for the users. Housing developers still build houses that are not energy efficient and badly fabricated. An immense change is needed in the behaviour of these developers and the government, to break the lobby-thinking of the current system and tackle energy poverty in the long-term. This section has been assessed as 'low' as awareness and first initiatives are there, but they are not considered to be enough to achieve equity and tackle energy poverty in the current energy system.

8.2.2 Vision for the desired future energy system

This section will focus on the desired future energy system in Nottingham. The analysis of the vision reflects on the future energy system across the themes of analysis: participation and collaboration, techno-economic development, business models, equity and energy poverty. The analysis of the interviews with different stakeholders across the four themes contributes to understanding of their collaborative vision and proposals of desirable features according to these themes for Nottingham's future energy system.

Participation and collaboration

The future energy system will have different stakeholders participating and collaborating. The government will have a central role but also technology companies will be important to bring technologies to the market, with the academia to share the knowledge about technological solutions. Engagement of the general public will be a crucial aspect, as they are needed for a democratic system and to provide their opinion. It will be expected that the municipal agency facilitates discussions between the public and private sector partners and encourages private sector participation in energy projects such as through social housing providers. In the desired future energy system, there will be a sense of a community for householders, property owners, tenants, and those more vulnerable to accept technology changes in a collaborative approach. It is envisioned that there will be trustworthy relationships at the community level in different neighbourhoods, as increasing trust among property owners leads to continuous investment on renovation and refurbishment of old buildings. At the same time, the interviewees envision a high level of consultation and discussions between the different stakeholder groups. That is, the various stakeholders value each other's views, exchange them, make recommendations, and have a feedback system. This will be especially important for the collaboration with communities to create a space to hear their opinions, problems, and feedback on implemented solutions. These different mechanisms will support a 'very high' level of collaboration in the future energy system.

Techno-economic development

The future energy system will demonstrate techno-economic solutions from the supply side so that consumer behaviour will not be that important anymore. The energy supply will consist of renewable energy from offshore wind farms, tidal power, solar power, and other solutions. For example, also vehicle to grid, virtual power plants, or communal battery storage could be in place to mitigate the demand on the power grid. It is desired that the high level of supply will even bring energy prices down, which will be beneficial for vulnerable households. The heating will be electrified, energy consumption will be reduced, managed, and understood, and buildings will be retrofitted and energy efficient. To reduce energy consumption in buildings a combination of energy-saving measures regarding isolation, heating, cooling, and ventilation is adopted. For buildings that cannot be renovated e.g., old multi-story concrete buildings, a business expert envisions that they could be used for local renewable power stations. They would have for instance solar PV and battery energy storage systems to power the local neighbourhood, or even the rest of the city, with economic pay-back to use for the maintenance of the building. The visions of the interviewees demonstrate that the future energy system will have a 'very high' level of techno-economic development.

Business models

The future energy system is unlikely to function in a subsidy-free way. Public funding will play a significant role not only in the energy transition, but also in the future energy system. It is the responsibility of governments to create new incentives for both business and residents to create new ventures. Government, potentially through policy actions, should provide long term certainty to developers to invest in financially viable business models. This will allow for an increased level of private investments. Also, citizens are envisioned to be involved in business models of the future energy system through innovative approaches and other institutional funders in 'crowd fundraising'. The business experts desire a system, where there is a paradigm shift away from the culture of 'owning things' to 'renting things' (for example houses and cars), allowing for new business models. Similarly, there could be innovative business models based on communal batteries and selling energy locally. At the same time, this could include new ownership models, where for instance the parish council could be the owner of the battery system, distributing the benefits to Nottingham citizens directly. Based on this overall vision, this dimension has been assessed to be 'high'.

Equity and energy poverty

While the interviewees think that demand management and changing energy consumption behaviour to help reduce energy poverty will be important, they believe that the future energy system cannot rely only on smart meters but rather energy efficient building stock. The interviewees desire improved policy measures reducing energy inequity and energy poverty, recognising their important role for a fair energy system in the future. In fact, the future energy system is desired to empower marginalised consumers, engage NGOs and other social associations. The interviewed researcher envisions that the local government regularly talks to vulnerable communities and allocates more funding to them. The awareness on equity and energy poverty will remain a 'high' priority in the future energy system.

8.2.3 The current and envisioned performance of the energy system

This section demonstrates the performance of the current energy system and its desired performance in the future. The domains of the current energy system are evaluated as mostly 'low' apart from business model innovation and feasibility with 'very low' as according to the interviewees there are still immense barriers. Similarly, the interviews demonstrated that the future energy system consists of 'very high' levels of participation and techno-economic development, and 'high' levels in the business model and equity and energy poverty domains. Nonetheless, this means that in all domains there are many efforts and changes needed to achieve the energy system transformation. Figure 8.2 shows both Nottingham's thresholds demonstrating the changes that have to be made under the local energy transition pathways. Nottingham is known for its engagement towards an energy transition, but according to the findings of this analysis the city council has to work even harder and more collaboratively to achieve its local energy transition. Still, many changes do not depend on the local government but upon the central government which provides financial resources and regulatory environment within which the local government can act. Finally, while the desired vision of the interviewees with regard to justice and elimination of energy poverty could also be very high, their more realistic vision demonstrates that they are aware of the challenge of it.

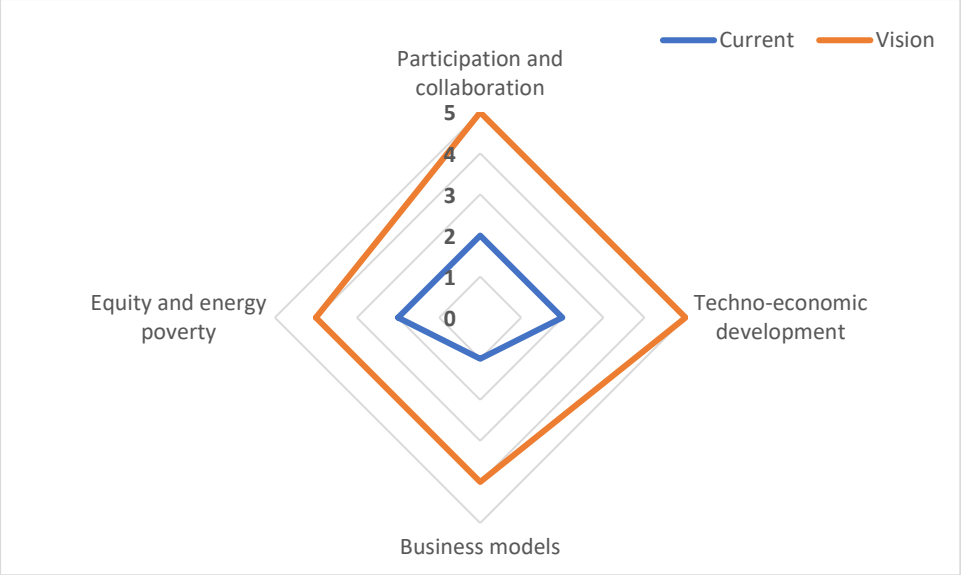

Figure 8.2. The current and envisioned performance of the energy system in Nottingham.

8.2.4 Desired energy transition pathway to achieve the vision

Considering the current level of performance of the current energy system, its drivers, barriers, and the local context, changes and action are required in order to achieve the previously elaborated vision for the future energy system. The interviews allowed to identify possible actions that support the local energy transition pathway towards the desired future energy system. Hence, this section describes the desired energy transition pathway and the individual actions respectively for each theme of the analysis.

Participation and collaboration

To achieve the very high levels of participation and collaboration the interviewees propose several actions. First, there should be a clear top to bottom dissemination of knowledge. That is, international level dissemination to the national level, national level to municipal level and municipal level to individual/community level and businesses. The interviewees are convinced that the energy transition will not be a bottom up, citizen led initiative, but their engagement can certainly increase along the pathway by increasing education and awareness about it. This can be achieved through various measures such as energy audits and awareness raising campaigns. Universities can act as 'vocal voices to whom people believe'. It is very important that altogether legislation, regulation, and government initiatives are being made understandable and less complex for the citizens. Furthermore, law should support towards removing infrastructure and economic barriers and facilitating behavioural change through policy measures and incentives, to make participation and engagement of citizens generally easier. Citizen engagement could further arise from seeing and learning from small scale trials of energy communities and the city council own implemented energy efficiency measures. Additionally, constant communication between local authority and community, where they listen to each other's opinions and establish trust, is an important action along the pathway, supporting a democratic and just transition. This can be achieved through various means such as surveys, referendums, public hearings, or monitoring and engaging on social media. This will create trustworthy relationships at and within the community level. With national and public government, private sector, academia, and general population all combining their efforts the interviewees believe that energy transition targets can be achieved.

Techno-economic development

The first step to achieve the future techno-economic development is to increase the general consciousness about energy use and provide information about technical benefits of appliances such as smart meters. Education is important as along the transition, skilled people will be needed to install the technologies; That is the gradual implementation of renewable energy sources, with then increasingly batteries along with heat pumps and solar PV systems at household level which will also play a role. In any way, the energy transition needs to be delivered by cost-effective and market ready solutions. Energy providers and citizens need to be incentivised to implement renewable energies. The increased electrification of heating and transport will be a major challenge at the beginning, which needs to be tackled. A starting point according to a business representative could be to nationalise the power grid. Furthermore, it is important to build energy efficient buildings and retrofit the old building stock. To reduce energy consumption in buildings a combination of energy-saving measures is needed to achieve the Net Zero target. Government and local authorities play an important role in supporting retrofitting through support via policy measures, increasingly tightened building standards, and incentives. In fact, the government should develop and follow a complete strategy and roadmap on how to transform the current building stock and other technologies. This implies a mindset shift away from business- as- usual towards a forward-looking perspective.

Business models

The national government needs to drive the engagement of business stakeholders and consumers, and the development of innovative, new business models. Legislation needs to be reviewed to reduce barriers preventing new business opportunities that can export clean technology, skills, and know-how and accelerators of the energy transition. At the same time, the government should continue to incentivise businesses, companies, and households to participate. Especially the housing sector needs funding and should be priority in the policies. Further support from the government to support companies within this transition can be through public private partnerships. A business representative states that it will not necessarily be important to provide direct financial support, but to reduce their costs through e.g., reducing taxes and provide reputational support. These actions can support their gradual transition and help them to make profit. Once support is in place, companies can maintain profit, and consumers are actively engaged, the government could gradually phase out from the business process.

Equity and energy poverty

The reduction of energy demand and changing towards a more sustainable energy behaviour could be the starting point and a sustainable long-term solution to tackle energy poverty. Still, this should not be the primary approach, instead, energy affordability and tackling energy inequality should be at the forefront of government policies. Additionally, not only the vulnerable households should be addressed but also the landlords should be involved in campaigns that target the overcoming of energy vulnerability. Furthermore, there should be demonstrations of successful technology adoptions and housing renovations for instance by a local neighbourhood. Monitoring of the houses over time to show usage, demand, and benefits could also serve as effective demonstrators for all stakeholders. Still, at all times, the actual needs and opinions of the vulnerable households 'need to be heard', as suggested by a business representative. Conducting interviews, engaging in social media, or making telephone calls could be valuable ways to reach out to the vulnerable part of the society, ensuring the increase of equity and decrease of energy poverty along Nottingham's energy transition pathway.

8.2.5 Discussion of overall scenario

This analysis looked at diverse perceptions of the current and envisioned future energy system amongst technical specialists, academics, and business stakeholders in Nottingham.

Currently, the local energy system of Nottingham presents potential 'silo thinking' among the many collaborators and municipalities and their energy contractors typically lack the time, knowledge, and human resources to complete energy transition projects. There are hurdles for technology and business innovation. However, the main issue in the current energy system resides in the inefficient building stock and the need for retrofitting. At the same time, in the UK and particularly in Nottingham social pressures become apparent at cooperative and household level as energy poverty is high. Nottingham's city council and social housing providers have resources committed to addressing fuel poverty and increase justice and social coherence.

The interviewees envision a future energy system with very high levels of collaboration and energy efficiency. Future collaboration and a sense of a community for householders, property owners, tenants, and those more vulnerable will support acceptance and implementation of modern technologies in a collaborative approach. Innovative business models and technologies are desired to be feasible in the future energy system. Interviewees envision approaches to implement a mix of technologies and to involve citizens or other institutional funders could be for example 'crowd fundraising' or new paradigms away from 'owning' things.

All stakeholders agree that reaching the net zero target is a huge challenge, but it can be achieved through combined efforts, addressing the four themes of analysis (Figure). They all think that the energy transition can be achieved involving not only technology but also social drivers. Then, further policies and incentives will be needed to enable the adoption of technologies and transformation to energy efficient buildings. In fact, the interviewees suggest regulatory changes with regard to all themes of analysis. That means, the key element of fostering the local transition and tackling the existing barriers is through policy.

The regulatory environment has been pointed out from the interviewees as the major barrier for a human-centric energy transition in Nottingham. At the same time, the interviewees positively mentioned some citizen initiatives in the housing sector, but stated that energy communities and sharing of electricity will be difficult to implement due to the lack of enabling laws but also due to the British culture. Also, the City Council is doing what it can within its powers and possibilities given the national regulatory context to initiate and follow a human-centric energy transition. The techno-economic development and certain social initiatives and approaches (e.g. district heating network or Robin Hood Energy) make Nottingham a forerunner in the just energy transition in the UK. The experience on tackling energy poverty and having 'fuel poverty' as a long-established concept demonstrate both ambition and skepticism of the interviewees regarding inclusion and engagement of citizens. The analysis of this region shows that it is not an easy task to develop PEDs, engage citizens in PEDs, and that full justice and absence of energy poverty is unlikely to be achieved in the future energy system. Nonetheless, PEDs could be developed supported by subsidies and changed regulations. Then, they could be appreciated in the future and designed to be a powerful tool to enable innovative business models and technologies and tackle energy poverty.

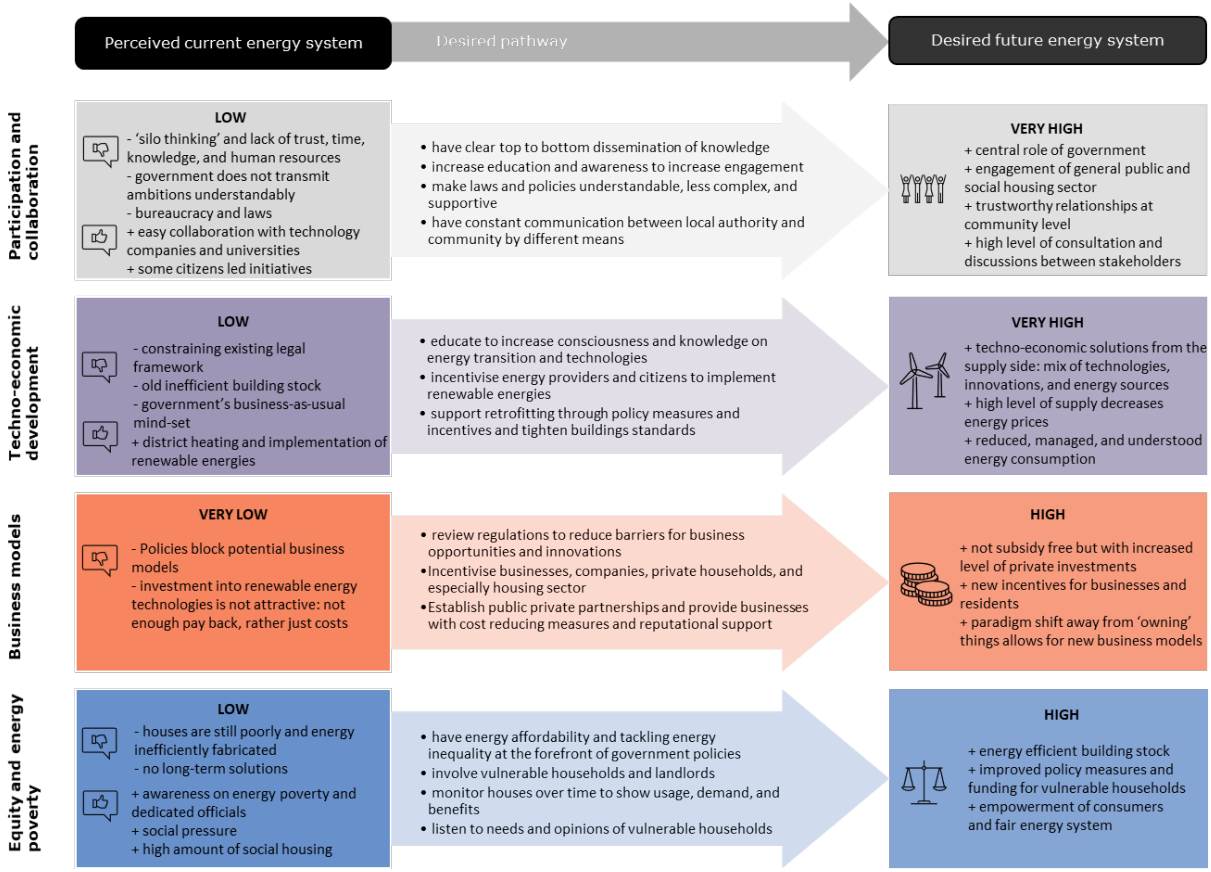

Figure 8.3. Key elements summarising the barriers and drivers of the current energy system, overall vision of the future energy system, and a possible pathway to achieve this vision in Nottingham.

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9 Vienna, Austria

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9.1 Context

Vienna is the capital, largest and most populous city (around 2 million inhabitants) of Austria. Its energy infrastructure is characterised by high level of centralisation, with one of the largest district heating systems in Europe. In Vienna, the sectors that contribute the most to its emissions are transport, energy, and buildings [1]. On the demand side, there are many mixed-use districts with residential and tertiary sectors dominating [2]. A small proportion of electricity consumed in the city of Vienna is coming from local renewable energy and a significant share is imported from its surrounding areas (e.g., the province of Lower Austria) [3]. In general, Austria is considered a frontrunner in green energy production, as it has many hydropower plants in its other provinces and bioenergy production [4]. Its last coal power plant was shut down in 2020; Oil and coal powered heating systems should phase out by 2035. The total energy supply from own and importated energy is given in Figure 9.1. Vienna has a typically dry climate with warm summers but cold winters, hence, heat constitutes the largest share of energy consumption. Another challenge that the local government is facing, is the city's growing population, wherefore increasing energy demand is expected [3].

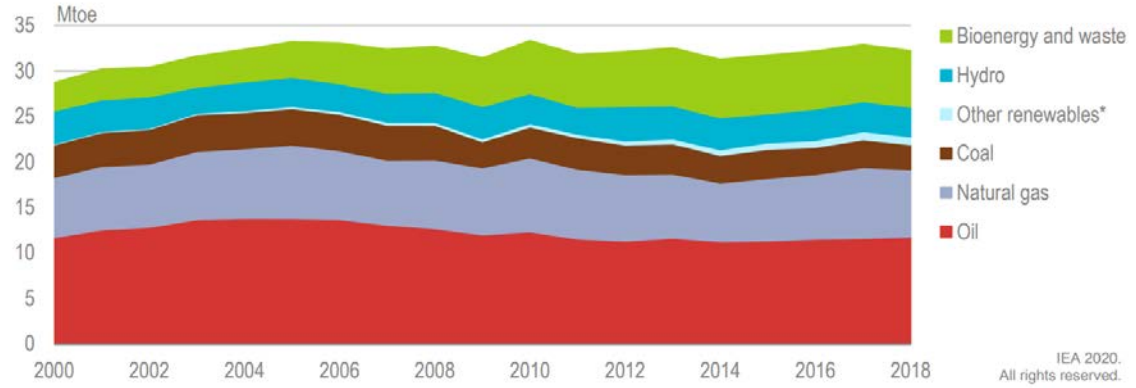

Figure 9.1 . Total primary energy supply by source in Austria, 2000-2018
Source: IEA (2020)
*Note: * Other renewables include solar, wind, and geothermal. Mtoe: million tonnes of oil equivalent. Total primary energy supply does not include bunker fuels. Electricity imports and exports are not shown in the chart.*

The local policy's focus is on decreasing building energy demand through stricter building codes, but also sustainable urban and energy planning, integrating digital technologies, and promoting sustainable transport modes (see Figure 9.1). The policy frameworks defining these include the Smart City Wien Framework Strategy 2030, the Climate Protection package, and the Urban Energy Efficiency Program 2030. The major stakeholder in the city that provide heat, electricity, transport services, etc is the municipality-owned utility company 'Stadtwerke'. At the same time, Vienna has a governance tradition that demonstrates dialogue with citizens and even co-creation processes. Hence, in Vienna

there is a close cooperation between the government and the public. Therefore, the government's priority has been an efficient service provision for all citizens, and since recently, also sustainability [3].

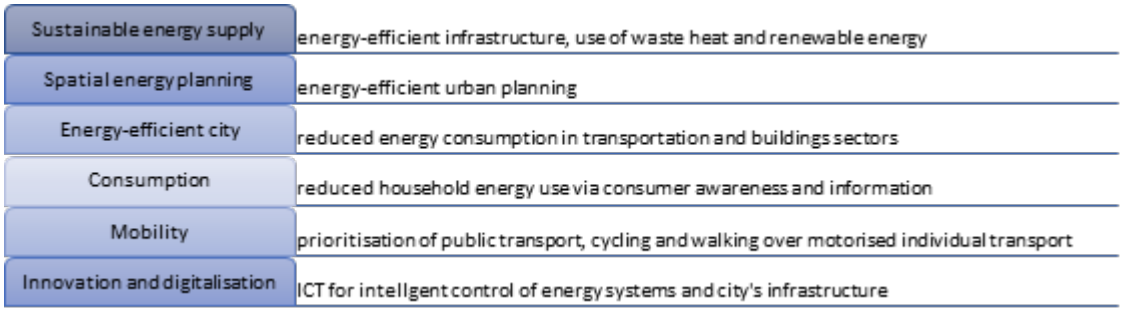

Figure 9.2 Key strategic areas of action in the Energy Framework Strategy 2030 for Vienna [3]

To approach the local energy transition more holistically, Vienna's strategy to develop a smart city includes several other technological but also business solutions and citizen-led initiatives. The local organisation 'Vienna Energy Forum' brings local and global stakeholders together to discuss and address challenges, strategies, finance, and other issues for sustainable development. Within this context, the share of renewable energy in the final energy consumption mix of Vienna has been increasing over the last years (from 5% to 10% between 2007 and 2014,) [3]. All new buildings under a subsidised housing programme will be supplied by 100% renewable energy and include innovative approaches for heating and cooling. At the same time, the city-owned energy provider, and subsidiary of 'Wieder Stadtwerke', Wien Energie supports the energy transition through a human-centric business model that supports ownership of local solar and wind power plants by the residents. Wien Energie established an ombudsman's office in 2011 as a contact, mediator, and counselling service for energy vulnerable households, collaborating with social services and government. Of 21,000 requests it had helped 14,000 households successfully in 2020[1] to tackle energy poverty and continuously develop the office and its services. Furthermore, the city invests into sustainable transport solutions to cut down emissions but also to provide future-proof sustainable urban mobility solutions for the growing number of citizens.

9.2 Results

This section presents the findings from the foresight interviews conducted in Vienna. It includes an overview of the current state of the energy system of Vienna, the desired future energy system, and a possible pathway to achieve this desired future starting from the baseline. The results are based on two interview rounds with a total of 8 interviews, with participants that represented the following stakeholder groups: policymakers, business experts/ industry representatives, technology experts, and environmental NGO's/ citizen group representatives.

9.2.1 Perceived current state of the local energy system

The analysis of the current energy system in Vienna reflects on the current barriers and drivers in the system across four themes: participation and collaboration, techno-economic development, business models, equity and energy poverty. The overview of the current energy system from the perspective of different stakeholders contributes to a complete picture of the baseline from which the energy transition in Vienna will take off or further continue.

Participation and collaboration

The perception of the interviewees in this region is that generally there are no stakeholder groups with which it is easier or more important to work with. The challenge is rather to include all groups of the society into a just energy transition process and identify a common basis among all stakeholders. That is, even though the goals and aims are the same, opportunities and possibilities for action may differ, which can hinder participation and collaboration. At the local authority level, for instance, there can be lack of capacity or strict need of compliance with laws and policies. Other stakeholders such as citizens need support to engage in participatory initiatives as they might not only lack of awareness but time or opportunities. Still, the citizen group representative mentioned the experience of developing and using a plan that outlines collaboration opportunities between varying stakeholders depending on the project stage. All interviewees state that participation and collaboration opportunities are developing. People increasingly try to make a change and participate in the local energy transition as, through media and discussions, their climate change awareness raises. The positive experiences of the interviewees allowed to assess the current energy system with a 'moderate' level of participation and collaboration.

Techno-economic development

The technology expert raises the point that in a high-density area like Vienna where energy demand is considered very high, there is not much space for implementation of renewable energies. At the same time. A scenario of even higher energy demand due to population growth and full electrification of the energy system seems unfeasible. In fact, an interviewee raises the point that the mobility sector is often neglected in these scenarios, while there are many opportunities for the city to develop sustainable solutions that decrease the energy consumption. But there is also an in-efficient building stock, and many citizens still not recognise the value energy efficiency. In Vienna, the energy transition at the district level will be fluent between the districts as currently the boundaries cannot be strictly set; that is e.g., cross district energy flows but also geographical boundaries. In any case, a challenge is that techno-economic solutions need to build on existing systems and infrastructure. In Vienna modernising the current building stock and implementing district heating and cooling as they are still not future proof. This important change is challenging due to the multitude of owners with different systems in place, which hinders easy implementation of innovative technologies. This limits the economic feasibility of technological solutions in the current energy system e.g., for geothermal energy or hydrogen, which could play an important role in Vienna's energy system. The interviews revealed that apart from current efforts, there are still many challenges regarding energy system's techno-economic development in Vienna, hence, this theme has been assessed with a 'low' level of development.

Business models

The interviewees identified environmental and economic drivers in the current energy system for energy consumers to participate in business models that support the local energy transition. In the current energy system, environmental motivations derive from a level of interest, awareness, and urgency, but also from the desire to be a part of the local/regional activities, which can be translated to a sense of belonging to the community. On the one hand, economic motivations arise from the decreased costs and investments due to available funds/subsidies from the government and increased market competitiveness of renewable energy technologies. On the other hand, economic motivations can be revenue driven, considering the financial benefit from energy sales or energy savings. According to the business stakeholder, a rise of public awareness and changes in people's behaviour in terms of saving energy and reducing waste can be recognised. He expects this trend to continue and become significant, which can create pressure on the private sector. Business actors in the current energy system are generally just motivated by economic benefits, and the interviewees are convinced

that the environmental value is just a part of complying with climate targets and positively supporting its sustainability image. Nonetheless, the Viennese experience demonstrates that there are businesses that are driven by competition and excellence in the field of innovation in order to become a frontrunner in the field. Therefore, this theme has been assessed with a 'low' level of innovation.

Equity and energy poverty

While none of the interviewees is directly engaged in any work to tackle energy poverty, they are aware of the need of a fair energy transition and their possible roles to achieve it. Interviewees know that excluding parts of the diverse society and possibly causing the poorer to get poorer will not be sustainable for the city. At the same time, an unfair transition will lose public acceptance, which is crucial for the overall feasibility and acceleration. In the current energy system, there are for instance a lot of subsidy programs in Austria to make heating systems more efficient. Already, several stakeholders referred to very low rents and subsidised social housing in Vienna, which reduces the risk of energy poverty. Another example mentioned is the exemption for poorer households from the levy for renewable electricity (Ökostrombeitrag). Still, all interviewees agree that affordability of energy and prevention of energy poverty should be of higher priority in local policy actions. Already now some people cannot afford the energy system as it is or others strongly depend on cars as they live in the remote areas, have no access to public transport, and need to commute to Vienna. A business stakeholder stated that it is not easy to allocate funds and grants equally to the society (incl. energy vulnerable households) in the current energy system. The current efforts towards a fair energy system, have been assessed with 'moderate'.

9.2.2 Vision for the desired future energy system

This section will focus on the desired future energy system in Vienna. The analysis of the vision reflects on the future energy system across the themes of analysis: participation and collaboration, techno-economic development, business models, equity and energy poverty. The analysis of the interviews with different stakeholders across the four themes contributes to understanding of their collaborative vision and proposals of desirable features according to these themes for Vienna's future energy system.

Participation and collaboration

All interviewees believe that the major stakeholders including citizens need to be brought together and collaborate in the future energy system. For example, the policymaker stakeholder foresees a 'triangle' collaboration between government/ municipality, real estate industry, and energy utilities. The business expert also identifies the automotive industry and public transport providers as an important stakeholder in the future. This interviewee further mentioned the role of large energy consumers e.g., big buildings or industry, which will have an important role as they could transform to become large energy prosumers. Hence, there will be collaboration between local, national, and transnational energy providers. The different interview participants raise the importance of energy communities and the collaboration between citizens and with citizens. In fact, the citizen group representative envisions the citizen involvement from embryonal stages of development and states that collaboration with and between citizens is more important than involvement of legal actors. The future energy system in Vienna is desired to be very human centric, with 'very high' levels of collaboration and participation among stakeholders including citizens.

Techno-economic development

The interviewees envision the future energy system to be fully sustainable and energy efficient involving sector coupling, decentralised system solutions, and innovative technologies. There will still be the need to import additional 'green' energy in the future energy system, provided by transnational,

national and local energy providers. The local context of Vienna will form the future techno-economic development to focus on heating and transportation. There will be new technologies for heating and cooling combined with increased building stock efficiency in the future through e.g., use of building's thermal inertia to store heat and cooling during the day. Also, districts might be grouped to Positive Energy Districts [5]; energy communities will become an important in the future energy system and form and support local energy production. Furthermore, in old buildings, active energy management will help in reducing energy consumption. Altogether, this will form districts with high energy self-sufficiency and an overall energy system with 'high' levels of development.

Business models

Stakeholders believe subsidies will be needed for a long time before the system becomes economically sustainable without them in the 'foreseeable future'. In the future energy system, there will be cost reductions due to start-ups that sell affordable readymade (innovative) solutions or energy efficiency measures and increased private sector investments. For example, the business stakeholder mentions the ESCO model that would be desirable in the future. Furthermore, the technology expert foresees an aggregator/manager who acts as a middleman between energy communities and other stakeholders such as the energy provider. As for the interviewee, this role is important in the future energy system to organise communities and reduce effort on the users' side. Nonetheless, the policymaker representative is convinced that in the future there will be stronger involvement of public sector, which will ensure a more democratic process and reduce the need to make profit. He envisions that companies could be public rather than private, which would facilitate the inclusion of the household perspective in business models and the promotion of sustainability. This vision demonstrates a 'very high' level of business model innovation and their role in future energy system.

Equity and energy poverty

Future energy communities and energy flexibility as part of energy transition should support increasing quality of life and address a neighbourhood level. Local ambitions and grassroots initiatives or even individuals, that e.g., produce energy locally, should be integrated into the energy system and supported by bottom-up approaches. The perspectives of the interviewees demonstrate the multifaceted aspects of social equity in the future energy system. The interviewees have several visions regarding the housing sector: social housing being used to implement and test new technologies and form energy communities; the sector giving users more decisional power (e.g., co-operative buildings); by law rent including energy services to push real-estate industry to retrofit buildings. An inclusive transport system is envisioned, which reduces dependency on cars but also together with other policies and solutions such as affordable metro tickets (1-2-3 ticket) maintains inclusiveness and limits the risk of transport poverty. In any case, the interviewees come back to the point that subsidies will be needed to support inclusiveness. It has been proposed that available funding should be effectively used and distributed to the vulnerable part of the society to connect 'climate problems' with everyday energy saving measures (retrofitting, replacing old boilers). According to the desired vision, the support of equity and elimination of energy poverty with policy measures or other means, can be assessed to be 'very high' in the future energy system.

9.2.3 The current and envisioned performance of the energy system

This section demonstrates the performance of the current energy system and its desired performance in the future. Overall, the domains of the current energy system are evaluated as 'low' and 'moderate' as the city already shows some progress in its energy system transformation. At the same time, the future energy system is envisioned to achieve its highly advanced state according to the experts' visions and the goals of the Energy Framework Strategy. The comparative analysis of the current

performance of the energy system domains and the envisioned performance of the future energy system 2040 in Vienna is shown in Figure .

It can be seen that Vienna, according to the perceptions and visions of the interviewees, is on the 'right' way of development as the gaps between the domains seem achievable given the current state of development and mindset of stakeholders. The biggest challenge will be the improvements and developments with regard to innovative business models. Overall, the interviewee's thinking seems to be in line with the Energy Framework Strategy 2030 for Vienna and vice versa. Spatial planning and sector coupling will be important for the transition in Vienna, but while the Energy Strategy mentions several areas of interventions, the interviewees point out especially heating and mobility. Nonetheless, the Energy Strategy areas of action do not include the human-centric aspect, which according to the interviewees, is important both in the current and future energy system of Vienna.

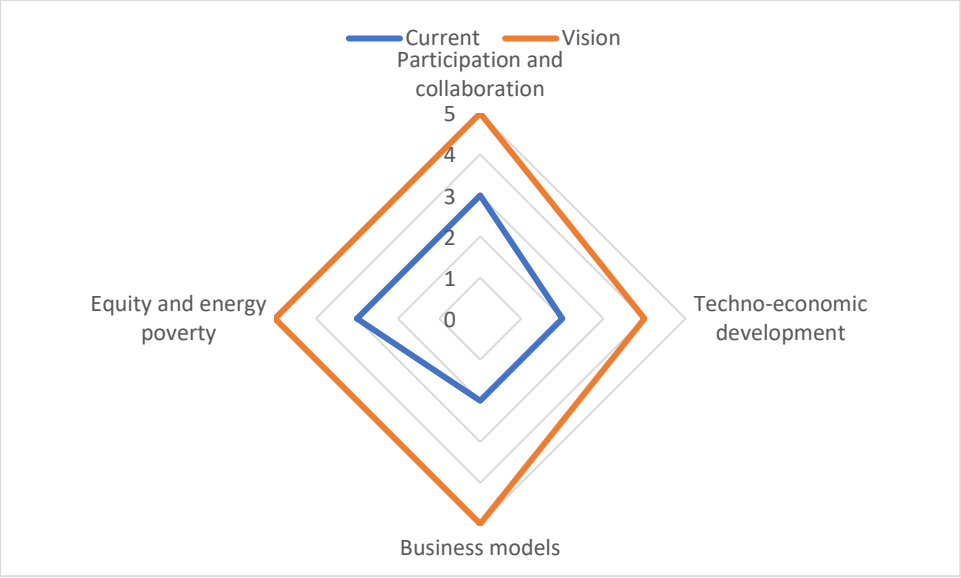

Figure 9.3. The current and envisioned performance of the energy system in Vienna.

9.2.4 Desired energy transition pathway to achieve the vision

Considering the current level of performance of the current energy system, its drivers, barriers, and the local context, changes and action are required in order to achieve the previously elaborated vision for the future energy system. The interviews allowed to identify possible actions that support the local energy transition pathway towards the desired future energy system. Hence, this section describes the desired energy transition pathway and the individual actions respectively for each theme of the analysis.

Participation and collaboration
More effort is needed to focus on increased awareness and establish strong participatory processes among all stakeholder groups. For instance, renovation projects will rely on strong participatory processes among the stakeholders. This will be a decisive factor in renovating the inefficient building stock. It needs alternative ways and strong pre-conditions to engage stakeholders to participate and collaborate in the energy transition pathway. This can be achieved through training and capacity building to practically engage the locals in the transformation towards a future energy system.

Techno-economic development

The context of Vienna gives the impression to interviewees that integrated technological solutions that work on local, regional, national, and even European context synergically are required to drive the local energy transition. A priority to achieve the vision is to push energy-efficient renovation (or retrofitting), which is more difficult to implement than regulating energy efficiency of new buildings. While for new buildings there should be compliance to standards before having authorisation for construction, renovation will require a different approach. First, it requires a high level of awareness from building owners and citizens; secondly, suitable, and efficient incentives, regulations, and financing/ business models; lastly, ready-made solutions that are easily replicable (similar to Energiesprong)[2]. The interviewees mention the difference of the pathways for rural and urban areas and that solutions such as in transportation, need to consider people that commute into the city. The mobility sector will require innovative solutions to support the reduction of the energy demand of the city, e.g., through car-sharing schemes. Furthermore, city ambitions should be aligned with national ambitions and EU policies and vice versa, facilitating for instance replicability and consistency of design of Positive Energy Districts in the EU. To achieve Positive Energy Districts, local ambitions should be supported through a bottom-up approach.

Business models

The stakeholders believe that subsidies and incentives will be required for at least 20 or more years. In fact, in addition to the EU funding, or subsidy programs of Austria for e.g., energy efficient heating systems, more financial support to all stakeholders is needed. According to the citizen group representative, especially citizens need those subsidies to support their investments into renovation processes to increase the energy efficiency of the building stock. Also, the business stakeholder states that private actors will invest into energy business models only a) when the customer requires sustainable products or b) when there are regulations and incentives from the government. The stakeholders claim that to reach targets and enable future innovative business models, regulations will need to get stricter but also need to become enablers.

Equity and energy poverty

All interviewees see subsidies as an important cornerstone to reduce energy poverty. These can be subsidies towards the transport system to help reduce expenses, or for energy efficiency renovations to tackle the high expenses for heating. For instance, drastic measures against private cars or increasing fuel prices would be an energy unjust pathway. Instead, a different mindset is needed with new policies and regulations which support inclusiveness and a fair energy transition. Along the way, technology improvements and increasing awareness at the user level will play a big role in reducing 'wrong' energy behaviour. More effort should be put to increased awareness and establish strong participatory processes and helping vulnerable households and social housings to implement technologies. The different stakeholders will have different responsibilities to support a just energy transition pathway, which range from communicating energy poverty, to bringing best practices together, developing policies and identifying cheap solutions with 'this thinking'. Additionally, in Vienna, the transport sector and its changes can lead to transport poverty. According to the business expert, a lot of people with low income rely on their vehicles, wherefore it is important to improve public transport.

9.2.5 Discussion of the overall scenario

There are several drivers and barriers of the current energy system in Vienna, Austria, with the old and inefficient building-stock being the biggest problem. On the one hand, the environmental awareness of the citizens is increasing, there are subsidies and economic benefits that enable attractive business models, and the transportation system in the city which provides many possibilities

for the mobility sector, drive the energy transition. On the other hand, stakeholders mention lack of time, capabilities, and capacities among all stakeholder groups, but also the size and context of the city establishes special and technical difficulties for the energy transition, which create barriers for the transition beyond building stock efficiency. By 2030 Vienna should be net-zero, having a fully sustainable energy system. The priorities are energy efficiency and sustainability of building stock, heating, and transportation, while providing a high quality of life for the citizens. This vision will include multi-stakeholder collaborations and participation of citizens. Inclusive subsidies but also obligations will be in place to enable a high building stock efficiency and energy efficient heating.

The future energy system will still have subsidies and incentives, as they will be needed to enable a fair energy system, with innovative business models, an inclusive transportation network, and the creation energy communities. In fact, to achieve sustainable and inclusive transport it requires inclusive regulations and policies. However, a key priority of Vienna's energy transition pathway focuses on achieving energy efficiency in building stock and heating. For this priority, several actions will be needed such as awareness and participatory processes, subsidies to all parts of society but also private investors, new roles for the housing sector, and specific energy efficiency measures and alignment of priorities and ambitions among all government levels. The increasing awareness about climate change and energy efficiency among Vienna's population will further support the local energy transition.

The proposed pathway priorities are technology driven and in line with the Energy Framework Strategy 2030 for Vienna but also human-centric. The human-centric aspect of the energy transition is strongly embedded in the consciousness of the different stakeholder groups and their vision for a future energy system. The context of Vienna, where stakeholder engagement and communication with citizens is already established, demonstrates the feasibility of the desired vision. The current 'Energy Framework Strategy 2030 for Vienna' does not explicitly list the fairness of the strategy. To provide equity and tackle energy poverty for a fair energy system is strongly desired by the interviewees. This could be a sign that while not a written key priority, the context and tradition of Vienna, and increasing social pressure, have influenced the mind-set of the stakeholder groups already. Actions will still be necessary to move from consciousness to implementation.

In order to transform the current energy system in Vienna into the envisioned energy system 2040, one of the possible scenarios of the energy transition focusses on eliminating the abovementioned barriers of the current system and using the drivers to achieve the goal 2040. The key elements of the foresight exercise for Vienna are summarised in Figure .

The foresight interviews within the context of Vienna demonstrated that the different stakeholders envision a human-centric approach and future energy system for their city. Sector coupling, and innovative heating and transportation solutions, but also energy communities and PEDs will support quality of life at a neighbourhood level. While the dense population and multi-owner and tenants' buildings could create challenges for PED development, the interviewees envision complete city districts to become PEDs. Through ESCO models and other business models and financing opportunities there should be full inclusion of all citizens in the PEDs at low effort, supporting a socially just PED development in Vienna.

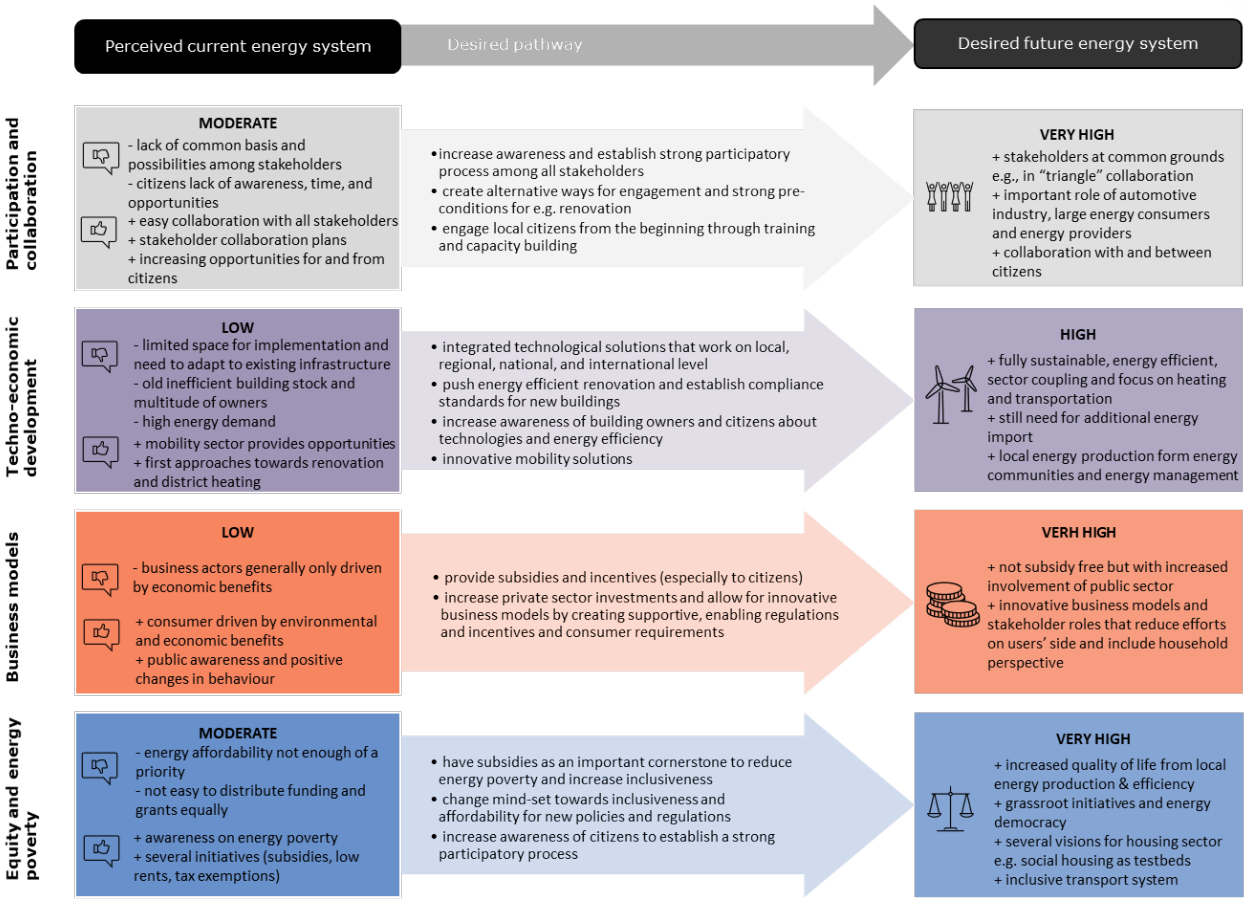

Figure 9.4. Key elements summarising the barriers and drivers of the current energy system, overall vision of the future energy system, and a possible pathway to achieve this vision in Vienna.

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10 Concluding remarks

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This regional foresight report presents base and vision scenarios that reflect the current and the future energy system in 8 EU regions along with the possible pathways to achieve the energy transition. It is based on semi-structured, Delphi style, foresight interviews that provide a detailed analysis on the regions' transition across four themes around techno-economic development, business models, participation and collaboration, and energy poverty. The Delphi technique allows us to iteratively approach the topic and draw meaningful conclusions based on the identified collaborative vision from the interviewees. The contribution of this report includes the qualitative nature of this research, as previous studies use predominantly quantitative methods such as optimisation and simulation models focusing mainly on techno-economic calculations for the energy transition, often ignoring the human aspect. Furthermore, this study provides examples on how the energy transition can be approached at different geographical scales with distinct contextual features and with a human-centric focus.

Based on our analysis, we conclude that the studied regions share a similar vision of the future energy system across the four themes. This vision enables them to achieve the requirements for a Positive Energy District (PED) with advanced techno-economic features, business models that allow inclusive, fair, and not burdening energy transition, and strong participation and collaboration of all stakeholders. The regions demonstrate common priorities on the way towards the desired vision and energy transition, namely increased technological development and a human-centric approach, facilitated through regulatory advancement. The first priority also is often the main aspect of the national/regional Energy strategies outlining the goals for the energy transition, while the last, prioritising the citizens in the energy system transformation, was less present in the published strategies but particularly highlighted by the interviewees across all studied areas. Also, the interviews revealed that immense regulatory changes will be needed to overcome the gap from the current to the future energy system to become enablers instead of hurdles. Interviewees pointed out the importance to include citizens in future energy communities and possible PEDs. This requires not only to have citizens as aware and knowledgeable collaborators, but also to ensure that they can participate and engage through incentives and subsidies offering all citizens the same financial resources and technological opportunities and a high quality of life. The visions and pathways of each analysed region include a human-centric approach and focus on the prioritisation and inclusion of all citizen groups in the different actions towards decarbonisation.

Nevertheless, there are differences in the pathways that the 8 regions have proposed. Contextual features differ in multiple regards including the climate conditions, cultural differences, the level of economic development, institutional and governance structures, advancement in the energy transition, amongst others. Therefore, we highlight that the contextual factors play an important role on defining possible scenarios for the local energy transitions. As such, the pathways are context-specific and can change through time due to disruptions in the system as well as adapt to the current/relevant contextual conditions. Consequently, the pathways directly depend on the context, and if the context changes, the pathway needs to change accordingly. The overview on possible energy transition scenarios that we presented in this study can be informative for similar regions in transition in terms of geographical scale and context specific characteristics. Of course, as highlighted above, the

contextual factors differentiate each case and makes it unique, hence, it is important to acknowledge that relevant assessments and propositions need to be made individually and based on the case's own merits.

Another crucial aspect that is important for developing an energy transition pathway is understanding the geographical and non-geographical scale of the transition. While we aim at achieving Positive Energy Districts, the concept of PED itself does not refer to the geographical boundaries of an area such as district. It refers to the area that comprises the system of elements/components of the energy system at a smaller scale. Therefore, this study offers the analysis of possible scenarios not for the geographically bounded areas, but the areas that are the systems of components of the bigger energy system. The four themes facilitated a meaningful discussion with the various stakeholders that revealed an understanding of the multifaceted aspects of the PED concept. While not all regions clearly envision PEDs, the baseline scenarios and the visions presented the feasibility of PED development in all regions. PEDs can often be an effective tool for technology implementation and public acceptance and engagement, but the interviews revealed that subsidies are still needed, at least in the early phases of the transition, to support PED development. Even if private investments increase, environmental and social value become more important for businesses, and citizens support financing through cooperative or crowdfunding schemes, the full development of PEDs would still require subsidies particularly to ensure the inclusivity and social coherence of the developments. Although most regions struggle with inefficient building stock, as shown in the case of Vienna, districts can be transformed to PEDs including the existing building stock. In fact, a human-centric approach can tackle and facilitate this transition without always requiring the development of new districts.

We have also highlighted that in the current energy systems, the engagement of citizens usually happens at 'later' stages, while all stakeholders desire higher citizen engagement from the 'beginning'. To overcome this, a human-centric approach should be prioritised, instead of making techno-economic solutions the fundamental element to achieve the transition as it is currently often the case. To conclude, it is important to consider the local context and the regional features to identify holistic, place-based local solutions with regard to participation and collaboration, techno-economic development, business models, and equity and energy poverty. These can significantly support the development of PEDs.

About the Smart-BEEjS Project

Energy transition is supported in the EU by legislative developments, such as the Strategic Energy Technology Plan that aims to transfer power to consumers by decentralising the energy eco-system at the local district-level. However, this transition occurrs at a time of increasing wealth inequality, energy poverty, and gender difference. Thus, the long-term vision of the Smart-BEEjS project is **to design transformational pathways** that tackle **Energy Poverty and Justice**, providing evidence and using the decentralised nature of **'Positive Energy Districts'** and **'Networks of Districts'** as the central platform of transformation, whilst recognising the economic, social and environmental challenges faced. Tackling the issue of energy injustice and poverty is an essential pillar for contributing to the **decarbonisation of our economies** without leaving large parts of the population behind.

Behind any decision or intervention – whatever the field of expertise, technological, business or policy – are **people**. Therefore, **the overarching training aim of Smart-BEEjS** is to provide, through a multilevel, multidiscipline and interdisciplinary training platform, a programme to produce the technology, policy making or business oriented **transformative and influential champions of tomorrow**; educated in the personal, behavioural and societal concepts needed to deliver the success of any technological proposition or intervention under the human-centric perspective of energy justice.

The Smart-BEEjS project recognises that the new level of decentralisation in the energy system requires the **systemic synergy of different stakeholders**, who are **inseparable** and interrelate continuously to provide feasible and sustainable solutions in the area of **energy generation and energy efficiency**. They balance attention towards technological and policy-oriented drivers from a series of perspectives:

- **Citizens and Society**, as final users and beneficiaries of PEDs;
- **Decision Makers and Policy Frameworks**, in a multilevel governance setting, which need to balance different interests and context-specific facets;
- **Providers of Integrated Technologies, Infrastructure and Processes of Transition**, as innovative technologies and approaches available now or in the near future;
- **Value generation providers and Business Model Innovation (BMI)** for PEDs and networks of districts, namely businesses, institutional and community-initiated schemes that exploit business models (BMs) to provide and extract value from the system.

In order to introduce cooperation and shared thinking, Smart-BEEjS presents a balanced consortium of beneficiaries and partners from different knowledge disciplines and different agents of the energy eco-system, **to train at PhD level** an initial generation of **transformative and influential champions** in policy design, techno-economic planning and Business Model Innovation in the energy sector, **mindful of the individual and social dimensions,** as well as the **nexus of interrelation between stakeholders** in energy generation, technology transition, efficiency and management.

The overarching aim of the project is to boost knowledge sharing across stakeholders, exploiting a human-centric and systemic approach to design Positive Energy Districts (PEDs) for sustainable living for all.

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